UNIVERSITY OF SOUTHAMPTON

Faculty of Medicine, Health and Biological Sciences
Institute of Human Nutrition

# *Factors affecting birth outcomes in South Asian women*

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## ABSTRACT

**Doctor of Philosophy**

# FACTORS AFFECTING BIRTH OUTCOMES IN SOUTH ASIAN WOMEN

**by Safiah Mohd. Yusof**

This study was set out to assess the relationship between physical activity and maternal size and subsequently on birth weight. Since valid and appropriate measures for assessment of physical activity in the South Asian community are not available they have to be developed. The first part of the research is a retrospective cohort study of South Asian births in Southampton that covered a period of about thirty years. Hospital maternity records with South Asian names were extracted and routine antenatal data were linked with birth outcomes, which include birth weight, placental weight, head circumference and birth length. 2432 full term singleton births were analysed.

In univariate analysis, maternal height, weight, BMI, iron status, age, parity, length of gestation, and infant sex were identified to have an influence on birth weight. In a multivariate model, lower haemoglobin levels in late pregnancy, lower BMI in early pregnancy and being a Sikh-Indian were associated with lower birth weight. Being younger and of lower parity, which was characteristic of the Sikh-Indians could be the underlying factors for the ethnic differences. Low haemoglobin in the third trimester was associated with a high placental to birth weight ratio. The South Asian babies were about 300 g lighter at birth compared to Caucasian babies born in the same hospital, but were 400 g heavier than babies born in India. A positive energy balance, thus an increased BMI, due to changes in physical activity levels of the South Asian women since migrating to the UK, could be a contributing factor to the changes in birth weight of the South Asian babies in the UK.

In the second part of the research, we have developed and validated a physical activity questionnaire that is appropriate for use in the South Asian community. The subjects in the validation study were 57 South Asian women, aged between 17 and 55 years who were recruited through a postal invitation and by personal approach. They answered a frequency of activity questionnaire (FAQ) and a 24-hour activity recall by interview, and completed a 7-day activity diary. The correlation between energy expenditure from the FAQ and the diary was moderate ($r = 0.44$, $p=0.001$), and the correlation between the 24-hour recall was higher ($r = 0.62$, $p=.000$). This study has shown that the FAQ, after taking account of the whole activity pattern, and the 24-hour recall can assess physical activity at group level. The FAQ and the 24-hour recall will be valid instruments to be used for future epidemiological studies to assess physical activity in South Asian populations at the group level, and the interaction of energy expenditure with birth weight.

This the first time that a physical activity questionnaire, an activity diary and the 24-hour recall has been administered in a South Asian community.

**The sure reality?**

**What is the sure reality?**

**and what will make**

**Thee realise what**

**The sure reality is?**

(Surat Haqqa, ayat -3, Al-Quran ul-Karim)

*FOR RAHIM*

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## LIST OF PUBLICATIONS

1. Safiah MY & Margetts BM (1996) Coronary heart disease mortality in Peninsular Malaysia. *Medical Journal of Malaysia* **51**, 3392-3395.

2. Mohd-Yusof S & Margetts BM (1996) Coronary heart disease in Peninsular Malaysia. *Proceedings of the Nutrition Society* **55**, 138A (Abstract).

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## ABBREVIATIONS

| | |
|---|---|
| ANOVA | Analysis of variance |
| BMI | Body mass index (weight in kilogram divided by height in meter squared) |
| CI | Confidence interval |
| g/L | Gram per litre |
| g/dl | Gram per decilitre |
| Hb | Haemoglobin |
| kJ | Kilojoules |
| LMP | Last menstrual period |
| MCH | Mean corpuscular haemoglobin |
| MCHC | Mean corpuscular haemoglobin concentration |
| MCV | Mean corpuscular volume |
| MJ | Megajoules |
| PCV | Packed cell volume |
| PET | Proteinuric pre-eclamptic toxaemia |
| RBC | Red blood cell |
| SD | Standard deviation |

# DEFINITION OF TERMS

| | |
|---|---|
| **Bias** | Any trend in data collection, analysis, interpretation, publication or reporting of data that can lead to conclusions that are systematically different from the truth. |
| **Full term** | Gestation of 37 weeks or more. |
| **Gravida** | Number of pregnancies, including the present pregnancy. |
| **Parity** | Number of live births and still births including the current birth. |
| **Regression line** | A line that can be described by the formula Y = a + bX, where Y is the dependent variable and X is the independent variable, a is the intercept, b is the slope and it is the rate of change in Y for a unit change in X. For any given value of X, Y can be calculated/predicted/estimated from the regression equation. |
| **Reliability** | Extent to which a variable or set of variables is consistent in what it is intended to measure. It differed from validity in that it does not relate to what should be measured, but instead on how it is measured. |
| **South Asian** | Groups of people who have origins in the Indian Subcontinent. |
| **Study power** | The probability of correctly rejecting the Null hypothesis when it is false. |
| **Validity** | Extent to which a measure or set of measures correctly represents the concept of study - the degree to which it is free from any systematic or non-random error. Validity is concerned with how much the concept is defined by the measures, while reliability is related to the consistency of the measures. |

Source: Last (1997); Hair *et al.* (1995)

# CHAPTER ONE

## 1 INTRODUCTION

The South Asian community forms a large proportion of the ethnic minority group in the UK (United Kingdom). They have settled here since after the end of the Second World War. The first generation immigrants who have settled down in this country have their children born here, and their children have become parents themselves. South Asians in the UK have come from different parts of the Indian Subcontinent, namely Pakistan, Bangladesh, and India (mainly Gujerat and Punjab). Among them there are variations in terms of religion, culture, dietary habits and physique depending on their origins.

Pregnancy outcomes and size at birth are of public health concern. Low birth weight is a risk factor for perinatal mortality. More recently, several adult diseases, such as coronary heart disease, non-insulin dependent diabetes and hypertension have been associated with small size at birth (Barker, 1995; Hales *at al.* 1991; Law *et al.* 1993). Studies in the UK have shown that the South Asian women who are on average shorter and lighter than Caucasian women give birth to lighter and smaller size babies.

Several factors have been recognised to influence birth weight. These include maternal weight and height, weight gain during pregnancy, length of gestation, smoking, parity, infant sex, iron status and the adequacy of antenatal care. In the Caucasian population maternal size and weight gain during pregnancy have been shown to be strong predictors of birth weight. Community studies suggest that South Asian women who live in the UK have higher BMI than their counter parts in the Indian Subcontinent. Increasing weight or body fat reflects positive energy balance. This can be a consequence of an energy intake, which is in excess of energy expenditure. Little is known about energy balance among the South Asian women who live overseas. It is not known whether urban life styles associated with increase mechanisation and sedentary living have brought about a positive energy balance and thus an increase in their BMI.

## 1.1 AIM

To study the effects of maternal anthropometry, medical and socio-demographic characteristics, on size at birth among South Asian babies born in Southampton

## 1.2 OBJECTIVES

1. To explore maternal factors during pregnancy associated with birth outcome among South Asian babies born in Southampton between 1957 and 1996.
2. To asses whether increased maternal weight associated with migration from the Indian Subcontinent to the UK is associated with increased birth weight in South Asian babies born in the UK, taking into account the effect of other maternal characteristics.
3. To assess whether the higher maternal weight in South Asian women in the UK can be explained by changes in levels of physical activity associated with migration to the UK, leading to a more positive energy balance.
4. To develop a valid method of assessing physical activity among South Asian women in Southampton in order to assess the effect of physical activity on maternal size.

## 1.3 HYPOTHESIS

1. The higher birth weight of South Asian babies born in the UK compared with those born in the Indian Subcontinent is explained by higher maternal weight of South Asian mothers in the UK.

2. Changes in levels of physical activity, as a result of migrating from the Indian subcontinent to the UK, leads to increased body weight as a consequence of a more positive energy balance.

## 1.4 RATIONALE

1. South Asian babies in the UK have lower birth weight than Caucasian babies.
2. Previous studies among the Caucasian population have shown that mother's weight and weight gain during pregnancy are strongly associated with baby's birth weight.
3. Studies among the South Asian women in the UK and India have shown that maternal weight is associated with birth weight. The effects of these factors on birth weight have not been studied among the South Asian community in Southampton.
4. Comparing data from the Indian Subcontinent and data from UK, South Asian women in UK are heavier than the women in India.
5. Studies in India have shown that women with a higher body mass index came from households with higher energy intake.
6. South Asian women who migrated to the UK may have achieved a positive energy balance by any of the following:
   a) Increased energy intake due to improved socio-economic status, but they have maintained similar physical activity level as before migration.
   b) Having similar energy intake to before migration, but they have reduced their physical activity level due to environmental changes.
   c) They have increased their energy intake, and at the same time reduced their physical activity level.

   These factors have not been studied before among South Asian population in the UK.

7. Limited data suggests that South Asian women have low levels of recreational activity, but there is little data available on total levels of physical activity, which takes account of housework and occupational activity levels.

8. Higher body weight of South Asian women in Southampton compared to women in India could explain the difference in size at birth of their babies.

9. In order to assess physical activity levels, valid measures are required which are appropriate for use in the South Asian population.

7. These measures do not exist and will have to be developed.

# CHAPTER TWO

# 2 LITERATURE REVIEW

## 2.1 FETAL GROWTH IN THE SOUTH ASIAN COMMUNITIES

### 2.1.1 Introduction and outline

South Asians are considered the largest ethnic minority group in the United Kingdom (UK), as they made up 2.7 percent of the total population (OPCS, 1993). This community consists of people who have origins from the Indian Subcontinent. Some of them were born in India, Pakistan or Bangladesh and have migrated to the UK and settled here. Some of them had migrated to East Africa first and later came to settle in the UK. There are now second or later generations of South Asians who have settled in the UK. According to the 1991 population census 44 percent (0.67 million) of South Asians were born in the UK (OPCS, 1993).

Most of the South Asian people in this country have origins from a few areas in the Indian Subcontinent (McAvoy & Donaldson, 1990). They include Punjabis from the Indian Punjab, who are predominantly, Sikh. The Gujaratis have tended to come from two areas of Gujarat, the northern area - Kutch, and Southern Gujarat. The majority of Gujaratis in the UK are Hindus, although there are communities of Gujarati-Muslims. People from Pakistan tend to have come from either the Pakistani Punjab - Punjabis; from the North West Frontier Province - Pathans; or from Mirpur district - Mirpuris. They are predominantly Muslim. People from Bangladesh have usually come from one main area in the north-east of the country - the district of Sylhet; most of them are Muslims too.

A proportion of the South Asian communities in the UK originated from East Africa, mainly from Uganda, Kenya, Tanzania, Malawi and Zambia. The main areas in the

Indian subcontinent from which immigration to East Africa occurred were Gujarat and the Punjab. There are some South Asian communities in the UK originating from Trinidad, Guyana, Fiji, Mauritius, and South East Asia. There are South Asian communities from the state of Tamil Nadu in south India, and from Sri Lanka, they are predominantly Hindus. There are also communities of Christian South Asians. They are mostly from Goa on the West Coast of India.

Clearly the South Asian people in the UK represent a diverse community, with differences in country of origin, language, religion and socio-cultural practices. Due to these differences it may be misleading to describe their characteristics and health outcomes as one entity.

The government (Department of Health, 1992) has highlighted differences in the rates of diseases and deaths between the Caucasian population and the ethnic minority groups in this country. This applies to both the adult and younger population. For example, since the early 1970s South Asians had the highest mortality rate due to coronary heart disease (Marmot *et al.* 1984; Balarajan *et al.*1984; Balarajan 1991; Balarajan 1995). Between 1988 and 1992 there was a 50 percent excess in mortality due to coronary heart disease among the South Asians compared to the general population of England and Wales. Bangladeshis appear to be worst off than other South Asians, for they had the highest mortality due to coronary heart disease, stroke and lung cancer (Balarajan, 1995). The South Asian community too had experienced high childhood mortality rates. For the period 1982-1985, perinatal mortality rate was highest among Pakistani births, almost twice those in UK-born mothers, 18.8 compared to 10.1 per thousand live births (Balarajan & Botting, 1989). It was also observed that perinatal mortality decreased with increasing birth weights, up to 4000 g, when it tended to increase. South Asians had a larger proportion of low birth weight babies compared to other ethnic groups.

However, these analyses were based on a person's country of birth. Inevitably they would have excluded rates for South Asians who were born in the UK. Figures for the 1980s and 1990s may not reflect the true mortality rates among South Asians, as the proportion of UK-born increase. In an independent report on the Nation's Health (Jacobson *et al.* 1991), one of the issues highlighted was the lack of reliable data on trends in risk factors affecting health among different ethnic groups. The report recommended more research in this area.

Birth weight and birth outcome have been the subject of interest in epidemiological studies in recent years, since the Barker hypothesis was put forward. This hypothesis proposes that undernutrition during critical periods of development in fetal life leads to permanent physiological and metabolic changes which have long-term consequences (Barker, 1992). These adaptive changes referred to as 'programming' will increase the body's susceptibility to chronic diseases in adult life. The hypothesis was developed based on epidemiological evidence from studies conducted in England and Wales.

Retrospective studies of adult men whose records of measurements at birth were kept, have shown that lower birth weight at term, and lower weight at one year of age is associated with increased risk of diabetes, hypertension, and increased mortality due to cardiovascular disease (Barker 1992; Barker 1994). These associations are independent of adult obesity, social class, smoking, and alcohol consumption. Besides birth weight, placental weight, and body proportions at birth have been shown to be related to risk of cardiovascular disease in adult life (Barker, 1994; Barker *et al.* 1990; Phillips *et al.* 1994; Law *et al.* 1995; Barker *et al.* 1995). Studies to explore the role of *in utero* programming in increasing susceptibility to adult chronic diseases have been repeated in other parts of the world.

Follow-up studies in the UK, Netherlands, Sweden, Jamaica, the United States and India have shown similar associations, in men and women, that support the hypothesis (Holland *et al.* 1993; Launer *et al.* 1993; Phipps *et al.* 1993; Godfrey *et al.* 1994, McCance *et al.* 1994, Yajnik *et al.* 1995, Frankel *et al.* 1996, Leon *et al.* 1996; Forrester *et al.* 1996; Curhan *et al.* 1996; Rich-Edwards *et al.* 1997; Stein *et al.* 1997).

In a review of the prevalence of coronary heart disease among the South Asian community, McKiegue *et al.* (1989) found that hypertension, cigarette smoking and increased serum cholesterol could not explain their higher rate of coronary heart compared to the general population. However, the prevalence of other coronary heart disease risk factors too are high among South Asians, for example diabetes (Mather & Keen, 1985; Simmons *et al.* 1989; Simmons *et al.* 1992; McKeigue *et al.* 1992a), insulin resistance and central obesity (McKeigue *et al.* 1991), and lack of physical activity (Rudat, 1994). They have not explored the contribution of these risk factors towards coronary heart disease among the South Asian community.

The Barker hypothesis of *in utero* fetal programming of adult diseases has added another dimension to the risk factors for the development of coronary heart disease among South Asians.

The purpose of this review is to present the current knowledge on factors that affect birth weight and other birth outcomes in the general population (section 2.1.2). Studies that have compared birth outcome between South Asian women and Caucasian women will be discussed. This review will attempt to find evidence for other factors, besides ethnicity, that can explain the differences in birth outcomes between South Asians and Caucasians. Studies on birth outcome of South Asian women who have migrated to the UK will be reviewed (section 2.1.3). Their findings will be compared with studies conducted among South Asian women in the Indian subcontinent (section 2.1.4). We shall try to find the evidence for differences in factors, particularly maternal size, between South Asian women in the UK and their counterparts in the Indian Subcontinent. This review will gather evidence of changes in dietary intakes and physical activity levels among South Asian women as a result of migration, and the effect it might have on maternal nutritional status, particularly in their energy balance (section 2.1.5).

### 2.1.2 Factors affecting fetal growth

Kramer (1987; 1993) has systematically reviewed studies on factors affecting birth weight published between 1970 and 1984. A meta-analysis of 875 studies identified seven broad areas that were found to have effects on birth weight. They were:

i. Genetic and constitutional factors
ii. Demographic and psychosocial factors
iii. Obstetric factors
iv. Nutritional factors
v. Maternal morbidity during pregnancy
vi. Toxic substances
vii. Ante-natal care

He was able to estimate the size of the effect of important factors on birth weight (Table 2.1). Clearly many of these factors are related to the mother's nutritional status before and during pregnancy. The WHO meta-analysis on the relationship between maternal anthropometry and pregnancy outcomes (WHO, 1995) has confirmed the findings of Kramer. Four indicators of maternal nutritional status seem to be important in predicting birth weight: maternal height, maternal prepregnant weight, maternal weight gain during pregnancy and maternal mid upper arm circumference (MUAC).

Table 2.1: Factors affecting birth weight

| Factor | Effect on birth weight |
|---|---|
| Cigarette smoking: | |
| Relative risk for smokers | -149.4 g |
| gram per cigarette per day | -11.1 g |
| Prior pregnancy: | |
| ≥ 1 prior low birth weight | -138.6 g |
| Parity: | |
| Multi-para | 82.7 g |
| Infant sex: | |
| Male-female difference in, | |
| Developed country | 126.4 g |
| Developing Country | 93.1 g |
| Gestational weight gain | 20.3 g/kg |
| Prepregnant weight | 9.5 g/kg |
| Maternal height | 7.8 g/cm |
| Ethnic group: | |
| Indian | Lower birth weight |

(Source: Kramer, 1987)

The WHO analyses showed that those women who were shorter than the median height for their population were prone to having small babies if their weight was also low and their weight gain during pregnancy was small. Maternal weight *per se* was also considered important in determining birth weight. Women who were at the lowest end of the weight distribution at term had a higher chance of producing smaller babies compared to women who were in the lowest end of the distribution for BMI, MUAC or weight gain. However, if the women were initially light, below the median weight for their population, then the size of the weight gain in pregnancy became very important. If the weight gain by week 20 was small, the odds ratio for risk of intrauterine growth retardation (IUGR) was 5.58. These findings seem to suggest that maternal nutrient stores in early pregnancy are also important for a favourable birth outcome.

Maternal height is a reflection of her own growth during fetal life and during childhood. The genetic potential, nutrition and the environment, or the combination of these factors affects it. For example, undernutrition *in utero* or in early childhood could have prevented a child from achieving his or her full growth potential, and in consequence growing up to be a short person. Thus, a woman who was small because she was undernourished in childhood, may impose a constraint on her own pregnancy, in terms of the fetal and placental growth as well as growth of the uterus.

Maternal body weight is an indicator of maternal health status. It is a reflection of her past growth, especially in early childhood. Weight is also a reflection of the recent and current health and nutritional status. In adulthood weight depends on height, to a certain extent, and also on her energy balance. Energy intakes, which are in excess of the requirement for the body's energy expenditure, will result in a positive energy balance. The body tends to store excess energy as fat. People who are in positive energy balance tend to put on weight. On the other hand energy intake, which are below that required for expenditure will result in a negative energy balance. People who are in negative energy balance tend to lose weight. Adequacy of calorie intake during pregnancy may be assessed by maternal weight gain. However, the types of diet, that is the proportion of fat, carbohydrates and protein, the mother has during pregnancy may also exert an influence on fetal growth (Godfrey *et al.* 1997).

It is possible that the mother's adult size is determined by her own weight at birth. Ounsted & Ounsted (1968) have shown that mothers in England, who themselves were born with lower than average birth weights had babies with lower than average birth weights. The influence of maternal birth weight on infant birth weight exists in other ethnic groups too. Klebanoff & Yip (1987) found a highly significant association between the mother's and infants birth weights in both black and white Americans. The risk of giving birth to a small-for-gestational-age infant increased with decreasing maternal birth weight in both ethnic groups.

Evidence for the effect of maternal size on the size of their offspring came from the longitudinal study of all births in one week in 1958 in England and Wales, and Scotland. The study suggests that the effect of maternal size on birth weights is transmitted through the maternal line (Emmanuel *et al.* 1992). In their study, the baby's birth weight was positively associated with grandmother's height, each 10 cm adding 53 g to birth weight of the grandchildren; the mother's non-pregnant weight, each 10 kg adding 92 g; the mother's own birth weight, each 100 g adding 16 g; and birth order, the mean increase of weight over the first born being 128 g for the second born, 209 g for the third born, and 306 g for the fourth born. These factors explained 15 percent of the variation of the infants birth weights. They suggested that other biological mechanisms that are still not understood could explain the remaining 85 percent of the variation in the infants birth weights.

Besides maternal nutritional status adequate antenatal care during pregnancy is also important for favourable birth outcome. Early diagnosis of complications means that the mother can be treated earlier to prevent morbidity. In the American population there were significant differences in the utilisation of antenatal care between white women and women from ethnic minority groups (Fuentes-Afflick & Hessol, 1997). Women from the ethnic minority group, including South Asian, were more likely to have inadequate antenatal care compared to white women. Utilisation of antenatal care was strongly associated with birth weight. Women who had inadequate utilisation of antenatal care services were four to six times more likely to have low birth weight infants than women with adequate utilisation of services.

### 2.1.3 South Asian babies in the UK

Studies in the UK that have compared birth weight of South Asian babies with Caucasian babies have shown that South Asian babies are lighter and smaller than Caucasian babies. The evidence is consistent in all the studies reviewed (Table 2.2). In each community studied, Caucasian women were heavier, taller and had higher BMI than South Asian women. In some studies there was a higher proportion of anaemic mothers among South Asians than Caucasians (Roberts *et al.* 1973, Perry *et al.* 1995). Using these general factors to characterise white and South Asian women, and knowing the effect these factors have on birth outcomes, it is tempting to extrapolate that South Asian babies are lighter and smaller than Caucasian babies because their mothers are smaller and lighter. However, there are other factors which have been recognised to influence birth outcome, for example the length of gestation, parity, maternal age, weight gain in pregnancy, smoking habit, socio-economic status, complications in pregnancy, and diet in pregnancy.

Several investigators have attempted to control for these factors by matching subjects from the two groups for maternal age and parity only (Chetcuti *et al.* 1985), for maternal age, parity, gestational age and smoking (Davies *et al.* 1982), for maternal age, parity, gestational age, smoking and social class (Alvear & Brooke, 1978). After matching for these factors, South Asian babies were found to be lighter and had a smaller head circumference than Caucasian babies. In a group of 692 healthy nulliparous women in Birmingham, 213 of whom were South Asians, Perry *et al.* (1995) have shown that being South Asian too had a negative effect on birth weight. After taking into account gestational age, BMI, maternal height and smoking, there was a 168 g reduction in birth

**Table 2.2: Studies comparing maternal characteristics and birth outcomes between Caucasians and South Asians in the UK**

| Study location; Reference | Caucasian | | | | | | | | | South Asian | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Maternal characteristics | | | | | Birth outcome | | | | Maternal characteristics | | | | | | Birth outcome | | | |
| | n | Weight kg | Height cm | BMI | Other | Birth wt. g | Head circ. cm | Length cm | Other | Ethnic group | n | Weight kg | Height cm | BMI | Other | Birth wt. kg | Head circ | Length cm | Other |
| Middlesex; Roberts *et al.* 1973 | 63 | | | | [h]123 ±12 | 3252 ±415 | | | | Pak & Bang | 28 | | | | [h]120 ±12 | 3090 ±428 | | | |
| | | | | | | | | | | Ind | 140 | | | | [h]119 ±12 | 2953 ±495 | | | |
| | | | | | | | | | | Afr-Ind | 23 | | | | [h]115 ±11 | 2842 ±484 | | | |
| West London; Alvear & Brooke, 1978 | 75 | 59.4 ±8.6 | 162 ±6.0 | 22.9 ±2.5 | | 3266 ±430 | 34.7 ±1.3 | 49.3 ±1.6 | | SA | 37 | 55.5 ±9.1 | 157 ±5.0 | 22.5 ±3.1 | | 2988 ±490 | 33.8 ±1.1 | 48.8 ±1.8 | |
| London; Brooke & Wood, 1980 | 243 | | | | | 3363 ±492 | 35.2 ±1.4 | 49.9 ±2.2 | | SA | 80 | | 156.1 | | | 3034 ±525 | 34.3 ±1.8 | 48.8 ±2.9 | |
| Leicester; Davies *et al.* 1982 | 70 | 59.9 ±8.6 | 160.1 ±5.2 | 23.2 ±3.2 | | 3320 ±420 | 34.7 ±1.3 | 49.7 ±1.3 | [p]627 ±9.3 | SA | 70 | 52.0 ±11.2 | 153.5 ±7.8 | 22.2 ±3.6 | | 2998 ±370 | 33.9 ±1.3 | 48.9 ±1.3 | [p]568 ±104 |
| London; McFadyen *et al.* 1984 | 486 | 63.3 ±9.1 | 162.7 ±6.4 | | | 3326 ±467 [a]3234 ±389 | | | | H | 664 | 55.3 ±8.6 | 153.5 ±5.6 | | | 2960 ±447 [a]3045 ±368 | | | |
| | | | | | | | | | | M | 132 | 58.0 ±8.3 | 158.0 ±5.6 | | | 3146 ±430 [a]3191 ±356 | | | |
| Leicester; Chetcuti *et al.* 1985 | 50 | 61.8 ±11.8 | 162.1 ±7.2 | | | 3486 ±407 | 35.3 ±1.2 | 50.7 ±1.5 | | S | 50 | 55.6 ±8.7 | 156.3 ±5.4 | | | 3245 ±429 | 34.3 ±1.3 | 50.4 ±2.1 | |
| | | | | | | | | | | M | 50 | 51.7 ±8.3 | 155.0 ±5.6 | | | 2998 ±359 | 33.6 ±1.3 | 49.4 ±1.8 | |
| | | | | | | | | | | H | 50 | 51.7 ±9.3 | 154.3 ±8.2 | | | 2967 ±444 | 33.9 ±1.5 | 49.4 ±2.0 | |
| Birmingham; Perryet *al.* 1995 | 367 | | 163 ±6.0 | 23.5 ±3.6 | [h]126 ±11 | 3241 ±522 | | | [p]643 ±142 | SA | 213 | | 158.0 ±6.0 | 22.0 ±3.7 | [h]122 ±13 | 3036 ±478 | | | [p]588 ±128 |
| Birmingham; Clarson *et al.* 1982 | | | | | | | | | | 1968 Ind | 106 | | 152.3 ±5.6 | | | 2908 ±490 | | | |
| | | | | | | | | | | Pak | 152 | | 152.8 ±6.9 | | | 3022 ±440 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1978 | | | | | |
| | | | Ind | 70 | | 153.6 ±5.5 | 2933 ±510 | |
| | | | Pak | 228 | | 153.3 ±5.5 | 3161 ±520 | |
| Birmingham; Wharton *et al.* 1984 | | | Pak-M | 37 | 59.2 ±11.0 | 157.3 ±6.3 | 3170 ±490 | |
| | | | Bang-M | 5 | 49.8 ±4.8 | 148.0 ±6.6 | 3190 ±370 | |
| | | | Sikh | 15 | 54.7 ±9.0 | 154.5 ±6.8 | 3140 ±360 | |
| | | | Hindu | 11 | 55.9 ±5.5 | 157.1 ±5.1 | 2780 ±630 | |
| Wolverhampton; Gatrad *et al.* 1994 | | | Male | | | | | |
| | | | Guj-M | 18 | | | 3060 | |
| | | | Pak-M | 95 | | | 3200 | |
| | | | Bang-M | 36 | | | 3130 | |
| | | | Sikh | 88 | | | 3170 | |
| | | | Hindu | 41 | | | 2970 | |
| | | | Female | | | | | |
| | | | Guj-M | 18 | | | 2990 | |
| | | | Pak-M | 86 | | | 3050 | |
| | | | Bang-M | 46 | | | 3100 | |
| | | | Sikh | 79 | | | 3090 | |
| | | | Hindu | 38 | | | 2830 | |

Figures are means and ±SD; n= number of subjects; a= adjusted birth weight, g; h= haemoglobin level, g/L; p= placental weight, g; circ.= circumference; BMI= body mass index; SA = South Asian; Pak= Pakistani; Bang= Bangladeshi; Ind= Indian; Afr= African; H= Hindu; M= Muslim; S= Sikh; Guj= Gujarati weight among South Asian babies compared to non-South Asian babies. Matching resulted in both groups having similar maternal characteristics, this implies that factors other than those matched are likely to explain the differences in their birth outcome. Nevertheless, to recruit subjects from both ethnic groups to match similar characteristics may cause a problem if the South Asian population in the study area is small, or the study had a limited time frame. Matching may not be complete; thus not all the factors are controlled for sufficiently (Alvear & Brooke, 1973). The study may then have a small sample size, and likely to reduce its statistical power.

Shorter gestational age at delivery may also explain the lower birth weight among South Asian babies. In a retrospective study of 16718 pregnancies in East London, Versi *et al.* (1995) had compared Caucasian births with Bangladeshi births. They found that Bangladeshi births had shorter gestations than Caucasian births, 39 compared to 40 weeks. The proportion of babies born less than 2500 g was higher (10.5 %) among Bangladeshis than white babies (8%). Mean birth weight was less among Bangladeshi babies than white babies (3099 versus 3281 g). A significantly higher proportion of the Bangladeshi women was less than 20 years old compared to white women.

Only one study published has attempted to take into account all the maternal factors that are known to affect birth weight by using regression analysis (McFadyen *et al.* 1984). The mean adjusted birth weight of Hindu babies was 189 g lower than Caucasian babies. The mean adjusted birth weight of Muslim babies was lower than that of white babies, but the difference was not significant. By controlling for factors known to affect birth weight, there were no differences in birth weight between the Muslim and white babies. This implies that variations in gestations, maternal size, parity, infant sex and smoking accounted for differences in their babies birth weight.

However, among the Hindus, these factors could only explain some of the difference in birth weight. Other factors not measured could account for the difference. In their study sample, the following factors were found to have a significant effect on birth weight:-

- gestational age (22 g/day),
- maternal weight (10.9 g /kg),
- maternal height (8.3 g/cm),
- male infants were on average 114 g heavier than female infants,
- cigarette smoking was associated with a mean reduction in birth of 110 g,
- multi-para was associated with a mean increase in birth weight of 106 g over primi-para.

It is likely that previous studies, which did not take into account the differences in smoking habits, heights and weights between South Asian and Caucasian women have overestimated the difference in birth weight. Thus comparing the adjusted birth weight of white and South Asian babies is more meaningful than comparing the crude birth weight.

There is a tendency for investigators to group the South Asian people as one, which may be misleading because they are not a homogeneous group. The criteria that have been used to separate subgroups of South Asian people include religion and country of birth. Using religion would differentiate the Sikh from Hindu Indians, but would place the Pakistanis and Bangladeshis into the same group. By using religious subgroups, Sikh mothers in Leicester were reported to be heavier than Muslim or Hindu mothers. Sikh babies had higher birth weight than Hindu or Muslim babies. There was no difference between Muslim and Hindu babies (Chetcuti *et al.* 1985).

Using the country of birth would separate the Pakistanis and Bangladeshis, but would place the Sikhs and Hindus into the same group. In addition, by using country of birth as criteria, South Asian people from East Africa, who have mixed origins, would be regarded as one group. By country of origins, Pakistani and Bangladeshi babies had a slightly higher birth weight than Indian and East African Indian babies (Roberts *et al.* 1973). It appears that using the criteria of religion or country of birth separately does not seem to be satisfactory because each criteria tends to combine distinct groups.

This could partly explain the lack of consistency between results from previous studies. Wharton *et al.* (1984) and Gatrad (1994) have attempted to disentangle this problem by using a combination of religion and country of origin to define subgroups of South Asian people. Their studies suggested that Hindu babies had the lowest birth weight compared to other South Asian ethnic groups, which confirmed the study on the Sikhs, Muslims and Hindus in Leicester (Chetcuti *et al.* 1985).

Comparison of crude birth weight between different groups can be misleading because factors that affect birth weight vary so much from group to group. There are likely to be other factors that are influencing birth outcome. However, to quantify the effect of maternal size on birth outcome, clearly these confounding factors should be taken into account, for example by using a regression analysis.

In conclusion, studies conducted in the UK have suggested that Caucasian women who are taller and heavier than South Asian women produce heavier and larger babies. However, these studies have their limitations and do not provide sufficient convincing evidence to prove that differences in birth outcome between Caucasians and South Asian people are due to differences in maternal size alone. Earlier studies did not take account of the confounding factors that also affected birth outcome. Therefore these studies may have either underestimated or overestimated the differences between white and South Asian babies. The sample size in some studies may have limited the generalisation of the results.

The notion of South Asian people being a homogeneous community group is also misleading. They consist of several distinct subgroups with differences in religion, socio-cultural practices and dietary habits, all of which may influence the relationship between maternal nutrition and birth outcomes.

### 2.1.4 South Asian babies in the Indian Subcontinent

Many studies from India, Pakistan and Bangladesh have focused their attention on the disparity in nutritional status and birth outcomes between the women from low-income group and women from high-income group (Table 2.3). Infants born to mothers from wealthy families were heavier than those born to mothers from poor families (Venkatachalam, 1962; Sibert *et al*, 1978; Raman 1981). The prevalence of low birth weight (<2500g) was higher in lower income groups compared to the higher income groups (Venkatachalam, 1962; Misra *et al*, 1995). Low birth weight was associated with teenage mothers, mothers aged more than 35 years and first time mothers. A high proportion of the low birth weight babies was born at full term (Misra *et al*, 1995).

Babies born at full term and weigh less than 2500 g are considered to have intra-uterine growth retardation, and they are sometimes referred to as small for gestational age (SGA). The high percentage of low birth weight babies among very young mothers and primipara among women in the Indian Subcontinent may be related to their socio-economic status. It is estimated that 30 per cent of the Indian women in the low-income group are married before the age of 18 and become pregnant (Raman, 1981). The situation may have changed in some states in India. For example, in Orissa (Central East West of India), the Child Marriage Prevention Act of 1978 made it illegal for girls less than 18 years to be married (Satpathy *et al*. 1990).

Table 2.3: Studies comparing maternal characteristics and birth weight for populations in the Indian Subcontinent

| Study location; Reference | Maternal characteristics | | | | | Birth weight, g |
|---|---|---|---|---|---|---|
| | n | Weight, kg | Height, cm | BMI | Hb, g/dl | |
| Madras; | | | | | | |
| Venkatachalam, 1962 | | | | | | |
| High social class | 1753 | | | | | 3182 |
| Low social class | 2777 | | | | | 2777 |
| Vellore, Madras; | | | | | | |
| Kapur *et al.* 1971 | | <35 | | | | 2530 |
| | | 35-39 | | | | 2700 |
| | | 40-44 | | | | 2810 |
| | | 45-49 | | | | 2910 |
| | | 50-54 | | | | 2960 |
| | | 55-59 | | | | 3040 |
| | | 60-64 | | | | 3090 |
| | | ≥65 | | | | 3290 |
| Vellore, Madras; | | | | | | |
| Sibert *et al.* 1978 | | | | | | |
| Paying | 150 | | 153.1 | | 11.6 | 2904 |
| Non-paying | 172 | | 150.0 | | 8.7 | 2698 |
| Vellore, Madras; | | | | | | |
| Mathai *et al.* 1992 | | | | | | |
| Non-smokers | 474 | | 151.6 | | | 2945 |
| Passive smokers | 520 | | 151.2 | | | 2840 |
| Hyderabad; | | | | | | |
| Naidu & Rao, 1994 | 81 | 35.4 | 151.9 | 16 | | 2510 |
| | 133 | 38.1 | 151.4 | 16-17 | | 2573 |
| | 460 | 40.9 | 151.2 | 17-18.5 | | 2653 |
| | 553 | 44.1 | 151.2 | 18.5-20 | | 2771 |
| | 717 | 49.6 | 151.0 | 20-25 | | 2812 |
| | 68 | 60.6 | 151.5 | 25-30 | | 2972 |
| | 5 | 75.5 | 151.7 | 30 | | 2972 |
| All | 2017 | 45.2 | 151.1 | | | 2742 |
| Vanarasi; | | | | | | |
| Singla *et al.* 1997 | 15 | | | | ≤6.0 | 2107 |
| | 19 | | | | 6.1-8.5 | 2363 |
| | 20 | | | | 8.6-10.9 | 2710 |
| | 22 | | | | ≥11.0 | 2844 |
| Pune | | | | | | |
| Tarapore, 1997 | 797 | 41.7 | 151.9 | 18.1 | 11.9 | [m]2654 [f]2568 |
| Orissa | | | | | | |
| Satpathy *et al.* 1990 | | | | | | |
| 1963 | 2254 | | | | | 2652 |
| 1983 | 3550 | | | | | 2724 |
| 1986 | 3368 | | | | | 2726 |
| India | | | | | | |
| Raman, 1981 | | | | | | |
| Income (Rs) | | | | | | |
| <400 | 1610 | 45.8 | 151.6 | | | 2690 |
| -799 | 650 | 47.4 | 152.3 | | | 2736 |
| ≥800 | 155 | 49.4 | 154.0 | | | 2872 |
| Pakistan | | | | | | |
| Hassan *et al.* 1991 | 200 | 54.5 | 152.9 | | | 2900 |

m - male; f - female

Nutritional status of the pregnant women in India, Pakistan and Bangladesh as indicated by their weight, height or haemoglobin level are related to their socio-economic status. There can be a 9 kg difference in maternal weight between women in the highest and the lowest socio-economic group (Kapur *et al.* 1971). The average weight and height of mothers from the highest socio-economic group (group I) was 52 kg and 151.5 cm, whereas, the average weight and height of mothers from the lowest socio-economic group (group VI) was 43 kg and 148.5 cm respectively.

Birth weight was also associated with socio-economic status. The birth weight of infants at full term decreased with lower socio-economic status (Kapur *et al.* 1971; Naidu & Rao 1994; Raman 1981). In a large sample of hospital births in South India, maternal height had a significant effect on infant birth weight. There was a 220 g difference in average birth weight between a mother who was less than 145 cm and a mother who was 160 cm (Raman, 1981). Besides maternal weight and height, body mass index (BMI) too had an influence on birth weight (Naidu & Rao, 1994; Hasin *et al.* 1996).

For similar heights, women from the higher income group (who were heavier) had heavier babies than women from the lower income group (who were lighter), (Kapur *et al.* 1971; Raman 1981; Naidu and Rao, 1994). These studies suggest that although childhood nutrition influences maternal height, good nutrition in adulthood results in increased birth weight despite the constraint of maternal height.

A study of their diets showed that calorie intakes were inadequate for the Indian mothers from all socio-economic groups, and protein intakes were inadequate among mothers of the lowest socio-economic groups (group V & VI), (Kapur *et al.* 1971). The average energy intake for women in the lowest socio-economic group was 1281 kcal compared to 2318 kcal per day for women in the highest socio-economic group. The dietary information was obtained by using questionnaires on sixty subjects (ten subjects in each socio-economic group). The maximum daily calorie intakes for women in socio-economic groups III to VI were similar. The minimum daily calorie intakes for women in socio-economic group VI was 638 kcal, which may be too low for life sustenance. The number of subjects may not have been sufficient to generalise the results for the whole study subjects.

Apart from lower maternal weight women from the low socio-economic group also suffered from iron deficiency anaemia. Anaemic women had lower birth weight babies than non-anaemic women (Venkatachalam, 1962, Sibert *et al.* 1978; Naidu & Rao 1994). Mothers with severe and moderate anaemia (haemoglobin less than 85 g/L) had babies with significantly lower birth weight, birth length, head circumference and chest circumference, compared to mothers with normal haemoglobin levels (> 110 g/L) (Singla *et al.* 1997). Among the urban poor community in Bangladesh, women who delivered low birth weight babies, had lower haemoglobin levels than women who delivered normal birth weight babies (Hasin *et al.* 1996). However, when other factors were taken into account, only gestational age, father's occupation, maternal weight and serum albumin were related to birth weight. Iron deficiency anaemia among these women is probably a consequence of poor socio-economic status.

The effect of maternal size on birth outcome has been studied on hospital deliveries in another region of India, Ahmedabad (Central West Coast State of India), (Mavalankar *et al.* 1994). Maternal anthropometric measurements were compared in 611 cases of perinatal deaths, 644 preterm low birth weight births, 617 full term low birth weight births (SGA babies) and 1851 normal birth weights. Maternal postpartum weight was more strongly associated with preterm low birth weights than full term low birth weight and perinatal deaths. Maternal height and BMI showed similar but less strong association with the three outcomes. After adjusting for maternal height and other confounding factors, maternal weight was a significant risk factor for perinatal mortality, preterm birth and SGA babies. For women who weighed 40 kg or less after delivery, the chances of having a low birth weight baby at term was almost two and a half times that of women whose weight were more than 50 kg.

Other factors that are known to affect birth outcome; for example smoking has not been explored extensively. This is probably because smoking is uncommon among South Asian women. However, the women could be exposed to cigarette smoke at home if there were male members in their household who smoked. In a hospital-based study, South Indian women who were non-smokers but exposed to cigarette smoke had lower birth weight babies than women who were not exposed to cigarette smoke (Mathai *et al.* 1992). Both groups of women were similar in height. However, the study did not consider other factors, which could affect birth weight, for example, maternal weight and socio-economic status. It is possible that women who were passive smokers also came from poor families, which could explain their lower birth babies.

Comparing the studies from India, Pakistan and Bangladesh, it suggests that Pakistani women are on average heavier and taller than the average Indian and Bangladeshi women. They have slightly heavier babies than the Indian and Bangladeshi women (Hassan *et al.* 1991; Hasin *et al.* 1996; Northrop-Crewes, 1998). On average, women in India are thinner and shorter, produce smaller babies than Hindu-Indian women in the UK, (Chetcuti *et al.* 1985; Wharton *et al.* 1984). For Pakistani and Bangladeshi women the differences are less clear because there are too few studies from Pakistan and Bangladesh to make comparisons. Most of the literature cited in this review were studies conducted in South and Central India. This could be due to the lack of studies in the other parts of India or due to bias in the western publications of studies in India.

There are differences in the dietary habits between communities from different parts of the country. For example, the consumption of fat was 8-19 times higher in Punjab (north India) compared to Madras in the south. The consumption of sugar, milk and milk products were higher in the north than in the south (Malhotra, 1967). North Indian women tend to be taller than south Indian women. The average height of north Indian women was 160 cm (5'3") and weighed 51.5 kg (Dewan *et al.* 1974). Punjab is considered the most economically developed state in India (Verma *et* al. 1992). There could be north-south socio-economic disparity. Since India is a vast country it is possible that the communities studied in India were not similar to the Indian community in the UK, thus the differences in the maternal size and birth weight of these two apparently similar populations.

Many of the studies reviewed were conducted among women who delivered in the hospitals, which are usually situated in urban areas. It is most likely that the subjects themselves have come from urban communities, or the surrounding suburban areas that are likely to be different from rural communities. South Asian people in the UK have originally come from the rural villages in India, Pakistan and Bangladesh, and they had an agricultural background (Healey & Islam, 1989). There is a possibility of bias in the subjects being studied. For example, a majority of the Bangladeshi women do not go to the hospital for deliveries (Karim & Mascie-Taylor 1997). This is also reflected in the low percentage of births attended by health personnel; 33, 35 and 5 per cent in India, Pakistan and Bangladesh respectively (UNICEF, 1995).

Women who give birth in hospitals are either from wealthy families, or they have been admitted because of potential complications. Findings from the hospital-based or health centre-based studies may not reflect the general population. In India, a majority of the women who seek antenatal care, either at the health centre or the hospital, do so very late in pregnancy (Raman, 1981). Thus, most of the maternal anthropometric measurements were done near delivery. Maternal weight in late gestation will be highly influenced by the product of pregnancy, that is fetal size, increased blood volume, amniotic fluid, enlargement of the uterus and the breasts. It is a poor indicator of maternal nutritional status.

There have been few studies that compare Pakistani, Indian and Bangladeshi women in the UK and women in their original villages in the Indian subcontinent. These types of studies would enable us to see what changes in terms of diet, physical activity and maternal size, have occurred in both populations. If there have been changes, we could evaluate how those changes have influenced their health status, nutritional status and their birth outcomes.

### 2.1.5 Changes in dietary intakes and physical activity among South Asian women overseas

Studies in the UK have consistently shown that South Asian women who are shorter and lighter than Caucasian women have smaller and lighter birth weight babies than the Caucasians. Possible factors that can account for these differences are gestational age at delivery and maternal size. However, due to poor study design and failure to take account of confounding factors, most of the previous studies have not shown sufficient evidence to support this argument.

If genetics plays an important role in determining the birth weight of South Asian babies, then babies born in the UK and the Indian Subcontinent should be similar in size. A review of studies (section 2.1.4) has suggested that Indian babies born in India are smaller and lighter than Indian babies born in the UK. However, it is possible that the Indian populations in India being compared with the Indian populations in UK are not truly the same populations. This is due to regional differences that exist in India. There have been too few of studies from Pakistan and Bangladesh published in the western journals to make meaningful comparisons. Thus it is not clear if there are similarities or otherwise between South Asian babies born in the UK and babies born in the Indian Subcontinent.

In the Indian Subcontinent, higher socio-economic status is associated with larger maternal size and bigger babies. Studies in the UK have rarely categorised South Asians into socio-economic groups. On the other hand, the criteria for different socio-economic levels in UK may not be the same as in India.

The South Asian people who have migrated to the UK mostly live in the city areas. Migrating from a rural environment in India, Pakistan or Bangladesh may have resulted in changes in their lifestyles. This part of the review will attempt to find evidence of differences in the dietary and physical activity patterns between South Asian women in the UK and those in the Indian Subcontinent. We are interested in evidence of changes that may cause a shift towards a positive energy balance for South Asian women in the UK, that will result in them being fatter and heavier than their counter parts in the Indian Subcontinent.

The literature on diets, body size and physical activity among South Asian communities in the UK and the Indian Subcontinent are mainly related to studies on coronary heart disease. This review is limited to those studies that have included women subjects.
In north India, the main food is milled wheat; its flour is made into chappatis. They are taken in every meal, mostly together with vegetable. Meat is not consumed regularly, and if at all, only meat from mutton or chicken. The bulk of their calories come from cereals, mainly wheat. A community survey of Punjab showed that only 20-25 percent of their calories came from fat (Werner & Sareen, 1978). Their average fat consumption was 50-80 g per day. Their main sources of fat were milk, ghee, fermented milk products and buttermilk.

Most South Asians in the UK still maintain dietary habits similar to the practices in their original communities in the Indian Subcontinent (Ganatra, 1989). The adult men and women still prefer to eat chappatis or rice with curries for lunch and dinner rather than having western meals. Some adults still have their traditional foods for breakfast. In a field survey of the Hindu Gujaratis in London, it was observed that their food habits and the content of their diets have subtle differences when compared to the Gujaratis in India (Kalka, 1988). The Gujaratis in London, who were mostly from the middle class, may have a choice of ready made cereals and milk or toast and marmalade for breakfast, apart from chappati or other traditional snack foods. Some of them have grown accustomed to western foods through their children, for example hamburgers and fish fingers.

The South Asian people in Southampton too still favour their traditional meal patterns similar to their origins in India, Pakistan or Bangladesh. In a study of 66 adult men and women in Southampton, the main sources of energy in their diet were chappati, breads, meat curry, milk and milk products. The Bangladeshis have rice with their curry instead of chappati. Because of the small number of Bangladeshis in the study, as a group, rice did not show as an important source of energy. Their main sources of fat were meat curry, vegetable curry, milk, milk products, paratha (chappati with added fat), and eggs (Karim, 1997).

Adult South Asians may still prefer to have chappatis or rice with curry for lunch and dinner, their children may not. However, dietary habits are changing among their offspring, particularly school children. They may take western type of foods while in school, and have chappatis or rice with curries for the evening meals when at home (Al-Dallal, 1998).

The types of foods eaten may remain the same, but the amounts consumed may have changed, for example if their socio-economic status has improved since coming into the UK. The mean daily intake of 35 adult South Asian women in Southampton was 1647 kcal (Karim, 1997). However, this low amount could be due to subjects under-reporting their food intakes. Using the basal metabolic rate (BMR) as a marker of energy requirement, 56 percent of the subjects recorded calorie intakes that were less than 1.2 times their BMR. It is assumed that energy intakes of 1.2 times BMR is the minimum required for maintenance.

In Birmingham, South Asian women were reported to have a mean energy intake of 1779 kcal per day at 18 weeks of pregnancy (Eaton *et al.* 1984). After adjusting for maternal size, their intakes using a 3-day weighed record were below the UK recommended daily amounts (RDA). The percentage of energy derived from fat (35%) was lower than the UK average of 41%. The percentage of carbohydrate energy was correspondingly higher. The proportion of energy from fat in the South Asian diet in Birmingham was much higher compared to the Punjabi community in India (Werner & Sareen, 1978). The investigators mentioned language problems with subjects who took part in the study. Thus the reliability of the results has to be questioned.

A later study, also conducted in Birmingham compared the types of dietary fats consumed by South Asian households with white and Afro-Caribbean households (Lip *et al.* 1995). It was estimated that the amount of fatty foods eaten per head was higher in the South Asian compared to the Afro-Caribbean households. There was no difference in fatty food consumption between South Asians and the whites. This suggests a pattern of increasing fat content in the diet of South Asians to become more like the UK diet.

In a survey of household food consumption among South Asians in London, it was reported that percent of energy from fat was 39% (McKeigue *et al.* 1985). The average fat consumption per person per day was 106g. The average daily calorie intake was 2415 kcal. Average consumption was calculated based on a seven-day record of all food brought into the home and a food frequency questionnaire. Household food consumption with the food frequency questionnaires at best may provide only rough estimates, because the validity of the questionnaire was not stated. The response rate was only fifty-one percent, and seventy-five percent of the respondents were Gujaratis. This study may not give a true reflection of the South Asian community.

Measuring dietary intakes using weighed records has been regarded as the gold standard, until recently. By using the doubly labelled water to measure energy expenditure, as a biomarker for energy intake, it has been shown that some subjects particularly obese people tend to under-report their food intakes, more than the others (Prentice *et al.* 1985; Schoeller, 1990). Thus reports of earlier studies on food intakes of South Asians are likely to have under-reporters, which has not been taken into consideration.

Obesity, in particular central obesity has been reported to be prevalent among South Asian men and women. In a study of South Asian community in London, the average BMI of adult women was 27 (McKeigue *et al.* 1991). There was a high percentage of central obesity indicated by a high waist-hip ratio. The average weight of the South Asian women, aged 40-69 years was 64.4 kg and their height was 154.6 cm. South Asian people in the UK have been reported to be heavier than their counterparts in the Indian subcontinent. For example, Keil *et al.* (1980) studied a group of Punjabi women in London and compared them with another community in Punjab. The weights of Punjabi women in London were on average 10 kg heavier than their counterparts in Punjab. It was noted that the Punjabis in London were 2-3 years younger than the

Punjabis in India. In another study of Punjabis in London and their siblings who live in Punjab, the Punjabi women in London had a significantly higher BMI than the women in Punjab, 27.4 versus 22.7 (Bhatnagar *et al.* 1995). The women on both groups were similar in age. These studies did not explore if the duration of living in the UK was related to the increase in obesity.

Data collected through the National Nutrition Monitoring Bureau of India showed that the average female Indian adult is 150.2 cm tall and weighs 43 kg (Naidu & Rao, 1994). Forty-seven percent of the women belong to the BMI range 18.5 to 25, and four percent were overweight (BMI more than 25). BMI was related to socio-economic status. Landless households, agricultural labourers and those with the lowest income had lower values of BMI compared to those with better occupation and income. Higher energy intakes were seen in households with better BMI. Mean energy intake per adult with BMI less than 16 was 1982 kcal per day compared to 2943 kcal per day for adult of BMI more than 30. Thus there is a large disparity between the higher and lower socio-economic groups.

In India, the disparity between the lower and higher socio-economic groups may be indicated by differences between the urban and rural populations. For example, in a population survey of 162 rural and 152 urban subjects aged 26-65 years in Moradabad, north India, Singh *et al.* (1995) found that the urban women were heavier than the rural women. The urban subjects had a three times better socio-economic status than the rural subjects. The urban men and women were eating higher amounts of fat, cholesterol and refined carbohydrates and less complex carbohydrates than the rural people. The percentage of energy from fat was lower in the rural subjects (15%) compared to urban subjects (25%).

In another cross-sectional study of the rural and urban community in Moradabad, central obesity was four times more common in the urban compared to the rural population (Singh *et al.* 1997). Physical activity level assessed by the distance walked during routine and spare time was higher in rural than urban subjects. The investigators did not report whether there were any differences in the physical patterns between men and women.

In a case-control study of South Asians and British whites in the UK and South Asians from New Delhi, Dhawan & Bray (1997) had compared their physical activity levels. In both cases and control subjects, seventy-eight percent of the British South Asians said they were mostly sedentary, while forty percent of the Indian South Asians were sedentary. Among British white, sixty-four percent were sedentary. Sedentary was defined as those who were on their feet for less than half the day as part of their job, and not taking any form of regular exercise. However, the investigators did not explain how this information on physical activity was obtained from the subjects.

South Asian people in the UK who mostly live in the cities, are more likely to live a sedentary lifestyle. A survey of ethnic minority groups in the UK has shown that adult female South Asians are least likely to be involved in sports and recreational activities (Rudat, 1994). A survey among 72 South Asian, 76 Afro-Caribbean, and 84 white housewives in Birmingham showed that South Asians had the lowest prevalence of doing regular exercise such as cycling, walking or physical workouts (Lip *et al.* 1996). Customs and traditions may restrict the South Asian women from doing these activities. However, these surveys did not assess total physical activity, which includes occupational activities and household chores.

The present literature suggests that South Asian people in the UK are sedentary and tend to be fatter than their counter parts in the Indian Subcontinent. Dietary studies suggest that South Asian communities in the UK have a higher proportion of fat as a source of energy than their counterparts in India. Similar changes in lifestyles have been observed in urban communities in India. This suggests that urbanisation, and possibly increased socio-economic status is related to increased food intake, particularly fatty foods, less physical activity, and increased obesity. Based on the methods used to assess dietary intakes and physical activity in these studies, the accuracy of their results is not certain. The information available is based mainly on cross-sectional surveys conducted among Indians. Little information is available about the diet and physical activity of Pakistanis and Bangladeshis.

Thus, follow-up studies of the South Asian community in the UK need to be conducted to confirm findings by these early studies. This type of study will be able to detect changes over time that is associated with living in the UK.

The physical activity levels and activity patterns of South Asian communities in the UK have not been studied extensively, particularly among the women. Previous surveys on physical activity have not assessed the total physical activity and their activity patterns. Due to customs and traditions South Asian people may be restricted in taking part in recreational activities, their activity patterns may not be the same as that of the general population. Therefore physical activity questionnaire that are used for the general population may not be totally appropriate for the South Asian communities.

## 2.2 ASSESSMENT OF PHYSICAL ACTIVITY

### 2.2.1 Introduction and outline

Epidemiological studies over the past 40 years have shown that higher levels of physical activity and fitness are associated with decreased risk of chronic diseases as well as with increased longevity (Bouchard *et al.* 1994). In 1995 the American College of Sports Medicine and the US Centre for Disease Control and Prevention specifically prescribed to the American adults to accumulate 30 minutes or more of moderate-intensity physical activity on most, preferably, all days of the week (Pate *et al.* 1995). This recommendation was reiterated in 1996 whereby children too have been included as their target group (NIH Consensus Development Panel on physical activity and Cardiovascular Health, 1996), in an effort to lessen the risk of cardiovascular disease among the Americans.

This is in contrast to their earlier recommendation that prescribed exercises vigorous enough to produce sweating or hard breathing (60-70 percent of maximal capacity) for at least 30 minutes, 3 times per week (American College of Sports Medicine, 1990). This is an indication that the relationship between physical activity and cardiovascular health is only recently well understood. However, less is known about the effects of physical activity on other chronic diseases such as cancer and osteoporosis, and on long-term health.

It appears there are still uncertainties on what type and how much physical activity should be recommended to the public to gain long-term health benefits. The prevailing uncertainty about the optimal intensity, frequency and duration of physical activity is probably due to several methodological issues in epidemiological studies of physical activities and health outcomes (Lee & Paffenbarger, 1996). One of the weaknesses in these studies is the lack of precision in measuring physical activities, particularly lower intensity activities. These are casual and less vigorous activities such as doing odd jobs in the house, or playing with children. In a survey questionnaire these types of activities are likely to be recalled with less precision, than say sporting activities. Further, there are many inter-correlated dimensions of physical activity that are associated with specific aspects of health.

The absolute energy expenditure regardless of intensity is associated with obesity, weight-bearing activity appears to be associated with bone density, and intense aerobic activity is associated with cardio-respiratory fitness (Caspersen *et al.* 1989). For example, 150 kilocalories expended during swimming may be beneficial to improve cardiovascular health, whereas 150 kilocalories expended in weight training may have a favourable effect on bone mass or osteoporosis risk. Clearly it is important that investigators should focus on particular dimensions of physical activity that are likely to be associated with the specific health outcome being studied. As in all epidemiological studies that try to establish true relationships between the exposure and outcome, physical activity epidemiologists have to be clear what to measure and how to measure it accurately.

This section of the literature review will first present basic concepts on the errors involved in epidemiological studies (section 2.2.2). The term measurement error refers to the combination of the systematic and random errors, which can arise at every stage of the study, from the design to the analysis stage. Error in the measurement of exposure and outcomes give rise to biased results that can lead to wrong interpretations of the findings. This section will discuss how measurement error can occur and the effects it has on the study findings.

This will be followed by an overview of the various methods that are available now for assessing physical activity in epidemiological studies (Section 2.2.3). The uses, advantages and disadvantages of objective measures of physical activity such as the heart rate monitoring and the motion sensor method will be presented. Their reliability and validity as an instrument to measure habitual physical activity will be discussed. The doubly labelled water method (DLW) has not been used in large-scale epidemiological studies. Since it has been regarded as a reference technique to measure energy expenditure in free-living subjects, it is included in this review. Other methods for the assessment of physical activity that will be discussed include the activity diary and the physical activity questionnaire. The questionnaire method has been used in almost all epidemiological research which examine the relationship between physical activity and health. In view of this, a separate section is devoted to a critical assessment of the studies that have been conducted to evaluate the validity of some of these questionnaires (Section 2.2.4).

### 2.2.2 Measurement error in epidemiological studies

#### *2.2.2.1 Introduction*

Epidemiology is defined as the study of determinants of health-related states or events in specified populations, and the application of this study to control of health problems (Last, 1997). The 'determinants' are referred to as all physical, biological, social, cultural, and behavioural factors that influence health. "Health-related states and events" include diseases, causes of death, behaviour such as use of tobacco, reactions to preventive regimens, and provision and use of health services. Nutritional epidemiology then is defined as the study of nutritional determinants of disease (Margetts & Nelson, 1991).

Generally, the aim of any epidemiological study is to describe the distribution and size of disease problems in human populations and to find out how a particular "determinant" affects a particular health outcome. The "determinant", usually referred to as the exposure variable, can be a virus, chemical agent, specific nutrients in foods, types of food or types of physical activity.

Epidemiologists are naturally interested to know what is the relationship between exposure and outcome. When a study shows that there is an association between the exposure and outcome, our next concern is whether it represents a true cause-and effect relationship. In other words, if we remove the exposure variable, would that affect the frequency of the disease or outcome?

In conducting an epidemiological study we pay particular attention to the measurement of both the exposure and outcome variables and make sure that they are measured as accurately as possible. Therefore the issue of concern in the design of an epidemiological study is to minimise the errors at every step, to be confident that the observed value or relationship under study is closer to the truth.

In every report of an epidemiological study the issue of bias and error is considered an essential component. The possibility of error and bias occurring at every step of the study must be discussed. Recently epidemiologists have used the expertise of mathematicians to correct for errors in exposure measurements that have caused difficulties in showing true cause-effect relationship in dietary studies. The consideration of bias and error in a study is important because they both can change the association between exposure and outcome.

In this section, the review to is confined to the measurement of exposure variable, for example physical activity and dietary intakes. The principles and concepts discussed are based on the current knowledge about measurement of exposure variables in epidemiological studies.

### 2.2.2.2 *Types of error in epidemiological studies*

Sources of error in the estimation of the exposure under interest may be classified as either random or systematic (non-random). The design of an epidemiological study should always consider how to minimise both types of error. Random error is the discrepancy between what we observe and the true population values, which is due to chance alone. Two major sources of random error in epidemiological studies are true within-person variations and sampling error. Factors such as eating different types of food every day, or doing different activities on a weekly, monthly, or seasonal basis contribute to random error. Biological variations, for example blood pressure is a source of random error.

Sampling error occurs as part of the process of selecting study participants who are always a sample of a larger population. Sampling error arises when by chance subjects in the sample do not accurately represent the population as a whole. The statistics we derive from the sample are not equal to the population values. One way of reducing random sampling error in an epidemiological study is to increase the size of the study. Statistical "sample-size" formulas are available to help epidemiologists plan the size of their studies according to the study design and the level of precision they require (Schellessman, 1974; Margetts & Nelson, 1997). Generally, for random errors the average of many repeated measures may cancel out the fluctuations. If the measurements are repeated, the average may also become nearer to the true value. If we have a large study sample, the mean values of our measurements too will approach the true value. In reality, sample size is usually determined by financial and logistic consideration. Sometimes investigators have to compromise between sample size and costs.

In a validation study, true within-person variations can be minimised by repeating the measurements on the same subjects. The average of these measurements is likely to reflect the individual's 'true' values.

Systematic error (or bias) occurs in epidemiology when there is a tendency to produce results that differ in a systematic manner from the true values. Possible sources of systematic error in the measurement of exposure include the process of selection of the study sample (selection bias), and errors in the measurement of subjects (information or observational bias).

Selection bias occurs when there is a systematic difference between the characteristics of the people selected for a study and the characteristics of those who are not. The statistics we derive from the sample is not equal to the population values because the sample is not a true random sample of the population. A common source of selection bias occurs when participants select themselves for a study, either because they have a personal interest, or because they are very aware of the subject being studied.

Selection bias can occur when the study has a low response rate. A review of studies of the characteristics of respondents and non-respondents in medical surveys noted that non-response was more common in the old and less well educated. Whites were noted to have higher non-response rates than blacks. Housewives, self-employed and unemployed people tended to have higher non-response rate than employed people (Armstrong *et al.* 1992).

Information bias occurs when the individual measurements or information obtained in the study are inaccurate. In other words they do not measure correctly what they are supposed to measure. Two common sources of information or observational bias are, recall and interviewer bias.

i) Recall bias - systematic error due to differences in accuracy or completeness of information obtained by memory recall of past events or experiences. For example, a person who has been diagnosed as having cancer is more likely than a healthy person to remember details of his or her past diets.

ii) Interviewer bias - this is the error due to differences in the way an interviewer obtains, records, processes the information, or interprets the data in different subjects. For example in case-control studies, the interviewer may change the emphasis of questions if he or she is aware which subjects belong to the case or control group. In studies where many interviewers are involved, one interviewer may be assigned to a different set of questions from another interviewer. This may result in bias of information obtained.

Systematic error in the information obtained or in the measurement of individuals has either one of two possible consequences, depending on the distribution of the error in the study groups. If error in the information or measurement occurs equally in the groups being compared, it leads to 'non-differential bias'. For example, in a case-control study, which wants to determine the association between cancer of the liver and excessive alcohol intake, cases (subjects with liver cancer) are compared with controls (subjects with no liver cancer). If excessive alcohol consumption truly causes liver cancer, there is likely to be more heavy drinkers among cases than among controls. It is usual for people to underestimate their alcohol intake. Suppose that all the heavy drinkers (exposed group) among cases, and all the heavy drinkers among controls did not admit to heavy drinking. The apparent result will be that excessive alcohol intake had no risk to liver cancer. The effect of 'non-differential bias' in an epidemiological study tends to result in an underestimation of the true strength of the relationship being investigated.

A 'differential bias' occurs when the different study groups give different information, or different study groups are measured differently. Using the same example as above, let us assume that, due to guilt, all of the heavy drinkers without liver cancer admitted to excessive alcohol consumption. Among the cases, say only ten percent admitted to excessive alcohol intake. The results will show that excessive alcohol intake is protective towards liver cancer, which is opposite of the 'true' association. Differential bias tends to show an apparent relationship between two factors when in fact there is none.

Systematic errors cannot be remedied by increasing the sample size. Systematic errors too cannot be detected or minimised by repeated measurements. That is, the mean of the measurement does not approach the true value with repeated measures. For example, an important activity for a subject (but not necessarily for all subjects) may have been left out from a questionnaire, or misinterpreted by a subject. If such a questionnaire is repeated, this same error is likely to happen again. Therefore the mean of many replicate measurements for an individual will not approach that person's true mean. Systematic error can be measured by comparing that method of measurement with a more accurate method. This is the essence of validation studies.

#### *2.2.2.3 Validity*

Validity is another way of saying how the instrument is capable of measuring what it is intended to measure. We can always check the precision of a laboratory chemical balance by using a standard weight. We know the true value of that standard weight and it is not likely to change. At the moment there is no 'gold standard' for measuring habitual dietary intakes or physical activities. We may never be able to measure the individual's 'true' long-term dietary intakes or physical activity levels. However, there are now methods that are considered to be able to measure fairly accurately indicators of habitual diet or physical activity.

For dietary studies the doubly labelled water method is considered the reference marker for calorie intakes, and the 24-hour urinary nitrogen excretion as a marker for protein intakes. Weighed food records have long been used as the reference method in dietary studies. For physical activity studies, the doubly labelled water too is considered as the reference method for physical activity assessment. It is a biological marker for energy expenditure, and considered as an objective method because it does not depend on the ability of the subjects to give the information required. The errors involved in using a biological marker are not related to the errors in measuring energy intakes using the diary and questionnaire methods. This is an important aspect to consider when we are comparing different methods of exposure measurement to estimate their relationships with the 'truth'. Other reference methods include the heart rate monitoring, the motion sensors, and the activity diary. Further discussions on these methods in physical activity studies will be presented in section 2.2.3.

These methods themselves do not measure the 'true' habitual physical activity. Thus, the comparison of a measurement instrument such as the questionnaire with any of the reference methods may only evaluate its validity against those methods, not the true values of habitual physical activity. For this reason, results of such validation studies are usually referred to as 'relative validity' of the measurement instrument. In this thesis, the term validity is used to infer relative validity.

#### *2.2.2.4 Methods of assessing validity*

The relative validity of physical activity questionnaires can be evaluated at two levels:

a) Its ability to assess the absolute energy expenditure at group level.

b) Its ability to correctly rank individuals according to energy expenditure or activity level.

Techniques in presenting validity study results include the following, (Nelson, 1997):

i) Comparison of group means or median (unpaired comparison).

ii) Differences between measurements within individuals.

iii) Ranking by thirds, fourths, fifths etc.

iv) Correlation analysis (Pearson, Spearman, intraclass, method of triads).

v) Regression analysis

vi) Bland-Altman analysis.

The aim of most dietary or physical activity studies is to estimate the correlation between questionnaire data and the subjects' habitual intake or activity level. Because there are no methods that can measure true, habitual food intake or activity level of individuals, validation studies can only describe the level of agreement between the test method and the reference (a better) method and estimate their relationship to the true measure. Most studies have used the correlation coefficient to assess agreement. Previously, if a statistically significant association was observed between the exposure measures obtained from the test and reference method, the test method was considered to be valid. However, it is now thought that this is not good enough.

The Spearman product moment correlation coefficient or the Spearman's rank correlation coefficient indicates the consistency of ranking between the two methods. The higher the correlation coefficient, the better the agreement between the test and reference measure. As the correlation coefficient falls, the number of subjects misclassified in the top or bottom of distribution of intakes, energy expenditure or activity levels increases. Validation studies, which compare several methods of exposure measurements, are able to estimate measurement variations and covariance. The correlation between the two measurements (ρ) is then calculated. The value of ρ can be used to estimate the percentage of individuals who could be classified in the correct third of the distribution of the true exposure using the measured exposure (Clayton & Gill, 1997). The table below shows that the number of subjects correctly classified in the extremes of the distribution falls dramatically as the value of ρ drops. The implication of low correlation coefficient is that the questionnaire will not be sensitive enough to show an activity-disease association because so many subjects will be misclassified.

The correlation coefficient however describes only one aspect of agreement that relates to ranking. High correlation coefficients do not necessarily mean good agreement between test and reference measures.

**Table 2.4: Correct classification by thirds of the exposure distribution**

| ρ | **% Correctly classified** |
|---|---|
| 0.1 | 42.8 |
| 0.2 | 46.5 |
| 0.3 | 51.4 |
| 0.4 | 54.8 |
| 0.5 | 59.2 |
| 0.6 | 63.2 |
| 0.7 | 67.9 |
| 0.8 | 73.4 |
| 0.9 | 81.0 |

(Source: Clayton & Gill, 1997)

These arise because of several factors. There may be a significant difference between means (constant bias between methods). The slope of the regression line may be significantly different from unity (a line of unity has a slope equal to one), either because the test measure increases as a proportion of the reference measure (proportional bias), or because there is a regression to the mean. Therefore it is preferable to assess validity using correlation coefficient together with other measures of agreement to describe the relationship between the test and reference measure.

Another method of assessing agreement between two measures is the Bland-Altman plot (Bland & Altman, 1995). This is a graphical presentation of the relationship between the difference of the reference and test measures against the sum of each pair of observation. This plot shows the size of difference between the two methods over a range of values. If the size of the difference were consistent across the range of values, then we would still be able to correctly classify subjects. However, if the size of the difference changes from the low to the high range, then we would not be able to correctly classify the subjects. Therefore the test method could not be used in place of the reference method.

Another way of assessing the validity of a questionnaire is to test the agreement in ranking of subjects between questionnaire and the reference method. Subjects can be classified according to their position in the distribution of a measurement (thirds, fourths, fifths, etc.). Ranking of subjects is one way of assessing the instrument measurement error. In physical activity measurements, the subjects are placed into groups, say low, medium, and high physical activity according to their rank in the distribution of physical activity. Comparison of their ranking by the test method, for example, the questionnaire with the reference method (say the doubly labelled water method), will identify those subjects who truly fall into the low, medium, and high physical activity. They are referred to as correctly classified subjects. The remainder of the subjects will be misclassified into other categories. Subjects who fall into opposite categories, for example, low by the questionnaire, and high by the DLW are referred to as grossly misclassified.

100% subjects belonging to the same category indicate perfect agreement between the two methods. However, this does not happen in reality because of the effect of chance. Even if there is perfect agreement between the two methods, by chance alone one third (33.3%) of the subjects would fall in the same third of the distribution, 44% would be in the adjacent thirds and 22.2% in the opposite thirds. Usually, in dietary or physical activity studies, agreement is reported as the percentage of subjects that fall in the same categories of distribution, and the percentage that fall into the extreme opposite categories. The Kappa statistics are used to indicate if the results are significantly different from chance.

There is a difference between **validation** and **calibration studies** (Margetts & Pietinen, 1997). A validation study aims to find the correlation between the questionnaire measurements and the individuals' true activity levels. It would want to evaluate whether a selected questionnaire method would measure a reasonable proportion of the between-person variation in true activity level in a given study population. The study can estimate the total relevant measurement errors and can separate the different sources of measurement errors. It requires at least two reference measurements for comparison. A validation study has to be conducted before the actual main study, and the study sample may not come from the main study subjects.

A **calibration** study aims to estimate the true activity levels predicted by the questionnaire measurements. It does not estimate the sources of measurement errors separately, but assesses the systematic measurement error and the variance of the calibrated measurement. These are the values needed to correct the relative risk for given increments of activity. Separate variances of the random measurement error and the true activity level is not estimated. A calibration study should be conducted on a truly representative sub-sample of the main study subjects. This is important because we can estimate the bias function in the sub-sample, to correct for bias in relative risk estimated in the main study subjects. A calibration study requires only one single reference measurement for comparison.

#### *2.2.2.5 Repeatability, Reproducibility, and Reliability*

**Repeatability** refers to the consistency with which a measure of exposure measures that exposure. Is the same result obtained if a measure is repeated? Differences between measures may be due to either true subject variation or the effect of measurement variation. Usually it is difficult to separate the two components.

**Reproducibility** is the extent to which a method of measurement is able to produce the same results every time, given the same circumstances (Nelson, 1997). Strictly speaking this may not always be possible because repeat measurements on the same subject may not be conducted under the same circumstances. In epidemiological studies, repeated measurements are conducted to assess the instrument's reliability and reproducibility.

It is now a standard requirement in any dietary or physical activity study that the questionnaires to assess diet or physical activities have proven to be reproducible and valid. Asking subjects to fill in the same questionnaire at intervals can assess reproducibility of the questionnaire measurement. The level of reproducibility is presented as the correlation coefficients of foods, food groups, nutrients or physical activity types or level between groups or subjects. The variation in the subject's response as well as actual changes in diet or physical activity may reduce its reproducibility. Both sources of variation will actually contribute to misclassification of subjects according to their long-term diet or activity pattern. Both are regarded as measurement errors. If the questionnaire is administered within a short period, subjects may remember their previous responses. On the other hand, if the questionnaire is administered over a long interval, say one year, subjects may actually change their diet or physical activity pattern. The assessment of reproducibility should be done over several intervals of time, so that any variations will only reflect the variation associated with completing the questionnaire.

Using the Bland-Altman plot as mentioned earlier can also assess reproducibility. The mean and standard deviation (SD) of the differences will enable us to estimate how far apart measurements at two time points, by the two methods, on the same subject are likely to be. The limit of agreement is indicated as 2SD above or below the mean difference. If the limits of agreement are not acceptable, then the reproducibility of the method of measurement is poor.

Intraclass correlation coefficients too have been used to assess reproducibility. In a reproducibility study, what we are interested in is the individual agreement (within-pair). A statistical method has been described to calculate this coefficient (Lee, 1980). For example, in the reproducibility study of a physical activity questionnaire, the physical activity data could be in terms of frequencies (i.e. the number of times the activity is done per week). The simplest method of quantifying individuals agreement is to present the percent of individual (pairs) with exact agreement within a selected number of units. When the physical activity data are in amounts (i.e. number of hours spent doing a particular activity per week), we can present the percentage of individuals (pairs) agreed to within a certain amount (e.g. percent agreed to ±10 hours/week say).

The percent agreement does not consider that a certain amount of individual agreement can be expected based on chance alone. For example, if activities were recorded for the same subjects by one method were completely independent, a certain proportion of these subjects will somehow show perfect agreement based on chance alone. Therefore a statistical index has been calculated to quantify individual agreements that can correct for the amount of chance-expected agreements. This index is called $r_I$, the intraclass correlation coefficient.

#### 2.2.2.6 *A model of measurement error*

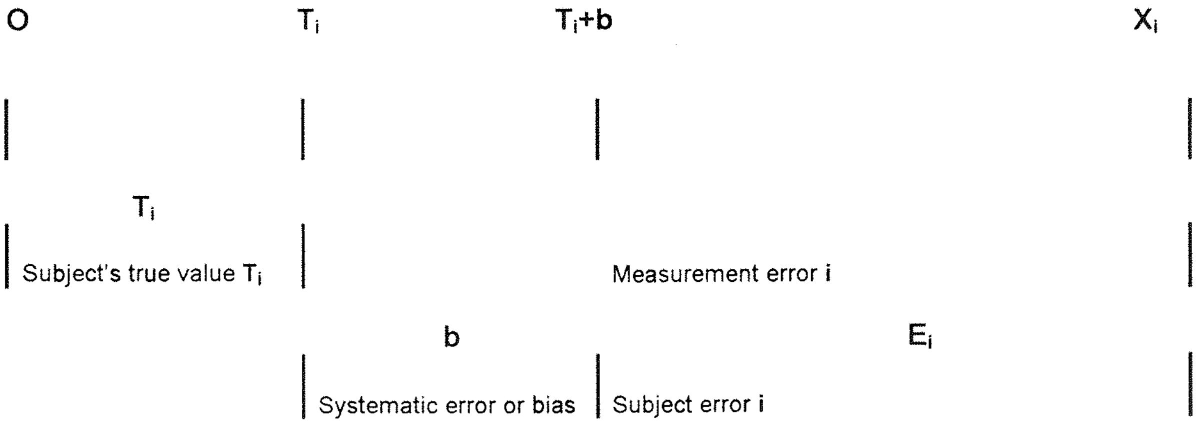
Armstrong *et al.* (1992) has described a simple model of measurement error in a population study as:

$$X_i = T_i + b + E_i$$

This model is illustrated in Figure 1. In it, the observed measure $X_i$ for a given individual **i** differs from the true value $T_i$ for that individual as a consequence of two types of measurement error. The first is the systematic error or bias **b**, which would occur for all measured subjects. The second, $E_i$, is the additional error in $X_i$ for subject **i**. **E** is referred to as the subject error. It varies from subject to subject. An example of subject error is his or her inability to recall accurately about a past activity. 'O' the start of the reference time.

**Figure 1:**

**A measurement error model (from Armstrong *et al.* 1992)**




Thus they have divided the measurement error into two components:

i) The systematic bias, **b**, that would affect all members of the study population.

ii) The remainder of the error E, that varies from subject to subject.

An example of a systematic bias, **b**, in a physical activity questionnaire is not asking about an activity that is performed by all subjects. In this case, the questionnaire tends to underestimate the physical activity of all subjects. If this is the only error for the questionnaire, it is still valid for the population. The physical activity measurement can still be used to rank each subject correctly in the physical activity distribution by his or her own value. However, if there were additional errors, that ranking would be lost. Validation studies usually aim to estimate the size of the bias **b**, and the variability the error **E** between subjects. A measure of the precision of the questionnaire is usually indicated as the correlation between the observed measurement **X** and the true value **T**, or the validity coefficient **X** or $\rho_{TX}$.

Kaaks (1997) has developed a model called the method of triads to estimate this validity coefficient. Plummer and Clayton and (1993) have described other measurement error models.

Measurement error of an instrument can vary between population groups, for example between ethnic groups. The same group may have different measurement error when two different instruments are used to measure the same exposure.

#### *2.2.2.7 Summary*

Ideally, any epidemiological research should be designed to measure the relevant exposure and outcome as precisely as possible. In reality this may not be possible or practicable, and usually only an indirect indicator of the exposure and disease are measured. Measurement error is the difference between the observed exposure value and the corresponding true but unknown value.

The aim of estimating measurement error is to assess the validity of the measured exposure. We would want to know the relationship of measured exposure to 'true' exposure in the study population. It is now possible to measure the errors involved in the measurement of exposure variables, which include errors that are related to the subjects' variations in activity levels as well as errors due to the measuring instrument. Measurement errors can be estimated by comparing the method of measurement with a more accurate method. This is can be done by conducting either a validation study or a calibration study.

It is preferable that we determine the measurement error of an instrument before it is being used in the main study. If the measurement error of our method is too large, the measuring instrument will not be sensitive enough to detect variations in individuals' physical activity levels or to correctly classify individuals into different categories of activity levels. In such a situation we must make a decision whether to abandon the method and look for a better method, or modify it in order to increase its accuracy and precision. In either case it will be necessary to carry out another validation study. There are several mathematical models that have been developed which can estimate the measurement errors of our instrument. Consequently, when that measuring instrument is used in a study, its estimated measurement errors will then be used to correct for the biased estimate of relative risk observed. Some investigators may prefer not to use this correction method. If the reference measure itself is not perfect, correction for the measurement error in the test instrument is not likely to make it a perfect measure.

### 2.2.3 Methods for assessment of physical activity

#### *2.2.3.1 Introduction*

The link between habitual physical activity and reduced risk of chronic diseases has increased the interest in physical activity research. Most epidemiological studies that examine risk factors for chronic diseases have included the assessment of physical activity in their study design. However, there is a need to develop an accurate, inexpensive and objective tool to measure physical activity in the community. LaPorte *et al.* (1985) in their review have presented more than 30 different techniques that have been used to measure physical activity in the field. In their opinion, there is no other health-related behaviour that has been measured in so many ways, except for dietary and nutritional assessments.

This part of the review will discuss five types of methods for physical activity assessment. They have been shown to be suitable to study subjects in free-living conditions. The doubly labelled water, the heart rate monitoring, and the motion sensor method are considered objective methods in physical activity measurements. The doubly labelled water method is not practical for studies that involve a large number of subjects, mainly due to its high cost. Since it has been recognised as a benchmark to measure energy expenditure in the field, this method will also be discussed. How good these instruments are in measuring physical activity will be examined. The activity diary and the physical activity questionnaires are the methods currently employed by epidemiologists to examine the relationship between physical activity and chronic diseases that involve thousands of subjects. Their accuracy, precision and reliability in measuring habitual physical activity will be discussed.

### *2.2.3.2 The doubly labelled water method (DLW)*

The doubly labelled water method is a relatively new approach for estimating energy expenditure in studies outside the laboratory. In this method every subject will be asked to drink a known quantity of water labelled with the stable isotopes deuterium and oxygen-18 ($^{2}H_2O$, $H_2{}^{18}O$). The concentration of the isotopes must be greater than that which occurs in nature. The isotopes are stable so there is essentially no risk to subjects (Klein & Klein, 1986). The subjects will be required to give urine samples at intervals up to a period of two weeks. The urine samples are analysed with isotope-ratio mass spectrometry to determine the rate of isotope elimination from the body.

From the difference in elimination rates of the two isotopes, carbon dioxide production can be calculated. Since carbon dioxide is the end product of substrate oxidation for the production of energy, it can be regarded as an indicator of energy production. By using standard indirect calorimetric equations, which also requires an estimate of the subject's respiratory quotient (RQ), energy expenditure is calculated from the carbon dioxide production.

Comparing carbon dioxide production measured by whole-body calorimetry with carbon dioxide production predicted from the doubly labelled water has tested the accuracy of this method. The difference was 1.9 percent in four adult subjects who were studied for 12 days (Coward & Prentice, 1985). Precision was substantially improved using measurements made over 12 rather than 5 days. One of the assumptions in using the

DLW is that the number of water molecules in the body remains constant during the observation period (Lifson & McLintock, 1966). So large unusual changes in body weight will result in error. Therefore, it may be necessary to measure changes in body weight during the measurement period, to make the necessary adjustments.

The calculations used to predict carbon dioxide production includes a correction for isotopic loss as water vapour through the body's surface area. The proportion of body water loss as vapour appears to be greater in obese than lean persons, (Prentice *et al.* 1986). Therefore, a different correction factor has to be used in lean and obese subjects.

The DLW is now considered to be the best method for measurement of energy expenditure in free-living subjects, children and adults, for long periods. It is not intrusive and less likely to interfere with subject's daily activity. Since the isotopes are costly this method has not been used in large-scale epidemiological studies. In addition to the cost of the sophisticated isotope-ratio mass spectrometer, technical expertise is required to operate the equipment. Since this method only measures total energy expenditure, it is not able to describe activity patterns of individuals or differentiate activity levels. However the DLW could be used as a reference method to compare measurement of physical activity by other less accurate but more practical methods.

#### *2.2.3.3 The heart-rate monitoring method (HRM)*

The heart rate monitoring method that was described by Bradfield (1971) is based on the principle that within a range of aerobic exercises the heart rate increases with physical exertion. Since this increase is linearly related to oxygen consumption the heart rate can be used to quantify physical activity or used to estimate oxygen consumption, (and then calculate the energy expenditure). This method requires subjects to undergo a calibration procedure in the laboratory, to determine their individual oxygen consumption regression line. This is partly due to wide variations in the resting heart rate from person to person. The calibration procedure involves simultaneous measurements of heart rate and oxygen consumption while the subject is at rest, and while doing different sets of exercises. Based on measurements during these activities a regression equation is computed to describe the individual's relationship between heart rate and oxygen consumption.

Earlier investigators who had attempted to estimate energy expenditure from heart rate encountered large errors because they had to fit a linear relationship between oxygen consumption to a single average heart rate accumulated over 24 hours. One major weakness in the method is that at low levels of activity heart rate can vary considerably while oxygen consumption remains unchanged. Another problem with the heart rate method is that for many people, the average heart rate over the 24-hour period is only a few beats per minute above the resting value, Dauncey & James (1979).

With recent developments in microchip technology investigators have been able to record minute-by-minute heart rate throughout the day. The device is small and light. It can record heart rate up to 34 hours in stored memory. Spurr *et al.* (1988) calibrated this type of instrument against the indirect calorimetry method. They found two ranges of heart rate, one during the rest period and one during exercise. For each subject there was a critical heart rate above which there is a strong relation between heart rate and oxygen consumption and below which the two variables are poorly correlated. This critical heart rate is called the 'flex heart rate'. For heart rates above 'FLEX' the regression line was used to predict energy expenditure, and for heart rates below 'FLEX' the resting heart rate was used to estimate energy expenditure.

Using this approach heart rate measurements were used to predict energy expenditure during minutes of activity where the relation between oxygen consumption is strong. Ceesay *et al.* (1989) found no significant difference in energy expenditure estimated by calorimeter and predicted by heart rate method for the group. Heart rate underestimated energy expenditure by 1.2 percent. This suggests that at the group level, there was good agreement between the two methods. It would be useful to know if the agreement was good at all levels of energy expenditure.

The heart rate monitoring method has been tested in a small-scale epidemiological study in Cambridge (Wareham *et al.* 1997). In this study, the total daily energy expenditure for the group was inversely related to the proportion of daytime hours spent with heart rate less than 'FLEX'. On the other hand there was a positive relationship between total energy expenditure and proportion of time spent with energy expenditure more than five times the basal metabolic rate. Their results suggest that the choice of 'FLEX' heart rate was appropriate. In this study, the mean PAL (ratio of the total energy expenditure to BMR) in men was 1.89 (SD 0.40), in women it was 1.76 (SD 0.31). This is slightly higher compared to the PAL value obtained for individual men and women by Black *et al.* (1996).

### Summary

The heart rate monitoring method has its advantages and disadvantages. The disadvantage in using this method is that every subject has to be brought to the laboratory to determine his or her own oxygen consumption and heart rate calibration curve. The procedure is time consuming. This can be a burden on the subjects as well as the researchers. Problems encountered in the field with the heart rate meters include electrode belts that come loose as subjects carry on with their normal activities, and signal interference from certain electrical appliances (Li *et al.* 1993; Wareham *et al.* 1997). The heart rate monitoring method has the advantage of estimating energy expenditure as well as determining patterns of activity. It does not interfere with subject's normal daily activities.

#### 2.2.3.4 *The motion sensors*

***The pedometer***

The pedometer is an instrument used for counting steps or for estimating distance walked. It looks similar to a stopwatch and is light. The pedometer is usually worn at the waist or on the ankle. The construction of the pedometer is based on a simple mechanical principle: a movable inner part, a lever arm, which is anchored to a spring that swings in response to a step. Movement of the lever arm causes a gear, which is attached to a digital dial, to rotate. The pedometers are designed to count steps in walking. An estimate of distance walked is obtained by calibrating the pedometer to strike length (Gayle *et al.* 1977; Montoye & Taylor, 1984). Pedometers are not suitable for measuring swimming, cycling or activities done in a more or less static position (Durnin, 1990).

Laboratory studies, which have tested various brands of pedometers, found them to be inaccurate in measuring distances walked at slower speed and fast walking or running. The pedometer overestimated actual step rate during fast walking and fast running. It underestimated the actual step rate while walking slowly (Saris & Binkhorst, 1977, Washburn *et al.* 1980). The test-retest reliability of various brands of pedometer has been tested. On treadmill walking at various speeds with the pedometer at the waist, the average correlation coefficient was from 0.49 to 0.70 (Washburn *et al.* 1980).

Calibration studies for the pedometer were mostly conducted in laboratories using standardised exercises. These exercises could not possibly mimic all the range of activities that are carried out during the daily life of the population. This can partly explain why the instrument performed poorly in the field tests.

***The actometer***

The actometer is a modified wristwatch, whereby the internal rotor is connected directly to the clock hands. Body movements result in rotation of the internal rotor that registers as a change in position of the clock hands. Activity is measured based on difference in time displayed on the watch. This is usually converted into 'minute counts'. The instrument will record not only movements but also movement intensity, since the stronger the movement the more the rotor will turn (Anderson *et al.* 1978). The actometer is designed to register movements of one plane at a time.

The validity of the actometer was studied by Avons *et al.* (1988) on twelve men while performing activities such as sitting, cycling, stepping and walking. Each subject wore three actometers, one on the wrist, one at the waist, and one on the ankle. Count from the actometers, excluding cycling, was related to actual measurements of energy expenditure while they were inside a whole-body indirect calorimeter for 17.5 hours. There were highly significant correlations, 0.75 (for wrist), 0.89 (for waist), and 0.96 (for ankle). The leg actometer showed lower counts for cycling than the waist and wrist actometers. It appears that the leg actometer was not sensitive to the smooth cycling movements. One drawback in using the actometers was that each instrument had to be calibrated for each subject, because of inter-instrument variability. Other investigators too had shown that there are large variations within one brand of actometer, Eaton & Keats (1982).

The actometer has been shown to give more reliable readings than the pedometer. When tested on subjects, who ran or walked on treadmill at different speeds, the actometer units increased proportionally to the speed of walking and running (Saris & Binkhorst, 1977). Actometers have the same problem as with pedometers, that is, the tension of the spring varies.

***The accelerometer***

When a person moves, the limbs and body are accelerated. Theoretically the amount of muscular forces generating the movement is proportional to the energy expended (Montoye *et al.* 1996). Accelerators are motion sensors, which measure the increase in the speed of body movements in the horizontal level, for example, forwards or backwards, as well as in the lateral or vertical directions. Presumably by combining measurements in all these directions it should be possible to obtain good information on the intensity and duration of physical activity.

The Caltrac is a portable single-plane accelerometer. It only measures acceleration in the vertical plane. It is produced commercially and is sold for personal use. The unit is small and light. It measures 14 x 8 x 4 cm, and weighs 400 g. It should be clipped firmly to a belt and is designed to clip tightly to the body so that the body's acceleration and deceleration can be measured accurately. The Caltrac has a transducer, which is made of two layers of peizoceramic material with a brass centre layer called the piezoelectric bender element. When the body accelerates, the transducer mounted on a cantilever beam balance position bends, and charge is produced proportional to the size of the acceleration. The ceramic transducer is more reliable and durable than spring mechanisms that are used in pedometers and actometers.

Schutz *et al.* (1988) have compared the rate of energy expenditure obtained by the Caltrac accelerometer with that measured by whole-body indirect calorimeter. Twenty-nine female adults were divided either into sedentary or active group, and studied for 24 hours. The correlation between 24-hour energy expenditure estimated by the accelerometer and that measured with the calorimetry chamber was significant (r = 0.92). However, in terms of absolute 24-hour energy expenditure, the Caltrac accelerometer underestimated kilocalories spent by 14 percent in the sedentary group and 15 percent in the active group.

One study has validated Caltrac measured energy expenditure using the heart-rate monitoring method as the reference measure (Swan *et al.* 1997). Caltrac over estimated energy expenditure by 14 percent in runners, and 19 percent in walkers, but underestimated energy expenditure in steppers by about 10 percent. The external environment where the runners and walkers did their exercises could have affected their heart rate monitoring results more than the steppers, who performed indoors.

The Caltrac measured energy expenditure has been validated against the DLW, (Heyman *et al.* 1991). There was a linear relationship between energy expenditure estimated by DLW and the Caltrac (r = 0.87). However, the Caltrac underestimated total energy expenditure by 22 percent. Energy expenditure estimated by the Caltrac does not appear to be consistent when compared with reference methods such as the DLW or the HRM. Several factors could have contributed to the errors in estimating energy expenditure by the Caltrac (Melanson & Freedman,1996). First, the Caltrac equation that predicts energy expenditure was developed with adult data, and may not be appropriate for other population. Second, the Caltrac was calibrated to a single activity (treadmill walking), and may not be able to precisely measure other activities. Third, because the Caltrac measures body accelerations only in the vertical direction, it is not sensitive to activities that include bending, or activity that involves the arms. Lastly, the Caltrac is not able to detect increase in metabolic rates during recovery from exercise.

With all these limitations, the Caltrac is still considered an objective measure of physical activity. It is suitable to be used in field studies because the instrument is light and not obtrusive. It can measure fairly accurately the walking component of subjects' physical activity. Caltrac does not measure swimming activities because it is not waterproof. Other activities such as cycling, weightlifting, isometric (stationery) exercises and sedentary activities such as sitting will be poorly measured. A new version of the

Caltrac has two additional modes added, one for cycling, and one for weight lifting. Research on the New Caltrac has not been published yet.

***The triaxial accelerometer***

As the name suggests, the instrument can measure movements in three dimensions - the vertical, horizontal and lateral directions. This instrument is more advanced than the Caltrac accelerometer. Laboratory tests using treadmill walking have shown that the triaxial accelerometer has an instrument coefficient variation of less than five percent. The test-retest reliability coefficient was found to be high (r = 0.98), (Montoye *et al.* 1996).

Investigators who have used the 'Tracmor' brand accelerator encountered some problems (Bouten *et al.* 1996). It recorded excessively high counts when subjects were travelling in a bus, bike or motorcycle. This was probably caused by vibrations of the vehicles, and not due to increase in activity of the subjects. Some of the subjects removed the instrument when they were playing sports. This is an important aspect to be considered for it to be a practical instrument in field studies.

A smaller and lighter portable triaxial accelerometer has been developed recently and marketed under the name *Tri Trac-R3D.* The accuracy of the *Tri Trac-3RD* has been compared with energy expenditure estimated from direct oxygen consumption (Eston *et al.* 1998). Energy expenditure estimated by the *Tri Trac-R3D* significantly correlated with oxygen consumption. Triaxial accelerometer predicated energy expenditure better than that predicted by the heart rate monitoring. Their study suggests that the triaxial accelerometer has the potential to estimate total physical activity more accurately than the heart rate monitoring method.

In summary, the pedometers and actometers are mechanical motion sensors that can count steps or estimate distance walked. Within a range of walking speed they can be accurate. The computerised single-plane accelerometer, like the Caltrac, is more accurate and reliable than the pedometer and actometer. It can count movements as well as convert movements into energy expenditure. However, it is not able to measure the whole spectrum of body movement, hence they are likely to underestimate physical activity levels of the subjects under study.

The single-plane accelerometer has its limitations in assessing the total physical activity that is encountered in the daily life of the average person. Nevertheless, it is relatively cheaper than the doubly labelled water or the heart rate monitoring method in assessing physical activity of people in their normal every day life. The triaxial accelerometer seems to be able to measure more types of activities than the single-plane accelerometer. For the time being, it is too costly and the instrument is bulky, it may not be practical to be used in studies which involve a large number of subjects. With advances in technology these problems will probably be overcome in the future.

#### *2.2.3.5 The physical activity diary*

The diary method of assessing habitual activity which requires subjects to record their own activities periodically. The record can be a detailed description of activities and its duration (Gorsky & Calloway, 1983), which is similar to a food diary, or may just give broad categories of activities, for example for moderate, heavy or very heavy (Durnin, 1967). Subjects may have to record their activity as frequently as every minute (Riumallo *et al.* 1989) or every four hours (LaPorte, 1979). In an activity diary, all 24 hours of the day should be accounted for by the subject's activity. The purpose of the diary is to estimate the time spent in various activities.

Usually a prepared form is given for subjects to keep their activity records. An example of a diary is that developed by Durnin & Passmore (1967). The diary has spaces for hours and minutes. Subjects had to record only when there is a change in activity. The activities have been coded into letters for example 'S' for sitting, 'ST' for standing, 'W' for walking. This lessens the burden for subjects if they have to maintain the diary for several days. Other investigators (Pols *et al.* 1997a) have used a similar diary. In the diary developed by Bouchard *et al.* (1983), the record for one day was divided into 96 periods of 15 minutes each. For each 15-minute period, the subjects had to enter the main activity during that period. The activities were grouped into nine categories, so that subjects only had to write the code which the activity belonged, and not describe the activity. The activities were later converted into total energy expenditure based on the energy cost of that activity per minute multiplied by the duration spent on that activity.

There are several advantages in using the diary method to estimate energy expenditure or physical activity. Data collection is relatively cheap because it does not require any observers. Many subjects can be asked to do the diary simultaneously. On the other hand there are disadvantages to the diary technique. Processing a large quantity of data is time consuming and can be expensive. If activities are not pre-coded, the list of activities recorded by subjects can be numerous. Needless to say the subjects must be literate, a factor always taken for granted in highly developed societies. It is necessary to have the subject's fullest co-operation and conscientiousness in order to get accurate records. Subjects may forget to record some of the activities or recorded the wrong activity or the wrong duration. These will cause error in the results. The longer the period of data collection, the less accurate the results may be, because keeping a diary is a tedious job. For these reasons it may not be appropriate to use this method in assessing children's physical activity.

Other sources of error that will be encountered in using the diary are in the conversion of activities into energy expenditure. The energy cost of each activity must be estimated and multiplied by the length of time subject spent for that activity. Subject's perceptions and interpretation of the intensity of the activity may vary, so that what is a strenuous activity for one subject may be light to another. Investigators in epidemiological studies use published tables of energy cost to translate activities recorded into energy expenditure. There are several sources of reference values that are widely used. The cost of activity can either be in absolute energy values, kilocalories or kilojoules or values that are multiples of the basal metabolic rates (physical activity ratio or PAR values), (James & Schofield, 1990; WHO, 1985), or multiples of the resting metabolic rate (metabolic ratio or MET), (Ainsworth *et al.* 1993). However, published values are based on studies on a few subjects. These values may not reflect energy expenditure levels across different populations. If absolute energy values are used, they do not consider inter individual differences in energy expenditure (LaPorte *et al.* 1985). If different investigators use different sources from which to derive energy costs of activities, it is difficult to compare results across studies.

Validity of the activity diary as a measure of habitual physical activity has been assessed by using the dietary intake/balance method (Acheson *et al.* 1980; Borel *et al.* 1984), the room calorimetry method (Geissler *et al.* 1986), and the doubly labelled water method, as the standard measures (Riumallo *et al.* 1989; Schulz *et al.* 1989). These investigators have shown that the diary method can give acceptable estimates of the energy expenditure of groups. The estimates for individuals have very large errors.

Acheson *et al.* (1980) considered the dietary intake/balance technique to be an accurate method of estimating energy expenditure. This technique is based on the basis that if energy intake and changes in body energy content are measured over a given period of time, then energy expenditure can be calculated as follows:

*Energy expenditure = Energy intake - change in body energy content*

This is assuming that energy intake can be monitored carefully and that changes in body energy content (fat and lean tissue) can be accurately determined by hydrostatic weighing or anthropometry. However, the assumptions may not always be true. For example, the estimation of body fat by using skinfold measurements is not as accurate as hydrostatic weighing (Borel *et al.* 1984). Records of dietary intakes are also subject to errors. Keeping an activity diary is tedious and inconvenient, and as a result subjects tend to delay making their entries (Acheson *et al.* 1980). Thus the activity diary may not provide an accurate account of the type and duration of a subject's activities. Thus in both studies described, it is hard to differentiate how much of the observed discrepancies are due to errors in the diary measurement of energy expenditure or that of the intake/balance measurement.

The calorimeter, which is a precise method of estimating energy expenditure, was used by Geissler *et al.* (1986) as a standard to compare with the diary method. Subjects had to complete a 24-hour activity diary on two separate days while they were in a room calorimeter. The diary underestimated energy expenditure by one percent for the group. At the individual level the difference ranged from -17 to +25 percent. As an estimate of an individual's energy expenditure, the diary values can be 400 kcal over or underestimated. This was shown to be an error of 16 to 25 percent of total daily expenditure.

Measurements of energy expenditure in the calorimeter has its limitations too. In the calorimeter subjects have to stay in an environment which is vastly different from their normal life. The activities that they can do are restricted. In this way the doubly labelled water method has the advantage of being able to monitor subject's energy expenditure without interfering with their normal daily activities. Compared to the DLW the diary appears to have given a good estimate of the group energy expenditure, Schulz *et al.* (1989),

The studies cited above have shown that at the group level energy expenditure estimated by the diary method was fairly good, with an error of not more than seven percent. In most of the studies the diary tended to underestimate energy expenditure slightly. The errors at the individual levels however, were large. In all the studies quoted, the factorial method was used in estimating energy expenditure. In this method energy costs for specific activities were measured for each subject by indirect calorimetry. These values were used to calculate their total energy expenditure from the diaries. They reported that the results were not significantly different if energy costs of activities were taken from published tables. It is obvious that the factorial method is not suitable for validation studies that involve a large number of subjects.

It should be recognised that these studies all involved a small number of adult subjects with strict criteria and laboratory conditions. Therefore we have to question whether the results will be applicable to the community. For example, even with such a small number of subjects who were probably under close supervision, the investigators found that subjects tended to delay recording their activities in the diary.

In summary, the diary method of estimating energy expenditure has its advantages and disadvantages. It requires a considerable effort and willingness from subjects in order to obtain accurate records. On the other hand it is a relatively simple and cheap method that can be administered to a large number of subjects. It seems to be a valid method for estimating energy expenditure levels of groups, but not individuals. From the literature available, it is not clear how many days of recording is required to account for an individual's day-to-day variations in activity. It has been suggested that several days of recording are required (Anderson *et al.* 1978), presumably it should include weekend days.

#### 2.2.3.6 *The physical activity questionnaire*

The relationship between vigorous physical activity, physical fitness and coronary heart disease is well established. Earlier studies were more likely to describe a small percentage of the population who is in the top of portion for physical activity level distribution. Many studies have probably measured moderate and low intensity physical activity poorly. The question we need to ask now is - if a study finds no relationship between disease or a disease risk factor and physical activity, is this because there is truly no relationship or because the method of assessing physical activity is inaccurate?

Early classic studies of London bus drivers and conductors by Morris *et al.* (1953), of railroad worker by Taylor *et al.* (1962), and of longshoremen by Paffenbarger *et al.* (1970), have only compared subjects based on their occupations. The types of activities included in physical activity questionnaires have expanded considerably since those early studies. Some questionnaires have only focused on leisure time activities. Later studies have included questions on occupation as well as activities during leisure time. More recent questionnaires tend to include all activities in normal daily life. This includes sleeping, eating, washing, household chores, getting about, as well as leisure and occupational activities. Most of the epidemiological studies that investigate chronic diseases have included the assessment of physical activity in their study design, mainly by using the questionnaire method.

In a review by Powell *et al.* (1987), they highlighted that out of 24 studies on the relationship between physical activity and coronary heart disease that were conducted before 1970, 20 assessed only occupational activity. There are limitations in using occupation to assess physical activity. First, the types of activities involved in a particular occupation may vary in its intensity. Second, with advances in technology, machines have replaced strenuous tasks that were once handled by man. Thus people in developed countries are more likely to have sedentary jobs, such that their activities at work are not different regardless of occupation. Lastly, by assessing only occupational activity other components of the daily activity are not measured. This includes activity in leisure time, household chores (especially for women), and activities for getting about. However, it is not yet clear what pattern or type of activities are associated with health.

Questionnaires to assess habitual physical activity can be in several forms. A prepared questionnaire can be self-administered or use an interviewer or a combination of both. A self-administered questionnaire can be sent by post or given in person for the respondent, who answers the questions without any assistance. An interviewer-administered questionnaire can be done either in person or by telephone. If the combination method is used, the respondent completes a questionnaire and, after checking the answers, the interviewer will ask further questions, either to clarify or crosscheck the responses.

The questionnaire method has several advantages compared to other techniques such as the diary, motion sensors, and heart rate monitoring. It is relatively cheap, easy to administer, and it does not influence the subject's activity to the extent that can happen in recording an activity diary. A questionnaire can assess several types of activities together with intensity and duration of the activity. Questionnaires too can estimate energy expenditure by using reference values for energy costs of activities. Questionnaires can be used to assess the physical activity of children, adults, and older people. At the moment the questionnaire is the most feasible method for large-scale epidemiological studies.

The questionnaire method has its limitations too, because it usually requires subjects to report about their past physical activities. They may not be able to recall their activities accurately. They may tend to overestimate time and intensity of activities (Montoye *et al.* 1996). Recall of recent activities, for example of activities over the past few days can be more accurate, but may not be representative of habitual activity patterns. On the other hand long-term recall, for example the frequency and duration of activities over the past year may be more representative of habitual activity patterns, but subjects may not remember very well those activities. There is evidence that strenuous activity is recalled more accurately than moderate or mild activity (Taylor *et al.* 1984). If the questionnaire is too long and detailed it is likely to discourage subjects from completing it.

If questionnaires were used for estimating energy expenditure, then the activities would be converted into energy values using the energy cost of activities from published tables. Limitations similar to that described in using the diary method to estimate energy expenditure by using reference values will apply to the questionnaire too. That is, published values are based on experiments with a few adult subjects and may not reflect the energy cost of activities for other populations. Many activities have a wide range of energy cost depending on how they are performed. For example, the amount of energy expended in walking depends on its speed. Subjects may not be able to describe the intensity of their activities accurately. Some questionnaires ask for information about sweating and breathlessness to indicate higher intensity. These criteria may not be appropriate for subjects living in tropical countries.

Questionnaires that are targeted for the adult populations may not be applicable to children or older people. Older people are retired, for them leisure time activities become more important, for example doing household chores, gardening, and walking. Only a small proportion of older people take part in moderate or strenuous physical activity (Blair *et al.* 1985; Dannenberg *et al.* 1989). If the physical activity data from the questionnaire were to be converted to energy expenditure values, there might be a problem. Most data in the energy cost of activities are based on tests with young adults. Elderly people are more likely to perform particular activities at lower intensities than young healthy subjects. Thus, estimations of energy expenditure may have to be adjusted for the older people.

Table 2.5 presents a list of some physical activity questionnaires for adults and older people that have been used in large epidemiological studies and a brief description of the types of activities assessed. The test-retest reproducibility of some of the questionnaires appears to be satisfactory. However, the validity of many of the questionnaires has not been adequately established, mainly because the measures used were themselves not reliable.

The validity of questionnaires as a measure of long-term physical activity patterns is difficult to evaluate. Objective criteria such as the doubly labelled water, the heart rate monitoring, and the motion sensors methods are considered acceptable, but their measurements can only be made over a short period of time. To make it more representative of the individual's long-term physical activity levels, the objective measurements can be repeated several time at intervals, say over a period of one year. This will increase the cost of the study exorbitantly.

A critical assessment of the validity studies for several physical questionnaires will be presented in the next section. It will describe the types of activities assessed and how they were assessed. Their validity will be evaluated on how well they can measure physical activity when compared to an objective measure, and whether their measurements are consistent when repeated. The review will discuss the problems that investigators have encountered in conducting validity studies.

**Table 2.5: Physical activity questionnaires for adults and the elderly**

| Reference | Name of questionnaire | Type of activities assessed |
|---|---|---|
| **For adults** | | |
| Shapiro *et al.* 1963 | The Health Insurance Plan of New York Questionnaire | History of "usual" activity patterns; 4 leisure & 6 occupational questions. |
| Yasin *et al.* 1967 | The British Civil Servant Questionnaire | All activities out of work hours during 2 days in the previous week (weekday & weekend day). |
| Montoye, 1975 | The Tecumseh & Minnesota Questionnaire | Normal activity pattern over the past year; 36 occupational, 63 leisure questions. |
| Taylor *et al.* 1978 | The Minnesota Leisure Time Physical Activity Questionnaire | Checklist of 64 leisure and 10 household activities engaged in the last 12 months. |
| Paffenbarger *et al.* 1978 | The Paffenbarger/Harvard Alumni Questionnaire | Number of flights of stairs climbed & number of city blocks walked each day; number of hours engaged in sports activity (light & strenuous). |
| Baecke *et al.* 1982 | The Baecke Questionnaire | History of "usual" activity patterns; occupational & leisure time questions; hours sleeping per day. |
| Gordon *et al.* 1983 | The Lipids Clinic Questionnaire | "Usual" activity pattern over previous week; 2 leisure & 2 occupational questions. |
| Blair *et al.* 1985; Sallis *et al.* 1985 | The Stanford Five-City Questionnaire | Occupational & leisure time activity over the past week. |
| Dannenberg *et al.* 1989 | The Framingham, Massachusetts Questionnaire | History of "usual" activity based on hours spent in various occupational & leisure time activities. |
| Wilhemsen, 1989 | The Gutenberg, Sweden Questionnaire | Activity at work & leisure time. |
| **For the elderly** | | |
| Voorrips *et al.* 1991 | The Modified Baecke Questionnaire for the Elderly | Activity during leisure & household activity; Number of hours sleeping per day. |
| Caspersen *et al.* 1991 | The Zutphen Questionnaire | Mobility, walking 7 walking pace, cycling, gardening, sports, hobby, household activities, hours of sleep per day. |
| DiPietro *et al.* 1993 | The YALE Physical Activity Survey | Household-related work, yard work, caretaking, exercise, recreational activities. |
| Washburn *et al.* 1993 | The Physical Activity Scale for the Elderly (PASE) | Occupational, leisure time and household activities, hours of sleep per day. |

### 2.2.4 Validation studies for physical activity questionnaires: A critical review

#### *2.2.4.1 Introduction*

*"One area of interest is that of differentiating how the various characteristics of amount, intensity, duration, frequency, type and pattern of physical activity are related to specific health or disease outcome ......."*

*(Editorial, 1996)*

There has been considerable interest over the last decade in evaluating physical activity questionnaires that have been used in epidemiological studies. It is now necessary for researchers to indicate the level of reliability and validity of the physical activity assessment instrument that they use in their main study. Previously it was acceptable to mention that the instrument was calibrated or validated, assuming that having done so was good enough. However, if an exposure is measured by a faulty instrument, it can lead to spurious relationships. The accuracy and precision of a method to assess physical activity can be determined by conducting a validity study. A validity study can quantify the measurement errors involved in using the method chosen. When the method is used in a large-scale study to assess the relationship between physical activity and risk of diseases, the associations observed can be evaluated or adjusted taking into account of its measurement error.

Most epidemiological studies have used the questionnaire method to assess physical activity. That is because questionnaires are easier to administer, not intrusive on the respondents, and relatively cheap. Therefore the review has focused on physical activity assessments using questionnaires. We are not aware of any article that has critically evaluated validity studies of physical activity questionnaires.

A computer search in the MEDLINE (January 1996 - December 1997) database was done using the search word 'physical activity'. Since physical activity is not a MEsH (Medical sub-heading) term, the computer combined the subject heading 'physical' and 'activity' to obtain 1087 hits. From this hit list there were only twelve titles on validity studies of physical activity questionnaires. More articles were obtained by a manual search in the recent publications of the International Journal of Epidemiology, The American Journal of Epidemiology, The Epidemiology Journal, and several public health journals as well as from the references cited in those articles.

The purpose of this review was to assess the current status of physical activity questionnaires and critically evaluate their validity studies.

In order to do a critical appraisal of the validity studies a checklist of questions that should be addressed in a good validation study was developed (refer to Appendix 1). This checklist has used the principles in dietary validation studies (Nelson, 1997) and has been adapted for physical activity studies. The knowledge gained from dietary studies during the last ten years may be used effectively to achieve high standards and quality in physical activity studies at a faster rate.

The studies are presented in descending chronological order; that is, the latest study published in 1997 will be presented first, followed by a study published previous to that. A summary on the background of the physical activity questionnaires are presented in Table 2.6, and a summary of the questionnaire and the reference measures are presented in Table 2.7. A summary of the results of the validity and reliability studies is shown in Table 2.8.

**Table 2.6: Summary background of physical activity questionnaire validation studies reviewed**

| Study no. | Name of physical activity questionnaire (PAQ) | Reference | Principal organisation conducting study | Country of study | Method of administration | Number of administrations | Time frame |
|---|---|---|---|---|---|---|---|
| 1 | Dutch Pre EPIC PAQ | Pols *et al.* 1997a | University of Utrecht | Netherlands | 1 | 3 in 1 year | 1 |
| 2 | EPIC short PAQ | Pols *et al.* 1997b | University of Utrecht | Netherlands | 1 | 3 in 1 year | 1 |
| 3 | Physical Activity Scale for the Elderly (PASE) | Schuit *et al.* 1997 | University of Wageningen | Netherlands | 1 | 1 | 4 |
| 4 | PAQ for the study of postmenopausal osteopaenia | Suleiman & Nelson 1997 | King's College, London | UK | 1 | 1 | 7 |
| 5 | a) Pre EPIC questionnaire for elderly women b) Baecke questionnaire for elderly women | Pols *et al.* 1996 | University of Utrecht | Netherlands | 1 | 3 in 1 year | 1 |
| 6 | Questionnaire d'Activitϑ Physique Saint-Etienne (QAPSE) for the elderly | Bonnefoy *et al.* 1996 | Centre Hospitalier Lyon-Sud | France | 1 | 2 in 6 weeks | 7 |
| 7 | PAQ for the Male Health Professionals Study | Chasan-Taber *et al.* 1996 | Harvard School of Public Health | USA | 1 | 2 in 2 years | 1 |
| 8 & 9 | Leisure-time PAQ for Australian adults | Booth *et al.* 1996a & b | University of Sydney | Australia | 2 | 2 in 2 weeks | 3 |
| 10 | Modified Baecke questionnaire on physical activity | Pols *et al.* 1995 | University of Utrecht | Netherlands | 1 | 3 in 2 years | 1 |
| 11 | Previous Day Physical Activity Recall (PDPAR) for youth | Weston *et al.* 1995 | University of South Carolina | USA | 1 | 2 in 1 hour | 5 |
| 12 | The Atherosclerosis Risk in Communities (ARIC)/Baecke questionnaire | Richardson *et al.* 1995 | University of Minnesota | USA | 1 | 2 in 2 months | 1 |
| 13 | The Nurses' Health Study PAQ | Wolf *et al.* 1994 | Harvard Medical School | USA | 1 | 2 in 2 years | 1 |
| 14 | College Alumnus PAQ | Ainsworth *et al.* 1993a | University of North Carolina | USA | 1 | 3 in 9 months | 1 |
| 15 | Modified Baecke questionnaire for older adults | Voorrips *et al.* 1991 | Wageningen Agricultural University | Netherlands | 2 | 2 in 20 days | 1 |
| 16 | Physical activity instrument for the Life in New Zealand National Survey | Hopkins *et al.* 1991 | University of Otago | New Zealand | 1 | 1 | 2 |
| 17 | The Liverpool Leisure Time PAQ (LLTPAQ) | Lamb & Brodie 1991 | University of Liverpool | UK | 2 | 2 in 4 weeks | 3 |
| 18 | PAQ for the Pima Indians | Kriska *et al.* 1990 | University of Pittsburgh | USA | 2 | 2 in 1-3 weeks | 1,4,6 |

Key

Method of administration: 1 = self-administered; 2 = interview; Time frame: 1 = past year; 2 = past 4 weeks; 3 = past 2 weeks; 4 = past 1 week; 5 = previous day; 6 = historical; 7 = usual

The questionnaires are discussed and evaluated by several aspects highlighted in Tables 2.7 and 2.8. They will be appraised by the type of subjects who took part in the validation study, that is, the recruitment process, sampling, sample size and response rate. The types of activities included in the questionnaires and how they are related to their validity results will be discussed. The reference methods that were used to compare with the questionnaire will also be evaluated and how they are related to validity of the questionnaires. Finally the repeatability studies and the overall validity of those questionnaires will be discussed.

#### *2.2.4.2 Subjects in the validity studies*

Study 7 had males only as subjects, and studies 4, 5 and 13 had females only as subjects (Table 2.7). Their subjects consisted mainly of adults of no specific age group. Several studies focused on particular groups, such as the elderly (study 5, 6 and 15), school children (study 11). If the study subjects consist of a wide range of age groups, it is important that the repeatability and validity of the questionnaire be assessed according to age groups. Some questionnaires that were designed for adults may have to be modified to suit older subjects. In study 5, the Baecke questionnaire was modified to make it applicable for use in elderly people. The QAPSE (study 6) and PASE questionnaires (study 3) were developed specifically for the elderly. This is important because older people may have poor long-term memory, so their recall of activity has to be short-term. Occupational activities are not very important in the elderly due to retirement, instead household activities, leisure time activities are more important, (particularly low intensity physical activities).

Should a physical activity questionnaire be gender specific? In questionnaires where the validity has been assessed in men and women, they have found differences between the sexes.

Table 2.7: Summary of questionnaire and reference measures

| Study no. | Subjects | Questionnaire measures | | Reference measures | | |
|---|---|---|---|---|---|---|
| | | *Activities measured* | *Physical activity measurements* | *Reference method* | *Measured variable* | *Physical activity measurements* |
| 1 | 64 M, 21-59 yr.<br>62 F, 22-71 yr.<br>Response rate 14 % | C, H, L, R, SL, SP, ST, T | kJ/24- hr | 3-day PA diary | 24-hr record of coded activities | kJ/24-hr |
| 2 | Same as above | CYC, H, L, OC, ST, W, X, | Same as above | Same as above | Same as above | Same as above |
| 3 | 10 M, 60-80 yr.<br>11 F, 60-80 yr.<br>Participants of another study | C, CYC, H, L, OC, Sit, SP, W | Hour spent on activity per week times the item weights | DLW,<br>indirect calorimetry | Total energy expenditure (TEE); resting metabolic rate (RMR) | TEE, (MJ/day);<br>Physical activity ratio, PAR (ratio of TEE/RMR)<br>Regression of TEE with RMR |
| 4 | 26 F, 43-54 yr.<br>Response rate 41 % | L, H, OC, SP, X, sit, stand. | Hours per week spent on activities by categories (light, moderate, vigorous) | 4-day activity diary of coded activities;<br>treadmill exercise test | 24-hr record of activities;<br>Oxygen consumption | Hours spent on categories of activities; VO2max |
| 5 | 33 F, 51-71 yr.<br>(they took part in study 1) | a)Pre EPIC-similar to study 1<br><br>b) Baecke- L, OC, SL, SP. | a) EE per 24-hr (kJ/24-hr)<br><br>b) Work index, sports index, leisure index to represent relative total score for each activity component | 3-day activity diary;<br>Caltrac;<br>12 monthly 24-hr dietary recall | 24-hr record of activities in 5 min periods; whole body movements; energy intake | kJ/day; Caltrac count; kJ/day |
| 6 | 70 M & F; 65-84 yr. | B, H, L, OC, T, Misc. | Daily EE (kJ/day); activity score in 5 main activity components; daily EE > 3 METs | Maximal treadmill exercise test;<br>anthropometry | VO2 max (ml/kg/min);<br>skinfold thickness; fat-free mass, % body fat | Physical fitness; body fatness |
| 7 | All males, 40-75 yr.<br>Caucasians - 132,<br>response rate - 88 %<br>African-Americans - 106,<br>response rate - 71 % | L, R, ST. | Average weekly EE in each activity component (MET/ week) | 1-week PA diary,<br>Step Test | Record of activity in hourly intervals for 1 week,<br>pulse rate before and after stepping | MET/week; physical fitness |
| 8 | 506 M, 480 F, 18-79 yr.<br>Response rate 82 % | L | Total EE for leisure activities; frequency of activity; classification into 4 categories:- vigorously/ moderately/ low active/ sedentary | Cycle ergometer | Physical work capacity at 75% of predicted maximum heart rate per kg body mass | pwc75/kg |
| 9 | Same as study 8 | L | Same as above | Same as above | Same as above | Same as above |
| 10 | Same subjects as study 1 | L, OC, SL, SP | Activity index as in study 5a | 3-day PA diary | Same as study 1 | Same as study 1 |
| 11 | 119 junior & senior high school students, boys & girls, median age 15 yr. | T, X, eating, sleeping, bathing, work/school, spare time, play, job, hobbies | EE for period measured (METs) | Pedometer, Caltrac; minute-by-minute heart rate monitoring | Footstrikes; whole body movements; heart rate corresponding to period recalled in PAQ | Total pedometer & Caltrac counts; % heart rate range. |
| 12 | 28 M, 23-57 yr.<br>50 F, 21-59 yr.<br>Volunteers | L (SP & X), L (non SP & X), OC | Relative score for work, sports & exercise leisure, non sport & exercise leisure | 48-hr activity diary; Caltrac; treadmill exercise test; body composition | Record of daily activities; whole body movements; VO2 peak; % body fat | METs*min/week; Caltrac counts; physical fitness; body fatness |

| | | | | | | |
|---|---|---|---|---|---|---|
| 13 | All females 25-42 yr., representative sample - 169, response rate - 81 % African-American sample - 105, response rate - 72 % | CYC, L, OC, SL, Sit, Stand, SP, ST, W, X | Total EE per week for activity & inactivity (MET*hr/ week) | 7-d activity diary; past week activity recall | Record of 7 categories of activities & inactivities | MET*hr/week categorised into activity & inactivity score |
| 14 | Same subjects as study 12 | SP, ST, W | Physical activity index (PAI) for the 3 activity components, and PAI activity intensity of activity (MET*min/week) | Same as study 12 | Same as study 12 | Same as study 12 |
| 15 | 26 M, 63-80 yr. 34 F, 63-80 yr. response rate 66.7 % | H, L, SP | Relative score for the 3 activity components | 3 times 24-hr activity recalls; pedometer | Average daily EE; foot strikes. | kJ/day; pedometer counts |
| 16 | 86 M; 54 F; 18-79 yr.; response rate 26 % | L, H, OC | EE from various activities categorised into low, high intensity score, & metabolism score | Cycle ergometer; spirometer; skinfold thickness; Stanford 7-day recall PAQ; anthropometry; demography | VO2 max; Vital capacity ; Sum of 4 skinfolds; BMI; socio-economic status | Physical fitness; body fatness |
| 17 | 77 M; 41 F; 18-64 yr. Volunteers | L | Daily EE from leisure activities (kcal/day) | Cycle ergometer; anthropometry; clinical tests | Physical work capacity (PWC); lung function; BMI, body fat; blood pressure, cholesterol. | Physical fitness; body fatness |
| 18 | 26 M, 43 F, 10-59 yr. Volunteers | L, OC, SP, TV, W | Average hour per week spent on each activity; EE per week (MET* hr/week); individual levels of PA | Caltrac | Whole body movements | Caltrac counts for 4 days |

Key
M = male; F = female; EE = energy expenditure; PA = physical activity;

B = basic daily living; C = caring for others; CYC = cycling; H = house work; L = leisure time / recreational activities (includes walking, sports, exercise); Misc. = miscellaneous; OC = occupational/ work; R = resting; SL = sleeping; SP = sport activities (if exclusively listed); ST = stair climbing; Sit = sitting; Stand = standing; T = transportation; TV = watching TV; W = walking (if exclusively listed); X = exercise (if exclusively listed).

The pre EPIC, PASE, Baecke, ARIC/Baecke questionnaires (studies 1, 3, 10 and 12) found that validity was lower in women compared to men. Household activities such as cooking, cleaning the home and taking care of children are carried out by women more frequently than men, so if these questions are omitted from the physical activity questionnaire its validity among women will be underestimated.

The subjects who take part in the validity study should ideally be a random sample that is representative of the population. They are more likely to be heterogeneous. This is because most main studies in which the physical activity questionnaire is used will have a random sample of the population as the study subjects. There are exceptions where study subjects are selected from particular groups.

In the 18 studies that were reviewed, only studies 8 and 9 (which used the same physical activity questionnaire) and study 16 have recruited subjects from a random selection of the population. However, study 16 had a poor response rate (26%). The other studies either used healthy volunteers or a non-random sample of the population. The number of subjects in some studies was too small, and they did not indicate the power of the study. It may be difficult to extrapolate the validity of these questionnaires to the general population.

Validity studies are very demanding on subjects' involvement and co-operation. So these self-selected subjects tend to be highly motivated, well educated and probably very conscious of their physical activities and health-related behaviour. Therefore, the validity of their physical activity questionnaires should be regarded with caution. It would be reasonable to assume that validity studies conducted among volunteers show the upper limits of agreement or the best the questionnaire can perform.

### 2.2.4.3 *The physical activity components measured*

In the 18 studies reviewed the physical activity components being measured varied (Table 2.7). Studies 8, 9 and 17 only focused on leisure time physical activity. The other studies had included leisure time activities as well as occupational, household and other activities. This shows the current emphasis on leisure time activities for all physical activity questionnaires. Occupational activities are also regarded as important as they were included in eleven studies. Household activities, which can occupy a substantial amount of time for certain groups of the population, for example, housewives and older people, were included in only 8 studies.

The purpose of studying physical activity in epidemiological research is to find the relationship between habitual physical activity and health. Therefore, physical activity has to be assessed with reference to long-term activity patterns. Baecke *et al* (1982) designed a self-administered questionnaire to measure habitual physical activity. By using principal components analysis they found that habitual physical activity can be described in three distinct dimensions. They were physical activity at work, sport during leisure time, and other physical activity during leisure time.

Several investigators have used the Baecke physical activity questionnaire, or the modified Baecke physical activity questionnaire to assess physical activity (studies 5, 10, 12 and 15). Studies 5 and 10 have added three questions to the original questionnaire, concerning gardening, do-it-yourself activities and sleeping. Among older women (study 5), the correlations between total Baecke index and total energy expenditure from the diary was 0.51. Classification into high and low levels of activity showed moderate agreement between the questionnaires and the diary. Among male and female adults (study 10), the correlation between physical activity questionnaire and diary were slightly higher among men (0.56) compared to women (0.44). However, when subjects were categorised into thirds of energy distribution 8 and 11 per cent of the men and women respectively, were grossly misclassified. This shows that the questionnaire did not measure adequately the complete range of physical activity patterns among the study subjects. This is after considering that the diary is not a 'gold standard' to record their total physical activity patterns. Study 15 had added questions on household activities to the Baecke physical activity questionnaire, because the investigators acknowledged the relative importance of these activities in the elderly. This questionnaire showed good agreement in the tertile classification with the twenty-four hour activity recall. The addition of household activities in the questionnaire seems to improve its validity. However, the twenty-four hour recall had a reference period of only 3 days, whereas the questionnaire refers to activities of the last year, so its level of validity has to be interpreted cautiously.

Studies 1, 6 and 13 had more activity components in the questionnaires compared to the other studies to assess long-term habitual activity. The Nurses' Health Study physical activity questionnaire (study 13) had specifically asked questions on sedentary activities and inactivities at home, at work or while driving, and standing, or walking at home or at work. The subjects had under-reported their inactivity level on the questionnaire. The question items on sedentary activities (sitting/standing/walking at home or at work) may be too simplistic, so those subjects may not be able to recall completely all activities.

The pre EPIC physical activity questionnaire (study 1) attempted to estimate usual individual daily energy expenditure. The questionnaire focused on the number of hours subjects usually spent in various activities that cover a twenty-four hour period. They found that the majority of subjects only covered between fifteen to twenty hours per day, and not the twenty-four hours as intended in the questionnaire. This shows that even with a long and detailed questionnaire weaknesses in its design make it difficult for people to report their full day activities.

Baecke's findings that habitual physical activity is encompassed in three components may be right (Baecke *et al.* 1982). Activities at work, sports and exercise activities during leisure are relatively easy for individuals to report. Activities at work usually have fixed hours and fixed types of activities. Sports and exercise are usually planned and carried out at regular intervals. However, the third physical activity component described by Baecke, consisting of non-sport and exercise leisure encompasses a wide range of activities. These activities occupy the rest of the individuals' time apart from work and playing sports or exercise. They include housework (cooking, washing, cleaning, shopping, and taking care of children or the elderly), activities for getting about (transportation), social activities, basic-daily living activities (washing, toilet, eating) and sleeping. Depending on the population being studied the emphasis for each component of the activities will be different. Because these activities are generally of moderate to low intensity, many individuals are likely to be misclassified at the lower end of the physical activity distribution if the questions are not precise. Therefore it is important that the physical activity questionnaire covers the complete spectrum of physical activity in order to be able to rank individuals correctly in their true physical activity levels. Physical activity questionnaires that did not include the three components of physical activity showed poor validity, or the physical activity questionnaire could only measure accurately vigorous activities (study 7).

#### 2.2.4.4 The reference methods used for validation of physical activity questionnaires

The details about reference methods for physical activity assessment, their strengths and weaknesses have been discussed in section 2.2.3. The activity diary and the exercise test appear to be the most commonly used reference methods to compare with physical activity questionnaire measures. These studies have either used the activity diary or the exercise test alone or together with other reference methods; for example, the pedometer, Caltrac accelerometer and the twenty-four hour activity recall (Table 2.7). This section will evaluate the questionnaires based on their validation criteria or reference methods. The validity of the physical activity questionnaires are assessed on their performance compared to the reference methods (table 2.8- validity results)

*The maximal exercise test*

The maximal exercise test is an indirect measure of physical activity, as it indicates the subjects' level of cardio-respiratory fitness. Subjects who have high levels of physical fitness imply that they have been performing vigorous or conditioning types of physical activities regularly. This method is appropriate as a comparison if the physical activity questionnaire intends to discriminate between subjects who are at the highest level of the physical activity distribution.

The questionnaire in study 4 intended to classify women into two halves of the physical activity distribution. There was no significant correlation between the maximum oxygen intake and the total hours of non-sedentary activity estimated from the questionnaire. The investigators did not explain this finding in their discussion. The probable reason for this non-significant finding is because non-sedentary activities in their study subjects consist of heavy and moderate type of activities. The total hours spent on heavy activities were very small compared to hours spent on moderate activities.

It suggests that VO2 max may not be an appropriate method of comparison for physical activity questionnaires that intend to discriminate individuals who are in the medium range of the physical activity level. Other studies found moderate correlation between

VO2 max with vigorous sports or exercises, but not with moderate or low intensity activities (studies 6,12,14&16). The measurement of maximal cardio-respiratory endurance requires a high degree of technical expertise and subject effort (Lamb &

Table 2.8: Summary of repeatability and validity studies

| Study no. | Repeatability measures: *Method of assessment* | Repeatability measures: *Results* | Validity measures: *Method of assessment* | Validity measures: *Results* |
|---|---|---|---|---|
| 1 | Spearman's rank correlation (95% CI) for total EE at 5, 11 months retest. | <u>5 months</u><br>Men: 0.76 (0.63 - 0.85)<br>Women: 0.58 (0.36 - 0.74)<br><br><u>11 Months</u><br>Men: 0.70 (0.54 - 0.81)<br>Women: 0.71 (0.54 - 0.82) | Mean EE from PAQ at 1st administration (Q1) and from the diary (kJ/24 hr, ∀SD)<br><br>Spearman's correlation (95% CI) between EE from Q1, Q3 and the diary | <u>Men</u> / <u>Women</u><br>Q1: 9455 ∀2282 / 8491 ∀1984<br>Diary: 12199 ∀1482 / 11960 ∀1085<br><br><u>Men</u> / <u>Women</u><br>Q1: 0.66 (0.49 - 0.78) / 0.43 (0.18 - 0.63)<br>Q3: 0.51 (0.28 - 0.68) / 0.44 (0.20 - 0.64) |
| 2 | Spearman's rank correlation for total EE at 5 months, 11 months retest. | <u>5 months</u><br>Men: 0.86<br>Women: 0.63<br><br><u>11 months</u><br>Men: 0.75<br>Women: 0.68 | Mean EE from PAQ at 1st administration (Q1), and from the diary (kJ ∀SD)<br><br>Spearman's rank correlation between EE from Q1 and the Diary | <u>Men</u> / <u>Women</u><br>Q1: 3429 ∀2549 / 4145 ∀2710<br>Diary: 12204 ∀1478 / 11960 ∀1085<br><br>0.43 / 0.51 |
| 3 | No repeatability study | | Spearman's rank correlation (95% CI) between PASE score & PAR, between PASE score & residuals of regression TEE with RMR (RES) | <u>PAR</u><br>Men 0.78 (0.31 - 0.95)<br>Women 0.59 ( 0.00 - 0.88)<br>All 0.68 (0.35 - 0.86)<br><br>**RES**<br>Men 0.79 (0.32 - 0.95)<br>Women 0.68 (0.15 - 0.90)<br>All 0.58 (0.50 - 0.81) |
| 4 | No repeatability study | | Pearson's correlation for total hours in each activity between PAQ and diary | Total 0.45*<br>Light 0.35<br>Moderate plus 0.49* (* p<0.05) |
| 5 | Pearson's correlation for test-retest at 5 and 11 months | <u>Pre EPIC</u> / <u>Baecke</u><br>5m 0.42* / 0.82*<br>11m 0.60* / 0.73*<br><br>*p< 0.05 | Pearson's correlation for PAQ and reference measures<br>(* p>0.05)<br><br>Percent agreement (%agmt) for classification below and above the mean & Cohen's kappa, k in parenthesis. | <u>pre EPIC</u> / <u>Baecke</u><br>Diary 0.64* / 0.51*<br>Caltrac 0.22 / 0.22<br>Energy intake -0.43 / -0.21<br><br><u>pre EPIC</u> / <u>Baecke</u><br>Diary 69 (38) / 62(24)<br>Caltrac 61 (21) / 61 (21)<br>Energy intake 46 (-8) / 39 (-23) |

| | | | | |
|---|---|---|---|---|
| 6 | Pearson's correlation for test-retest of activity components PA measures from PAQ | MHDEE 0.967<br>DEE > 3 MET 0.851<br>Prof. 0.662<br>L 0.770<br>H 0.873<br>B 0.774<br>Moving 0.648<br>SP 0.851 | Pearson's correlation for QAPSE activity indices and references measures | \| Skinfold \| % body fat \| VO2 max<br>MHDEE -0.12 \| -0.50 \| 0.56**<br>DEE>3 MET -0.02 \| -0.08 \| 0.37*<br>Prof 0.81 \| -0.07 \| -0.02<br>L -0.01 \| -0.24 \| 0.37**<br>H -0.02 \| 0.12 \| 0.10<br>B -0.36** \| -0.64** \| 0.32*<br>Moving -0.14 \| -0.28 \| 0.27*<br>SP -0.13 \| -0.23 \| 0.46**<br>* p < 0.005; ** p < 0.05 |
| 7 | Intra class correlation between Q1 & Q2 (0, 24m) | \| Caucasian \| Afr-Amer<br>Vigorous 0.53 \| 0.52<br>Non vigorous 0.27 \| 0.61<br>Inactivity 0.33 \| 0.43 | Median values (25th & 75th percentile) for Q1, and average of 4 weekly diaries (MET/week).<br><br><br><br><br><br><br>Pearson's correlation for EE from Q1 and the diary<br><br>Pearson's correlation for EE from Q2 and the diary | **Q1**<br>Vigorous activity: 4.2 (0.4, 17.5)<br>Non vigorous activity: 10.2 (4.4, 22.5)<br>Overall inactivity : 30.5 (18.5, 48.0)<br><br>**Diary**<br>Vigorous activity: 5.7 (1.0, 16.3)<br>Non vigorous activity: 144.3 (120.2, 172.6)<br>Overall inactivity: 53.4 (42.8, 63.1<br><br>\| Caucasian \| Afr-Amer \| All<br>Vigorous activity 0.49 \| 0.47 \| 0.48<br>Non vigorous activity 0.13 \| 0.30 \| 0.20<br>Overall inactivity 0.23 \| 0.35 \| 0.23<br><br>\| Caucasian \| Afr-Amer \| All<br>Vigorous activity 0.58 \| 0.46 \| 0.51<br>Non vigorous activity 0.19 \| 0.28 \| 0.25<br>Overall inactivity 0.43 \| 0.23 \| 0.39 |
| 8 & 9 | Intra class correlation (ICC, 95% CI) and 95% limits of agreement (LoA) for energy expenditure (EE) and activity frequency (AF) for total activity in complete sample | **Different period**<br>ICC \| 95% LoA<br>AF: 0.64 (0.52 - 0.73) \| 14.9<br>EE: 0.58 (0.45 - 0.69) \| 8.7<br><br>**Same period**<br>ICC \| 95% LoA<br>AF: 0.90 (0.86 - 0.93) \| 7.8<br>EE: 0.86 (0.80 - 0.90) \| 4.4 | Spearman's rank correlation for TEE and pwc75/kg | **Age (yr.)** \| **Men** \| **Women** \| **All**<br>18-78 \| 0.22 \| 0.22 \| 0.21<br>18-29 \| 0.28 \| 0.40<br>30-39 \| 0.22 \| 0.26<br>40-49 \| 0.30 \| 0.23<br>50-59 \| 0.19 \| 0.14<br>60-78 \| 0.15 \| 0.29 |
| 10 | Pearson's correlation (95% CI) for questionnaire scores at 5 months retest. | **Men**<br>SP: 0.88 ( 0.81 - 0.93)<br>OC: 0.89 (0.82 - 0.93)<br>LT: 0.76 (0.63 - 0.85)<br>**Women**<br>SP: 0.71 (0.55 - 0.82)<br>OC: 0.80 (0.68 - 0.88)<br>LT: 0.83 (0.73 - 0.90) | Pearson's correlation (95% CI) for Baecke index from Q1, and EE from the diary<br><br>Percent agreement, %agmt, (Cohen's kappa, k), gross misclassification, GM for classification in tertiles, for Q1 compared with the diary | \| **Men** \| **Women**<br>Q1 0.56 (0.36 - 0.71) \| 0.44 (0.20 - 0.63)<br>Q2 0.66 (0.48 - 0.78) \| 0.42 (0.17 - 0.62)<br><br>\| **Men** \| **Women**<br>**Q1**<br>% agmt 56.7 (35.0) \| 40.0 (10.0)<br>% GM 8.3 \| 10.9 |

| | | | | |
|---|---|---|---|---|
| | Percent agreement (% agmt) in tertiles of total activity index, Cohen's Kappa(k), percent gross misclassification (GM) at 5 months retest | **Men**<br>%agmt (k) 71.4 (57.1)<br>% GM 0.0<br>**Women**<br>%agmt (k) 60.7 (41.0)<br>%GM 5.4 | | **Q2**<br>%agmt 58.3 (37.5) 44.4 (16.7)<br>%GM 8.3 11.1 |
| 11 | Correlation coefficients between test & retest (0, 30 min) | 0.98 ($p<0.01$) | Pearson's correlation between PAQ estimated EE and Caltrac counts, and pedometer counts, and % HRR | Caltrac 0.77<br>Pedometer 0.88<br>% HRR 0.53 |
| 12 | Age-adjusted Pearson's correlation for test-retest (0, 1 m) | **Men** **Women**<br>Tot LT: 0.92* 0.90*<br>SP& X: 0.92* 0.87*<br>non SP& X: 0.88* 0.86*<br><br>* p≤ 0.01 | Total PA index from PAQ, total EE from diary and Caltrac (MET*min/day, ∀SD)<br><br>Age-adjusted Pearson's correlation between PA index and EE from diary and from Caltrac counts<br><br>Pearson's correlation between sports & exercise leisure activity and VO2 peak and % body fat | **Men** **Women**<br>PA index 2.95 ∀0.61 2.84 ∀0.68<br>Diary 1901 ∀285 1923 ∀248<br>Caltrac 1826 ∀156 1861 ∀147<br><br>Diary 0.59 0.33<br>Caltrac 0.24 0.19<br><br>VO2 peak 0.67* 0.45*<br>% body fat -0.37 -0.44*<br>* p ≤ 0.01 |
| 13 | Pearson's correlation (95% CI) for test-retest (0, 24m) in representative sample (RS) and African-American sample (Afr-Am) | **Activity score** **Inactivity score**<br>RS: 0.59 ( 0.48 - 0.69) 0.52 (0.39 - 0.63)<br>Afr-Am: 0.39 (0.19 - 0.56) 0.55 (0.38 - .69) | Pearson's correlation (95% CI) between EE from Q2 and diary, for representative sample (RS) and African-American sample (Afr-Am) | **Activity scores** **Inactivity scores**<br>RS 0.57 (0.46 - 0.67) 0.38 (0.23 - 0.51)<br>Afr-Am 0.47 (0.32 - 0.63) 0.39 (0.19 - 0.56) |
| 14 | Age-adjusted correlation coefficients for short (1m), long term (8 & 9m) test-retest for PA index | **Men** **Women** **All**<br>Visits<br>1,8 0.45* 0.30 0.34**<br>1,9 0.37 0.52** 0.43**<br>8,9 0.61** 0.75 0.72**<br><br>* p<0.05; ** p<0.01 | EE from PAQ and Diary (MET*min/week, ∀SD)<br><br>Age-adjusted correlation between College Alumnus Questionnaire Physical Activity Index (PAI-CAQ) and reference measures | **Men** **Women** **All**<br>PAQ 1897 1243 1270<br>Diary 4420 3540 3856<br><br>#Diary 0.65** 0.54** 0.60**<br>#Tot LTPA 0.60** 0.34** 0.42**<br>Caltrac 0.19 0.19 0.29*<br>VO2max 0.58** 0.53** 0.60**<br>% Body fat -0.36 -0.36* -0.44**<br>* p< 0.05; ** p< 0.01 |
| 15 | Spearman's correlation between 1st & 2nd interview (0, 20 day). | 0.89 | Spearman's correlation for PAQ score with reference measures | Activity recall 0.78<br>Pedometer 0.72 |

| | | | | |
|---|---|---|---|---|
| | Percent agreement (% agmt) into tertiles, gross misclassification (GM) & Kendal's tau-b corr. coef. (K) | % agmt 72<br>% GM 0.0<br>K 0.74 | Percent agreement (%agmt) into tertiles, gross misclassification (GM), Kendal's tau-b correrlation (K) for PAQ and pedomater scores | % agmt 67<br>% GM 0.0<br>K 0.68 |
| 16 | No repeatability study | | Pearson's correlation for PAQ score and reference measures | VO2max / HR rest / BMI / Socio-econ<br>High 0.40 * / -0.29* / -0.05 / 0.04<br>Met 0.03 / 0.08 / 0.16* / 0.26*<br>Low -0.10 / 0.02 / 0.14* / 0.21*<br>* p<0.05 |
| 17 | Test-retest intra class correlation for LTPA | Men / Women / All<br>Total LTPA 0.83 / 0.93 / 0.86<br>Very hard LTPA 0.65 / 0.88<br>Hard LTPA 0.56 / 0.85 / 0.72<br>Moderate LTPA 0.56 / 0.88 / 0.60<br><br>(All correlations p<0.01) | Correlation for total LTPA with reference measures | Men / Women / All<br>PWC 0.43** / 0.47** / 0.48**<br>Peak flow 0.12 / 0.29* / 0.21*<br>BMI 0.25* / 0.02 / 0.19*<br>Body fat -0.05 / 0.24 / -0.21*<br>Systolic -0.14 / 0.18 / 0.01<br>Diastolic -0.16 / -0.14 / -0.11<br>Chol -0.06 / -0.26 / -0.11<br>Resting pulse -0.32** / -0.28 / -0.37**<br>* p < 0.05; ** p < 0.01 |
| 18 | Spearman's rank correlation for past year and past week leisure activity (hr/week) test-retest<br><br>Spearman's rank correlation for reported hours/week of leisure activities, between test-retest.<br><br>Spearman's correlation for reported hours/week of occupational activity, between test-retest | Past year / Past week<br>Age group (yr.)<br>10-20 0.37 / 0.35<br>21-36 0.92 / 0.62<br>37-59 0.88 / 0.77<br><br>Walking exc. / Walking incl.<br>Historical PAQ<br>12 - 18 yr. 0.90 / 0.78<br>19 - 34 yr. 0.96 / 0.76<br>Total 0.93 / 0.77<br><br>Historical 0.86<br>Past-year 0.88 | Spearman's rank correlation for reported hours per week of PA and Caltrac counts, n=17 | Test / Retest<br>Walking excluded<br>Leisure past week 0.62* / 0.58*<br>Leisure past year 0.44 / 0.32<br>Occupational past year 0.41 / 0.41<br>‡Combination past week 0.53* / 0.60*<br><br>Test / Retest<br>Walking included<br>Leisure past week 0.80* / 0.50*<br>Leisure past year 0.69* / 0.27<br>Occupational past year 0.41 / 0.41<br>‡Combination past week 0.59* / 0.66*<br><br>*p<0.05 |

Key
DEE = daily energy expenditure; MHDEE = mean habitual DEE; Prof. = Professional activities; L = leisure activities; H = housework; B = basic daily living activities; moving = moving index activities; SP = sports activities; CI = confidence interval; PA = physical activity; LTPA = leisure time physical activity; met = metabolism intensity; Socio-econ. = socio-economic status; PWC = physical work capacity; Chol. = cholesterol # Diary: components compared were- no. of flights of stairs climbed, no. of city blocks walked, sports & recreation activities. # Tot. LTPA = total LTPA from the diary
‡combination of leisure PA over past week & occupational activity over past year

Brodie, 1991). The precision of VO2 max determination depends on the exercise protocol and the method of determining oxygen intake (Bonnefoy *et al.* 1996). Assuming that the assessment of cardio-respiratory fitness was conducted with minimal measurement error, then studies that showed strong correlations between physical fitness and physical activities suggest the precision of the questionnaire.

*The physical activity diary*

As a reference method for physical activity measurements the activity diary is relatively cheaper to administer compared to other methods. Because it is an on-going record and not based on subjects' recall, the errors between recording and recall are minimised. However, in order to account for within-person daily variations of physical activity and variations during weekdays and weekends the diary should be recorded over several days, which include weekdays and weekend days. In the nine studies that administered activity diary, the number of days of recording varied from two days (studies 12 and 14) to seven days (studies 1 and 13) including week days and weekends. All the studies, except for study 4, repeated the activity diaries from four to six times, and the average of the repeat diaries was used in the validity assessment. This is probably an important requirement for a reference method to be used in a validity study. Because physical activity questionnaires usually assess habitual physical activities, a one-time record of activity may not be an accurate reflection of long term physical activity. Studies that administer reference methods only once have be cautious in interpreting the validity of their questionnaire.

Studies which compared estimates of total daily or weekly energy expenditure from the questionnaires and the diary, found that the questionnaires under estimated energy expenditure by as much as 72% (for men in study 2), 65% (for women in studies 2 and 14), 57% (for men in study 14). The physical activity questionnaire in studies 2 and 14 were not intended to estimate individuals energy expenditure, so this questionnaire did not cover all the components of individuals' physical activity. However, in study 1 the objective of the questionnaire was to estimate individuals' energy expenditure. It was shown that the physical activity questionnaire did not assess the complete range of physical activities performed by subjects in their study. At group level their physical activity questionnaire underestimated daily energy expenditure by 23% in men and 29% in women. The authors suggested that their physical activity questionnaire could be used for estimating absolute energy expenditure at group level but not at the individual level.

The highest correlations for physical activity measures from the diaries and physical activity questionnaires were found among men in study 1 (0.66), which is considered moderate. Generally the correlations among men were higher than among women. Women, especially older women, not having a regular job may find it difficult to make correct estimates of the time they spend of various activities (study 1). For study 12, correlations between the diary and physical activity questionnaire in women was low. The questionnaire accounted for only 11% of the variance in physical activity record for total leisure time. This suggests that many activities carried out by women are not assessed by the questionnaire. Household activities, taking care of children has been shown to be an important component of daily physical activity, especially in women (Ainsworth *et al.* 1993a).

Most studies used correlations to evaluate the validity of their physical activity measurements. Correlations indicate only associations. In comparing two methods, it has been recommended to show agreement between the two methods (Bland & Altman, 1986). A plot of difference against the mean of the two methods will indicate agreement across the whole scale of the physical activity measures being tested.

This plot will also show if there is good agreement between the two methods across the whole range of physical activity levels. None of the studies presented the validity results using the Bland-Altman plot. Therefore agreement between both methods can only be deduced if correlations were presented for different physical activity levels. Studies 4, 7, 12, 13 and 14 had low correlations for low intensity physical activities. It suggests that these questionnaires are not accurate enough in assessing physical activities in the lower end of the physical activity distribution. It is probably because the activities in this spectrum are too numerous and many would be left out of the questionnaire. It can also be due to the questionnaire not being precise enough, so subjects could not recall these activities accurately.

The relationship between the physical activity diary and questionnaire is more meaningful when expressed in terms of comparisons between thirds, fourth and fifths of the physical activity distribution. Percentage of subjects correctly classified into thirds, fourths and fifths of the physical activity distribution reflects the accuracy of the questionnaire measurement. Clayton and Gill, (1997) had demonstrated the effect of exposure misclassification in thirds, on observed relative risk. Only study 10 made comparisons for correct classification in thirds of the physical activity distribution. Eight per cent of men and 11 per cent of women were grossly misclassified. This implies that the modified Baecke questionnaire when used in an epidemiological study would have a large attenuation of relative risk in both men and women. The effect is more serious in women because only 40 per cent of the subjects were correctly classified.

*Pedometers, accelerometers*

Both instruments are motion sensors. The pedometer registers the frequency of steps or foot strikes. The accelerometer is an electronic motion sensor that can assess the quantity and intensity of subjects' movement. Study 18 had used the Caltrac accelerometer as the only reference method in their validity study. Whereas, in studies 5, 11, 12, 14 and 15, they have used the pedometer and Caltrac together with other reference methods.

In study 18 the Caltrac counts per hour was significantly related to reported leisure past - week activity. The correlation coefficient was only 0.62 (<0.05), after excluding the contribution of walking activity. This suggests that assessment of other physical activity was a better indicator of walking, since the assessment of walking among the Pima Indians was very unreliable. The Caltrac is considered suitable for the Pima Indians in this study because they depend on walking as a major form of transportation. There were no significant correlations between Caltrac counts and the reported activity estimate for past year leisure and past year occupational activity, after excluding walking. This is expected since the Caltrac measures current physical activity. Study 11 found high correlations between the Caltrac counts, pedometer counts and the estimated energy expenditure based on recall of activity for the same period. Thus the questionnaire was considered as a reliable measure of the current total energy expenditure at group level.

However, study 5 found low correlations between estimated energy expenditure from the Caltrac and from the questionnaire. Probably the number of days for which the Caltrac was worn was not long enough to obtain an accurate estimate of long term energy expenditure. In study 5, it was worn for 24 hours only. In studies 12 and 14 the subjects had worn the Caltrac for a period for 48 hours, fourteen times. There was no significant correlation between the Caltrac and the ARIC/Baecke questionnaire (study 12). There were low correlations between the activity score and Caltrac's estimated energy expenditure, except for stair climbing activity in study 14. This shows that the types of activities reported in the questionnaire do no represent the total day's activities. The Caltrac does not measure activities such as cycling, swimming and weigh lifting.

The Caltrac accelerometer is a reliable instrument to assess physical activity when walking or running is the main component of daily activities (Pambianco *et al.* 1990). It should be used with other reference methods, so that other activities that are not sensitive to the Caltrac can be validated. Because the Caltrac is sensitive to both the amount and intensity of movement, it should be used in preference to the pedometer.

*Heart rate monitoring*

Heart rate monitoring is considered to be an objective method for physical activity assessment, therefore suitable for use as a reference method to validate physical activity questionnaires. Only study 11 used heart rate monitoring as a validation criteria for their physical activity questionnaire. Mean energy expenditure using both mode and intensity of activity were found to be significantly related to the percent heart rate range for the period being studied (r = 0.53, P = 0.006). Correlations were not significant when energy expenditure from the physical activity questionnaire used mode only or intensity only. The heart rate monitoring method also showed that the physical activity questionnaire could discriminate bouts of moderate and vigorous physical activity among the study subjects.

*The doubly labelled water method (DLW)*

Only one study used the DLW as a reference method for its validity study. In study 3, the PASE score was compared with the residuals of the regression of total energy expenditure against resting metabolic rate. The correlation was significant, higher in men than in women. As women performed these activities more frequently than men did, the questionnaire overestimated women's physical activity as compared to men. The physical activity ratio, PAR (TEE/BMR) was also significantly correlated with the PASE score. The DLW can estimate individual energy expenditure. As the strength of the correlations indicated, the PASE does not accurately measure individual metabolic activity. The DLW only estimates total energy expenditure, but it cannot detect intensities of activities or discriminate activity patterns. It is suitable for comparing questionnaires that intend to assess energy expenditure at group level and to classify subjects into levels of physical activity.

Other less appropriate measures that have been used as the reference include body mass index, other physical activity questionnaires, body composition, blood pressure and socio-economic status.

#### *2.2.4.5 Repeatability of the physical activity questionnaires*

Repeatability is a measure of the reproducibility of the questionnaire. Reproducibility requires that the questionnaire be tested repeatedly under the same conditions, which is not possible in human studies. Therefore, most studies assess the reproducibility of their physical activity questionnaire by administering the questionnaires to the same subjects at different times. Performance of the questionnaire at each of the tests assesses both the stability of subjects' physical activity and variations due to the questionnaire measurements.

Reproducibility of the questionnaire is then assessed in the context of the population tested (random or selected sample), conditions in which it was tested (similar or not to field conditions) and the order of administration (before or after the reference method).

There is no hard-and-fast rule about the number of times physical activity questionnaires should be repeated and the duration between tests. The intervals should not be too short to avoid learning effect, nor should it be too long because of the likelihood of a true change in physical activities of the subjects. It should be repeated at least once, but preferably several times, at intervals, or in different seasons of the year to take into account seasonal variations in physical activity.

Three of the questionnaires were not tested for their repeatability, (Table 2.8). No conclusions were made whether the questionnaires would produce similar results when administered again to the same population. The main purpose of conducting a repeatability study is to estimate random errors due to within-person variations in physical activity.

Questionnaires in studies 1, 2, 5, 10 and 14 were administered three times within nine to twelve months. They could compare short and long term repeatability of the questionnaires. Study 1 found that difference in mean energy expenditure between the first, second and third administration were small. So, at group level, the estimate of absolute energy expenditure was reproducible, both for short and long term.

In study 2, the actual questions from the questionnaire were not tested. Its reproducibility and validity was only estimated by selecting from study 1 data the answers to a number of questions from the pre EPIC questionnaire that resembled the EPIC short questionnaire. Spearman correlations between baseline and the second administration for men ranged from 0.58 to 0.89. Correlation between baseline and the third administration ranged from 0.47 to 0.83. For women, the correlations were between 0.59 to 0.81 and between 0.49 to 0.72. On average, reproducibility at second administration (five months) was better than at the third administration (eleven months).

Among older women, reproducibility of the pre EPIC questionnaire (study 5) was poor at five months ($r = 0.42$) and good at eleven months ($r = 0.60$). The lower five-month reproducibility may have been partly caused by seasonal influences (winter versus spring). Reproducibility of the Baecke questionnaire among the same subjects was higher than the pre EPIC. It is possible that subjects found it easier to answer the Baecke questionnaire than the pre EPIC questionnaire.

Other studies in this review repeated their questionnaire only once. The interval between the first and second administration ranged from thirty minutes (study 11) to two years (studies 7 and 13). Besides the long interval, subjects in studies 7 and 13 were asked to complete four weekly diaries and four past-week recalls between the first and second questionnaire. The median values of energy expenditure in vigorous, non-vigorous and overall inactivities from the second questionnaire (study 7) were higher compared to values from the first questionnaire. The intraclass correlations for non-vigorous activity and overall inactivity were low among the Caucasian subjects. In study 13 subjects reported more sitting activity in the second questionnaire compared to the first questionnaire, which could be due to a learning effect. True changes in the activity patterns of subjects, imprecision in recall and their increased awareness of the questionnaire may have underestimated the reproducibility of both questionnaires in studies 7 and 13.

Studies that repeated their questionnaire within a short interval, from three to four weeks showed good reproducibility (studies 12, 14, 15, 17 and 18). The ARIC/Baecke and the Liverpool Leisure Time physical activity questionnaire had high correlations for their test and re-test activity scores. The two questionnaires particularly asked subjects to recall their leisure time physical activities. In study 12 the subjects were participants of an intensive activity-monitoring programme for twelve months. This is probably the reason why they could recall their activities accurately. Therefore the reproducibility of these questionnaire may not be as good if tested in the general population.

The College Alumnus physical activity questionnaire was tested for short term as well as long term reproducibility. The questionnaire showed good reproducibility at one month.

This could mean that subjects were able to recall their activities accurately when their activity patterns are not likely to change. The reproducibility over longer period was poor. This may reflect seasonal variability in physical activity habits over time, or inability to recall accurately.

Study 11 showed high reproducibility for its questionnaire. However, the interval, between the first and second administration was only one hour. It is likely that subjects who took part in the study could remember what they had answered in the first questionnaire. If the second test was conducted after a longer time interval the reproducibility may not be as high.

Low repeatability could be due to either true variations in the activities reported or to poor design of the questionnaire or both. The physical activity questionnaire for Pima Indians (study 15) showed low repeatability among subjects of youngest age group (10-14 years). It indicates that the questionnaire was not suitable for assessing physical activity in young individuals. Younger subjects who have no regular or routine activities will have so much variability in their day to day activities that, it may be difficult to measure their physical activities. Walking as a leisure activity among the Pima Indians also showed poor reproducibility. The Pima Indians depend on walking as a major form of transportation. Probably the walking question was not focused, so the subjects were not consistent in their recall about walking as a leisure activity.

#### *2.2.4.6 Summary of the critical review on validation studies*

Physical activity questionnaires have been developed and used in population studies since the 1960s. There has been an increase in the number of new physical activity questionnaire developed and published in the 1980s and 1990s compared to earlier years. A total of thirteen questionnaires were published from 1980 to 1989 and sixteen questionnaires for 1990 to 1995 (Pereira *et al.* 1997). Because these questionnaires were to be used in large surveys to study the relationship between physical activity and disease, it is important to know their validity and reliability. We now understand that this process has not been easy. It is partly because physical activity is a complex human behaviour, which is difficult to measure. Another reason was the lack of a "gold standard" that can be used to compare with what has been reported in the questionnaire. One of the recommendations of the Surgeon General's report was to improve the validity and comparability of self-reported physical activity in national surveys (Editorial, 1996).

The experiences learned in the development of dietary assessment methods have been useful because it can be applied to physical activity assessment. Similar to a food frequency questionnaire the hierarchy of importance in a physical activity questionnaire would be to include all relevant activities, the duration of each activity and estimate its intensity. The questionnaire has to be developed so that it is appropriate for the target population, for example for children, adults, the elderly or even men and women. There is a possibility that in order to satisfy this requirement the physical activity questionnaire may be lengthy and impose a heavy burden on the respondents. Investigators will face similar practical constraints, such as reduced response rate, as in the food frequency questionnaire. It is apparent that research on physical activity has evolved from focusing on aerobic and high intensity activities only, to measuring the whole spectrum of activities. This is driven by findings that people can benefit from even moderate levels of physical activity. Research findings have also indicated that physical activities affects several systems in our body differently, the musculo-skeletal, cardiovascular, respiratory and the endocrine system.

From the eighteen studies reviewed five studies had attempted to include as many components of physical activity as possible. The correlation coefficients between questionnaire measures and the reference measures for these studies were not very high. This shows the difficulty in assessing complete physical activity, considering the subjects who took part in the validation studies were mostly highly motivated, well educated and health conscious people. The correlation would be lower when these questionnaires were applied to the general population.

Another important aspect of the validity of physical activity questionnaire is the reference method used for comparison. The physical activity diary is the commonest reference method used, because it is relatively inexpensive and easy to administer. Physical activity questionnaires should be validated against at least one objective method, for example, the doubly labelled water method, the minute-by-minute heart rate monitoring method, or the motion sensors.

The subjects who take part in validity studies should be representative of the population in which the physical activity questionnaire is going to be used. In this way the internal as well as the external validity of the questionnaire can be assessed. Studies that have recruited volunteers as subjects to validate their physical activity questionnaire should consider the validity of their questionnaires to be in the upper limit.

The validity of an instrument takes into consideration its reliability or repeatability. Therefore a validation study must also include a repeatability study. Repeat measurements can be done at intervals and take into account fluctuations in physical activity.

Using the correlation between physical activity measures from the questionnaires and the reference method we can evaluate the strength of the associations between these two measures. If we use the cut off point of 0.7 for a high correlation coefficient, 0.4-0.6 to be moderate, many of the studies have moderate correlation. Only studies 3, 11 and

15 showed correlation higher than 0.7. Two of the questionnaires were for older people, and one questionnaire was for younger people. These studies which suggested being reliable and valid for the target population had limitations due to their sample bias, as well as bias in their reference measures. To make it more applicable for epidemiological investigations they may have to be re-tested among random sample of the target population and test its validity against more direct measurement of energy expenditure, (for example the doubly labelled water method).

The other fifteen studies reviewed showed only moderate correlation between physical activity questionnaire measures and the reference measures. This level of agreement between the two measures suggests moderate agreement, which are probably due to large measurement errors in the questionnaire. This implies that these questionnaires when applied to epidemiological studies are likely to misclassify a large number of subjects in their distribution of physical activity level. The degree of attenuation of relative risk will depend on the proportion of subjects misclassified.

Attenuation of relative risks due to measurement error can be corrected to a certain extent by applying mathematical models. In conclusion, physical activity questionnaires can be valid instruments for measuring physical activities provided they have included all the relevant activities for the target population and able to obtain accurate information about their duration and intensity from the subjects.

## 2.3 SUMMARY OF THE LITERATURE REVIEW

Factors that have been recognised to affect birth weight include maternal weight and height, weight gain during pregnancy, period of gestation, smoking, parity, infant sex, iron status, and the adequacy of antenatal care. Studies in the UK that have looked at the South Asian women as a group have found that on average they are shorter and lighter than white Caucasian women. South Asian babies in the UK are generally lighter and smaller than Caucasian babies.

However, if the South Asian people are categorised into subgroups, either by their religion or their country of origin, the Muslim women are more likely to produce bigger babies than the Hindu or Sikh women. In some studies, Sikh-babies were heavier than the Muslim babies. There appears to be differences within subgroups of the South Asian communities, largely due to the regions in the Indian subcontinent where they had originated. This could be identified by combining both their religion and country of origin as the criteria.

Thus in the UK, Hindu-Indian babies were found to have the lowest birth weight, and the Pakistani babies the highest birth weight. Among Muslim South Asians their lower maternal size and gestational age could explain their having lower birth weight babies than the Caucasian women. Among the Hindu-Indians, maternal size, gestation, and possibly nutritional factors, could account for the difference in birth weight compared to Caucasian women.

In the Indian subcontinent, birth weight is related to socio-economic status. Indian women from higher income group, presumably well nourished, are heavier than women from lower income group, and produce bigger babies. Comparisons of birth weight between South Asians in the UK and the Indian subcontinent have to take into consideration their regional, urban and rural differences. These are mainly due differences in socio-economic status of the communities. Studies have suggested that Indian babies in India are smaller and lighter than Indian babies in the UK. The difference could be due to the lower socio-economic level and poorer nutritional status of the Indian women in India.

On the other hand, south Indian women, where most of the studies were cited, have a different dietary habits, social and cultural practices from the Indian women in the UK, who have come mainly from north India. Thus the two populations may not be comparable. There appears to be no difference between the Pakistani babies born in Pakistan and those born in the UK, and between Bangladeshi babies born in Bangladesh and those born in the UK. However, the studies published are too few, and may not be representative of the general population in Pakistan or Bangladesh to make firm conclusions.

Due to poor study design, earlier studies could not determine if maternal size was an important factor in determining differences in birth weight between the South Asian and the Caucasian communities.

There is evidence to suggest that Indian women in the UK are sedentary, and the prevalence of obesity is higher among the South Asian women in the UK than their counter parts in India. A plausible explanation that could bring about these differences is that the South Asian women in the UK who mostly live in urban environments are having energy intakes in excess of their requirements and reduced physical activity since coming to live in the UK. Similar trends in increasing obesity and reduced physical activity have been observed among urban communities in India.

Although the South Asian people in the UK have maintained their traditional diets, there are suggestions that the fat content of their diet has increased. This is probably due to improved socio-economic status since living in the UK. Previous studies on dietary intakes of the South Asian people has faced methodological problems, thus the reliability of their results is questionable. It is not certain if their dietary intake is different from the general UK population or not. There have been no studies to detect changes in dietary intakes over time associated with migration to the UK.

There is a lack of comparative and follow up studies in the UK, India, Pakistan and Bangladesh to monitor changes in the dietary habits and physical activity levels of the South Asian communities associated with migration to the UK. These studies would be able to assess the impact of migration on maternal size and birth outcomes among South Asian women in the UK.

Assessment of physical activity among the South Asian community has mainly focused on participation in sporting and recreational activities. There was no indication if the questionnaires had been validated and tested for its appropriateness for this community. An instrument that has been validated for use in a population may not be necessarily appropriate for another population.

One of the problems to be addressed in an epidemiological study is the validity of the instrument used in the measurement of the exposure of interest (for example physical activity). Another issue of concern is quantifying the measurement error involved in assessing the exposure variable.

In physical activity measurements, the physical activity questionnaire is the most widely used method because it is relatively inexpensive and not intrusive. Several objective measures of physical activity have been recognised to be reference methods to evaluate the physical activity questionnaire. These include the DLW, HRM, the motion sensors, and the activity diary methods. These methods have their own limitations, advantages and disadvantages.

The activity diary can estimate fairly accurately energy expenditure at the group level. This is the cheapest method available. The choice of a reference method to be used in a validation study will ultimately depend on the balance of benefits between costs and their accuracy.

A review of the literature has indicated that investigators have been faced with several problems when conducting validation studies of physical activity questionnaire. One of them is the recruitment of subjects. Some studies had low response rate while others had recruited volunteers. To conduct a validation study on subjects who are not a representative sample of the target population may overestimate the validity of the questionnaire. This is because volunteers or self-selected subjects are likely to be more educated and health conscious than the general population. The sample size for the studies varied from a small number of subjects to a large sample that is representative of the population. Calculation of the sample size to estimate the power of the study was seldom mentioned.

The components of physical activity being measured varied from leisure activities only to a combination of occupational and leisure activities, to the whole spectrum of activities. It is apparent that some studies did not have a specific objective on which particular component of the physical activity to be validated. The time frame over which physical activity was assessed was varied. It ranged from 24-hours to the usual, which can be a whole lifetime. The time frame could partly determine how the questionnaire is to be validated.

A wide range of reference methods has been used in the studies. There vary from other questionnaires to more objective measures such as the doubly labelled water and the heart rate monitoring method. Components of physical fitness have been used in several studies as their validation criteria. Questionnaires that focused on vigorous activities found higher correlation with VO2max than those that focused on the total daily physical activity. This does not mean that the questionnaire was not valid, but it was probably because the validation criteria were not appropriate.

The activity diary and the Caltrac were the most commonly used reference methods in the validation studies. As these are not considered the 'perfect method', the results of their studies may have been less than perfect. At the moment there is a lack of a "gold standard" with which to compare questionnaires that assess long-term physical activity. Investigators have used a combination of several objective methods that assess different components of physical activity to estimate the validity of physical activity questionnaires to assess total habitual physical activity. The weaknesses of one method can be overcome by another method. Due to high costs it may not be practical to conduct the DLW, heart rate monitoring or motion sensors more than once on the subjects. But the activity diary and the activity recall could be repeated at intervals. The average of these repeat measures should be compared with the questionnaires to reflect true long-term physical activity.

Validation of a physical activity questionnaire should include both a repeatability and validity study. Reproducibility of the physical activity questionnaire is affected by its design and how precisely the questions were worded. Simple and precise questions would make it easier for subjects to recall their physical activity rather than complex and unfocused questions. The physical activity questionnaire should be suitable for the target population (for example children, adults, older people, male, females or ethnic groups).

# 3 A STUDY ON SOUTH ASIAN BIRTHS IN SOUTHAMPTON

## 3.1 Introduction

Studies elsewhere in the UK have suggested that the South Asian women who are smaller and lighter than the Caucasian women tend to have smaller and lighter birth weight babies. Southampton has a large number of South Asian population. In the 1991 census for Southampton there were approximately 5371 people who belonged to the South Asian ethnic group. Of the total Southampton population 2.0 percent were Indians, 0.5 percent were Pakistanis, and 0.3 percent were Bangladeshis (Southampton City Council, 1994).

In view of the current knowledge on '*in-utero* programming' and its consequences in disease risk during adult life there is a need to understand what factors play an important role in determining size at birth among South Asian babies in Southampton. This would help in future planning of targeted public health programmes for the South Asian community in Southampton.

This chapter reports on the first research project of this thesis. Section 3.2 is on the methodology, followed by the results and discussions in sections 3.3 and 3.4 respectively.

The aim of this study was to explore maternal factors during pregnancy associated with birth outcome among South Asian babies born in Southampton between 1957 and 1996.

### 3.1.1 Summary of the results

1. A total of 2729 South Asian births from 1957 to 1996 have been studied; main results were based on 2342 full-term singleton births. Birth records were not complete for all vairables of interest mainly due to changes in the recording forms used during the time of data collection. Missing data on some variables limited the statistical inferences that could be drawn for some factors.

2. Low birth weight occurred in twelve percent of the total birth. Placental weight, head circumference and birth length were strongly correlated with birth weight. Maternal characteristics such as age, height, weight, BMI, parity, gravida and iron status had weaker, but statistically significant correlations with birth weight. There was no significant correlation between maternal height and birth length. Weight gain during pregnancy showed a positive relationship with ponderal index, but not with other birth measurements.

3. There was a linear relationship between haemoglobin levels in the third trimester and birth weight. Anaemia, which was prevalent in 25 percent of the pregnancies was more common among younger than older women. Anaemia and lower haemoglobin levels were associated with a lower birth weight and higher placental weight to birth weight ratio. The youngest, or the shortest, or the lightest mothers, or those with the lowest Hb, had babies with the smallest birth weight, placental weight, and the smallest head circumference.

4. There were ethnic group differences: Sikh-Indian women were the youngest and their babies had the smallest birth weight and placental weight. Being a Bangladesh-Muslim carried a reduced risk of having a lower birth weight. The Parkistani-Muslim women were on average heavier and had a higher BMI compared to Hindu and Sikh-Indians. Pakistani-Muslim women had the highest haemoglobin

levels, the largest placentas, and produced the heaviest and longest babies compared with women from the other ethnic groups. Male babies were on average heavier than female babies. The gestational age at birth and weight gain was similar in all ethnic groups.

5. Being a Sikh-Indian or female baby, or being the first born child, or born at term but less than 40 weeks, or born to a thin mother or born by a mother with low haemoglobin or born in the 1970s, carried some risk of having a lower birth weight.

6. Birth weights of babies by mothers born in the UK were smaller than those born to mothers originating in the Indian sub continent; this may be partly accounted for by their younger age, lower BMI and lower haemoglobin. This finding warrants further more detailed investigation to explore possible mechanisms.

## 3.2 STUDY DESIGN AND METHODS

### 3.2.1 Extracting the birth records

This research was conducted mainly at the District Inactive Library (DIL) and the Microfilm Unit of the Royal South Hants Hospital, and at the Princess Anne (maternity) Hospital, Southampton. The medical records of patients from the maternity unit of the Southampton General Hospital, or now the Princess Anne Hospital, were sent to the DIL at the Royal South Hants Hospital after three years. The records were kept at the DIL for another three years before they were stored on microfilms, provided the patient had not visited the maternity unit during that period. After being microfilmed the original records were destroyed. It is the hospital policy to keep patients' records for at least 30 years. The maternity records available on microfilm went back to the 1950s. This study has been approved by the local ethical committee.

Maternity records between the years 1950 and mid 1960s were stored in microfiche. Each piece of microfiche contained the patient's maternity notes for one pregnancy. It usually started from the first time the patient came to see the obstetrician, after being referred by her GP, until she and her baby left the hospital. The microfiche were arranged systematically according to the year of birth of the baby, and within each year, the patients' names were arranged in alphabetical order. The patients' names and maternity numbers appeared in bold at the top of each microfiche and can be seen clearly when one flips through them. For this study each microfiche was checked manually to select records with South Asian names. A microfilm reader was used to scrutinise the details, which were recorded manually in a prestructured recording book.

To search for South Asian birth records from mid 60s to mid 80s, logbooks were examined to identify South Asian names. These books contained the list of patients' names, maternity numbers and the microfilm spool in which their records were kept. Each microfilm spool contained the maternity notes of between 80 and 120 patients. Before the hospital started to computerise its registration system, each mother would be given one maternity number for every pregnancy. The records for each pregnancy were then kept separately. Since computerisation in the early 1980s, a mother would be given the same maternity number for all her pregnancies. A patient who had delivered more than one baby at the Southampton General Hospital may have all her maternity records kept together in the same spool.

Birth records for the 1990's that had not been microfilmed were kept in their clinic folders and stored in boxes at the DIL. They were labelled with their serial maternity numbers. South Asian birth records in these folders were studied manually and their data abstracted. Records that were still used by the maternity hospital, mostly from recent births were kept at the Princess Anne Hospital. South Asian names were identified from the clinic register book and their folders were identified.

The information being abstracted from the birth record included the mother's and that of the babies'. The information about the mothers that were abstracted included: -

- Maternity number, full name, address, occupation, religion, country of origin, age or date of birth, weight, height, gravida, parity, weeks of gestation or the LMP date, complications during pregnancy, type of supplement given, obstetric history, congenital abnormality at birth, smoking status, and iron status during pregnancy.

The following information about their babies had been abstracted: -

- Date of birth, infant sex, birth weight, placental weight, head circumference, and birth length.

Examples of the maternity records and the various formats used are attached in Appendix 2.

### 3.2.2 The process of identifying South Asian patients

South Asians are defined as the group of people who are residents of Britain who originally came from the Indian subcontinent or their descendants. In Britain three ethnic groups are sometimes collectively referred to as South Asian. They consist of Indians, Bangladeshis and Pakistanis. South Asian names were identified from the birth records using our prior knowledge and by referring to Henley (1979). Kaur is the second name usually used by female Sikhs. Bibi or Begum is the second name used by many female Muslims from Pakistan and Bangladesh.

The mothers' religion was also used to identify South Asian patients. As most of the South Asians in Britain are Hindus, Muslims or Sikhs, all mothers with any of the three religions were included. However, Muslim mothers from other countries for example

Saudi Arabia, Egypt, Iran or Malaysia might have similar names. It is possible that some earlier data had included records of women from those countries. Later on the records had information on mothers' place of birth, which reduced uncertainties about the patient's ethnicity.

Women with South Asian names who were Sikh, Hindu or Muslim but born elsewhere, for example, in East Africa, Mauritius or Fiji have been included in the data too. When the name was ambiguous and the place of birth was unknown, religion was the factor to decide whether the patient was likely to be a South Asian or not. In this thesis, country of origin as well as religion has been used to characterise subjects in the study (Pearson, 1991). Records of South Asian students or wives of students were not included because they were not likely to be long-term residents of this country. Mothers with Christian first names, but having South Asian surnames were probably Caucasian women who had married South Asian men. Their records have been excluded because we wanted both parents to be South Asians.

### 3.2.3 The unit of measurements

Records in the 1960s and early 1970s used the imperial units in all their measurements. Birth weights and placental weights were recorded in pounds and ounces, head circumference and birth length in inches and the mother's height in feet and inches. For these records, pounds and ounces have been converted to grams to the nearest gram. Feet and inches were converted to centimetres to the nearest 0.5 centimetre (Appendix 3).

### 3.2.4 The gestation period

In the 1960s the period of gestations were recorded as maturity at birth in weeks. From the 1970s onwards, the dates of the last menstrual period and expected dates of delivery were recorded. We presume that most mothers were sure of their LMP dates, although there is no basis on which this can be substantiated. The period of gestation was calculated as the difference between the date of LMP and the date of delivery.

In cases where the date of LMP was not known the midwife or the doctor used the uterus fundus height to estimate the gestation period. In later records ultra sound scans had been used to estimate foetal size and therefore its 'age'. There were records where the calculated period of gestation was more than 44 weeks, which may have been due to inaccurate LMP dates. Under normal circumstances a pregnancy that is four weeks post term would not be allowed to continue. Records that had their gestation periods of more than 44 weeks were coded as gestation missing.

### 3.2.5 Completeness of the records

In order to ensure that the birth records collected were complete they had to be checked with another independent source. The 1991 census for South Asian people in Southampton, who were born in the UK, was compared with figures in the study.

### 3.2.6 Data entry and analysis

1. All the information collected were entered into an SPSS database. The data was cleaned and checked for accuracy of entry. Statistical analyses were conducted using SPSS for windows (SPSS Inc. Release 6.1.3).

2. The following variables were computed by SPSS if they were not available in the records: -

a. <u>Maternal age</u> (years) by subtracting mother's date of birth from date of delivery.

b. <u>Estimated maternal weight at 15 weeks</u>, (kg) will be referred to as the <u>estimated booking weight</u>. This was derived by linear regression analysis, using weights taken before 13 weeks, between 13 to 15 weeks and between 17 to 20 weeks. This was done in order to increase the number of births with data on weight at a specific gestation in early pregnancy.

c. Weight gain, (kg) by subtracting the estimated booking weight from weight before delivery (weight before delivery was the weight taken during mother's last visit, from one to two weeks before delivery).

d. Gestational age (weeks) by subtracting the date of LMP from date of delivery.

e. Ponderal index ($kg/m^3$) was calculated by dividing the birth weight in kilograms by birth length in meter cubed.

f. Body mass index ($kg/m^2$) was calculated as weight in kilogram divided by height in meter squared.

3. Maternal height if recorded in feet and inches was converted into centimetres to one decimal place.

4. Maternal weight, if recorded in stones, pounds and ounces, was converted into kilograms to two decimal places.

5. Birth weight and placental weight, if recorded in pounds and ounces was converted into grams, to the nearest gram.

6. Head circumference and birth length, if recorded in inches was converted to centimetres.

7. Haemoglobin level, if recorded as per cent, was converted to gram per litre.

8. To study birth outcomes by maternal age, parity and ethnic group, only singleton births born at gestational period of 37 completed weeks or more were included in the analysis.

9. All continuous variables were checked for normality (or symmetry) in their distributions using the Kolmogorov-Smirnov Goodness of Fit Test. The 0.05 significance level was used as the cut off point. Variables that did not have a Normal distribution were transformed and tested again for normality. Results of these tests for all variables are attached in Appendix 4.

The following variables had a normal distribution before transformation: -

- Body mass index (BMI) at 12 weeks gestation.
- RBC during first, second and third trimester.
- Hb for the first and third trimester.
- PCV levels in the first, second and third trimester.
- MCV and MCH levels in the first trimester.

Variables which had Normal distributions after transformation were: -

- Log (natural) ratio of placental to birth weight.
- Square roots of birth weight, estimated booking weight at booking and BMI before delivery.
- Squares of ponderal index.
- Squares of Hb and MCH levels in the second trimester.
- Cube of MCV level in the second and third trimester.
- Cube of MCH levels in the third trimester.

Other variables did not have a normal distribution even after various transformations. Some of the continuous variables had distributions that were close to normal even though they had failed the K-S goodness of fit tests (Appendix 5). With a large data set the analysis is more robust, thus we are more likely to obtain a result which suggests a population with a non- normal distribution when in fact it is (SPSS, 1993).

**10.** The results will present both the means (95% confidence intervals) and medians (25th and 75th percentiles). The parametric test for detecting differences in means between groups is the one-way analysis of variance (ANOVA). This test is used to compare each group separately and to indicate if there are differences in means between any of the groups. As most of the variables in the birth records did not have a normal distribution, non-parametric statistical analysis are considered more appropriate. The Kruskall-Wallis test is the non-parametric equivalent of one-way ANOVA. However, this test does not indicate if there are differences between individual groups. For variables that showed significant group differences using the Kruskall-Wallis tests, the one-way ANOVA tests may be used as a guide as to which groups might be different. The chi-squared test was used to test for differences between groups for categorical variables.

*Logistic regression analysis*

The data were skewed and several variables did not have a symmetrical distribution even after transformations. As they did not fulfil the assumptions required to conduct a multiple regression analysis we had to use the logistic regression analysis to understand what factors play a role in birth outcomes of South Asian women. In this analysis the birth outcome of interest is birth weight, transformed into a dichotomous variable, that is birth weight above or below the median. The maternal characteristics (or predictors) were categorised into two or more groups to establish risk ratios. Gestational age was put into two groups, above or below the median; parity into two groups, either parity 1 or parity more than 1; and infant sex was grouped as male or female.

Maternal height, the estimated maternal weight at booking and maternal BMI at booking were categorised into a 3-level grouping, based upon thirds of distribution of each variable. The haemoglobin levels during the third trimester were put into a 4-level grouping, using the WHO criteria for anaemia in pregnancy as the cut-off point between the two lower and upper groups (WHO, 1972). Four ethnic groups, that is Bangladeshi-Muslim, Pakistani-Muslim, Hindu-Indian and Sikh-Indian were used as a predictor variable for ethnicity. Baby's year of birth were categorised into groups, namely the late fifties, the seventies, the eighties and the early nineties. Maternal origins was categorised either as born overseas or in the UK. The reference group with which the other categories were compared for was the group in the highest part of the distribution. For infant sex male was the reference group and for ethnicity Bangladeshi-Muslim was the reference group.

Based on this categorisation, the logistic regression analysis estimated the risk associated with being a subject in the lowest group, relative to those for the highest group. We assumed that the lowest risk of a poor birth outcome was to be found in the group of women in the highest part of the distribution. This assumption is reasonable if the risk decreases progressively with the predictor variable. If the risk relationship was not progressive, say "u" shaped, the risk will increase again at very high levels of the distribution. This did not occur in our analysis.

## 3.3 RESULTS

### 3.3.1 Completeness of the data

Due to changes in the format for collecting information in the hospital records, not all information of interest was available in all the records. However, information on maternal characteristics and birth outcomes for full term births that we were interested in was the most complete. These were infant's date of birth, infant sex, birth weight, placental weight, gestational age, maternal age, gravida, and religion (Table 3.1).

Table 3.1: Number of records with data available for the variables of interest (all births)

| | Variable name | Valid records | % Missing | (number) |
|---|---|---|---|---|
| | **About the baby** | | | |
| 1. | Date of birth | 2729 | 0.0 | (0) |
| 2. | Infant sex | 2729 | 0.0 | (0) |
| 3. | Gestation | 2688 | 1.5 | (41) |
| 4. | Birth weight | 2725 | 0.1 | (4) |
| 5. | Placental weight | 2641 | 3.2 | (88) |
| 6. | Head circumference | 2420 | 13.2 | (309) |
| 7. | Birth length | 355 | 86.9 | (2374) |
| 8. | Congenital abnormality | 1539 | 43.6 | (1190) |
| 9. | Type of feeding on discharge | 1745 | 36.0 | (984) |
| | **About the mother** | | | |
| 10. | Age at booking | 2723 | 0.2 | (6) |
| 11. | Height | 2432 | 10.8 | (297) |
| 12. | Gravida | 2726 | 0.1 | (3) |
| 13. | Parity | 2238 | 17.9 | (491) |
| 14. | Religion | 2678 | 1.8 | (51) |
| 15. | Country of origin | 2193 | 19.6 | (536) |
| 16. | Occupation | 2279 | 16.4 | (450) |
| 17. | Smoking status | 1360 | 50.1 | (1369) |
| 18. | Medical condition during pregnancy | 1645 | 32.4 | (787) |
| 19. | Type of drug given | 1347 | 50.6 | (1382) |
| 20. | Type of delivery | 1829 | 32.9 | (900) |
| 21. | Number of previous abortions | 2252 | 17.4 | (477) |
| 22. | Number of previous miscarriages | 2252 | 17.4 | (477) |
| 23. | Number previous still births | 2251 | 17.5 | (478) |
| 24. | Weights at clinic visits | (Table 3.2) | | |
| 25. | Iron status at clinic visits | (Table 3.3) | | |

The following information was available in more than 80 per cent of the records: head circumference, maternal age, maternal height, gravida, parity, mother's origin, religion, occupation of mother and obstetric history. The following information was available in about fifty per cent of the records: - congenital abnormality at birth, type of feeding on discharge, medical conditions during pregnancy, type of delivery. Information on maternal weight at clinic visits varied (Table 3.2), as was information on iron status (Table 3.3).

Table 3.2: Number of records with data on mother's weight taken during clinic visits (All births)

| Gestation (weeks) | Code | Valid records | % missing | (number) |
|---|---|---|---|---|
| 0-12 | A | 455 | 81.3 | 1977 |
| 13-16 | B | 739 | 69.6 | 1693 |
| 17-20 | C | 760 | 68.8 | 1672 |
| 21-24 | D | 700 | 71.2 | 1732 |
| 25-28 | E | 1269 | 47.8 | 1163 |
| 29-32 | F | 1443 | 40.7 | 989 |
| 33-35 | G | 1474 | 39.3 | 958 |
| 36 | H | 925 | 62.0 | 1507 |
| 37 | I | 792 | 67.4 | 1640 |
| 38 | J | 908 | 62.7 | 1524 |
| 39 | K | 641 | 73.6 | 1791 |
| 40 | L | 401 | 83.5 | 2031 |
| >40 | M | 119 | 95.1 | 2313 |

Table 3.3: Number of records with information on maternal iron status (All births)

| | First trimester | | Second trimester | | Third trimester | |
|---|---|---|---|---|---|---|
| | Valid records | % missing | Valid records | % missing | Valid records | % missing |
| RBC | 154 | 93.7 | 599 | 75.4 | 1219 | 49.9 |
| Hb | 226 | 90.7 | 1142 | 53.0 | 1703 | 30.0 |
| PCV | 155 | 93.6 | 610 | 74.9 | 1227 | 49.5 |
| MCV | 153 | 93.7 | 603 | 75.2 | 1218 | 49.9 |
| MCH | 153 | 93.7 | 601 | 75.3 | 1221 | 49.8 |
| MCHC | 151 | 93.8 | 602 | 75.2 | 1224 | 49.7 |

### 3.3.2 Summary of the data

The total number of South Asian live birth records studied was 2729, which were for births from 1957 to 1996 (Table 3.4). The annual number of South Asian babies born in Southampton has increased steadily since records were available. The number of records for the years 1977 and 1978 were lower than the previous two years. It is possible that for these two years the record abstraction was not complete.

Table 3.4: Number of South Asian live births, Southampton 1957-1996

| Year of birth | No. of births | Year of birth | No. of births | Year of birth | No. of births | Year of birth | No. of births |
|---|---|---|---|---|---|---|---|
| 1957 | 1 | | | | | | |
| 1958 | 0 | | | | | | |
| 1959 | 1 | | | | | | |
| 1960 | 2 | 1970 | 72 | 1980 | 95 | 1990 | 103 |
| 1961 | 0 | 1971 | 57 | 1981 | 97 | 1991 | 110 |
| 1962 | 7 | 1972 | 86 | 1982 | 85 | 1992 | 116 |
| 1963 | 19 | 1973 | 81 | 1983 | 121 | 1993 | 97 |
| 1964 | 26 | 1974 | 60 | 1984 | 106 | 1994 | 106 |
| 1965 | 52 | 1975 | 72 | 1985 | 138 | 1995 | 65 |
| 1966 | 59 | 1976 | 52 | 1986 | 113 | 1996 | 24 |
| 1967 | 70 | 1977 | 16 | 1987 | 123 | | |
| 1968 | 74 | 1978 | 33 | 1988 | 143 | | |
| 1969 | 91 | 1979 | 50 | 1989 | 106 | | |
| Total | 402 | | 579 | | 1127 | | 621 |
| Grand total | | | | | | | **2729** |

A majority of South Asian births were delivered by women from India (Table 3.5). The next largest group of births was by Pakistani women. Births by South Asian women who were born in the UK, who could be from any of the four ethnic groups formed the third largest group. The first birth by a South Asian mother born in the UK was recorded in 1972. Sikh-Indian women delivered fifty-one percent of the births from 1957 to 1996, and twenty-four percent were by Pakistani-Muslim women. Births by Hindu-Indian and Bangladeshi-Muslim women contributed to 12 and 10 percent of the total South Asian birth respectively (Table 3.6).

In order to assess the completeness of record abstraction, the birth data were compared with data from the 1991 population census, which had included information on ethnicity and place of birth (Table 3.7). Our data on births by ethnicity matched the relative proportions of UK born Indians, Pakistanis, and Bangladeshis from the census. However, the UK born South Asian people enumerated in the census may not all have been born in Southampton. There was likely to be some in- and out-migration of the people, for example by marriage. However, it is concluded that the number of records, which had been missed, was relatively small.

Table 3.5: South Asian births by maternal origin, Southampton from 1957 to 1996

| Year of birth | India | Pakistan | Bangladesh | East Africa | UK | Other countries | Origin Unknown | Total birth |
|---|---|---|---|---|---|---|---|---|
| 1957 - 1960 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 1961 - 1965 | 77 | 15 | 0 | 2 | 0 | 5 | 5 | 104 |
| 1966 - 1970 | 267 | 62 | 2 | 10 | 0 | 4 | 21 | 366 |
| 1971 - 1975 | 195 | 68 | 9 | 24 | 7 | 6 | 47 | 356 |
| 1976 - 1980 | 113 | 59 | 21 | 24 | 9 | 8 | 12 | 246 |
| 1981 - 1985 | 251 | 96 | 52 | 69 | 50 | 10 | 19 | 547 |
| 1986 - 1990 | 212 | 115 | 86 | 50 | 113 | 7 | 5 | 588 |
| 1991 - 1996 | 129 | 107 | 89 | 37 | 150 | 5 | 1 | 518 |
| Total (%) | 1248 (45.7) | 522 (19.1) | 259 (9.5) | 216 (7.9) | 329 (12.1) | 45 (1.6) | 110 (4.1) | 2729 |

Table 3.6: South Asian births by ethnic group, Southampton from 1957 to 1996

| Year of birth | Sikh-Indian | Hindu-Indian | Pakistani-Muslim | Bangladeshi-Muslim | Other/ unknown | Total |
|---|---|---|---|---|---|---|
| 1957 - 1960 | 4 | 0 | 0 | 0 | 0 | 4 |
| 1961 - 1965 | 75 | 6 | 17 | 0 | 7 | 104 |
| 1966 - 1970 | 249 | 35 | 72 | 2 | 8 | 366 |
| 1971 - 1975 | 189 | 63 | 87 | 10 | 6 | 356 |
| 1976 - 1980 | 104 | 47 | 69 | 24 | 2 | 246 |
| 1981 - 1985 | 267 | 87 | 125 | 58 | 10 | 547 |
| 1986 - 1990 | 278 | 63 | 141 | 87 | 19 | 588 |
| 1991 - 1996 | 224 | 37 | 154 | 95 | 8 | 518 |
| Total (%) | 1390 (50.9) | 338 (12.4) | 665 (24.4) | 276 (10.1) | 60 (2.2) | 2729 |

Table 3.7: **South Asian population in Southampton, (Census 1991)***

| | Indian | Pakistani | Bangladeshi | Other | Total |
|---|---|---|---|---|---|
| Male | 1950 | 531 | 247 | | |
| Female | 1913 | 462 | 268 | | |
| Total | 3863 | 993 | 515 | | 5371 |
| **Born in UK, by census (%)** | **1914 (72.6)** | **515 (19.6)** | **204 (7.8)** | | **2633** |
| **South Asian births recorded up to 1991 (%)** | **1530 (65.9)** | **536 (23.1)** | **200 (8.6)** | **55** | **2321** |

* Source: Southampton City Council, 1994

The average birth weight, placental weight, birth length, and head circumference for all births are shown in Table 3.8. One case had the infant sex as uncertain and two infants had missing data on sex, thus total male and female values was one less than the total. The median gestational age was 40 weeks, and pre-term birth occurred for 224 cases, 8.3 % (Figure 2). There was a tendency for gestational age to be recorded to the nearest whole number, such that there was a clumping of the data. The rate of low birth weight (less than 2500 gram) was 12.7 percent, lower among boys than girls, (11% compared to 14.5%).

For further analysis only data from full term singleton births were used. This will make data comparable to other published studies, which have mainly presented results of full term births. The total number of singleton birth after excluding 46 twin births was 2683. From this 210 pre-term births and another 41 babies without data on gestational age were excluded. This made the total number of births available for subsequent analysis to be 2432.

Placental weight, head circumference and birth length were highly correlated with birth weight (Table 3.9). Maternal height and RBC in the third trimester had the lowest corelations with birth weight.

Table 3.8: Birth outcomes for South Asian babies (all gestations) born in Southampton, 1957-1996

| | Number | Mean* | 95% confidence interval | Median | 25th; 75th percentiles |
|---|---|---|---|---|---|
| <u>Birth weight, g</u> | | | | | |
| All | 2725 | 3032 | 3011 - 3052 | 3040 | 2726; 3350 |
| Male | 1370 | 3088[a] | 3058 - 3118 | 3100 | 2780; 3420 |
| Female | 1354 | 2974[b] | 2946 - 3002 | 2890 | 2660; 3290 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 30.4 ; | <u>≤0.0001</u> / | 41.8 ; | <u>≤0.0001</u> |
| <u>Placental weight, g</u> | | | | | |
| All | 2641 | 585 | 580 - 590 | 582 | 500; 656 |
| Male | 1331 | 588 | 580 - 595 | 590 | 500; 667 |
| Female | 1309 | 583 | 575 - 590 | 580 | 500; 650 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.9 ; | .3421 / | 0.8 ; | .3624 |
| <u>Head circumference, cm</u> | | | | | |
| All | 2420 | 33.7 | 33.6 - 33.7 | 34.0 | 33.0; 34.6 |
| Male | 1212 | 33.9[a] | 33.8 - 34.0 | 34.0 | 33.0; 35.0 |
| Female | 1207 | 33.4[b] | 33.3 - 33.5 | 33.5 | 32.5; 34.5 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 43.6 ; | <u>≤0.0001</u> / | 66.5 ; | <u>≤0.0001</u> |
| <u>Birth length, cm</u> | | | | | |
| All | 355 | 50.5 | 50.0 - 50.9 | 50.0 | 48.0; 52.0 |
| Male | 182 | 50.7 | 50.2 - 51.2 | 50.0[a] | 49.0; 52.5 |
| Female | 173 | 50.2 | 49.6 - 50.9 | 49.0[b] | 48.0; 52.0 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 1.0 ; | .3295 / | 7.1 ; | <u>≤0.05</u> |
| <u>Gestational age, weeks</u> | | | | | |
| All | 2688 | 39.2 | 39.1 - 39.2 | 40.0 | 38.0; 40.0 |
| Male | 1357 | 39.1 | 38.9 - 39.2 | 39.7 | 38.0; 40.0 |
| Female | 1330 | 39.2 | 39.1 - 39.3 | 40.0 | 38.0; 40.0 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 1.7 ; | .1955 / | 1.6 ; | .2009 |

*Group means with different superscripts are different; group means with no superscript are similar, using one-way ANOVA; F ratio - for one-way ANOVA statistics; $\chi^2$ - for Kruskall-Wallis one-way ANOVA statistics.

A scatter plot of placental weight with birth weight indicates their relationship (Figure 3). Other variables had significant but low correlations with birth weight. A correlation matrix of the variables (appendix 6) indicate that several variables were highly correlated. However, maternal height had no significant correlation with birth weight. Examples include gravida with age and parity; head circumference with length, age and parity; BMI at 12 weeks with age, gravida, parity, BMI before delivery, estimated booking weight and BMI at booking; RBC with haemoglobin levels. Maternal weight gain had the lowest correlation with birth weight. Weight gain could be calculated for only 941 full term births.

Figure 2: A scatter plot of gestational age against birth weight (for births with known gestation) (n=2684)

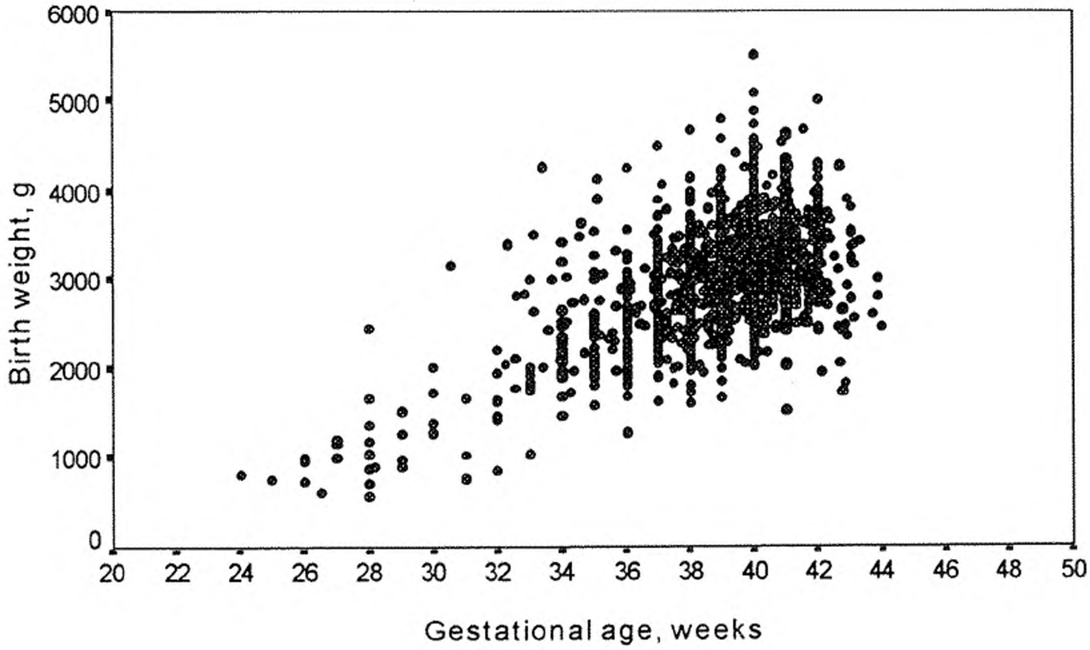
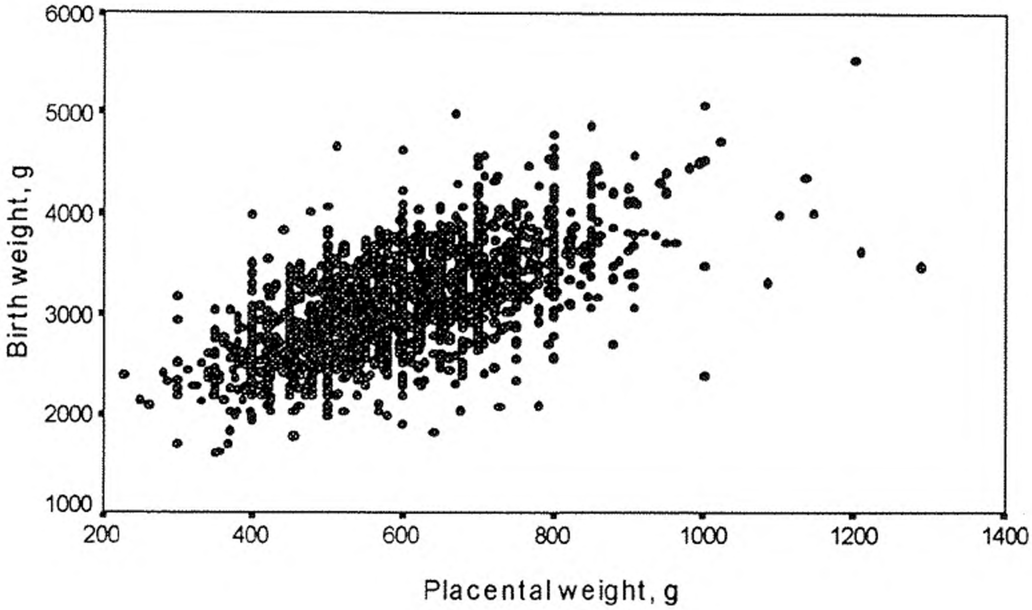



Table 3.9: **Spearman rank correlation coefficients ( r ) between birth weight and other variables**

| Variable name | Valid cases | r | p-value |
|---|---|---|---|
| Placental weight | 2355 | 0.60 | <0.0001 |
| Head circumference | 2182 | 0.58 | <0.0001 |
| Birth length | 320 | 0.58 | <0.0001 |
| Ponderal index | 320 | 0.24 | <0.0001 |
| Infant sex | 2427 | -0.14 | <0.0001 |
| Gestational age | 2429 | 0.20 | <0.0001 |
| Maternal height | 2216 | 0.13 | <0.0001 |
| Maternal age | 2424 | 0.20 | <0.0001 |
| Gravida | 2427 | 0.19 | <0.0001 |
| Parity | 2054 | 0.20 | <0.0001 |
| BMI at 12 wk. | 453 | 0.18 | <0.0001 |
| Estimated booking weight | 1406 | 0.22 | <0.0001 |
| BMI at booking | 1383 | 0.19 | <0.0001 |
| Weight gain | 941 | 0.10 | <0.01 |
| RBC in 3$^{rd}$ trimester | 1219 | 0.25 | <0.0001 |
| Hb in 3rd trimester | 1702 | 0.21 | <0.0001 |
| Weight before delivery | 1195 | 0.25 | <0.0001 |
| BMI at delivery | 1174 | 0.21 | <0.0001 |

There were sex differences in birth weights and head circumference (Table 3.10a). Male babies were on average heavier and had a larger head circumference than female babies. Birth length and placental weights were similar for both sexes.

Figure 3: A scatter plot of placental weight against birth weight (Full term births)




The median age of the mothers was 25 years, and on average they had three pregnancies including the current pregnancy (Table 3.10b). Their average height was 156.3 cm (5' 1.5") tall and their estimated booking weight was 59.2 kg (130 pounds).

The median weight gain during pregnancy was 8.1 kg. The average haemoglobin level in the third trimester was 113 g/L. The UK-born mothers with mean age of 23 years were younger compared to mothers from the Indian subcontinent or East Africa. The UK-born mothers were the lightest and had the lowest BMI (data not shown). Almost forty percent of the mothers were identified as having a medical condition during pregnancy. The commonest condition was anaemia (25.3 percent). We presume that they had used the WHO criteria of Hb levels less than 110g/L as the cut off point for anaemia. Other conditions included hypertension, PET and diabetes.

About sixty percent of the women were given iron or folic acid supplements or both. Some women had been given iron injections during their pregnancy.

Table 3.10 a: **Birth outcomes for full term singleton births**

| Birth outcome | Number | Mean* | 95% confidence interval | Median | 25th; 75th percentiles | Min. | Max. |
|---|---|---|---|---|---|---|---|
| **Gestational age, weeks** | | | | | | | |
| All | 2432 | 39.6 | 39.6 - 39.7 | 40.0 | 39.0; 40.0 | 37.0 | 44.0 |
| Male | 1220 | 39.6 | 39.5 - 39.6 | 40.0 | 39.0; 40.0 | 37.0 | 43.9 |
| Female | 1209 | 39.6 | 39.6 - 39.7 | 40.0 | 39.0; 40.0 | 37.0 | 44.0 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.9 ; | .3413 / | 1.0 ; | .3178 | | |
| **Birth weight, g** | | | | | | | |
| All | 2429 | 3110 | 3091 - 3128 | 3090 | 2810; 3390 | 1610 | 5530 |
| Male | 1219 | $3176^a$ | 3150 - 3202 | 3160 | 2860; 3450 | 1720 | 5080 |
| Female | 1207 | $3042^b$ | 3016 - 3068 | 3020 | 2740; 3300 | 1610 | 5530 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 51.9 ; | <0.0001 / | 51.2 ; | <0.0001 | | |
| **Placental weight, g** | | | | | | | |
| All | 2358 | 588 | 583 - 593 | 595 | 500; 660 | 227 | 1287 |
| Male | 1187 | 591 | 584 - 598 | 595 | 500; 670 | 227 | 1287 |
| Female | 1168 | 585 | 578 - 592 | 590 | 500; 650 | 250 | 1210 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 1.6 ; | .2037 / | 1.4 ; | .2411 | | |
| **Placental/birth weight ratio %** | | | | | | | |
| All | 2355 | 18.9 | 18.9 - 19.1 | 18.7 | 16.9; 20.8 | 9.4 | 41.5 |
| Male | 1186 | $18.7^a$ | 18.5 - 18.8 | 18.5 | 16.7; 20.5 | 9.4 | 36.9 |
| Female | 1166 | $19.3^b$ | 19.1 - 19.5 | 19.0 | 17.0; 21.2 | 9.4 | 41.5 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 23.4 ; | <0.0001 / | 16.6 ; | <0.0001 | | |
| **Head circumference, cm** | | | | | | | |
| All | 2182 | 33.8 | 33.8 - 33.9 | 34.0 | 33.0; 35.0 | 27.0 | 39.5 |
| Male | 1091 | 34.1 | 34.0 - 34.2 | 34.0 | 33.0; 35.0 | 27.0 | 39.5 |
| Female | 1088 | 33.6 | 33.5 - 33.7 | 33.5 | 33.0; 34.5 | 28.6 | 39.4 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 74.0 ; | <0.0001 / | 73.6 ; | <0.0001 | | |
| **Birth length, cm** | | | | | | | |
| All | 320 | 50.5 | 50.1 - 50.8 | 50.0 | 48.3; 52.0 | 43.0 | 60.0 |
| Male | 168 | $50.9^a$ | 50.4 - 51.4 | 50.8 | 49.0; 52.8 | 45.0 | 60.0 |
| Female | 152 | $50.0^b$ | 49.5 - 50.4 | 49.8 | 48.0; 52.0 | 43.0 | 58.4 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 7.8 ; | <0.05 / | 7.6 ; | <0.05 | | |
| **Ponderal index ($kg/m^3$)** | | | | | | | |
| All | 320 | 24.5 | 24.1 - 24.9 | 24.5 | 22.2; 26.6 | 12.2 | 37.4 |
| Male | 168 | 24.3 | 23.7 - 24.9 | 24.2 | 22.1; 26.5 | 12.2 | 37.4 |
| Female | 152 | 24.6 | 24.1 - 25.2 | 24.7 | 22.3; 24.7 | 15.6 | 35.9 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.8 ; | .3793 / | 0.9 ; | .3521 | | |

* Group means with different superscripts are different; F ratio - for one-way ANOVA statistics; $\chi^2$ - for Kruskall-Wallis one-way ANOVA statistics.

Most of the mothers had normal deliveries (84.7 percent). About sixteen percent of the women had experienced at least one miscarriage. The proportions of women who had abortions and still birth were less, 6.1 and 2.9 percent respectively. Less than two per cent (27 cases) of the babies born had any type of congenital abnormality. Of the cases recorded two had severe congenital abnormality, one had hydrocephalus and one had anencephaly. There were nine cases of limb deformities.

Table 3.10 b: **Maternal characteristics for full term births**

| Characteristics | Number | Mean | 95% confidence interval | Median | 25th; 75th percentiles | Min. | Max. |
|---|---|---|---|---|---|---|---|
| Age, years | 2427 | 25.9 | 25.7 - 26.1 | 25.0 | 22.0; 29.0 | 16.0 | 55.0 |
| Height, cm | 2219 | 156.3 | 156.1 - 156.5 | 156.2 | 153.0; 160.0 | 139.7 | 177.8 |
| Gravida | 2430 | 3.0 | 2.9 - 3.0 | 2 | 1; 4 | 1 | 11 |
| Parity | 2057 | 2.6 | 2.6 - 2.7 | 2 | 1; 4 | 1 | 11 |
| BMI at 12 wk. gestation | 453 | 23.9 | 23.7 - 24.1 | 23.8 | 22.4; 25.3 | 15.3 | 35.1 |
| Estimated booking wt., kg | 1408 | 59.2 | 58.8 - 59.6 | 59.0 | 53.9; 63.8 | 35.9 | 91.3 |
| BMI at booking | 1385 | 24.1 | 24.0 - 24.3 | 23.9 | 22.4; 25.8 | 14.6 | 35.4 |
| Weight gain, kg | 941 | 8.3 | 8.2 - 8.5 | 8.1 | 7.0; 9.3 | -0.17 | 25.2 |
| Weight before delivery, kg | 1195 | 67.2 | 66.8 - 67.7 | 67.4 | 61.6; 72.2 | 42.1 | 107.6 |
| BMI before delivery | 1174 | 27.5 | 27.3 - 27.6 | 27.1 | 25.7; 29.2 | 17.1 | 38.5 |
| RBC 3rd trimester | 1219 | 3.99 | 3.96 - 4.01 | 3.99 | 3.66; 4.29 | 2.16 | 5.73 |
| Hb 3rd trimester, g/L | 1703 | 113 | 112 - 113 | 113 | 104; 121 | 61 | 157 |
| PCV 3rd trimester, fl | 1227 | 0.341 | 0.339 - 0.343 | 0.339 | 0.316; 0 .364 | 0.199 | 0.574 |
| MCV 3rd trimester, fl | 1218 | 82.9 | 82.5 - 83.3 | 84.0 | 78.2; 88.0 | 57.0 | 102.0 |
| MCH 3rd trimester, pg | 1221 | 28.1 | 27.9 - 28.2 | 28.4 | 26.5; 29.9 | 17.5 | 34.6 |
| MCHC 3rd trimester, g/L | 1224 | 335 | 334 - 335 | 335 | 317; 351 | 234 | 390 |

| <u>Gravida</u> | n | % | <u>Obstetric history</u> | n | % |
|---|---|---|---|---|---|
| 1 | 630 | 25.9 | No. of miscarriages | | |
| 2 | 589 | 24.2 | None | 1699 | 83.6 |
| 3-5 | 942 | 38.8 | 1 | 255 | 12.5 |
| >5 | 269 | 11.1 | 2 | 60 | 3.0 |
| <u>Parity</u> | | | >2 | 19 | 0.9 |
| 1 | 647 | 31.5 | No. of abortions | | |
| 2 | 541 | 26.3 | None | 1908 | 39.9 |
| 3-5 | 715 | 34.8 | 1 | 93 | 4.6 |
| >5 | 154 | 7.4 | 2 | 23 | 1.1 |
| <u>Complications in pregnancy</u> | | | >2 | 9 | 0.4 |
| None | 997 | 60.6 | | | |
| Hypertension/ PET | 112 | 6.8 | No. of stillbirths | | |
| | | | None | 1973 | 97.1 |
| Anaemia | 416 | 25.3 | 1 | 56 | 2.8 |
| Diabetes | 50 | 3.0 | 2 | 3 | 0.1 |
| Other | 70 | 4.3 | >2 | 0 | 0 |
| <u>Treatment</u> | | | <u>Feeding at discharge</u> | | |
| Iron /or folic acid | 715 | 57.0 | Breast | 663 | 40.7 |
| Other | 109 | 8.7 | Bottle | 918 | 56.4 |
| None | 429 | 34.2 | Mixed | 48 | 2.9 |
| <u>Type of delivery</u> | | | | | |
| Normal | 1441 | 84.7 | <u>Congenital abnormality</u> | 27 | 1.8 |
| Caesarean | 189 | 11.1 | | | |
| Forceps | 52 | 3.1 | <u>Smoking</u> | 7 | 0.6 |
| Other | 20 | 1.2 | | | |

Other problems were hare lip/cleft palate (1 case), extensive meningocele (1 case), hypospadias (1 case), probable diaphragmatic hernia (1 case), birth mark or discoloration of part of the body (3 cases), query on sex (1 case), imperfect hymen (1 case), severe sugar loaf (1 case), vertex wide and sagital suture in centre (1 case), limp and pale (1 case), both eyes swollen (1 case), moulding (1 case), covered in the eyes (1 case), unknown (1 case).

Eighty-four percent of the women were housewives, and nearly six percent were working in skilled non-manual occupations. Others were involved in professional, semi-professional, and manual jobs. Hardly any of the South Asian women were smokers.

### *3.3.3* Characteristics of South Asian mothers in Southampton

Records for full term births have been analysed with the mothers categorised into different age, parity and ethnic groups.

#### *3.3.3.1 Comparison by age*

Mothers in the youngest age group were the lightest (54.4 kg) and those in the oldest age group were heaviest (64.1 kg). However, there was no significant difference in weight gain during pregnancy between the age groups (Table 3.11a). There was no difference in the means and median of the gestational age, RBC in the third trimester and Hb in the third trimester between any age group. Gravida, parity, height, BMI at 12 weeks gestation and BMI at delivery increased as age increased, and their differences between age groups were significant. A higher proportion of the older women, aged more than 30 years had hypertension or PET during pregnancy, compared to younger women (Table 3.11b). Among younger women anaemia was the commonest form of medical condition during pregnancy.

Table 3.11a: **Maternal characteristics by age group, means (95 % confidence intervals); median (25th & 75th percentiles)**

| | < 20 years (n = 211) | | | 20 - 30 years (n = 1771) | | | > 30 years (n= 445) | | | F ratio; F Prob. |
|---|---|---|---|---|---|---|---|---|---|---|
| Parametric statistics | no. | mean* | 95%CI | no. | mean* | 95%CI | no. | mean* | 95%CI | |
| Gestation, weeks | 211 | 39.6 | 39.5 - 39.8 | 1771 | 39.6 | 39.6 - 39.7 | 445 | 39.5 | 39.4 - 39.7 | 0.73 ; .4811 |
| Maternal height, cm | 192 | 154.8[a] | 154.0 - 155.6 | 1630 | 156.3[a] | 156.1 - 156.5 | 395 | 157.0[c] | 156.4 - 157.5 | 11.3 ; .0000 |
| Est. booking weight, kg | 95 | 54.4[a] | 52.8 - 56.1 | 1042 | 58.4[b] | 57.9 - 58.8 | 270 | 64.1[c] | 63.0 - 65.2 | 87.6 ; .0000 |
| Weight gain, kg | 60 | 8.5 | 7.8 - 9.2 | 703 | 8.5[a] | 8.3 - 8.6 | 177 | 7.8[b] | 7.4 - 8.3 | 5.1 ; .0062 |
| BMI at 12 wks | 26 | 22.0[a] | 21.4 - 22.7 | 366 | 23.7[b] | 23.5 - 24.0 | 61 | 25.6[c] | 24.9 - 26.3 | 24.5 ; .0000 |
| BMI at delivery | 88 | 25.9 | 25.4 - 24.5 | 870 | 27.2[b] | 27.0 - 27.3 | 215 | 29.4[c] | 28.9 - 29.9 | 66.6 ; .0000 |
| Gravida | 211 | 1.3 | 1.3 - 1.4 | 1770 | 2.7 | 2.6 - 2.8 | 444 | 4.7 | 4.5 - 4.9 | 378.1 ; .0000 |
| Parity | 174 | 1.2 | 1.1 - 1.3 | 1493 | 2.4 | 2.3 - 2.5 | 388 | 4.1 | 3.9 - 4.4 | 293.7 ; .0000 |
| RBC 3rd trim. | 91 | 4.00 | 3.90 - 4.10 | 926 | 3.98 | 3.95 - 4.01 | 201 | 4.01 | 3.95 - 4.07 | 0.33 ; .7177 |
| Hb 3rd trim. g/L | 136 | 112 | 110 - 115 | 1256 | 113 | 112 - 113 | 308 | 113 | 112 - 115 | 0.5 ; .6062 |
| Non parametric statistics | no. | median | 25th ; 75th percentiles | no. | median | 25th ; 75th percentiles | no. | median | 25th ; 75th percentiles | $\chi^2$ ; sig. |
| Gestation, weeks | 211 | 40.0 | 38.9; 40.0 | 1771 | 40.0 | 39.0; 40.0 | 445 | 40.0 | 39.0; 40.0 | 1.8 ; .4112 |
| Maternal height, cm | 192 | 154.9 | 151.3; 158.0 | 1630 | 156.2 | 153.0; 159.5 | 395 | 157.2 | 153.7; 161.0 | 22.4 ; .0000 |
| Est. booking weight, kg | 95 | 52.8 | 48.7; 57.7 | 1042 | 58.6 | 54.0; 62.4 | 270 | 64.8 | 58.5; 69.6 | 147.1 ; .0000 |
| Weight gain, kg | 60 | 8.2 | 7.0; 9.8 | 703 | 8.2 | 7.1; 9.3 | 177 | 7.8 | 6.6; 9.1 | 8.6 ; .0138 |
| BMI at 12 wks | 26 | 22.3 | 21.2; 23.2 | 366 | 23.8 | 22.4; 25.2 | 61 | 25.5 | 23.8; 26.7 | 45.4 ; .0000 |
| BMI at delivery | 88 | 25.8 | 25.6; 26.8 | 870 | 27.0 | 25.7; 28.8 | 215 | 29.1 | 27.1; 32.0 | 111.0 ; .0000 |
| Gravida | 211 | 1 | 1; 2 | 1770 | 2 | 1; 4 | 444 | 5 | 3; 6 | 522.6 ; .0000 |
| Parity | 174 | 1 | 1; 1 | 1493 | 2 | 1; 3 | 388 | 4 | 2; 6 | 413.9 ; .0000 |
| RBC 3rd trim. | 91 | 4.01 | 3.76; 4.28 | 926 | 3.97 | 3.66; 4.29 | 201 | 3.99 | 3.75; 4.27 | 0.6 ; .7427 |
| Hb 3rd trim. g/L | 136 | 114 | 103; 124 | 1256 | 113 | 104; 121 | 308 | 114 | 105; 122 | 1.1 ; .5837 |

* Group means with different superscripts are different, group means with the same superscript or with no superscript are similar, using one-way ANOVA.

Table 3.11b: **Maternal characteristics by age group**

| | < 20 years | | 20-30 years | | > 30 years | |
|---|---|---|---|---|---|---|
| | % | number | % | number | % | number |
| **Ethnic group** | | | | | | |
| Pakistani-Muslim | 20.1 | 42 | 23.7 | 417 | 24.4 | 108 |
| Bangladeshi-Muslim | 12.4 | 26 | 10.0 | 177 | 15.2 | 67 |
| Hindu-Indian | 3.3 | 7 | 12.9 | 227 | 18.6 | 82 |
| Sikh-Indian | 64.1 | 134 | 52.8 | 931 | 41.0 | 181 |
| Others | - | - | 0.6 | 11 | 0.9 | 4 |
| **Maternal origin** | | | | | | |
| Pakistan | 18.0 | 29 | 20.6 | 296 | 17.3 | 77 |
| Bangladesh | 14.3 | 23 | 10.5 | 151 | 14.4 | 54 |
| India | 28.0 | 45 | 41.5 | 597 | 39.3 | 175 |
| UK | 33.5 | 54 | 15.5 | 223 | 2.4 | 9 |
| East Africa | 4.3 | 7 | 9.5 | 137 | 13.8 | 52 |
| Others | 1.9 | 3 | 2.3 | 33 | 2.4 | 9 |
| **Complications in pregnancy** | | | | | | |
| None | 64.3 | 83 | 62.3 | 753 | 52.3 | 160 |
| Hypertension/ PET | 2.4 | 3 | 5.0 | 61 | 15.7 | 48 |
| Anaemia | 27.1 | 35 | 27.0 | 326 | 18.0 | 55 |
| Diabetes | 1.6 | 2 | 2.3 | 28 | 6.5 | 20 |
| Other | 4.7 | 6 | 3.3 | 40 | 7.5 | 23 |
| **Treatment** | | | | | | |
| Iron /or folic acid | 59.0 | 59 | 57.5 | 522 | 54.7 | 133 |
| Other | 7.0 | 7 | 8.6 | 78 | 9.9 | 24 |
| None | 34.0 | 34 | 33.9 | 308 | 35.4 | 86 |
| **Type of delivery** | | | | | | |
| Normal | 79.5 | 105 | 84.9 | 1055 | 85.8 | 279 |
| Caesarean | 12.1 | 16 | 11.4 | 142 | 9.5 | 31 |
| Forceps | 5.3 | 7 | 3.0 | 37 | 2.5 | 7 |
| Other | 3.0 | 4 | 0.7 | 9 | 2.2 | 7 |
| **Obstetric history** | | | | | | |
| No. of miscarriages | | | | | | |
| 1 | 5.2 | 9 | 12.8 | 189 | 15.0 | 57 |
| 2 | 0 | 0 | 2.6 | 39 | 5.5 | 21 |
| >2 | 0 | 0 | 0.8 | 11 | 2.1 | 8 |
| No. of abortions | | | | | | |
| 1 | 2.9 | 5 | 4.5 | 67 | 5.5 | 21 |
| 2 | 0 | 0 | 1.2 | 18 | 1.3 | 5 |
| >2 | 0 | 0 | 0.3 | 4 | 1.3 | 5 |
| No. of stillbirths | | | | | | |
| 1 | 0.6 | 1 | 2.6 | 38 | 4.5 | 17 |
| 2 | 0 | 0 | 0.1 | 2 | 0.3 | 1 |
| >2 | 0 | 0 | | | | |
| **Smoking** | 0 | | 0.4 | 2 | 1.5 | 2 |
| **Congenital abnormality** | 1.7 | 2 | 1.7 | 18 | 2.5 | 7 |
| **Feeding at discharge** | | | | | | |
| Breast | 42.2 | 54 | 42.1 | 503 | 34.8 | 106 |
| Bottle | 56.3 | 72 | 55.0 | 657 | 61.3 | 187 |
| Mixed | 1.6 | 2 | 2.8 | 34 | 3.9 | 12 |

The difference was not statistically significant. More than fifty percent of the women in all age groups had received iron or folic supplements or both during pregnancy. For all age groups, the majority of births were by a normal delivery. There was a slightly higher proportion of caesarean delivery for women aged less than 20 years compared to other age groups. For all age groups the proportion of miscarriages were higher compared to the proportion of abortions and still births. In all age groups more babies were being bottle-fed than breast-fed while in the hospital. The women in the oldest age group tended to bottle-feed their babies more than women in the younger age group. There was no apparent difference in the pattern of iron or folic acid supplements between various age groups.

#### *3.3.3.2 Comparison by parity*

There was no significant difference in the gestational age, RBC and haemoglobin levels between any parity groups (Table 3.12a). Maternal age, estimated booking weight, BMI at booking, BMI at 12 weeks of gestation and BMI before delivery increased as the number of children they have had increased. The parametric statistical tests showed that women with first-born child gained significantly higher weight during pregnancy than women with subsequent born children. However, the non-parametric tests indicated that there were no differences in weight gain between the parity groups. Thus, the interpretation that there are differences between the groups has to be treated with caution. For all parity groups, anaemia was the commonest form of medical condition during pregnancy (Table 3.12b), and more than fifty percent of the women in each parity group received supplements during pregnancy. However, there was no significant difference in the proportion of anaemic mothers or mothers receiving supplements between the parity groups.

Table 3.12a: **Maternal characteristics by parity group**

| | Parity 1 (n = 647) | | | Parity 2 (n = 541) | | | Parity 3 - 5 (n = 715) | | | Parity > 5 (n = 154) | | | F ratio; F Prob. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parametric statistics | no. | mean | 95% CI | no. | mean | 95% CI | no. | mean | 95% CI | no. | mean | 95% CI | |
| Gestation, weeks | 647 | 39.6 | 39.5 - 39.7 | 541 | 39.5[a] | 39.4 - 39.6 | 715 | 39.6 | 39.5 - 39.7 | 154 | 39.7[b] | 39.5 - 39.9 | 2.2; .0838 |
| Maternal age, years | 647 | 22.9[a] | 22.5 - 23.2 | 541 | 25.9[b] | 24.7 - 25.5 | 715 | 27.8[c] | 27.4 - 28.1 | 152 | 33.8[d] | 32.9 - 34.6 | 307.1; .0000 |
| Maternal height, cm | 624 | 156.5 | 156.1 - 156.9 | 530 | 156.6[a] | 156.1 - 157.0 | 691 | 156.0 | 155.6 - 156.4 | 137 | 155.6[b] | 154.7 - 156.6 | 2.5; .0589 |
| Maternal weight, kg | 457 | 56.3[a] | 55.7 - 56.9 | 382 | 59.0[b] | 58.3 - 59.70 | 485 | 61.3[c] | 60.6 - 62.0 | 84 | 64.1[d] | 62.0 - 66.2 | 48.4; .0000 |
| Weight gain, kg | 298 | 8.7[a] | 8.4 - 9.0 | 268 | 8.3[b] | 8.0 - 8.6 | 324 | 8.2[b] | 7.9 - 8.4 | 51 | 7.7[b] | 7.0 - 8.5 | 3.5 ; .0148 |
| BMI at 12 wks | 163 | 22.8[a] | 22.5 - 23.1 | 128 | 23.7[b] | 23.2 - 24.1 | 147 | 25.0[c] | 24.6 - 25.4 | 15 | 26.9[d] | 25.5 - 28.3 | 33.6; .0000 |
| BMI at delivery | 369 | 26.4[a] | 26.1 - 26.6 | 325 | 27.2[b] | 26.9 - 27.5 | 409 | 28.3[c] | 28.0 - 28.6 | 71 | 29.2[d] | 28.4 - 30.2 | 39.8; .0000 |
| RBC 3rd trim. | 417 | 3.99 | 3.95 - 4.04 | 339 | 4.01 | 3.97 - 4.07 | 406 | 3.96 | 3.92 - 4.01 | 57 | 4.00 | 3.86 - 4.14 | 0.8 ; .5109 |
| Hb 3rd trim. g/L | 517 | 113 | 112 - 114 | 425 | 113 | 111 - 114 | 563 | 113 | 112 - 114 | 109 | 113 | 110 - 116 | 0.2; .8654 |
| Non parametric statistics | no. | median | 25th ; 75th percentiles | no. | median | 25th ; 75th percentiles | no. | median | 25th ; 75th percentiles | no. | median | 25th ; 75th percentiles | $\chi^2$; sig. |
| Gestation, weeks | 647 | 40.0 | 39.0; 40.0 | 541 | 40.0 | 39.0; 40.0 | 715 | 40.0 | 39.0; 40.0 | 154 | 40.0 | 39.0; 40.0 | 5.8; .1201 |
| Maternal age, years | 647 | 22.0 | 20.0; 25.0 | 541 | 24.0 | 22.0; 28.0 | 715 | 27.0 | 25.0; 30.0 | 152 | 33.0 | 30.0; 38.0 | 608.2; .0000 |
| Maternal height, cm | 624 | 156.4 | 153.0; 160.0 | 530 | 156.9 | 153.0; 160.0 | 691 | 156.0 | 153.0; 159.0 | 137 | 156.5 | 152.4; 158.9 | 5.8; .1230 |
| Maternal weight, kg | 457 | 56.6 | 51.3; 60.7 | 382 | 58.8 | 54.5; 63.6 | 485 | 61.3 | 56.7; 66.3 | 84 | 64.5 | 57.9; 69.9 | 131.7; .0000 |
| Weight gain, kg | 298 | 8.2 | 7.2; 9.6 | 268 | 7.9 | 6.9; 9.2 | 324 | 8.2 | 7.0; 9.2 | 51 | 8.0 | 6.5; 9.2 | 5.0; .1684 |
| BMI at 12 wks | 163 | 22.8 | 21.7; 23.8 | 128 | 23.7 | 22.3; 25.1 | 147 | 24.9 | 23.6; 26.2 | 15 | 26.7 | 25.8; 28.7 | 90.4; .0000 |
| BMI at delivery | 369 | 26.3 | 25.2; 27.5 | 325 | 27.1 | 25.8; 28.8 | 409 | 28.4 | 26.3; 30.4 | 71 | 29.4 | 26.9; 32.5 | 119.1; .0000 |
| RBC 3rd trim. | 417 | 3.98 | 3.66; 4.29 | 339 | 4.03 | 3.67; 4.31 | 406 | 3.94 | 3.64; 4.24 | 57 | 4.00 | 3.67; 4.36 | .23; .3856 |
| Hb 3rd trim. g/L | 517 | 114 | 104; 123 | 425 | 112 | 104; 120 | 563 | 113 | 104; 121 | 109 | 114 | 104; 124 | .23; .3856 |

* Group means with different superscripts are different, group means with the same superscript or with no superscript are similar, using one-way ANOVA

Table 3.12b: **Maternal characteristics by parity group**

| | Parity 1 | | Parity 2 | | Parity 3 - 5 | | Parity > 5 | |
|---|---|---|---|---|---|---|---|---|
| | % | n | % | n | % | n | % | n |
| **Ethnic group** | | | | | | | | |
| Pakistani-Muslim | 23.4 | 150 | 23.7 | 128 | 25.2 | 180 | 26.6 | 41 |
| Bangladeshi-Muslim | 10.3 | 66 | 9.3 | 50 | 12.8 | 91 | 23.4 | 36 |
| Hindu-Indian | 15.3 | 98 | 13.9 | 75 | 8.7 | 62 | 2.6 | 4 |
| Sikh-Indian | 50.2 | 322 | 52.5 | 283 | 53.2 | 379 | 47.4 | 73 |
| Others | 0.9 | 6 | 0.6 | 3 | 0.1 | 1 | | |
| **Maternal origin** | | | | | | | | |
| Pakistan | 18.3 | 103 | 18.9 | 86 | 21.3 | 137 | 24.4 | 33 |
| Bangladesh | 9.4 | 53 | 9.9 | 45 | 13.4 | 86 | 23.0 | 31 |
| India | 34.6 | 195 | 40.6 | 185 | 45.7 | 294 | 48.1 | 65 |
| East Africa | 12.3 | 69 | 12.1 | 55 | 6.1 | 39 | 0.7 | 1 |
| UK | 22.7 | 128 | 16.4 | 75 | 12.1 | 78 | 3.0 | 4 |
| Others | 2.7 | 15 | 2.2 | 10 | 1.4 | 9 | 0 | 0 |
| **Complications in pregnancy** | | | | | | | | |
| None | 60.7 | 316 | 64.1 | 275 | 59.0 | 340 | 55.5 | 66 |
| Hypertension/PET | 6.7 | 35 | 5.6 | 24 | 6.9 | 40 | 10.9 | 13 |
| Anaemia | 28.2 | 147 | 24.0 | 103 | 24.8 | 143 | 19.3 | 23 |
| Diabetes | 2.3 | 12 | 3.3 | 14 | 2.8 | 16 | 6.7 | 8 |
| Other | 2.1 | 11 | 3.0 | 13 | 6.4 | 37 | 7.6 | 9 |
| **Treatment** | | | | | | | | |
| Iron /or folic acid | 58.9 | 220 | 53.5 | 174 | 58.0 | 264 | 56.4 | 57 |
| Other | 8.3 | 31 | 11.1 | 36 | 7.0 | 32 | 9.9 | 10 |
| None | 32.7 | 122 | 35.4 | 115 | 34.7 | 158 | 33.7 | 34 |

The proportion of mothers having diabetes was highest among the high parity group (>5). This was significantly higher than women in other parity groups. There was a large increase in the proportion of mothers who had at least one miscarriage, from 8.6 per cent for parity 1, to 13.5 per cent for parity 2 (data not shown). Delivery by forceps was more frequent for first-born babies compared to subsequent births. Mothers with first-born babies preferred to breast-feed rather than bottle-feed their babies.

### *3.3.3.3 Comparison by ethnic group*

Table 3.13a shows the maternal characteristics of different ethnic groups. There was no difference in the gestational age at delivery, weight gain, BMI at 12 weeks of gestation, parity, and the number of children had between any ethnic group. Sikh-Indian women

Table 3.13a: **Maternal characteristics by ethnic group**

| | Pakistani-Muslim (n = 569) | | | Bangladeshi-Muslim (n = 270) | | | Hindu-Indian (n = 317) | | | Sikh-Indian (n = 1248) | | | F ratio; F Prob. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Parametric statistics** | no. | mean* | 95% CI | no. | mean* | 95% CI | no. | mean* | 95% CI | no. | mean* | 95% CI | |
| Gestation, weeks | 569 | 39.7 | 39.5 - 39.6 | 270 | 39.5 | 39.4 - 39.6 | 317 | 39.5 | 39.4 - 39.7 | 1248 | 39.6 | 39.6 - 39.7 | 1.7; .1676 |
| Maternal age, years | 567 | $26.1^{ac}$ | 25.7 - 26.5 | 270 | $26.6^{a}$ | 25.9 - 27.4 | 316 | $27.3^{c}$ | 26.7 - 27.8 | 1246 | $25.3^{b}$ | 25.0 - 25.5 | 15.2; .0000 |
| Maternal height, cm | 534 | $156.5^{a}$ | 156.1 – 156.9 | 253 | $155.2^{b}$ | 154.6 - 155.9 | 289 | $156.5^{a}$ | 155.9 - 157.1 | 1119 | $156.3^{a}$ | 156.0 - 156.6 | 3.8; .0097 |
| Maternal weight, kg | 358 | 59.7 | 59.0 - 60.5 | 188 | 59.7 | 58.4 - 61.0 | 153 | 59.0 | 57.7 - 60.3 | 696 | $58.7^{b}$ | 58.2 - 59.3 | 1.9; .1355 |
| Weight gain, kg | 255 | 8.4 | 8.1 - 8.6 | 128 | 8.3 | 7.9 - 8.6 | 90 | 8.6 | 8.1 - 9.2 | 460 | 8.3 | 8.1 - 8.5 | 0.6; .5931 |
| BMI at 12 wks | 119 | 24.1 | 23.6 - 24.6 | 59 | 24.0 | 23.2 - 24.7 | 40 | 23.7 | 22.7 - 24.7 | 231 | 23.8 | 23.5 - 24.0 | 0.7; .5829 |
| BMI at delivery | 316 | $27.8^{a}$ | 27.4 - 28.1 | 145 | $27.7^{a}$ | 27.1 - 28.2 | 111 | $27.7^{a}$ | 27.1 - 28.3 | 593 | $27.2^{b}$ | 27.0 - 27.4 | 2.9; .0337 |
| Gravida | 569 | $3.1^{a}$ | 2.9 - 3.2 | 269 | $3.4^{b}$ | 3.1 - 3.7 | 316 | $2.4^{c}$ | 2.2 - 2.5 | 1248 | $3.0^{a}$ | 2.9 - 3.1 | 15.6; .0000 |
| Parity | 499 | $2.7^{a}$ | 2.6 - 2.9 | 243 | $3.2^{b}$ | 2.9 - 3.4 | 239 | $2.0^{c}$ | 1.9 - 2.2 | 1057 | $2.6^{a}$ | 2.5 - 2.7 | 19.1; .0000 |
| RBC 3rd trim. | 315 | $4.11^{a}$ | 4.06 - 4.16 | 197 | $3.92^{b}$ | 3.86 - 3.99 | 115 | $3.94^{b}$ | 3.85 - 4.04 | 579 | $3.95^{b}$ | 3.91 - 3.99 | 8.5; .0000 |
| Hb 3rd trim. g/L | 408 | $115^{a}$ | 114 - 116 | 214 | $112^{c}$ | 111 - 114 | 172 | $114^{ac}$ | 112 - 116 | 893 | $112^{bc}$ | 111 - 113 | 7.8; .0000 |
| **Non parametric statistics** | no. | median | $25^{th}$; $75^{th}$ percentiles | no. | median | $25^{th}$; $75^{th}$ percentiles | no. | median | $25^{th}$; $75^{th}$ percentiles | no. | median | $25^{th}$; $75^{th}$ percentiles | $\chi^2$ ; sig. |
| Gestation, weeks | 569 | 40.0 | 39.0; 40.0 | 270 | 40.0 | 39.0; 40.0 | 317 | 40.0 | 39.0; 40.0 | 1248 | 40.0 | 39.0; 40.0 | 5.5; .1374 |
| Maternal age, years | 567 | 25.0 | 22.0; 29.0 | 270 | 25.0 | 22.0; 32.3 | 316 | 27.0 | 24.0; 31.0 | 1246 | 24.0 | 21.0; 28.0 | 57.5; .0000 |
| Maternal height, cm | 534 | 156.5 | 153.5; 159.1 | 253 | 156.0 | 152.0; 158.8 | 289 | 156.8 | 153.0; 160.0 | 1119 | 156.2 | 153.0; 160.0 | 9.0; .0298 |
| Maternal weight, kg | 358 | 59.8 | 54.4; 64.8 | 188 | 59.7 | 54.4; 64.7 | 153 | 59.7 | 52.3; 65.8 | 696 | 58.5 | 53.6; 62.7 | 7.4; .0603 |
| Weight gain, kg | 255 | 8.2 | 7.1; 9.3 | 128 | 8.2 | 7.0; 9.1 | 90 | 8.5 | 7.0; 9.2 | 460 | 8.0 | 7.0; 9.3 | 1.0; .8068 |
| BMI at 12 wks | 119 | 24.0 | 22.5; 25.6 | 59 | 23.9 | 22.3; 26.1 | 40 | 24.1 | 22.4; 25.6 | 231 | 23.7 | 22.4; 25.0 | 2.6; .4590 |
| BMI at delivery | 316 | 27.6 | 25.9; 29.4 | 145 | 27.3 | 26.0; 29.4 | 111 | 27.4 | 25.7; 29.7 | 593 | 26.9 | 25.5; 28.9 | 10.0; .0186 |
| Gravida | 569 | 3.0 | 2; 4 | 269 | 3 | 2; 5 | 316 | 2 | 1; 3 | 1248 | 3 | 1; 4 | 34.9; .0000 |
| Parity | 499 | 2 | 1; 4 | 243 | 3 | 1; 5 | 239 | 2 | 1; 3 | 1057 | 2 | 1; 3 | 43.4; .0000 |
| RBC 3rd trim. | 315 | 4.08 | 3.80; 4.39 | 197 | 3.88 | 3.61; 4.27 | 115 | 3.91 | 3.66; 4.24 | 579 | 3.96 | 3.64; 4.26 | 24.9; .0000 |
| Hb 3rd trim. g/L | 408 | 116 | 103; 124 | 214 | 113 | 104; 120 | 172 | 114 | 105; 124 | 893 | 112 | 103; 121 | 26.4; .0000 |

* Group means with different superscripts are different, group means with the same superscripts or with no superscripts are similar, using one-way ANOVA.

Table 3.13b: **Maternal characteristics by ethnic group**

| | Pakistani-Muslim | | Bangladeshi-Muslim | | Hindu-Indian | | Sikh-Indian | |
|---|---|---|---|---|---|---|---|---|
| | % | n | % | n | % | n | % | n |
| <u>**Complications in pregnancy**</u> | | | | | | | | |
| None | 64.4 | 261 | 53.2 | 109 | 66.0 | 105 | 5.97 | 515 |
| Hypertension/PET | 7.9 | 32 | 9.8 | 20 | 7.5 | 12 | 5.3 | 46 |
| Anaemia | 19.3 | 78 | 28.8 | 59 | 17.0 | 27 | 28.9 | 249 |
| Diabetes | 3.5 | 14 | 5.9 | 12 | 4.4 | 7 | 1.9 | 16 |
| Other | 4.9 | 20 | 2.4 | 5 | 5.0 | 8 | 4.3 | 37 |
| <u>**Treatment**</u> | | | | | | | | |
| Iron /or folic acid | 58.9 | 220 | 53.5 | 174 | 58.0 | 264 | 56.4 | 57 |
| Other | 8.3 | 31 | 11.1 | 36 | 7.0 | 32 | 9.9 | 10 |
| None | 32.7 | 122 | 35.4 | 115 | 34.7 | 158 | 33.7 | 34 |

were on average younger than the Pakistani-Muslims, Bangladeshi-Muslims and Hindu-Indians. This is probably because 80% of the Sikh-Indians were born in the UK. They contributed to 64% of mothers who less than 20 years old. The Hindu-Indian women were slightly older than the Pakistani and Bangladeshi women. The Bangladeshi women were on average shorter compared to the other women. The Pakistani and Bangladeshi-Muslims weighed heavier and had a higher BMI than the Hindu and Sikh-Indians.

Hindu-Indian, on average had fewer children than either ethnic group. Bangladeshi-Muslim had more children compared to other ethnic groups. The Sikh-Indian women had the lowest BMI before delivery compared to other women.

The Pakistani-Muslims and the Hindu-Indians had higher haemoglobin levels during the third trimester compared to the Bangladeshi-Muslims and the Sikh-Indians. Anaemia was the commonest medical condition during pregnancy for all ethnic groups (Table 3.13b). The prevalence of anaemia was highest among Bangladesh-Muslims and Sikh-Indians. The proportion receiving iron or folic acid supplements was similar in all ethnic groups. It ranged from 49% in Bangladesh-Muslim to 61% in Sikh-Indian. More than fifty percent of the women had received supplements during their pregnancy.

More than eighty per cent of the deliveries were normal. This proportion is similar for all ethnic groups. The Pakistan-Muslims and Bangladesh-Muslims preferred to breast feed than bottle feed. This pattern was reversed among the Sikh-Indians.

### 3.3.4 Characteristics of South Asian babies in Southampton

To compare birth outcomes by maternal characteristics, birth weight, placental weight, placental to birth weight ratio, head circumference and ponderal index were analysed by maternal characteristics which were put into discrete categories. They are as follows: -

1. Ethnic group - Pakistani-Muslim; Bangladeshi-Muslim; Sikh-Indian; Hindu-Indian.
2. Maternal age - < 20; 20-30; > 30 years.
3. Maternal height in thirds - <150.0; 154.0-158.0; >158.0 cm.
4. Parity (birth order) - 1; 2; 3-5; >5.
5. Estimated booking weight in thirds - <56.3; 56.3-61.7; >61.7 kg.
6. BMI at booking in thirds - <22.6; 22.6-25.2; >25.1.
7. Weight gain in thirds - <7.4; 7.4-8.8; >8.8 kg.
8. Hb in third trimester in fourths - <100; 100-109; 110-119; >120 g/L.
9. Complications during pregnancy - none, hypertension/PET; anaemia; diabetes; other.
10. Iron/ or folic acid supplement - 'yes' or 'no'.

_Birth weight_

The Pakistan-Muslim women had the highest birth weight babies (Table 3.14). Bangladeshi-Muslims had lighter babies, but weighed more than the Hindu-Indians. Sikh-Indians had the lightest babies. Birth weight increased significantly as parity, maternal age, estimated booking weight, BMI at booking, and BMI before delivery increased. Mothers who were in the lowest thirds of the height distribution had lighter babies compared to mothers who were taller. Mothers whose haemoglobin levels in the third trimester were lower than 120g/L, had significantly higher birth weight babies than mothers whose haemoglobin levels were lower. There appears to be a linear relationship between the mothers' haemoglobin levels in the third trimester and birth weight. The lowest birth weight babies were by mothers who were anaemic during pregnancy. Diabetic mothers produced the heaviest babies. Mothers who received supplements had lighter babies than mothers who did not. It was likely that they were women who had low haemoglobin levels during pregnancy.

There were no significant differences in birth weight between thirds of weight gain during pregnancy. The mean birth weight in the highest third of weight gain was 69 g higher than the mean birth weight in the lowest third of weight gain. The power to detect this difference can be calculated by using this difference between the groups (Cole, 1997). At 0.05 significant level and using the standard deviation for mean birth weight and the births for which both birth weights and weight gains are known, the power was calculated to be 2.6. This is too low to correctly reject the null hypothesis of no difference. Among the UK-born mothers, there were no trends in increasing birth weight from the 1970's to the 1990's.

*Placental weight*

The Pakistani-Muslims had the heaviest placentas compared to other women (Table 3.15). Placental weight increased significantly as maternal age, height, parity, estimated booking weight and BMI at booking increased, similar to the trend in birth weight. Mothers who were younger or having their first child had the lightest babies and lightest placentas, compared to older mothers and mothers with more children. Mothers who were in the lowest third of BMI before delivery had lighter placentas than mothers with higher BMI. Mothers whose haemoglobin levels in the third trimester were lower than 110g/L had lighter placentas than mothers with higher haemoglobin levels. Anaemic mothers had the lightest placentas compared to mothers with other complications.

*Placental to birth weight ratio*

There was no significant difference between placental to birth weight ratios and maternal characteristics, except for mothers with Hb less than 100g/L and mothers diagnosed as anaemic. They had the highest placental to birth weight ratios compared to other groups (Table 3.16).

*Head circumference*

Head circumferences for the Pakistan-Muslim and Hindu-Indian babies were greater compared to the Bangladesh-Muslim and Sikh-Indian babies (Table 3.17). Babies of shorter mothers (less than 154.0 cm) had babies with a slightly lesser head circumference than taller mothers. First born babies had a lesser head circumference than later born babies. Mothers from the oldest age group (more than 30 years) and mothers who were in the highest third for weight gain, BMI at booking, had babies with a greater head circumference than younger mothers, those who had lower weight gain and BMI respectively. Babies born by mothers who had haemoglobin levels lower than 100g/L had a lesser head circumference compared to babies whose mothers had higher haemoglobin levels.

*Birth length and ponderal index*

Pakistani-Muslim babies were longer compared to other babies. Mothers who were younger (less than 20 years) had shorter babies than older mothers. Mothers who gained more than 8 kg during pregnancy had babies with a significantly higher ponderal index than mothers who gained less weight. There was no difference in birth length and ponderal index between the other groups (Tables 3.18 and 3.19). This was probably due to the small number of data available for length. Mothers with haemoglobin levels in the range between 100 and 109 g/L had babies with lower ponderal index than mothers with haemoglobin levels less than 100 g/L and levels higher than 109 g/L. This finding could have occurred by chance because of the small number of births with birth length.

Table 3.14: Birth weight (g) by maternal characteristics

| | number | mean* | 95% CI | median | 25th; 75th percentiles |
|---|---|---|---|---|---|
| **Ethnic group** | | | | | |
| Pakistani-Muslim | 568 | **3216**$^{a}$ | 3176 - 3255 | **3190** | 2920; 3500 |
| Bangladeshi-Muslim | 270 | **3159**$^{ac}$ | 3102 - 3216 | **3185** | 2850; 3422 |
| Hindu-Indian | 317 | **3073**$^{bc}$ | 3023 - 3123 | **3030** | 2810; 3320 |
| Sikh-Indian | 1246 | **3061**$^{b}$ | 3036 - 3086 | **3040** | 2760; 3330 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 16.5 ; | $\leq$0.0001 / | 47.6 ; | $\leq$0.0001 |
| **Maternal age, years** | | | | | |
| < 20 | 211 | **2960**$^{a}$ | 2901 - 3018 | **2970** | 2690; 3220 |
| 20 - 30 | 1769 | **3095**$^{b}$ | 3074 - 3116 | **3070** | 2800; 3360 |
| >30 | 444 | **3241**$^{c}$ | 3195 - 3286 | **3200** | 2940; 3517 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 30.4 ; | $\leq$0.0001 / | 52.9 ; | $\leq$0.0001 |
| **Maternal height, cm** | | | | | |
| <154.0 | 756 | **3037**$^{a}$ | 3005 - 3068 | **3020** | 2722; 3324 |
| 154.0 - 158.0 | 732 | **3128**$^{b}$ | 3096 - 3161 | **3120** | 2830; 3388 |
| >158.0 | 728 | **3154**$^{b}$ | 3120 - 3189 | **3140** | 2840; 3410 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 13.7 ; | $\leq$0.0001 / | 8.0 ; | $\leq$0.05 |
| **Birth order** | | | | | |
| 1 | 647 | **2996**$^{a}$ | 2963 - 3030 | **3000** | 2720; 3270 |
| 2 | 541 | **3109**$^{b}$ | 3073 - 3145 | **3100** | 2840; 3375 |
| 3 - 5 | 712 | **3186**$^{c}$ | 3152 - 3220 | **3180** | 2890; 3470 |
| >5 | 154 | **3314**$^{d}$ | 3223 - 3406 | **3295** | 2900; 3678 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 30.4 ; | $\leq$0.0001 / | 81.0 | $\leq$0.0001 |
| **Estimated booking weight, kg** | | | | | |
| <56.3 | 465 | **3011**$^{a}$ | 2973 - 3050 | **3010** | 2725; 3290 |
| 56.3 - 61.7 | 466 | **3116**$^{b}$ | 3077 - 3156 | **3123** | 2830; 3402 |
| >61.7 | 474 | **3238**$^{c}$ | 3191 - 3284 | **3200** | 2920; 3520 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 28.8 ; | $\leq$0.0001 / | 47.8 ; | $\leq$0.0001 |
| **BMI at booking, kg/m$^2$** | | | | | |
| <22.96 | 461 | **3026**$^{a}$ | 2986 - 3065 | **3000** | 2740; 3300 |
| 22.96 - 25.05 | 462 | **3102**$^{b}$ | 3062 - 3142 | **3123** | 2840; 3366 |
| >25.05 | 460 | **3237**$^{c}$ | 3191 - 3283 | **3200** | 2920; 3548 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 25.3 ; | $\leq$0.0001 / | 42.8 ; | $\leq$0.0001 |
| **Weight gain, kg** | | | | | |
| <7.4 | 310 | **3114** | 3059 - 3169 | **3100** | 2768; 3410 |
| 7.4 - 8.8 | 311 | **3115** | 3064 - 3166 | **3095** | 2840; 3420 |
| >8.8 | 304 | **3183** | 3133 - 3233 | **3180** | 2900; 3428 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 2.2 ; | .1124 | 5.5 ; | .0655 |
| **Hb 3rd trimester, g/L** | | | | | |
| <100 | 251 | **2938**$^{a}$ | 2870 - 2991 | **2940** | 2580; 3280 |
| 100-109 | 414 | **3024**$^{b}$ | 2981 - 3068 | **2980** | 2720; 3303 |
| 110-119 | 510 | **3163**$^{c}$ | 3125 - 3200 | **3150** | 2878; 3403 |
| ≥120 | 527 | **3224**$^{d}$ | 3184 - 3264 | **3200** | 2960; 3480 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 31.0 ; | $\leq$0.0001 / | 87.0 ; | $\leq$0.0001 |
| **Complications in pregnancy** | | | | | |
| None | 996 | **3191**$^{af}$ | 3165 - 3217 | **3180** | 2931; 3440 |
| Hypertension | 112 | **3295**$^{bg}$ | 3187 - 3402 | **3275** | 2933; 3600 |
| Anaemia | 415 | **2837**$^{c}$ | 2797 - 2878 | **2820** | 2530; 3100 |
| Diabetes | 50 | **3433**$^{eg}$ | 3295 - 3573 | **3353** | 3155; 3725 |
| Other | 70 | **3146**$^{df}$ | 3046 - 3248 | **3055** | 2825; 3355 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 62.1 ; | $\leq$0.0001 / | 216.6 ; | $\leq$0.0001 |
| **Iron/ or folic acid** | | | | | |
| Yes | 714 | **3022**$^{a}$ | 2989 - 3056 | **3010** | 2728; 3310 |
| No | 428 | **3181**$^{b}$ | 3137 - 3226 | **3165** | 2890; 3458 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 31.6 ; | $\leq$0.0001 / | 25.9 ; | $\leq$0.0001 |

* Group means with different superscripts are different, group means with the same superscript or with no superscript are similar, using one-way ANOVA. F ratio - for one-way ANOVA statistics; $\chi^2$ - for Kruskall-Wallis one-way ANOVA statistics.

Table 3.15: Placental weight (g) by maternal characteristics

| | number | mean* | 95% CI | median | 25th; 75th percentiles |
|---|---|---|---|---|---|
| **Ethnic group** | | | | | |
| Pakistani-Muslim | 549 | **605**$^{a}$ | 596 - 615 | **600** | 520; 680 |
| Bangladeshi-Muslim | 268 | **589** | 573 - 606 | **590** | 500; 660 |
| Hindu-Indian | 301 | **581**$^{b}$ | 567 - 596 | **580** | 500; 650 |
| Sikh-Indian | 1212 | **582**$^{b}$ | 575 - 589 | **581** | 500; 652 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 5.0 ; | ≤0.005 / | 17.8 ; | ≤0.001 |
| **Maternal age, years** | | | | | |
| < 20 | 202 | **560**$^{a}$ | 543 - 578 | **552** | 483; 640 |
| 20-30 | 1714 | **585**$^{b}$ | 579 - 590 | **589** | 500; 650 |
| >30 | 438 | **614**$^{c}$ | 601 - 626 | **600** | 510; 691 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 15.3 ; | ≤0.0001 / | 23.5 ; | ≤0.0001 |
| **Height, cm** | | | | | |
| <154.0 | 732 | **573**$^{a}$ | 565 - 582 | **575** | 500; 650 |
| 154.0-158.0 | 715 | **592**$^{b}$ | 583 - 601 | **600** | 500; 676 |
| >158.0 | 705 | **596**$^{c}$ | 587 - 605 | **600** | 500; 670 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 7.0 ; | ≤0.005 / | 11.1 | ≤0.005 |
| **Birth order** | | | | | |
| 1 | 628 | **562**$^{a}$ | 553 - 572 | **550** | 480; 650 |
| 2 | 526 | **593**$^{b}$ | 582 - 603 | **600** | 500; 650 |
| 3-5 | 698 | **600**$^{b}$ | 591 - 609 | **600** | 500; 680 |
| >5 | 152 | **623**$^{c}$ | 598 - 647 | **600** | 500; 710 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 15.6 ; | ≤0.0001 / | 41.2 ; | ≤0.0001 |
| **Estimated. booking weight, kg** | | | | | |
| <56.3 | 446 | **566**$^{a}$ | 556 - 577 | **567** | 500; 640 |
| 56.3-61.7 | 463 | **594**$^{b}$ | 583 - 605 | **600** | 500; 670 |
| >61.7 | 469 | **612**$^{c}$ | 600 - 625 | **600** | 510; 683 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 16.0 ; | ≤0.0001 / | 24.7 ; | ≤0.0001 |
| **BMI at booking, kg/m$^2$** | | | | | |
| <22.96 | 443 | **569**$^{a}$ | 558 - 580 | **567** | 486; 650 |
| 22.96 - 25.05 | 459 | **595**$^{b}$ | 584 - 607 | **600** | 500; 670 |
| >25.05 | 455 | **609**$^{b}$ | 597 - 622 | **600** | 520; 680 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 12.4 ; | ≤0.0001 / | 1.8 ; | .1642 |
| **Weight gain, kg** | | | | | |
| <7.4 | 304 | **599** | 585 - 613 | **592** | 500; 674 |
| 7.4-8.8 | 310 | **586** | 572 - 599 | **600** | 500; 663 |
| >8.8 | 294 | **598** | 584 - 612 | **600** | 500; 664 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 1.1 ; | .3393 / | 24.7 ; | .5004 |
| **Hb 3rd trimester, g/L** | | | | | |
| <100 | 246 | **567**$^{a}$ | 551 - 583 | **550** | 480; 050 |
| 100-109 | 411 | **575**$^{a}$ | 564 - 586 | **580** | 500; 641 |
| 110-119 | 503 | **596**$^{b}$ | 585 - 606 | **595** | 500; 678 |
| ≥120 | 513 | **604**$^{b}$ | 593 - 615 | **600** | 510; 680 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 7.6 ; | ≤0.0001 / | 26.6 ; | ≤0.0001 |
| **Complications in pregnancy** | | | | | |
| None | 975 | **598**$^{a}$ | 590 - 605 | **600** | 506; 680 |
| Hypertension | 112 | **623**$^{b}$ | 594 - 652 | **600** | 500; 708 |
| Anaemia | 413 | **551**$^{c}$ | 540 - 562 | **540** | 477; 620 |
| Diabetes | 50 | **628**$^{ab}$ | 594 - 663 | **619** | 543; 681 |
| Other | 67 | **618**$^{ab}$ | 591 - 644 | **600** | 511; 700 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 15.8 ; | ≤0.0001 / | 56.7 ; | ≤0.0001 |
| **Iron/ or folic acid** | | | | | |
| Yes | 701 | **576**$^{a}$ | 567 - 585 | **567** | 500; 652 |
| No | 420 | **600**$^{b}$ | 588 - 612 | **600** | 500; 680 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 10.1 ; | ≤0.005 / | 8.3 ; | ≥0.005 |

* Group means with different superscripts are different, group means with the same superscript or with no superscript are similar, using one-way ANOVA; F ratio - for one-way ANOVA statistics; $\chi^2$ - for Kruskall-Wallis one-way ANOVA statistics.

Table 3.16: **Placental to birth weight ratio by maternal characteristics**

| | number | mean* | 95% CI | median | 25th; 75th percentiles |
|---|---|---|---|---|---|
| **Ethnic group** | | | | | |
| Pakistani-Muslim | 548 | **18.93** | 18.67 - 19.18 | **18.71** | 16.80; 20.74 |
| Bangladeshi-Muslim | 268 | **18.65** | 18.32 - 19.07 | **18.41** | 16.38; 20.47 |
| Hindu-Indian | 301 | **18.95** | 18.59 - 19.31 | **18.52** | 16.75; 20.73 |
| Sikh-Indian | 1210 | **19.08** | 18.89 - 19.26 | **18.89** | 17.00; 20.86 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 1.3 ; | .2588 / | 4.9 ; | .1791 |
| **Maternal age, years** | | | | | |
| < 20 | 202 | **18.97** | 18.51 - 19.42 | **18.97** | 16.73; 20.76 |
| 20-30 | 1712 | **18.96** | 18.81 - 19.12 | **18.73** | 16.85; 20.69 |
| >30 | 437 | **18.99** | 18.69 - 19.29 | **18.69** | 16.85; 21.05 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.01 ; | .9891 / | .06 ; | .9726 |
| **Height, cm** | | | | | |
| <154.0 | 732 | **18.95** | 18.71 - 19.19 | **18.84** | 16.84; 20.81 |
| 154.0-158.0 | 712 | **18.97** | 18.73 - 19.21 | **18.56** | 16.73; 20.93 |
| >158.0 | 705 | **18.96** | 18.72 - 19.19 | **18.73** | 16.89; 20.69 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.007 ; | .9930 / | 0.8 ; | .9617 |
| **Birth order** | | | | | |
| 1 | 628 | **18.86** | 18.59 - 19.14 | **18.68** | 16.45; 20.85 |
| 2 | 526 | **19.12** | 18.86 - 19.39 | **19.02** | 17.13; 20.71 |
| 3-5 | 695 | **18.92** | 18.69 - 19.16 | **18.59** | 16.71; 20.69 |
| >5 | 152 | **18.80** | 18.24 - 19.37 | **18.52** | 16.62; 21.05 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.8 ; | .5231 / | 4.1 ; | .2480 |
| **Estimated booking weight, kg** | | | | | |
| <56.3 | 445 | **18.90** | 18.59 - 19.21 | **18.77** | 16.63; 20.77 |
| 56.3-61.7 | 463 | **19.13** | 18.83 - 18.42 | **18.90** | 17.05; 20.83 |
| >61.7 | 468 | **18.99** | 18.69 - 19.30 | **18.72** | 16.80; 21.04 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.6 ; | .5677 / | 1.4 ; | .5045 |
| **BMI at booking, kg/m$^2$** | | | | | |
| <22.96 | 442 | **18.90** | 18.61 - 19.19 | **18.75** | 16.67; 20.80 |
| 22.96 - 25.05 | 459 | **19.26** | 18.95 - 19.58 | **19.05** | 17.05; 21.00 |
| >25.05 | 454 | **18.91** | 18.60 - 19.22 | **18.66** | 16.75; 20.83 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 1.81 ; | .1642 | 3.42 ; | .1812 |
| **Weight gain, kg** | | | | | |
| <7.4 | 304 | **19.34** | 18.93 - 19.75 | **19.16** | 16.97; 21.10 |
| 7.4-8.8 | 310 | **18.83** | 18.48 - 19.17 | **18.52** | 16.67; 20.78 |
| >8.8 | 294 | **18.84** | 18.48 - 19.20 | **18.69** | 16.82; 20.69 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 2.4 ; | .0898 / | 2.5 | .2889 |
| **Hb 3rd trimester, g/L** | | | | | |
| <100 | 246 | **19.52**[a] | 19.01 - 20.02 | **19.05** | 17.05; 21.26 |
| 100-109 | 411 | **19.14** | 18.74 - 19.02 | **18.72** | 17.01; 21.06 |
| 110-119 | 503 | **18.89**[b] | 18.73 - 19.33 | **18.77** | 16.85; 20.59 |
| ≥120 | 512 | **18.80**[b] | 18.50 - 19.13 | **18.69** | 16.67; 20.60 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 3.1 ; | ≤0.05 / | 12.2 | ≤0.05 |
| **Complications in pregnancy** | | | | | |
| None | 974 | **18.76**[a] | 18.57 - 18.95 | **18.71** | 16.67; 20.61 |
| Hypertension | 112 | **18.92** | 18.27 - 19.57 | **18.57** | 16.68; 21.03 |
| Anaemia | 412 | **19.58**[b] | 19.21 - 19.95 | **19.05** | 17.23; 21.46 |
| Diabetes | 50 | **18.36**[c] | 17.53 - 19.19 | **18.12** | 16.10; 20.25 |
| Other | 67 | **19.87**[b] | 19.03 - 20.71 | **19.22** | 17.34; 22.06 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 6.2 ; | ≤0.001 / | 15.3 | ≤0.005 |
| **Iron/ or folic acid** | | | | | |
| Yes | 700 | **19.21** | 18.94 - 19.47 | **18.86** | 16.82; 21.09 |
| No | 419 | **18.96** | 18.64 - 19.28 | **18.75** | 16.71; 20.83 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 1.3 ; | .2485 / | 0.6 ; | .4278 |

* Group means with different superscripts are different, group means with the same superscript or with no superscript are similar, using one-way ANOVA; F ratio - for one-way ANOVA statistics; $\chi^2$ - for Kruskall-Wallis one-way ANOVA statistics.

Table 3.17: Head circumference (cm) by maternal characteristics

| | number | mean* | 95% CI | median | 25th; 75th percentiles |
|---|---|---|---|---|---|
| **Ethnic group** | | | | | |
| Pakistani-Muslim | 511 | **34.1**[a] | 33.9 - 34.2 | **34.0** | 33.0; 35.0 |
| Bangladeshi-Muslim | 258 | **33.7**[b] | 33.5 - 33.9 | **34.0** | 33.0; 34.7 |
| Hindu-Indian | 280 | **34.0**[a] | 33.8 - 34.2 | **34.0** | 33.0; 35.0 |
| Sikh-Indian | 1107 | **33.7**[b] | 33.7 - 33.8 | **34.0** | 33.0; 34.5 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 6.8 ; | <u><0.001</u> / | 21.3 ; | <u><0.001</u> |
| **Maternal age, years** | | | | | |
| < 20 | 181 | **33.7**[a] | 33.4 - 33.9 | **33.7** | 33.0; 34.5 |
| 20-30 | 1606 | **33.8**[a] | 33.7 - 33.9 | **34.0** | 33.0; 34.5 |
| >30 | 391 | **34.2**[b] | 34.0 - 34.3 | **34.0** | 33.0; 35.0 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 12.1 ; | <u><0.0001</u> / | 29.4 ; | <u><0.0001</u> |
| **Height, cm** | | | | | |
| <154.0 | 682 | **33.7**[a] | 33.6 - 33.9 | **33.7** | 33.0; 34.5 |
| 154.0-158.0 | 372 | **33.8**[b] | 33.8 - 34.0 | **34.0** | 33.0; 35.0 |
| >158.0 | 656 | **33.9**[b] | 33.8 - 34.0 | **34.0** | 33.0; 34.5 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 5.2 ; | <u><0.01</u> / | 8.9 ; | <u><0.05</u> |
| **Birth order** | | | | | |
| 1 | 589 | **33.6**[a] | 33.5 - 33.8 | **33.5** | 33.0; 34.5 |
| 2 | 506 | **33.8**[ab] | 33.7 - 33.9 | **34.0** | 33.0; 34.5 |
| 3-5 | 642 | **33.9**[b] | 33.8 - 34.0 | **34.0** | 33.0; 35.0 |
| >5 | 129 | **34.2**[c] | 33.9- 34.5 | **34.0** | 33.0; 35.3 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 6.1 ; | <u><0.001</u> / | 22.4 ; | <u><0.001</u> |
| **Estimated booking weight, kg** | | | | | |
| <56.3 | 422 | **33.6**[a] | 33.5 - 33.9 | **33.5** | 33.0; 34.5 |
| 56.3-61.7 | 443 | **33.7**[a] | 33.5 - 33.8 | **33.5** | 33.0; 34.5 |
| >61.7 | 454 | **33.9**[b] | 33.7 - 34.0 | **34.0** | 33.0; 34.5 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 3.0 ; | .0504 / | 4.7 ; | .0965 |
| **BMI at booking, kg/m²** | | | | | |
| <22.96 | 422 | **33.6**[a] | 33.5 – 33.8 | **33.5** | 33.0; 34.5 |
| 22.96 - 25.05 | 442 | **33.7** | 33.6 – 33.8 | **33.5** | 33.0; 34.5 |
| >25.05 | 441 | **33.8**[b] | 33.7 – 33.9 | **34.0** | 33.0; 34.8 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 2.2 ; | .1131 / | 4.3 ; | .1171 |
| **Weight gain, kg** | | | | | |
| <7.4 | 294 | **33.6**[a] | 33.4 - 33.7 | **33.5** | 32.6; 34.5 |
| 7.4-8.8 | 308 | **33.6**[a] | 33.4 - 33.7 | **33.5** | 33.0; 34.5 |
| >8.8 | 287 | **33.9**[b] | 33.8 - 34.1 | **34.0** | 33.0; 35.0 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 6.7 ; | <u><0.005</u> / | 10.0 ; | <u><0..01</u> |
| **Hb 3rd trimester, g/L** | | | | | |
| <100 | 227 | **33.4**[a] | 33.2 - 33.6 | **33.0** | 32.0; 34.5 |
| 100-109 | 387 | **33.5**[b] | 33.3 - 33.6 | **33.5** | 32.5; 34.3 |
| 110-119 | 476 | **33.8**[b] | 33.7 - 34.0 | **34.0** | 33.0; 34.5 |
| ≥120 | 470 | **34.1**[c] | 34.0 - 34.2 | **34.0** | 33.0; 35.0 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 19.4 ; | <u><0.0001</u> / | 63.2 ; | <u><0.0001</u> |
| **Complications in pregnancy** | | | | | |
| None | 898 | **34.0**[a] | 33.9 - 34.1 | **34.0** | 33.0; 35.0 |
| Hypertension | 104 | **34.0**[a] | 33.7 - 34.2 | **34.0** | 33.0; 35.0 |
| Anaemia | 400 | **33.0**[b] | 33.7 - 34.2 | **33.0** | 32.0; 34.0 |
| Diabetes | 47 | **34.0**[a] | 33.7 - 34.3 | **34.0** | 33.0; 34.5 |
| Other | 53 | **34.1**[a] | 33.7 - 34.5 | **34.3** | 33.0; 35.0 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 37.3 ; | <u><0.0001</u> / | 130.5 ; | <u><0.0001</u> |
| **Iron/ or folic acid** | | | | | |
| Yes | 637 | **33.6**[a] | 33.5 - 33.7 | **33.5** | 32.5; 34.5 |
| No | 376 | **33.9**[b] | 33.7 - 34.0 | **34.0** | 33.0; 34.9 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 6.0 ; | <u><0.05</u> / | 4.8 ; | <u><0.05</u> |

* Group means with different superscripts are different, group means with the same superscript or with no superscript are similar, using one-way ANOVA; F ratio - for one-way ANOVA statistics; $\chi^2$ - for Kruskall-Wallis one-way ANOVA statistics.

Table 3.18: Birth length (cm) by maternal characteristics

| | number | mean* | 95% CI | median | 25th; 75th percentiles |
|---|---|---|---|---|---|
| **Ethnic group** | | | | | |
| Pakistani-Muslim | 67 | **51.4**[a] | 50.6 - 52.2 | **51.0** | 49.0; 530 |
| Bangladeshi-Muslim | 15 | **49.6**[b] | 48.4 - 50.8 | **49.0** | 48.0; 51.0 |
| Hindu-Indian | 42 | **49.9**[b] | 48.9 - 50.9 | **50.0** | 48.0; 52.0 |
| Sikh-Indian | 192 | **50.6**[b] | 49.9 - 51.3 | **50.0** | 48.3; 52.0 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 3.4 ; | <u>≤0.05</u> / | 9.2 ; | <u>≤0.05</u> |
| **Maternal age, years** | | | | | |
| < 20 | 18 | **48.9**[a] | 47.7 - 50.2 | **48.2** | 47.0; 50.2 |
| 20-30 | 231 | **50.5**[b] | 50.1 - 50.9 | **50.0** | 48.3; 52.0 |
| >30 | 67 | **50.9**[b] | 50.2 - 51.7 | **50.8** | 49.0; 53.0 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 3.5 ; | <u>≤0.05</u> / | 8.4 ; | <u>≤0.05</u> |
| **Height, cm** | | | | | |
| <154.0 | 69 | **50.0** | 49.2 - 50.8 | **50.0** | 48.0; 52.0 |
| 154.0-158.0 | 72 | **50.5** | 49.9 - 51.1 | **50.0** | 48.3; 52.0 |
| >158.0 | 74 | **50.3** | 49.6 - 51.0 | **50.0** | 48.2; 52.0 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.5 ; | .5969 / | 1.0 ; | .6113 |
| **Birth order** | | | | | |
| 1 | 25 | **49.6** | 48.7 - 50.4 | **49.0** | 48.0; 52.0 |
| 2 | 34 | **50.3** | 49.3 - 51.3 | **49.5** | 48.2; 52.3 |
| 3-5 | 66 | **51.0** | 50.2 - 51.8 | **50.5** | 49.0; 52.0 |
| >5 | 22 | **51.4** | 50.1- 52.8 | **50.9** | 49.8; 53.3 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 2.0 ; | .1166 / | 5.7 ; | .1299 |
| **Estimated. booking weight, kg** | | | | | |
| <56.3 | 25 | **50.2** | 49.0 - 51.5 | **50.8** | 48.2; 52.0 |
| 56.3-61.7 | 13 | **51.6** | 49.0 - 54.2 | **50.0** | 48.5; 55.8 |
| >61.7 | 24 | **51.1** | 50.0 - 52.2 | **50.4** | 50.0; 52.8 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.9 ; | .4194 / | 0.8 ; | .6832 |
| **BMI at booking, kg/m$^2$** | | | | | |
| <22.96 | 22 | **50.0** | 48.9 – 51.1 | **49.5** | 48.8; 52.0 |
| 22.96 - 25.05 | 17 | **50.9** | 48.9 – 52.9 | **50.0** | 48.0; 52.5 |
| >25.05 | 18 | **51.2** | 49.8 – 52.7 | **50.9** | 49.8; 53.6 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.9 ; | .4274 / | 1.8 ; | .4269 |
| **Weight gain, kg** | | | | | |
| <7.4 | 14 | **50.8** | 49.1 - 52.5 | **50.9** | 47.8; 53.6 |
| 7.4-8.8 | 2 | **53.5** | 34.4 - 72.6 | **53.5** | Min. = 52.0; Max. = 55.5 |
| >8.8 | 14 | **50.6** | 49.6 - 51.6 | **50.5** | 49.2; 52.0 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 1.3 ; | .2943 / | 2.3 ; | .3155 |
| **Hb 3rd trimester, g/L** | | | | | |
| <100 | 27 | **50.2** | 49.3 - 51.1 | **50.0** | 48.0; 52.0 |
| 100-109 | 28 | **51.6** | 50.4 - 52.8 | **51.4** | 50.0; 53.2 |
| 110-119 | 40 | **50.7** | 49.7 - 51.7 | **50.4** | 48.1; 52.0 |
| ≥120 | 61 | **50.3** | 49.6 - 51.0 | **50.0** | 48.3; 52.0 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 1.5 ; | .2214 / | 3.6 ; | .3027 |
| **Complications in pregnancy** | | | | | |
| None | 97 | **50.7** | 50.1 - 51.3 | **50.0** | 48.8; 52.0 |
| Hypertension | 5 | **52.4** | 47.6 - 57.2 | **54.0** | 49.0; 55.0 |
| Anaemia | 14 | **50.3** | 48.7 - 52.0 | **50.9** | 47.8; 52.0 |
| Diabetes | - | - | - | - | - |
| Other | 18 | **50.8** | 49.5 - 52.0 | **50.0** | 49.0; 52.3 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.6 ; | .6270 / | 2.3 ; | .5162 |
| **Iron/ or folic acid** | | | | | |
| Yes | 99 | **50.7** | 50.2 - 51.3 | **50.1** | 48.5; 52.0 |
| No | 29 | **50.7** | 49.3 - 52.0 | **50.0** | 48.7; 53.2 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.008 ; | .9280 / | 0.04 ; | .8258 |

* Group means with different superscripts are different, group means with the same superscript or with no superscript are similar, using one-way ANOVA; F ratio - for one-way ANOVA statistics; $\chi^2$ - for Kruskall-Wallis one-way ANOVA statistics.

Table 3.19: Ponderal index (kg/m³) by maternal characteristics

| | number | mean* | 95% CI | median | 25th; 75th percentiles |
|---|---|---|---|---|---|
| **Ethnic group** | | | | | |
| Pakistani-Muslim | 67 | **24.1** | 23.1 - 25.2 | **24.0** | 21.4; 26.5 |
| Bangladeshi-Muslim | 15 | **25.1** | 22.6 - 27.7 | **24.7** | 21.6; 28.9 |
| Hindu-Indian | 42 | **24.6** | 23.4 - 25.8 | **23.8** | 22.4; 29.8 |
| Sikh-Indian | 192 | **24.4** | 23.9- 24.9 | **24.7** | 22.3; 26.7 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.4 ; | .7802 / | 1.2 ; | .7551 |
| **Maternal age, years** | | | | | |
| < 20 | 18 | **25.7** | 23.7 - 27.7 | **25.7** | 22.0; 28.8 |
| 20-30 | 231 | **24.3** | 23.9 - 24.8 | **24.5** | 22.2; 26.5 |
| >30 | 67 | **24.5** | 23.5 - 25.4 | **24.0** | 22.1; 26.1 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 1.2 ; | .2953 / | 2.1 ; | .3474 |
| **Height, cm** | | | | | |
| <154.0 | 69 | **24.7** | 23.8 - 25.7 | **24.6** | 22.2; 27.8 |
| 154.0-158.0 | 72 | **24.5** | 23.7 - 25.2 | **24.6** | 22.3; 26.5 |
| >158.0 | 74 | **24.5** | 23.7 - 25.4 | **24.9** | 22.1; 26.8 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.09 ; | .9162 / | 0.05 ; | .9763 |
| **Birth order** | | | | | |
| 1 | 25 | **24.5** | 23.3 - 25.7 | **24.4** | 22.1; 26.8 |
| 2 | 34 | **24.8** | 23.7 - 25.9 | **24.8** | 22.9; 26.7 |
| 3-5 | 66 | **24.7** | 23.7 - 25.7 | **24.8** | 22.0; 27.6 |
| >5 | 22 | **24.4** | 22.8 - 26.0 | **24.6** | 22.2; 26.8 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.07 ; | .9758 / | 0.2 ; | .9843 |
| **Weight at booking, kg** | | | | | |
| <56.3 | 25 | **24.7** | 22.9 - 26.4 | **25.0** | 21.4; 26.6 |
| 56.3-61.7 | 13 | **23.9** | 21.5 - 26.3 | **24.4** | 21.2; 26.8 |
| >61.7 | 24 | **24.8** | 23.5 - 26.2 | **25.5** | 23.7; 26.7 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.2 ; | .7812 / | 0.6 ; | .7444 |
| **BMI at booking, kg/m²** | | | | | |
| <22.96 | 22 | **24.7** | 23.2 – 26.1 | **25.5** | 22.1; 26.7 |
| 22.96 - 25.05 | 17 | **24.4** | 21.9 – 26.8 | **24.4** | 20.6; 26.9 |
| >25.05 | 18 | **25.0** | 23.1 – 26.8 | **25.9** | 23.6; 26.8 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.2 ; | .8975 / | 1.0 ; | .6192 |
| **Weight gain, kg** | | | | | |
| <7.4 | 14 | **22.6**[a] | 20.4 - 24.7 | **22.7** | 19.5; 25.9 |
| 7.4-8.8 | 2 | **22.8**[a] | -3.8 - 49.4 | **22.8** | Min. 20.7; Max. 24.9 |
| >8.8 | 14 | **26.0**[b] | 24.4 - 27.7 | **25.7** | 23.6; 28.5 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 4.1 ; | <u>≤0.05</u> / | 6.2 ; | <u>≤0.05</u> |
| **Hb 3rd trimester, g/L** | | | | | |
| <100 | 27 | **25.4**[a] | 24.2 - 26.7 | **24.8** | 23.4; 27.7 |
| 100-109 | 28 | **23.3**[b] | 22.1 - 24.4 | **23.4** | 20.7; 25.9 |
| 110-119 | 40 | **24.6** | 23.2 - 26.0 | **24.6** | 22.5; 26.7 |
| ≥120 | 61 | **24.7** | 23.8 - 25.7 | **24.9** | 22.2; 26.8 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 1.6 ; | .1904 / | 5.7 ; | .1265 |
| **Complications in pregnancy** | | | | | |
| None | 97 | **24.7** | 24.0 - 25.5 | **24.8** | 22.3; 26.7 |
| Hypertension | 5 | **24.3** | 19.5 - 29.0 | **23.0** | 21.3; 27.9 |
| Anaemia | 14 | **25.1** | 23.1 - 27.1 | **24.8** | 23.1; 28.0 |
| Diabetes | - | - | - | - | - |
| Others | 18 | **23.5** | 21.8 - 25.2 | **23.4** | 20.9; 26.6 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.6 ; | .5904 / | 2.2 ; | .5281 |
| **Iron/ or folic acid** | | | | | |
| Yes | 99 | **24.5** | 23.8 - 25.2 | **24.5** | 22.1; 26.7 |
| No | 29 | **25.1** | 23.4 - 26.8 | **25.2** | 22.1; 28.0 |
| F ratio ; F prob. / $\chi^2$ ; sig. | | 0.6 ; | .4410 / | 0.6 ; | .4405 |

* Group means with different superscripts are different, group means with the same superscript or with no superscript are similar, using one-way ANOVA; F ratio - for one-way ANOVA statistics; $\chi^2$ - for Kruskall-Wallis one-way ANOVA statistics.

Trends over years in maternal characteristics and birth outcomes

Baby's birth weights and other birth outcomes were also analysed according to the period when they were born and their maternal birthplace. This was carried out to get an idea of how the South Asian babies and mothers have changed over time. For this purpose the babies' dates of birth were grouped into four categories, that is the periods from 1957 to 1969, from 1970 to 1979, from 1980 to 1989 and from 1990 to 1996. Their mother's place of birth was identified either as in the UK or overseas.

Tables 3.20a and 3.20b show that for all births there was an increasing trend in birth weight from the 1970's to the 1990's. Births in the 1960's were all born by mothers from overseas. Their birth weights were on average similar to the births in the 1990's. In each group of ten-year period the mean birth weight for babies of overseas-born mothers was higher than the mean birth weight of UK-born mothers. Gestation seems to be shorter for births in the 1990's compared to previous decades for all groups by year of birth. Births by the UK-born were by younger women compared to births by the overseas-born women. In each decade the UK-born mothers were shorter, lighter, had a lower BMI than the overseas-born mothers. This is probably because the women were younger and had fewer children compared to the overseas-born women. In each decade from 1970 to 1996 UK-born mothers had lower haemoglobin levels compared to overseas-born mothers. For overseas-born mothers there was a trend in increasing height from the 1960's to the 1990's. For UK-born mothers there was no trend in increasing maternal height. For all subjects their BMI in the 1980's and 1990's were significantly higher compared to the 1960's and the 1970's. For overseas-born mothers their BMI increased in each decade, the highest was for the 1990's. This suggests that the South Asian women who had migrated to the UK are now fatter compared to the South Asian women thirty years ago.

**Table 3.20a: Birth weight and maternal characteristics by year of birth and place of birth**

(Parametric statistics)

| Place Of Birth | F Ratio | F-Prob. | Year Of Birth 1957-1969 No. | Mean* | 95% C1 | 1970-1979 No. | Mean* | 95% C1 | 1980-1989 No. | Mean* | 95% C1 | 1990-1996 No. | Mean* | 95% C1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Birth weight (g)** | | | | | | | | | | | | | | |
| Overseas | 4.237 | <0.01 | 372 | 3140$^{ac}$ | 3092-3188 | 487 | 3073$^{b}$ | 3034 -- 3112 | 894 | 3109$^{a}$ | 3078 -- 3140 | 390 | 3179$^{c}$ | 3133 -- 3226 |
| UK | 0.237 | 0.789 | - | - | - | 11 | 2964 | 2675 -- 3253 | 121 | 3035 | 2959 -- 3110 | 154 | 3055 | 2977 -- 3133 |
| Total | 2.872 | <0.05 | 372 | 3140$^{a}$ | 3092-3188 | 498 | 3071$^{b}$ | 3032 -- 3110 | 1015 | 3100 | 3072 -- 3128 | 544 | 3144$^{a}$ | 3104 -- 3184 |
| **Gestational age (weeks)** | | | | | | | | | | | | | | |
| Overseas | 19.322 | <0.0001 | 374 | 39.8$^{a}$ | 39.7-39.9 | 488 | 39.9$^{a}$ | 39.8 – 40.0 | 894 | 39.6$^{b}$ | 39.5 – 39.7 | 390 | 39.3$^{c}$ | 39.2 – 39.4 |
| UK | 5.063 | <0.05 | - | - | - | 11 | 40.2$^{a}$ | 39.4 – 41.4 | 121 | 39.5$^{b}$ | 39.3 – 39.7 | 154 | 39.3$^{c}$ | 39.1 – 39.5 |
| Total | 24.484 | <0.0001 | 374 | 39.8$^{a}$ | 39.7-39.9 | 499 | 39.9$^{a}$ | 39.8 – 40.0 | 1015 | 39.6$^{b}$ | 39.5 – 39.6 | 544 | 39.3$^{c}$ | 39.2 – 39.4 |
| **Maternal age (years)** | | | | | | | | | | | | | | |
| Overseas | 12.850 | <0.0001 | 373 | 26.6$^{a}$ | 25.9-27.2 | 484 | 25.3$^{b}$ | 24.9 – 25.8 | 894 | 26.1$^{a}$ | 25.8 – 26.4 | 390 | 27.6$^{c}$ | 27.0 – 28.1 |
| UK | 17.928 | <0.0001 | - | - | - | 11 | 20.9$^{a}$ | 19.0 – 22.9 | 121 | 21.6$^{a}$ | 21.1 – 22.2 | 154 | 24.1$^{b}$ | 23.5 – 24.7 |
| Total | 8.585 | <0.0001 | 373 | 26.6$^{a}$ | 25.9-27.3 | 495 | 25.2$^{b}$ | 24.8 – 25.7 | 1015 | 25.6$^{b}$ | 25.3 – 25.9 | 544 | 26.6$^{a}$ | 26.1 – 27.0 |
| **Haemoglobin in 3$^{rd}$ trimester (g/L)** | | | | | | | | | | | | | | |
| Overseas | 7.085 | <0.0001 | 293 | 112$^{a}$ | 110-113 | 210 | 116$^{b}$ | 114 -- 117 | 551 | 115$^{a}$ | 114 -- 116 | 389 | 112$^{a}$ | 111 -- 113 |
| UK | 0.081 | 0.922 | - | - | - | 7 | 111 | 101 -- 121 | 100 | 110 | 108 -- 113 | 153 | 110 | 108 -- 112 |
| Total | 7.950 | <0.0001 | 293 | 112$^{a}$ | 110-113 | 217 | 115$^{b}$ | 114 -- 117 | 651 | 114$^{b}$ | 113 -- 115 | 542 | 111$^{a}$ | 110 -- 112 |
| **Maternal height (cm)** | | | | | | | | | | | | | | |
| Overseas | 8.430 | <0.0001 | 313 | 155.5$^{a}$ | 154.9-156.2 | 364 | 156.3$^{b}$ | 155.8-156.9 | 868 | 156.3$^{b}$ | 155.9-156.6 | 390 | 157.4$^{c}$ | 157.0-157.9 |
| UK | 0.234 | 0.792 | - | - | - | 11 | 156.3 | 153.9-158.7 | 119 | 155.5 | 154.6-156.4 | 154 | 155.7 | 155.1-156.3 |
| Total | 5.585 | <0.005 | 313 | 155.5$^{a}$ | 154.9-156.2 | 375 | 156.3$^{bc}$ | 155.8-156.9 | 987 | 156.2$^{b}$ | 155.8-156.5 | 544 | 156.9$^{c}$ | 156.6-157.3 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Estimated booking weight (kg)** | | | | | | | | | | | | | | |
| Overseas | 20.533 | <0.0001 | 157 | 57.2[a] | 55.9-58.6 | 96 | 56.7[a] | 54.9 – 58.4 | 540 | 59.1[b] | 58.4 – 59.8 | 356 | 61.9[c] | 61.2 – 62.6 |
| UK | 0.850 | 0.429 | - | - | - | 7 | 60.2 | 51.4 – 69.1 | 98 | 57.3 | 55.8 – 58.8 | 154 | 58.1 | 57.2 – 59.0 |
| Total | 14.028 | <0.0001 | 157 | 57.2[a] | 55.9 -- 58.6 | 103 | 56.9[a] | 55.2 – 58.6 | 638 | 58.8[b] | 58.2 – 59.4 | 510 | 60.8[c] | 60.2 – 61.3 |
| **BMI at booking** | | | | | | | | | | | | | | |
| Overseas | 13.952 | <0.0001 | 144 | 23.5[a] | 23.0 -- 24.1 | 90 | 23.0[a] | 22.3 – 23.7 | 538 | 24.1[b] | 23.9 – 24.4 | 356 | 24.9[c] | 24.6 – 25.2 |
| UK | 0.339 | 0.713 | - | - | - | 7 | 24.5 | 21.7 – 27.3 | 96 | 23.8 | 23.4 – 24.3 | 154 | 23.9 | 23.6 – 24.3 |
| Total | 11.048 | <0.0001 | 144 | 23.5[a] | 23.0 -- 24.1 | 97 | 23.1[a] | 22.4 – 23.8 | 634 | 24.1[b] | 23.8 – 24.3 | 510 | 24.6[c] | 24.4 – 24.8 |

* Means with different superscripts are different, means with the same superscripts or with no superscript were similar, using one-way ANOVA

Table 3.20b: **Birth weight and maternal characteristics by year of birth and place of birth**

(Non-parametric statistics)

| Place Of Birth | $\chi^2$ | P-value | 1957-1969 No. | 1957-1969 Median | 1957-1969 25th ; 75th percentiles | 1970-1979 No. | 1970-1979 Median | 1970-1979 25th ; 75th percentiles | 1980-1989 No. | 1980-1989 Median | 1980-1989 95% C1 | 1990-1996 No. | 1990-1996 Median | 1990-1996 25th ; 75th percentiles |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Birth weight (g)** | | | | | | | | | | | | | | |
| Overseas | 11.801 | <0.01 | 372 | 3155 | 2825 ; 3430 | 487 | 3050 | 2780 ; 3360 | 894 | 3080 | 2810 ; 3350 | 390 | 3173 | 2900 ; 3422 |
| UK | 0.578 | 0.749 | - | - | - | 11 | 2900 | 2650 ; 3240 | 121 | 3010 | 2740 ; 3320 | 154 | 3020 | 2740 ; 3420 |
| Total | 8.864 | <0.05 | 372 | 3155 | 2825 ; 3430 | 498 | 3044 | 2770 ; 3360 | 1015 | 3070 | 2800 ; 3350 | 544 | 3140 | 2840 ; 3420 |
| **Gestational age (weeks)** | | | | | | | | | | | | | | |
| Overseas | 51.842 | <0.0001 | 374 | 40 | 39.0 ; 40.0 | 488 | 40.0 | 39.0 ; 40.7 | 894 | 40.0 | 39.0 ; 40.0 | 390 | 39.0 | 38.0 ; 40.0 |
| UK | 6.854 | <0.05 | - | - | - | 11 | 40.0 | 39.9 ; 41.7 | 121 | 40.0 | 39.0 ; 40.0 | 154 | 39.0 | 38.0 ; 40.0 |
| Total | 65.818 | <0.0001 | 374 | 40 | 39.4 ; 40.0 | 499 | 40.0 | 39.0 ; 40.7 | 1015 | 40.0 | 39.0 ; 40.0 | 544 | 39.0 | 38.0 ; 40.0 |
| **Maternal age (years)** | | | | | | | | | | | | | | |
| Overseas | 47.568 | <0.0001 | 373 | 26.0 | 22.0 ; 30.5 | 484 | 24.0 | 21.0 ; 28.0 | 894 | 26.0 | 22.0 ; 29.0 | 390 | 27.0 | 24.0 ; 31.0 |
| UK | 32.272 | <0.0001 | - | - | - | 11 | 21.0 | 19.0 ; 24.0 | 121 | 21.0 | 19.0 ; 24.0 | 154 | 24.0 | 21.0 ; 27.0 |
| Total | 28.670 | <0.0001 | 373 | 26.0 | 22.0 ; 30.5 | 495 | 24.0 | 21.0 ; 28.0 | 1015 | 25.0 | 22.0 ; 29.0 | 544 | 26.0 | 23.0 ; 30.0 |
| **Haemoglobin in 3rd trimester (g/L)** | | | | | | | | | | | | | | |
| Overseas | 18.641 | <0.0001 | 293 | 112 | 102 ; 123 | 210 | 117 | 106 ; 125 | 551 | 114 | 106 ; 123 | 389 | 113 | 104 ; 120 |
| UK | 0.383 | 0.826 | - | - | - | 7 | 114 | 99 ; 119 | 100 | 112 | 100 ; 119 | 153 | 110 | 103 ; 117 |
| Total | 23.039 | <0.0001 | 293 | 112 | 102 ; 123 | 217 | 117 | 106 ; 125 | 651 | 114 | 106 ; 122 | 542 | 112 | 104 ; 119 |
| **Maternal height (cm)** | | | | | | | | | | | | | | |
| Overseas | 24.304 | <0.0001 | 313 | 155.6 | 152.4 ; 158.8 | 364 | 153.2 | 152.4 ; 160.0 | 868 | 156.5 | 153.0 ; 159.8 | 390 | 156.0 | 153.0 ; 158.0 |
| UK | 2.452 | 0.293 | - | - | - | 11 | 155.0 | 152.4 ; 159.0 | 119 | 154.8 | 152.0 ; 158.0 | 154 | 156.0 | 153.0 ; 158.0 |
| Total | 15.350 | <0.005 | 313 | 155.6 | 152.4 ; 158.8 | 375 | 156.2 | 152.4 ; 160.0 | 987 | 156.0 | 153.0 ; 159.5 | 544 | 157.0 | 154.0 ; 160.0 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Estimated booking weight (kg)** | | | | | | | | | | | | | | |
| Overseas | 65.071 | <0.0001 | 157 | 56.2 | 50.7 ; 62.7 | 96 | 56.2 | 51.3 ; 62.2 | 540 | 59.3 | 53.5 ; 63.8 | 356 | 61.3 | 57.7 ; 66.4 |
| UK | 3.147 | 0.207 | - | - | - | 7 | 66.1 | 52.9 ; 67.6 | 98 | 56.5 | 52.9 ; 61.5 | 154 | 58.6 | 53.6 ; 61.7 |
| Total | 47.349 | <0.0001 | 157 | 56.2 | 50.7 ; 62.7 | 103 | 56.3 | 51.4 ; 64.2 | 638 | 58.7 | 53.2 ; 63.6 | 510 | 60.4 | 56.7 ; 64.6 |
| **BMI at booking** | | | | | | | | | | | | | | |
| Overseas | 43.921 | <0.0001 | 144 | 23.0 | 20.9 ; 25.5 | 90 | 23.0 | 20.7 ; 25.1 | 538 | 24.0 | 22.2 ; 26.0 | 356 | 24.3 | 23.2 ; 26.1 |
| UK | 1.092 | 0.579 | - | - | - | 7 | 26.2 | 22.2 ; 26.7 | 96 | 23.7 | 22.4 ; 25.4 | 154 | 23.7 | 22.5 ; 25.4 |
| Total | 34.853 | <0.0001 | 144 | 23.0 | 20.9 ; 25.5 | 97 | 23.1 | 20.8 ; 25.7 | 634 | 23.9 | 22.2 ; 25.9 | 510 | 24.1 | 23.1 ; 25.8 |

There was no change in the mean placental weight by the decades of birth (data not shown). There was no difference in the mean placental weight between babies born to first generation and second generation mothers, and there was no difference in the ratio of placental weight to birth weight between decades of birth (data not shown). Parity decreased from the 1960's to the 1990's (data not shown).

Using the results of the one-way ANOVA and the Kruskall-Wallis one-way ANOVA, the following variables appear to have an effect on birth weights. They are year of birth, ethnic group, maternal age, height, mother's place of birth, and birth order. BMI and weight at booking, haemoglobin levels, complications during pregnancy, and iron supplements during pregnancy too had an effect on birth weight. Therefore these variables were selected to be included in the logistic regression analysis. Another reason for selecting these variables was to increase the efficiency of the statistical analysis because they had a large number of records with valid data.

A logistic regression analysis was performed to assess the risk of having birth weight below the median, for both sexes and male and female infants separately. After taking account of gestational age, infant sex, parity, year of birth, maternal place of birth, maternal weight and BMI at booking and maternal height, babies of mothers whose haemoglobin levels were the lowest (less than 100 g/L) during the third trimester had more than three times the risk of having lower birth weight, compared to babies by mothers with haemoglobin levels more than 120 g/L (Table 3.21). Sikh-Indian babies were more likely to be born with lower birth weight compared to the Bangladeshi-Muslim babies. First born babies, female babies and babies born at less than 40 weeks gestation were more likely to be born with a lower birth weight. Maternal BMI at booking lower than 23 had an increased risk of producing lower birth weight babies compared to mothers with a higher BMI. Maternal height had no significant effect when all the factors were accounted for.

Weight, height and maternal origins did not have a significant effect on birth weight, after taking into account all the factors listed in Table 3.24. When male and female infants were analysed separately, haemoglobin levels, gestational age, ethnicity and parity had similar trends in the risk for lower birth weight (Table 3.22 and Table 3.23). For male babies maternal BMI at booking, maternal height, year of birth and maternal origins had

**Table 3.21: Risks of infants born with lower birth weight* (both sexes)**

| Variable name | B | p-value | Odds ratio | 95% CI |
|---|---|---|---|---|
| Hb in 3rd trimester, g/L | | | | |
| <100 | 1.3265 | <0.0001 | 3.6 | 2.4 - 5.9 |
| 100 - 109 | 1.0780 | <0.0001 | 2.8 | 2.1 - 4.2 |
| 110 - 119 | .3477 | <0.05 | 1.4 | 1.0 - 2.0 |
| ≥120 | § | | 1 | |
| Gestational age, weeks | | | | |
| <40 | 1.0505 | <0.0001 | 2.9 | 2.2 - 3.7 |
| ≥ 40 | § | | 1 | |
| Ethnic group | | | | |
| Sikh-Indian | .7231 | <0.001 | 2.1 | 1.4 - 3.0 |
| Hindu-Indian | .4155 | 0.1175 | 1.5 | 0.9 - 2.5 |
| Pakistani-Muslim | .2426 | 0.2585 | 1.3 | 0.8 - 1.9 |
| Bangladeshi-Muslim | § | | 1 | |
| Infant sex | | | | |
| Female | .6573 | <0.0001 | 1.9 | 1.5 - 2.5 |
| Male | § | | 1 | |
| Parity | | | | |
| 1 | .6469 | <0.0001 | 1.9 | 1.4 - 2.5 |
| 2 or more | § | | 1 | |
| Year of birth | | | | |
| 1957 - 1969 | .0103 | 0.9653 | 1.0 | 0.6 – 1.6 |
| 1970 - 1979 | .5408 | 0.0622 | 1.7 | 1.0 – 3.0 |
| 1980 - 1989 | .3388 | <0.05 | 1.4 | 1.1 – 1.9 |
| 1990 - 1996 | § | | 1 | |
| BMI at booking, $kg/m^2$ | | | | |
| <22.96 | .4591 | <0.05 | 1.6 | 1.1 - 2.2 |
| 22.96 - 25.05 | -0.0375 | 0.8135 | 1.0 | 0.7 - 1.3 |
| >25.05 | § | | 1 | |

*Birth weight below the median; §- reference category.
Maternal height & births by UK-born mothers are not significant factors in the model

no significant effects on birth weight after all the factors included in the model were accounted for. Among male infants lower maternal Hb had a higher risk being born with lower birth weight compared to female infants.

Only 1178 births (48%) were included in the logistic regression model because other births had missing data. Table 3.24 shows the number of valid cases in each category that was included in the analysis. However, there were no significant differences in birth weight between cases included and cases not included in the analysis.

**Table 3.22: Risks of male infants born with lower birth weight***

| Variable name | B | p-value | Odds ratio | 95% CI |
|---|---|---|---|---|
| **Hb in 3rd trimester, g/L** | | | | |
| <100 | 1.3813 | <0.0001 | 4.7 | 2.1 - 7.4 |
| 100 - 109 | 1.1891 | <0.0001 | 3.3 | 1.9 - 5.5 |
| 110 - 119 | 0.5079 | <0.05 | 1.7 | 1.0 - 2.7 |
| ≥120 | § | | 1 | |
| **Gestational age, weeks** | | | | |
| <40 | .8769 | >0.0001 | 2.4 | 1.7 - 3.5 |
| ≥ 40 | § | | 1 | |
| **Ethnic group** | | | | |
| Sikh-Indian | .6990 | <0.05 | 2.0 | 1.2 - 3.5 |
| Hindu-Indian | .2690 | 0.4926 | 1.3 | 0.6 - 2.8 |
| Pakistani-Muslim | .2420 | 0.4353 | 1.3 | 0.7 - 2.3 |
| Bangladeshi-Muslim | § | | 1 | |
| **Parity** | | | | |
| 1 | .7070 | <0.001 | 2.0 | 1.4 - 3.0 |
| 2 or more | § | | 1 | |
| **Year of birth** | | | | |
| 1957 - 1969 | -.2326 | 0.4996 | 0.8 | 0.4 - 1.6 |
| 1970 - 1979 | .84656 | <0.05 | 2.3 | 1.1 - 5.1 |
| 1980 - 1989 | .6000 | <0.01 | 1.8 | 1.2 - 2.7 |
| 1990 - 1996 | § | | 1 | |

* Birth weight below the median; § - reference category. Maternal height, BMI & births by UK-born mothers are not significant factors in the model.

Table 3.23: Risks of <u>female</u> infants born with lower birth weight*

| Variable name | B | p-value | Odds ratio | 95% CI |
|---|---|---|---|---|
| **Hb in 3rd trimester, g/L** | | | | |
| <100 | 1.2203 | <0.001 | 3.4 | 1.8 - 6.4 |
| 100 - 109 | .9231 | <0.001 | 2.5 | 1.6 - 4.1 |
| 110 - 119 | .1391 | 0.5477 | 1.1 | 0.7 - 1.8 |
| ≥120 | § | | 1 | |
| **Gestational age, weeks** | | | | |
| <40 | 1.1915 | <0.0001 | 3.3 | 2.3 - 4.7 |
| ≥ 40 | § | | 1 | |
| **Ethnic group** | | | | |
| Sikh-Indian | .7995 | 0.0030 | 2.2 | 1.3 - 3.8 |
| Hindu-Indian | .5788 | 0.1083 | 1.8 | 0.9 - 3.6 |
| Pakistani-Muslim | .2906 | 0.3276 | 1.3 | 0.7 - 2.4 |
| Bangladeshi-Muslim | § | | 1 | |
| **Parity** | | | | |
| 1 | .7194 | <0.0001 | 2.1 | 1.4 - 3.1 |
| 2 or more | § | | 1 | |
| **BMI at booking, kg/m$^2$** | | | | |
| >22.96 | .5546 | <0.05 | 1.7 | 1.1 - 2.8 |
| 22.96 - 25.05 | .0664 | 0.7570 | 1.1 | 0.7 - 1.6 |
| >25.05 | § | | 1 | |

* Birth weight below the median; § - reference category. Maternal height, year of birth & births by UK-born mothers are not significant factors in the model.

Table 3.24: The number of valid cases included in the logistic regression model

| Variable | Category | Number |
|---|---|---|
| Hb in 3rd trimester, g/L | <100 | 150 |
| | 100 - 109 | 299 |
| | 110 - 119 | 382 |
| | ≥120 | 347 |
| Ethnic group | Sikh-Indian | 587 |
| | Hindu-Indian | 119 |
| | Pakistani-Muslim | 298 |
| | Bangladeshi-Muslim | 174 |
| Gestational age, weeks | <40 | 541 |
| | ≥ 40 | 637 |
| Infant sex | Female | 616 |
| | Male | 562 |
| Parity | 1 | 384 |
| | 2 or more | 794 |
| Year of birth | 1957 - 1969 | 117 |
| | 1970 - 1979 | 68 |
| | 1980 - 1989 | 491 |
| | 1990 - 1996 | 502 |
| BMI at booking, kg/m$^2$ | >22.96 | 354 |
| | 22.96 - 25.05 | 428 |
| | >25.05 | 396 |
| No. of cases included in the analysis | | 1178 |
| Total number. of cases | | **2432** |

### 3.3.5 Summary of the results

1. A total of 2729 South Asian births from 1957 to 1996 have been studied. A large proportion of the births was by women from India.
2. The composition of birth by ethnic group was similar to the ethnic composition in the population census. Indians (Hindus & Sikhs) formed 63 percent of the birth, 24 percent were Pakistanis, and 12 percent were Bangladeshis.
3. The median gestational age for all births was 40 weeks. Eight percent of the babies were born before term. Low birth weight occurred in twelve percent of the total birth.
4. Male babies were on average heavier than female babies.
5. A total of 2432 full-term singleton births were used for further analysis in order to make the results comparable to other studies.
6. The birth records did not have complete information on all variables of interest. One reason was due to changes in the format for the maternity and birth records from time to time. Missing data caused some problems for the statistical analysis, especially in performing multivariate analysis.
7. Placental weight, head circumference and birth length had high correlations with birth weight. Maternal characterisitics such as age, height, weight, BMI, parity, gravida and iron status had low but significant correlations with birth weight.
8. Age, gravida, parity and BMI were correlated. BMI before delivery was correlated with weight at booking.
9. There was no significant correlation between maternal height and birth length.

10. More than 30 percent of the births were by first time mothers. Twenty-six percent were for second born, and forty percent were for third and subsequent born babies.

11. There was a linear relationship between haemoglobin levels in the third trimester and birth weight.

12. Anaemia was prevalent in 25 percent of the pregnancies. It was more common among younger than older women. The prevalence was high among Bangladeshi-Muslims and Sikh-Indians.

13. Bangladeshi-Muslim women and women of Indian origin had a higher proportion of births that were for sixth or subsequent born babies. This may reflect their older age. Their earlier births could have occurred in Bangladesh and India.

14. Women who were younger, or with fewer children were lighter, were thinner at the beginning and end of their pregnancies, compared to older women or those who had had more children.

15. Older women gained less weight during pregnancy than younger women.

16. The gestational age at birth and weight gain was similar in all ethnic groups.

17. Bangladeshi-Muslim women were shorter but had similar BMI compared to other women. They had more children compared to other women.

18. Sikh-Indian women were the youngest and Hindu-Indians were the oldest group.

19. The youngest, or the shortest, or the lightest mothers, or those with the lowest haemoglobin or who were anaemic, had the babies with the smallest birth weight, placental weight, and the smallest head circumference.

20. The highest placental to birth weight ratios occurred in anaemic women, and women with the lowest haemoglobin levels in late pregnancy.

21. Sikh-Indian babies had the smallest birth weight and placental weight.

22. The Pakistani-Muslim women, who were on average heavier and had a higher BMI compared to the Hindu and Sikh-Indians, they had the highest haemoglobin

levels, had the largest placentas, produced the heaviest and longest babies compared to other ethnic groups.

23. Weight gain during pregnancy showed a positive effect on ponderal index, but not on other birth measurements.

24. Being a Sikh-Indian, or female, or being the first born child, or born at term but less than 40 weeks, or born by a thin mother or born by a mother with low haemoglobin levels, or born in the 1970s, carried some risk in having a lower birth weight.

25. Being a Bangladeshi-Muslim carried a reduced risk of having a lower birth weight.

## 3.4 DISCUSSION

### 3.4.1 Record of South Asian births in Southampton

The first South Asian birth available on record was in 1957 and the number gradually increased in the 1980's and in the 1990's. To estimate the coverage of the birth records, the data were compared with the population census of 1991 for Southampton. The Indian births appeared to be under-reported. There were similar numbers for UK born Pakistani and Bangladeshi in the census as in the birth records. In-migration to Southampton and out-migration could have balanced the figures for Pakistani and Bangladeshi. For example, women who were born in other parts of the UK and got married to men from Southampton are more likely to live here with their husbands' families. This custom could also cause out-migration of the South Asian women. Compared to the census figures there was a twelve-percent drop in the birth data for the Indians. There is a possibility that some records have been missed, for example, births for the year 1977 and 1978. Some of the patient folders for births in 1995 and 1996 were still 'actively used'. As the missed records were relatively few, it is not likely to cause a bias in the results.

To select South Asian names from a list containing both South Asian and European name is considered a reliable method for this study. The distinct South Asian names can be identified easily, Nicoll *et al.* (1986) found that by using both first and second names they could classify 98.5% of the South Asians compared with a reference judgement correctly.

The data collected were a cohort of births, based on deliveries at the Southampton General Hospital that spanned over thirty years. Therefore one individual mother may have contributed to more than one birth record, during the study period. As investigators we had no control over the type of information recorded. The formats had changed from time to time. Unfortunately this led to most of the records having information missing on some variables of interest. This has posed a problem in developing a model to assess the association between birth outcomes and maternal characteristics using multiple regression analysis. Since the study was based on routine data recorded in the prenatal clinics and labour wards, the measurements and information collected were not for the purpose of scientific research. This could have contributed to measurement errors in the data.

As most of the information has been collected in the past, assessing the accuracy and quality of the information recorded was difficult. How much measurement error was involved in various anthropometric measures for the mothers as well as for the babies could not be determined. A faulty weighing scale that gave the wrong reading at every measurement by a constant factor may not be a problem for ranking. In that case every subject would have been consistently different from her true weight. This would not affect the association between weights and other variables. However, if the wrong reading differed at different weights, this would have caused some subjects to be misclassified. This type of error would have reduced the chances of detecting a relationship between weights and the birth outcomes if there was one. There has not been frequent change in the type of infant weighing scales used in the labour ward (personal communication). Measurement errors due any faulty weighing scales would be consistent in all subjects. Similarly there was no mention of whether baby's birth length was measured in standardised way or not.

For maternal height, the records did not say whether they were measured with or without shoes. Preferably all mothers were measured without their shoes on. If all mothers had been measured with shoes it would make them consistently taller than they were. However, this will not alter the association of maternal height with the birth weight measurements because the error has occurred in all the mothers. On the other hand, if some mothers had been measured with shoes and some without, the error was not consistent throughout. Some mothers would have their "true" heights and there would be mothers who appeared taller because of the effect of their shoes. This would have caused some women to be misclassified in their height categories.

There would have been a certain amount of within- and between-measurer errors because there was no indication that the quality of their measurements was checked. Midwives who took the measurement were likely to change over the whole study period. Other sources of error include weighing of subjects with clothing. The weight of clothing could vary from person to person. There was no indication that this was taken into account. These errors were more likely to be randomly distributed among the subjects. Its effect would be to reduce the true between-subject variation for weight or height. Subsequently it tends to weaken any relationship between the maternal weights or heights with the birth measurements. The measurement errors related to maternal anthropometry were not likely to be correlated with that of infants' anthropometry because they were conducted by different staff and in different clinics.

Maternal age was recorded in whole years or recorded as their dates of birth. In the former case, the information on the mother's age was likely to be accurate to the nearest whole year. One would expect mothers to know their age fairly accurately with a few exceptions. For example, the mother probably could not give that information to the staff if there was a language barrier between them. If mother's date of birth had been available calculation of maternal age would tend to be more accurate.
Errors in gestational age were more likely to occur if mothers were unsure of their LMP dates, or they did not have their menses after the previous delivery. This could have occurred in the earlier records before ultra-sound scanning became a routine procedure. However, it is assumed that gestational age of more than 44 weeks was probably due to wrong dates of LMP, therefore these cases had been excluded from the main analysis. Cases where gestational age was missing were also excluded.

### 3.4.2 Birth outcome of South Asian babies in Southampton

For all births, percent low-birth-weight babies was higher compared to the UK population. However, this proportion is considerably lower if compared to babies in the Indian Subcontinent. Low birth weight has been reported to be 23 percent in urban India (Misra *et al.* 1995), 31 percent in rural India (Naidu & Rao, 1994), 26 percent in Pakistan (Hassan *et al.* 1991), and 21-41 percent in Bangladesh (Huque & Hussein, 1991; Karim & Mascie-Taylor, 1997). Factors, which have been found to be associated with low birth weight among the women in the Indian Subcontinent, include socio-economic status, maternal weight, height, BMI, energy intake, and anaemia. Improved socio-economic status and prenatal care in the UK could have contributed to the reduction in the prevalence of low birth weight among babies born in Southampton.

For full term births, low birth weight babies were born on average one week earlier than the average births. There were more low birth weight babies born after term than before term, and they are regarded as small-for-gestational-age, or growth retarded. The highest percentage of low birth weight babies was by UK born South Asian women. Younger age and lower maternal weight among UK born South Asian women could explain this higher rate of low birth weight.

Table 3.25 compares the birth weights of South Asian babies in Southampton with South Asian babies elsewhere and with Caucasian babies. Compared to the Caucasian babies at the Southampton General Hospital, South Asian babies were smaller in all birth measurements, such as head circumference and placental weight.

**Table 3.25: Comparison of birth weights for South Asian and Caucasian babies**

| Reference | Mean birth weight, g (SD) | Number |
|---|---|---|
| 1. The present study | | |
| All infants | 3110 (462) | 2429 |
| Sikh-Indian | 3061 (446) | 1246 |
| Hindu-Indian | 3073 (454) | 317 |
| Bangladeshi-Muslim | 3159 (477) | 270 |
| Pakistani-Muslim | 3216 (480) | 568 |
| **2.** Southampton Caucasian (Godfrey *et al.* 1996) | | |
| Male | 3527 (496) | |
| Female | 3344 (463) | |
| Total | | 538 |
| **3.** Birmingham (Wharton *et al.* 1984) | | |
| Sikh | 3140 (360) | 15 |
| Hindu | 2780 (630) | 11 |
| Bangladeshi-Muslim | 3190 (370) | 5 |
| Pakistani-Muslim | 3170 (490) | 37 |
| **4.** London (Brooke & Wood, 1980) | | |
| South Asian | 3034 (525) | 80 |
| Caucasian | 3363 (492) | |
| **5.** Pune, India (Tarapore, 1997) | | |
| Male | 2654 (492) | 304 |
| Female | 2568 (378) | 263 |

For example, the male Caucasian babies weighed 350 g more and the female Caucasian babies weighed 300 g more than the South Asian babies (Godfrey *et al.* 1996). There appears to be no difference when the Southampton South Asian babies were compared to South Asian babies born elsewhere in the UK (Brooke & Wood, 1980; Wharton *et al.* 1984). However, South Asian babies in the Indian Subcontinent are lighter than South Asian babies in Southampton (Hasan *et al.* 1991; Tarapore, 1997; Northrop-Crewes, 1998).

### 3.4.3 Factors affecting birth weight

#### *3.4.3.1 Gestation*

For all births, the median gestational age at birth was 40 weeks. This is higher than that of Indian women in Tamil Naidu, which was 39 weeks, (Mathai *et al.* 1995), but not lower than the median gestation for the British women, which was 40.5 weeks (Park, 1968). Differences in gestational age between South Asian and Caucasian births have not been consistent. Some studies did not find any difference (Alvear & Brooke, 1978; Perry *et al.* 1995), while other studies have found that shorter gestation among South Asian births partly accounted their lower birth weight compared to the Caucasians (McFadyen *et al.* 1984; Steer *et al.* 1995). Different methods in the assessment of gestational age may bring about the discrepancy between studies. Future studies should have a standardised method to estimate gestational age.

In the present study gestation had a positive effect on birth weight, placental weight and head circumference even after a full term pregnancy. Babies born at term but before 40 weeks were 3 times more likely to have lower birth eight than babies born at 40 weeks or more. The effect of gestational age on birth is well documented (Milner & Richards, 1974; Anderson *et al.* 1984; Goldenberg *et al.* 1992). There is no one particular factor that may have an effect on gestation. Studies suggest that factors such as pre-pregnancy weight, parity, weight gain in pregnancy, smoking and a history of a previous low birth weight may influence gestation (Kramer, 1987). We found that women who were anaemic had shorter gestation than women who were not anaemic. This suggests that anaemia may be a marker for an unfavourable *in-utero* environment for fetal growth, such that it may be advantageous for the fetus to be born sooner rather than later.

#### 3.4.3.2 *Maternal size*

We found that lower maternal weight and BMI at booking and lower maternal height was associated with lower birth weight. Among a group of white, Hindu and Muslim women in London, both maternal weight and height had significant effects on birth weight (McFAdyen *et al.* 1984). Several other studies too have found a positive effect of maternal size on birth weight (Thomson *et al.* 1968; Klebanof & Yip, 1987). Among Caucasian women, the increase in birth weight was between 5.0 to 7.8 g per kg increase in maternal weight (Williams *et al.* 1997), and it could be between 9.1 to 14.0 g per kg increase in maternal weight (Anderson *et al.* 1984).

In the present study the association between maternal weight and height and birth weight was weak. There was no correlation between maternal height and birth length. Other studies have shown stronger correlation between maternal size and birth outcomes (Emmanuel *et al.* 1992). The regression analysis indicated a lack of relationship between maternal weight, height and birth weight. This could be due to measurement errors. Inconsistencies in the techniques of taking weights and heights between the clinic staff (measurers) may have caused a systematic error in their weight and height measurements. Variations in the reading of measurements between different clinic staff could have contributed to the measurement error as well.

Our data may be biased with regards to record for maternal weight in early pregnancy. Women who came to the clinic before eighteen weeks gestation and had their weights recorded could have been different from those who came later. The latter were not included in the regression analysis. However, there was no difference in the birth weight_between cases included and not included in the analysis. It is likely that the results were not biased. Among the South Asian women BMI could be a better indicator of maternal size than height. However, haemoglobin levels and the period of gestation which showed the highest odds ratios in the regression analysis may be the predominant factors in determining birth weight among the South Asian women. In both circumstances current nutritional status of the mothers particularly haemoglobin levels, appear to be more important than other factors for fetal growth among the South Asians. The lack of relationship between maternal height and birth length is probably due to the measurement error. The method of measuring birth length was not standardised. Moreover, the number of records with birth length measurement was relatively small.

Using logistic regression analysis BMI showed a significant effect on birth weight. The odds ratio of 1.6 indicates that women who were in the lowest third of the BMI distribution are at approximately 60 percent greater risk of delivering a lower birth weight infant than are women with higher BMI. Thin mothers were more likely to give birth to lower birth weight babies, which is an indication of fetal growth retardation. This finding of low BMI associated with lower birth weight agrees with many other studies (de Groot, 1999). Lower birth weight babies are at risk of developing coronary heart disease in adult life. On the other hand, overweight mothers were more likely to produce higher birth weight babies. Since the South Asian people are generally small at birth, becoming obese during adults may not be favourable for their health and the health of their babies, if they are females. Since infants born by overweight women who themselves may have experienced fetal growth retardation are prone to develop non-insulin dependent diabetes mellitus (Stein, 1997). If the women develop hyperglycaemia during pregnancy, their babies are prone to develop non-insulin dependent diabetes mellitus. Among male infants maternal BMI was not a significant factor. This could be because among male infants other factors such as haemoglobin levels and period of gestation are more important for growth.

South Asian women in Southampton have lower birth weight babies compared to Caucasian women. Studies in the UK have consistently shown that the South Asian women are shorter and weigh less than the Caucasian women. Earlier studies did not take into consideration other maternal factors, which could influence birth weight, therefore it is not certain if the differences detected were attributed to maternal size only. In an American study, after adjusting for maternal age, infant sex and parity, South Asian women had a higher risk of having low birth weight babies than white American women, but no adjustment was made for maternal size (Fuentes & Hessol, 1997). It is reasonable to expect that bigger mothers would have bigger babies and vice versa. Maternal size is likely to exert its influence on fetal growth through the size of the uterus, the capacity of the utero-placental circulation and the placenta itself (Hytten & Leich, 1971).

In the Indian subcontinent maternal weight and BMI, which are both related to socio-economic status are positively associated with birth weight. Mothers from higher socio-economic status were taller and heavier, and produced bigger babies (Kapur *et al.* 1971). Mothers with better BMI status came from households with higher energy intakes (Naidu & Rao, 1994). Maternal heights were the same in all BMI categories. This again implies that current nutritional status as indicated by BMI had an effect on birth weight.

Maternal weight is a summary of the mother's stature, body fat and lean body mass. Mother's stature is a combination of the effect of her nutrition during childhood and puberty, and her genetic potential. Whereas body fatness and lean body mass are related to her current nutritional status, before and during pregnancy. Energy intake in excess of energy expenditure will result in a positive energy balance and subsequently fat deposition. There is evidence to suggest that the South Asian women in the UK are fatter than their counterparts in the Indian subcontinent (Keil *et al.* 1977; Keil *et al.* 1980;

Bhatnagar *et al.* 1995). Their low levels of participation in recreational and sporting activities (Rudat, 1994) and higher fat content in the diet (Werner & Sereen 1978; Lip *et al.* 1995), probably due to improved socio-economic status, are likely to result in a positive energy balance. However, this needs to be confirmed in a well-designed study. Increased maternal weight due to increased fatness, and subsequently producing higher birth weight babies may imply that later generations of South Asian babies will have higher birth weight than the current trend.

Indeed Dhawan (1995) reported that second generation South Asian women in Hull had babies who were 280 g heavier than babies from first generation women. The difference was found at all gestations and after taking into account other confounding factors. We could not detect a trend of higher birth weight of babies born by UK-born women compared to babies born by overseas-born women. The crude mean birth weight of babies by UK-born women in Southampton was lower compared to the birth weight of babies by women born outside UK. The UK-born women were on average five years younger than those women who were born overseas. They were probably still growing and needed additional nutrients for their growth as well as the growth of their unborn babies. Their nutritional status was poor as indicated by their lower haemoglobin levels. The poorer nutritional status of the UK born women compared to the women born outside the UK could account for the lack the lack of improvement in the birth weight of babies by the second-generation South Asian women.

The second generation South Asian women in Southampton who start having children at a young age are more likely to produce smaller babies. This implies that the risk of developing adult chronic diseases will still exist among the third generation of South Asians, who will become adults within the next millennium.

About 80 percent of the South Asian mothers in Southampton were housewives. Their activities would involve looking after the children, other family members and doing the household chores. Previous studies have suggested that the South Asian women are sedentary with regards to sporting and recreational activities. However, none of the surveys conducted have compared other types of activities that the South Asian women do. For example, looking after children and living with extended families are likely to occupy a substantial amount of their time. Studies on birth outcomes of South Asian women in the Indian Subcontinent did not indicate the proportion of women who did not go out to work, to the farms or to do other types of work. Thus there is not sufficient basis to make comparisons between their physical activity levels.

There is an indication that the South Asian women from overseas who have settled in Southampton are fatter and heavier than before. It may imply that their duration of staying in the UK is associated with an increase in energy balance that caused them to put on weight and have a higher BMI than before. However this could also indicate that South Asian women who have migrated from overseas later in the 1980's and the 1990's are heavier than those came to the UK earlier. Both suggest that the current South Asian women are on average heavier and have a higher BMI than before irrespective of where they live.

Currently there is a lack of information on the energy balance of South Asian women who have migrated to the UK. Many studies have been carried out to assess their dietary intakes, which is only part of the equation for energy balance. There have been no comparative studies to detect changes in the energy intakes and physical activity levels between South Asian women who migrated and those who did not. Studies in energy balance will be able to determine what changes have taken place in the diet and physical activity patterns of the South Asian women who had migrated from India, Pakistan and Bangladesh. If there have been changes, how have they contributed to changes in their body weight and body mass index which seem to be an important positive factor for fetal growth among this community.

### *3.4.3.3 Weight gain*

Weight gain during pregnancy did not have a significant effect on birth weight of South Asian babies in Southampton. The average weight gain for the South Asian women in the present study was lower compared with other populations, (Seidman *et al.* 1989). Among other populations, weight gain during pregnancy has been shown to exert a direct influence on birth outcome (Naeye, 1979). For example, among African-American women the effect of weight gain on birth weight was stronger, a 290 g increase in birth weight per kg weight gained, after taking into account gestational age, infant sex, smoking, race and pre-pregnant weight (Neggers *et al.* 1997). The small weight gain among the South Asian women and the relatively small number of subjects with data on weight gain could explain the lack of effect.

In a study among Caucasian women, weight gain during the second trimester was more strongly associated with birth weight than weight gain in the first and third trimester (Abrams & Selvin, 1995). Most of the maternal weight gain during the first and second trimester is due to increase in maternal tissues (expanded blood volume, uterus, breasts and fat). It has been suggested that maternal undernutrition (low maternal weight or inadequate food intake) might cause an inadequate increase in maternal plasma volume, which limits the uterine-placental blood flow, therefore reducing the transfer of nutrients to support fetal growth (Rosso, 1990).

Younger South Asian women in Southampton were lighter at the beginning of pregnancy and gained more weight in pregnancy than older women. A similar observation has also been reported by Siedman *et al.* (1989). There may be an interaction between weight gain and pre-pregnant weight such that for women who began pregnancy with larger fat stores, weight gain might have little effect on fetal growth. On the other hand, thin women might benefit from weight gain and thereby an increased birth weight.

Gestation, haemoglobin levels and weight gain are factors that prevail during the current pregnancy. It is likely to be strongly influenced by the current maternal nutritional status. Health education would create awareness among the South Asian community about the importance of seeking early antenatal care, and improving dietary intakes during pregnancy. As an immediate measure the South Asian community is more likely to benefit from this type of programme.

#### *3.4.3.4 Age, parity and infant sex*

The baby's size at birth, that is birth weight, head circumference and birth length increased as maternal age, gravida and parity increased. This could be explained by the increase in maternal weight as age, gravida and parity increased, because gravida and parity were strongly correlated with maternal age. A lower proportion of older women or women with more than five children were anaemic compared to younger women, or women with fewer children. This factor could account for the older women having bigger babies than younger women.

The effect of parity *per se* on fetal growth is not certain. Second and subsequent babies grow faster than first babies. The parity differences could be influenced by differences in the fetal environment, for example improved efficiency of the uterine circulation in second and subsequent pregnancies (Thomson & Hytten, 1968). The sex difference in birth outcomes is well established. Male infants appear to have a faster growth rate than female infants. This may be due to a sex hormone difference. Testosterone, for example, is recognised as having a stimulating effect on growth (Thomson & Hytten, 1968).

#### *3.4.3.5 Iron status*

It was found that poor iron status during pregnancy as indicated by low haemoglobin levels had a negative effect on birth weight. A high proportion of the women were considered anaemic. Lowest birth weights, placental weights, and head circumferences were from anaemic mothers. Among mothers who had anaemia, mean haemoglobin levels were lowest during the first trimester, 98 g/L. Among the South Asian women in Southampton, the risk of having a lower birth weight babies increased as the haemoglobin levels in late pregnancy decreased.

The effect of haemoglobin levels during pregnancy on birth weight has varied. Apparently it depends on when the haemoglobin was measured. Indian women whose haemoglobin levels were less than 110 g/L at delivery had babies with significantly lower birth weight, head circumference, chest circumference, mid-arm circumference and birth length, compared to mothers with normal haemoglobin levels ($\geq$ 110 g/L), (Singla *et al.* 1997). These were full term deliveries, so small-for-dates infants were not included. On the other hand among Caucasian women, if haemoglobin was measured throughout pregnancy, and the lowest level recorded was used to assess its relationship with birth weight, a different finding emerged (Steer *et al.* 1995). Maximum mean birth weight was achieved with the lowest range of haemoglobin concentration in pregnancy, which was between 85 to 95 g/L. Haemodilution has been suggested to have a positive effect on birth weight (Taylor & Lind, 1979).

In the present study there was a linear relationship between birth weight and haemoglobin levels during the third trimester. Baby's birth weight decreased as haemoglobin levels decreased. Measurement error due to lack of precision in the haemoglobin level or birth weight measurements could have masked the true relationship between haemoglobin and birth weight. However this study had detected a significant relationship between haemoglobin levels and birth weight but the opposite to what is expected. A systematic error in birth weight or haemoglobin measurements could have produced this effect. However this is unlikely due measurement error in birth weight because the study has shown significant relationships between birth weight and several other maternal variables. The type of relationship shown by this study is unlikely due to a systematic error in haemoglobin measurement because they were based on measurements taken over a long period of time for a large number of subjects.

The probable reason why haemodilution did not appear to have a positive effect on birth weight could be because the haemoglobin measurements were taken towards the end of pregnancy. This period may be too late for haemoglobin to have a favourable effect on birth weight. Low haemoglobin level at this stage is probably an indicator of poor nutritional status, particularly iron, which subsequently contributes to reduced fetal growth. Furthermore, the range of haemoglobin levels among the South Asian women in Southampton could be within a narrow band that forms part of a U-shaped relationship between haemoglobin and birth weight.

The haemoglobin concentration reflects total red cell mass per unit plasma volume. During pregnancy, both plasma volume and red cell mass increase. The increase in plasma occurs earlier in pregnancy and is larger than the increase in red cell mass. It is not clear what is the mechanism by which expansion of the plasma volume promotes fetal growth. It could be because reduced blood viscosity eases the blood flow between mother, placenta and the fetus (Bothwell *et al.* 1979). As a consequence, nutrients are more available to the fetus. This is considered a physiological fall in haemoglobin, not

due to iron deficiency. Thus, a fall in haemoglobin during the first and second trimester might be favourable for fetal growth. In the present study, haemoglobin levels were measured in late pregnancy. The consequence of low haemoglobin at this stage may not be similar to the effect in early pregnancy.

At what stage of pregnancy anaemia was diagnosed, or when they were given iron or folic acid supplements could not be determined. However, iron or folic acid supplements did not appear to improve birth weight for the anaemic women. It is not certain whether this was due to lack of compliance in taking the tablets, or due to the ineffectiveness of the iron tablets in increasing the blood iron levels of the South Asian women. On the other hand blood haemoglobin level may not be a good indicator of the body's demand for iron.

Lower weight at birth has been found to be associated with lower haemoglobin levels in adolescent female South Asians (Al-Dallal, 1998). This implies that if the iron status of South Asian women is not improved they will continue to produce lower birth weight babies with a higher risk of becoming anaemic in adolescence and during pregnancy. This vicious cycle among the South Asians will perpetuate.

The prevalence of anaemia was highest among Sikh-Indian and Bangladeshi-Muslim, higher in the younger than older women, in primipara than multiparous women. This may partly explain the higher rate of low birth weight among Sikh-Indian compared to the Pakistani-Muslim and Hindu-Indian babies. Anaemia during pregnancy and low haemoglobin levels in late pregnancy were also associated with a higher placental to birth weight ratio. A similar relationship was reported for Caucasian women (Godfrey *et al.* 1996; Williams *et al.* 1997).

The placental transfer of iron has been found to be greatest during late pregnancy (Fletcher & Suter, 1969). The South Asian women who had low haemoglobin levels during the third trimester were probably iron deficient. Their placental weight to birth weight ratio was higher than other women. It may be because the placenta had to compensate by growing larger in order to improve the supply of iron and presumably other nutrients to the fetus. The ratio of placental weight to birth weight could be a marker for the transfer of nutrients from the placenta to the fetus and subsequently fetal nutritional status. Higher placental weight to birth weight ratio is a predictor of adult blood pressure (Barker *et al.* 1990). This has public health implications on the development coronary heart disease risk factors, such as blood pressure among the South Asian community.

Iron status is regulated by iron absorption and availability. The actual amount of iron that can be absorbed by the gut is influenced by the amount of iron in the food and its bioavailability. In turn, bioavailability depends on the amount of meat in the diet and on the balance in the diet between promoters of iron absorption (vitamin C and meat) and iron inhibitors, for example phytates and polyphenols (Bothwell, 1995). A cereal-based diet that forms the staple food of the South Asian people contains a large amount of inhibitors of iron absorption. It is not likely that the present generation of the South Asian people will change their diet. Therefore, food sources rich in iron found in their traditional diets must be promoted to improve the health status of their people, particularly the females.

### 3.4.3.6 *Ethnicity*

The South Asian population in Southampton is heterogeneous because they have different religion, culture, language and dietary habits. To classify them as a single group may be too broad, and may fail to pick up any variation in birth outcome by country of origin, religion, language, dietary habits or other factors related to health and disease.

By classification into four ethnic groups we were able to detect differences between the groups. The Pakistani-Muslim and the Bangladeshi-Muslim had a better haemoglobin level and higher BMI than the Sikh-Indian and the Hindu-Indian. This may be a reflection of a better nutritional status among the Pakistani-Muslims and Bangladeshi-Muslims compared to the other ethnic groups. Pakistani-Muslim and Bangladeshi-Muslim infants were heavier than Sikh-Indian and Hindu-Indian infants. A similar trend was also found among the same South Asian subgroups in Birmingham (Wharton *et al.* 1984).

The differences in their body weight and body mass index is probably a contributing factor to the differences in their babies' birth weights. This also suggests that in this population maternal weight and BMI had a greater influence on birth weight than height. The results of the logistic regression analysis confirmed this. Thus among the South Asian community there are differences between the subgroups in their babies' birth weights. If it is presumed that current socio-economic status of the various subgroups that are living in the UK is similar, other factors such as their growth *in-utero* and growth during infancy should be studied.

The Sikh-Indian women appeared to be at a disadvantage, because most of them were younger and were not as heavy as their older counterparts. Generally they had a poorer iron status compared to other women. These two factors could explain that the Sikh-Indian babies had the lowest birth weight and the smallest head circumference. The Hindu-Indian women were on average older than other women, but did not have as many children. Their BMI's were similar to the Pakistani-Muslims and the Bangladeshi-Muslims. However, their babies were on average lighter and had a smaller placenta

compared to the Pakistani and Bangladeshi-Muslims. Other maternal constituents, such as their diet during pregnancy may play a role in this difference. The prevalence of anaemia was highest among the Sikh-Indians and Bangladeshi-Muslims. This may partly explain the Sikh-Indian babies having lower birth weight compared to the Pakistani-Muslim and Hindu-Indian babies.

The Hindu-Indian women in the present study could be compared with the South Indian women, who are mostly Hindus. South Indians whose weight ranged from 55 to 59 kg had babies with mean birth weight of 3040 g ±450 (Kapur *et al.* 1971). The Hindu-Indian women in Southampton had a median weight of 59 kg at booking, and their infants had a median birth weight of 3030 g, which is similar. However, the difference was more pronounced when birth weights were compared for mothers of similar height. Hindu-Indian women in Southampton had a slightly higher birth weight babies than South Indian women who had similar heights. The South Indian women came from poorer socio-economic background. Calorie intakes were found to be inadequate for most women, and protein intakes were inadequate in women from the lowest socio-economic groups. There were no data on weights of the South Indian women to compare with the Hindu-Indian women in Southampton. However it is likely that they had lower maternal weights than the Hindu-Indian women in Southampton.

McFadyen *et al.* (1984) found that the difference in birth weight between Pakistani-Muslim (from Pakistan and East Africa) and European in Middlesex was mainly due to differences in length of gestation and maternal size. The crude birth weight for the Pakistani-Muslims in Southampton was 110 g lower than that of the Europeans and 79 g higher than the Pakistani-Muslims in Middlesex.

Ethnic differences in maternal size and birth outcome could be due to socio-economic differences that existed in previous generations between the distinct regions of the Indian subcontinent. If the South Asian women in Southampton have improved their economic status and received better health care in the UK, they could have attained a better nutritional status compared to those who are living in the Indian subcontinent. This could partly explain the higher maternal weight among South Asians in the UK compared to those in India, Pakistan and Bangladesh. However, differences between the ethnic groups still persist in the UK South Asian population. It may take several generations of improved maternal nutritional status to observe improvement in infant birth weight of the South Asians in the UK, (Emmanuel *et al.* 1992).

Prepregnant weight, maternal height, age, and parity are factors that prevail before the mother became pregnant. Associated with these factors are the effects of socio-economic status and ethnicity. Maternal pre-pregnant weight is considered a modifiable factor that can influence the birth weights of future South Asian babies in the UK. In assessing changes in the weights of the South Asian women we have to measure both components of their energy balance equation, that is energy intakes as well as energy expenditure. There is a need to study trends in the physical activity pattern of this community and what are its long-term effects on maternal size and birth weights of their future generations.

Currently most of the physical activity questionnaires used in epidemiological studies have been developed for the white population. Due to cultural differences these questionnaires may not be suitable for use among the South Asian community. There is a lack of validated instrument that measures physical activity of the South Asian people. Thus before any study on physical activity can be conducted a valid tool must be developed. The next part of this thesis is focussed on the development and validation of a physical activity questionnaire for South Asian women.

# CHAPTER FOUR

# 4 VALIDATION OF A PHYSICAL ACTIVITY QUESTIONNAIRE

## 4.1 INTRODUCTION AND AIMS

There is evidence that South Asian people in the UK are sedentary and tend to be fatter than their counterparts in the Indian subcontinent. Urban lifestyles and increased prevalence of obesity have been observed in urban communities in India. This suggests that urbanisation, and possibly increased socio-economic status, is related to changes in their energy balance. This may be related to increased food intake, change in the portion size of food high in the fat content and less physical activity which together results in increased obesity. The South Asian communities in the UK mostly reside in the cities. That could explain their sedentary lifestyle. A survey of ethnic minority groups in the UK has shown that adult female South Asians are least likely to be involved in sports and recreational activities (Rudat, 1994). Customs and traditions may restrict the South Asian women from doing these activities. One part of the equation in establishing changes in the energy balance of the South Asian women since migrating to the UK is to assess their physical activity.

Previous surveys on physical activity in the South Asian community however, have used questionnaires that have been developed for the European or Caucasian population. The physical activity questionnaires mainly assessed the sports and exercise components of their physical activity. Occupational and household related activities have not been included. The South Asian culture and lifestyle may differ from the Caucasian population such that those questionnaires may not be appropriate for the

South Asian community. Thus it needs to be determined whether there is a need to develop an appropriate instrument to measure physical activity of the South Asian community.

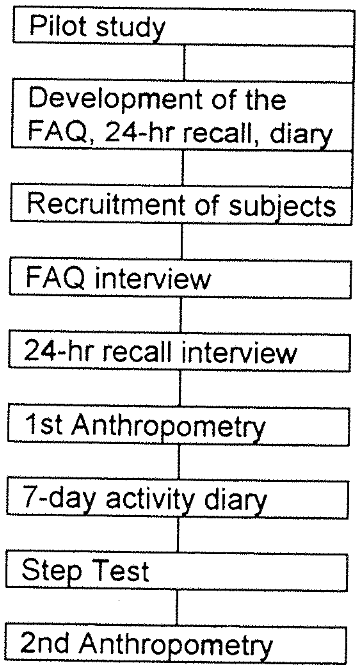
This chapter is focused on the second research project for this thesis. The aim of this study is to develop and validate a questionnaire appropriate for assessing physical activity among South Asian women in Southampton. The chapter begins with the section on the design of the questionnaire, the recruitment of the subjects in the validation study and the process of data collection (section 4.2). The results of the study are presented in section 4.3 and the discussion follows in section 4.4.

## 4.2 DESIGN AND METHODS

Methods for the assessment of physical activity have been discussed in section 2.2.2. Currently, the questionnaire is considered the most suitable method to be used to measure physical activity in epidemiological studies that involve a large number of subjects. The questionnaire is relatively cheap to produce and administer, does not intrude on subjects' privacy (if self-administered), and does not impose a heavy burden on the subjects. Questionnaires can either be administered by face-to-face interview, telephone interview, or self-administered.

This study has been approved by the local ethical committee. Figure 4 shows the overall plan for the validation study. A pilot study was conducted among a small group of South Asian women in Southampton to obtain the relevant questions to be included in the questionnaire. Two types of questionnaire were developed, the frequency of activity questionnaire and the 24-hour activity recall. Both questionnaires were administered by interview. A 7-day activity diary was used as a reference method for habitual physical activity measurements. Formats of the questionnaire, 24-hour activity recall and the diary are attached in Appendix 7.

**Figure 4:** **The Study Design for the validation study**




### 4.2.1 The frequency of activity questionnaire (FAQ)

The aim of the FAQ was to assess the subject's level of physical activity. Information about physical activity was obtained from recall of physical activity during the previous year. In order to include all the components of a subject's daily physical activity, the questionnaire has a section that asks questions on the following:- activity at work, housework, activities during leisure, stair climbing at work and at home, and sleep. The questionnaire was divided into two parts. The first part asked questions on the frequency and duration of leisure time activities and household chores during the previous twelve months. The design and format of this part of the questionnaire is similar to the Minnesota Leisure Time Physical Activity Questionnaire (Taylor *et al.*

1978). The second part asked questions on activity at work, stair climbing at work and at home, and amount of time spent sleeping.

The pattern of activity at work is obtained from questions 4, 5 and 7 of the section on activity at work. If subjects had a second job they would be asked to describe it in the same the way as the first job. In these cases a second questionnaire would be used for the second job. For questions on stair climbing subjects needed to give a 'yes' or 'no' response. The questions on occupational activity asked information on the number of hours per week subjects spent at work and the type of activity that the subjects spent most of the time during work. This was sitting, standing, walking about or doing more vigorous work.

To obtain accurate information on the frequency and duration of the past year's physical activity, the questionnaire had four columns which denote the four seasons of the year, spring, summer, autumn and winter. Each seasonal column contained respective months for the season so that the reference months would be standardised for all subjects. To help them recall their activities, subjects were shown a list of activities in an alphabetical order and they were asked to pick out those activities that they had performed during the last twelve months. For each activity identified, the interviewer asked in which season it was done, the number of times per weeks it was done, and how long each activity lasted in each occasion. If any activity was carried out only during certain months in a particular season, the month was noted. The list of activities was selected based on the pilot study. They were as follows: -

- Aerobic exercises, cycling, dancing, housework (itemised as vacuuming, cleaning the bathroom, cleaning the kitchen, preparing vegetables, cooking, washing dishes, hand washing clothes, ironing and food shopping - not including travelling time), walking, jogging, gardening, do-it-yourself activities and others.

Subjects were also asked if there had been a change in their activities during the last five years.

### 4.2.2 The 24-hour activity recall

The aim of this questionnaire was to obtain a complete account of the subject's activity for one day. The activities recalled from this questionnaire accounted for all 1440 minutes of the 24-hour period. At the interview the subject was asked to describe in chronological order everything they did on the day before the interview. The starting point for each recall would be the time they got out of bed, and the ending would be the time they went to bed. They would begin by giving the time when they got up and described the activity that immediately followed. Subsequent activities would start from the time the previous activity had ended. Each activity was given a code, S for sitting, ST for standing, W1 for walking at the normal/leisurely pace, W2 for walking briskly, W3 for fast walking, C for climbing stairs, L for lying down. At the end of the recall subjects were also prompted if there was any activity that they had missed out.

### 4.2.3 The 7-day activity diary

The activity diary was designed for subjects to keep a record of their daily activities for seven consecutive days. They were to begin each day's recording in the morning at the time they get out from bed. This was followed by describing the activity they did immediately after getting up, for example, brushing her teeth and taking a shower. The time that an activity ended would be the time to record the subsequent activity. This recording should be done continuously throughout the day until they went to bed. The diary aimed to cover the total daily physical activity in a 24-hour period. For this reason subjects were asked to carry the diary with them all the time.

The diary was given to the subjects after they had completed the frequency of activity questionnaire and the 24-hour recall by interview. They were asked to record their activities the same way that the interviewer had done for the 24-hour recall. There were written instructions on the front page of the diary booklet on how to record their activities for the next seven days. An example of a diary was also included in the booklet. Subjects were told to contact the interviewer if they faced any difficulties with the recording. When a subject had completed their 7-day activity diary a second meeting was arranged. At this meeting the interviewer checked for completeness and queried any activity that was ambiguous, on its type, amount and duration.

### 4.2.4 Sequence of the interview

Most of the interviews were conducted in the subject's home, with no relatives present to ensure privacy and confidentiality. This arrangement was favourable to most subjects. Some subjects preferred to be interviewed either at their place of work, at the community centre, or at other places that were convenient to them, where there was privacy too. The researcher (SMY) conducted all the interviews for this study.

The meeting always started with the researcher introducing herself and a short background history. They were told that the researcher was a student at the University of Southampton, and that the study was part of her research for a PhD degree in nutrition. This was followed by an explanation on the rationale for the study, its objectives, and the sequence of questions that would be asked. Their personal details including full name, date of birth, home address and telephone number were obtained first to establish a rapport with the subject and make her feel at ease.
The sequence of interview was as follows:

i. Part 1 of the FAQ - the frequency and duration of various activities during the previous twelve months.

ii. Part 2 of the FAQ - questions on physical activity at work, stair climbing at work and at home, and the amount of hours spent sleeping every day.

iii. The 24-hour recall of their activities.

**4.** Instructions on how to record their physical activities for the next seven days.

### 4.2.5 The anthropometric measurements

At the end of the interview session the subject's weight, height, waist circumference and hip circumference were measured. A second set of measurements was taken at the second meeting when the subject had completed the 7-day activity diary and the step test. All measurements were conducted using techniques recommended by Lohman *et al.* (1988). The anthropometric measurements were taken to assess any relationship between BMR, body weight, BMI and waist-hip ratio with their physical activity reporting.

a) *Weight*

A portable electronic weighing scale (CMS Weighing Equipment Ltd.) was used to measure subjects' weight. The subject would stand still over the centre of the platform with weight evenly distributed between both feet. They were weighed with light clothing on (without sweaters, jackets or shoes). Weights were taken to the nearest 0.1 kg. The weighing scale was calibrated regularly with a standard weight. The difference between reading on the scale and the standard weight at each calibration session was less than 0.1 kg, which was within the limit of the manufacturer's range of error.

b) *Height*

Subject height was measured using a portable stadiometer. This simple equipment consists of a 5-inch by 7-inch thin metal platform, to be placed on a flat surface. A retractable steel tape was then hooked on to its narrower side. The subject, barefooted, would stand on the platform. A horizontal bar attached to the other end of the extended steel tape measure would be placed on the subject's head. The position of the bar was kept horizontal by a spirit level. The tape measure should be straightened and at right angle to the platform. The subject's heels should be placed together, her weight should be evenly distributed on both feet, and her head in the Frankfort Horizontal Plane. Her arm should hang loosely by the side, with palms facing the thighs. The researcher would then place her hands below the subject's ears and apply a slight traction. Heights were recorded to the nearest 0.1 cm.

c) *Waist and hip circumference*

The waist circumference was measured at the midpoint between the lowest intercostal rib and the iliac crest. The hip circumference was measured at the widest protrusion of the buttocks. Because some subjects felt too embarrassed about having their body measured, sometimes the hip circumference was measured over clothing. What the subject was wearing when she was measured was noted down. If they were wearing jeans or the Punjabi trousers, 3.6 cm. was subtracted, and if she was wearing leggings 1.2 cm was subtracted from the measurement (based on trials done on a few subject). A 60-inch PVC coated fibreglass tape measure was used for all the measurements.

d) *An intra-measurer variability study*

An intra-measurer variability study was carried out to assess the measurement error for the anthropometric measurements conducted by the researcher. In this study one female subject was measured for ten consecutive days at different times of the day.

### 4.2.6 The Step Test

The Step Test was conducted to obtain an independent measure of long-term physical activity. It is based on the Canadian Home Fitness Test (Shephard *et al.* 1976). The Step Test was carried out at the second meeting with subject after she had completed the 7-day activity diary. It is a marker for long term physical activity independent of recall. The 'step' was a portable double-step made from chipboard. It measured 20 cm (8") in height, 25 cm (10") in width, and 60 cm (24") long. For the test, each subject was asked to step up and down the two steps in standardised sequence, at a specific rhythm to beats of a metronome, specific for their age. The test consists of two 3-minute stepping sequences, with a thirty-second rest in between. The second stepping was performed at a faster rate than the first. The researcher gave the signals when the subject should start and stop the stepping. The researcher measured the 10-second radial pulse rate before stepping, immediately after stepping for the first 3 minutes period, and after stepping for the second 3 minutes period (the protocol for this test is attached in Appendix 8). Pulse rate was measured while subject was sitting down, because there were less body movements in this position. An evaluation chart for personal physical fitness based on the 10-second pulse rate was used to assess the subject's fitness level (Shephard *et al.* 1976).

### 4.2.7 Subjects

a) *Sample size*

The sample size was calculated on the premise that we wanted to detect a significant correlation coefficient of 0.3 between the diary and the FAQ physical activity measurements. At 80 percent power and 5 percent significant level, the number of subjects required would be 84 (Machin & Campbell, 1987).

b) *Subject recruitment*

The target population was South Asian women, aged 17 years and above, who resided in Southampton. From a list of GP clinics in the Southampton area their practice managers were contacted to explain that we were planning to carry out a health survey of the South Asian women in Southampton. This was the original plan of the study. They were also informed that we needed their co-operation in order for us to contact South Asian women who were registered with their practices. Four GP clinics gave their consent for us to study their register of female patients born before 1979 (written consent from two GP clinics are attached in Appendix 9). From this list 589 patients who had South Asian names were manually selected.

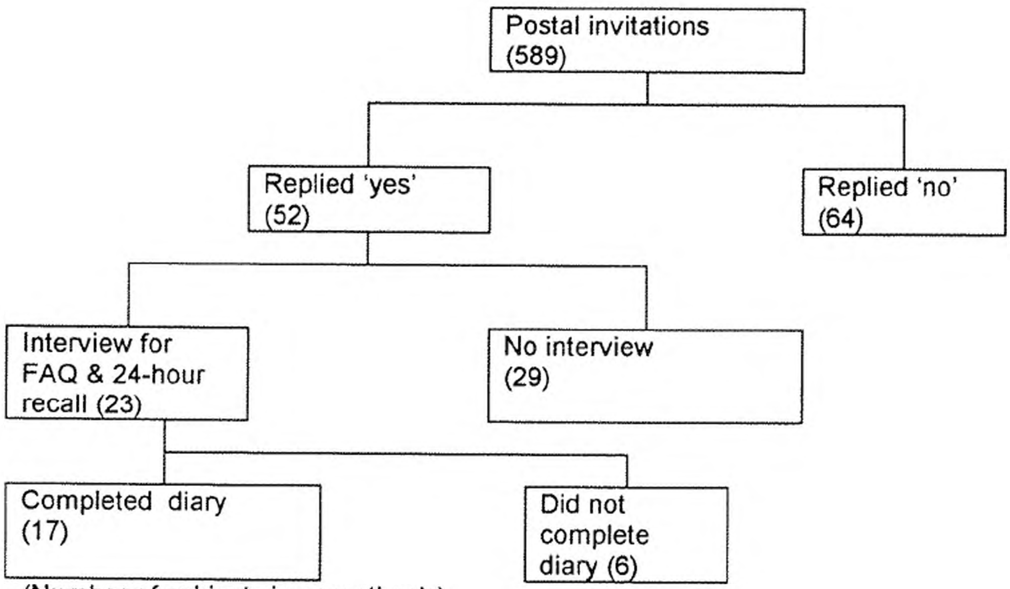
A letter together with a short self-administered questionnaire on diet, health, and physical activity was sent to all the selected patients. The questionnaire asked if they would be willing to be contacted for future studies, if 'yes' they should write their telephone number for us to contact them. They were asked to return the completed questionnaires in the prepaid envelopes provided. A reminder letter together with another copy of the questionnaire was sent if we did not receive their reply after one month (the letter and postal questionnaire are attached in Appendix 10).

A total of 116 replies (a 20 percent response rate) were received. From those who replied 52 (9%) said 'yes' they could be contacted for future studies, and 64 (11%) said 'no'. The fifty-two subjects who said 'yes' were contacted by telephone to explain to them about the validation study and ask them if they would like to take part in it. Only 23 subjects agreed to take part, who were then interviewed for the FAQ and the 24-hour activity recall, and asked to record their physical activities for 7-days. Seventeen of those who were interviewed completed and returned the 7-day diary. Figure 5 is a flow chart diagram showing the recruitment procedure for subjects by postal invitation.

Due to the poor response from the invitation by post, we decided to get volunteers through the community and by personal approach. Below is a list of strategies used to obtain volunteers for the validation study: -

i. Personal invitations to the women who attended the women-only sessions, drop-in sessions, playgroup sessions at several community centres in the St Mary and Portswood areas.

**Figure 5: Procedure for subject recruitment by letters**




(Number of subjects in parenthesis)

ii. Personal invitations to the women who were attending English classes at the Argyle Centre, the Women-in-Technology (WIT) classes at the Mount Pleasant primary school.

iii. Personal invitations to South Asian teachers in schools in the St Mary and Portswood areas as well as South Asian staff and students at the Southampton University.

iv. Requesting the volunteers to introduce the researcher to their friends or relatives who were interested to take part in the study.

v. Advertisements to invite students to take part in the study were also placed at the Southampton City College and the Southampton Institute, with permission from their respective authorities (a copy is attached in Appendix 11).

vi. An advertisement in the University Daily Bulletin inviting South Asian students to take part in the study.

### 4.2.8 Data analysis and statistical methods

a) *The FAQ*

Information from the questionnaire was entered into the computer. The number of minutes per week spent on each activity was multiplied by the number of weeks subjects had regularly performed it during the past year to obtain the total number of minutes spent in that activity per year. This total was divided by 365 to obtain the average minutes per day spent in that activity, and multiplied by the energy cost of that activity to obtain the energy expended in performing that activity per day. We used the reference values by James & Schofield (1990).

For women with employment, the total time spent at work per week was divided by seven days to obtain the average daily time spent at work. Appendix 12 is a list of subjects' occupations in the study. The total time in minutes per day spent at work was multiplied by the energy cost of their predominant work activity to obtain their daily energy expenditure for occupational activity. If they answered 'yes' to stair climbing at work only or at home only, we assumed that each subject spent 5 minutes per day in stair climbing. If they answered 'yes' to stair climbing both at work and at home, we assumed that they spent 10 minutes per day in stair climbing.

b) *The 24-hour recall and the activity diary*

For the 24-hour activity recall, a coding sheet was used to transfer manually information on the duration for each activity, its energy cost per minute, and its PAR (physical activity ratio) value (Appendix 3). Duration of each activity was multiplied by its energy cost per minute to obtain the total energy cost for that activity. Total energy cost of all activities was the total energy expenditure per 24-hours. The number of minutes spent per day in each PAR category was also computed for each subject. This information was then entered into the computer. Similar calculations were done for each day of recording in the activity diary. The total daily expenditure per seven days was divided by seven to obtain the average daily energy expenditure from the dairy. The total minutes spent in each activity category by their PAR for seven days was divided by seven to obtain the daily average.

Appendix 13 gives a list of the most commonly mentioned activities in the diary and the 24-hour recall and their energy cost per minute. Data analysis was performed using SPSS (Statistical Package for Social Science, for Windows. Release 6.1.3, 1995). The subject's basal metabolic rate (BMR) was calculated using the Schofield's equation (Schofield *et al.* 1985).

## 4.3 RESULTS

The results are presented in four sections. The first section (4.3.1) presents a comparison between subjects who responded 'yes' and those who responded 'no' to our postal invitations, and a comparison of the characteristics of subjects who completed and those who did not complete the validation study. Section 4.3.1 also presents the results of the within-measurer variability study for anthropometric measurements. The next section (4.3.2) presents the data from the 7-day activity diary and the 24-hour activity recall. It includes subjects' activity patterns, and their energy expenditure levels. Section 4.3.3 describes the physical activity measurements from the frequency of activity questionnaire (FAQ). The relative validity of the FAQ as an instrument to measure habitual physical activity among South Asian women was evaluated using the physical activity measurement from the diary and the 24-hour recall (section 4.3.4). Relative validity was assessed by comparing the group mean daily energy expenditure from the FAQ and the diary and the 24-hour recall, and correlation between the measures. The Bland-Altman analysis was used to test the level of agreement in physical activity measurements between methods. This section will also present results on the ranking of subjects into thirds of their energy expenditure distribution by the FAQ, the diary, and the 24-hour recall method. The effect of body weight on physical activity reporting was also explored and is presented in section 4.3.5. The last section (4.3.6) presents results of the 'Step Test'

### 4.3.1 Subjects

This study was conducted from July 1995 to March 1997 (20 months). From a total of 589 postal questionnaires and one reminder letter that we sent to South Asian women residing in Southampton, we received 116 replies (a 20 percent response rate). From those who replied, 52 (9%) said 'yes' they could be contacted for future studies. We contacted them by phone and invited them to take part in the validation study. Only 23 subjects agreed to take part, they were later interviewed for the FAQ and the 24-hour activity recall, and asked to record their physical activities for 7-days. Seventeen of those who were interviewed completed and returned the 7-day diary.

Twenty-nine subjects had replied 'yes' but did not agree to take part in the validation study. The following were reasons given for their not taking part (table 4.1).

**Table 4.1: Reasons for not taking part in the validation study**

| Reason | Number |
|---|---|
| Unable to speak to the subject after more than three phone calls | 5 |
| Subject lived outside of Southampton | 5 |
| Subject had gone to India | 5 |
| Subject was not interested to take part | 4 |
| Subject was busy with job and housework | 4 |
| Subject failed to keep with three or more appointments | 2 |
| Subject had no telephone | 2 |
| Their telephone was not in service | 1 |
| Subject did not speak English very well | 1 |

The proportion of Indians among 'yes' respondents were higher compared to the 'no' respondents. The 'yes' respondents appeared to have higher educational levels and had higher BMI than the 'no' respondents. Due to the poor response from the invitation by post, subjects were recruited through the community and by personal approach. By using this approach 67 subjects volunteered to participate. They completed the FAQ and the 24-hour recall interview, 40 of whom returned the 7-day activity diary. Fifty-seven subjects had completed the interview and the 7-day diary. However, one of them had her FAQ missing, and two subjects had their 24-hr recall missing. The final number of subjects who completed all the three methods of assessments, that is the FAQ, the 24-hour activity recall, the activity diary was 55, as shown in table 4.3.

**Table 4.2: Characteristic of respondents to the postal invitation**

| | Replied 'yes' | Replied 'no' |
|---|---|---|
| **Number of subjects** | 52 | 64 |
| **Ethnic group** | **% (n)** | **% (n)** |
| Indian | 71 (37) | 58 (37) |
| Pakistani | 27 (14) | 30 (19) |
| Bangladeshi | 2 (1) | 11 (7) |
| Other | - | 1 (1) |
| % Born in the UK | 58 | 58 |
| **Educational level** | **(%)** | **(%)** |
| Nursing, polytechnic, university | 11.5 | 6.3 |
| City or Guilds certificates | 9.6 | 9.5 |
| GCE 'A' level | 21.2 | 14.3 |
| GCE 'O' level or equivalent | 19.2 | 17.5 |
| Educated outside the UK | 25.0 | 17.5 |
| No formal education | 3.8 | 25.4 |
| Other | 7.7 | 7.9 |
| Do not know | 1.9 | 1.6 |
| % Employed | 58 | 45 |
| Age (years), mean (±SD) | 26.0 (±5.7), n = 52 | 24.3 (±5.5) n = 63 |
| Weight (kg), mean (±SD) | 58.1 (±9.0) n = 46 | 53.4 (±9.5) n = 59 |
| Height (cm), mean (±SD) | 157.9 (±5.9) n = 47 | 158.4 (±7.5) n = 59 |
| Body mass index, mean (±SD) | 23.5 (±3.6) n = 45 | 21.5 (±4.3) n = 56 |

Two subjects who received the postal questionnaire and had replied 'no', later agreed to take part after they were introduced by their relative to the interviewer. Both had completed the validation study. Another two subjects, who received the postal questionnaire but did not reply, had later agreed to take part after they were introduced by their friends to the interviewer. One of them had completed the validation study, the other subject had only completed the FAQ and the 24-hour recall.

It is possible that other subjects whom the interviewer met at the community centres were not from the four GP clinics that had given their co-operation.

Table 4.3: Number of subjects who completed the assessment

| Method | Number |
|---|---|
| FAQ | 89 |
| Recall | 88 |
| Diary | 57 |
| All | 55 |
| Step test | 49 |

Table 4.4 compares the characteristics between the 57 respondents (subjects who completed the FAQ, the 24-hr recall and the activity diary), and the 33 non-respondents (those who completed the FAQ, the 24-hr recall but not the diary). There was a higher proportion of Pakistanis, Bangladeshis among respondents than the non-respondents. The proportion of Indians was lower in the respondents compared to the non-respondents. More respondents were employed compared to the non-respondents. Respondents tended to be younger than the non-respondents.

Table 4.4: Comparison of respondents and non-respondents for the validation study

| | Respondents | Non respondents |
|---|---|---|
| Number of subjects | 57 | 33 |
| **Ethnic group** | **% (n)** | **% (n)** |
| Indian | 56 (32) | 70 (23) |
| Pakistani | 31.5 (18) | 24 (8 |
| Bangladeshi | 9 (5) | 6 (2) |
| Other | 3.5 (2) | - |
| % Employed | 61 | 45.5 |
| Age (years), mean (±SD) | 28.9 (±8.7) | 30.3 (±9.2) (n =33) |
| Weight (kg), mean (±SD) | 59.4 (±12.1) | 57.7 (±11.8) (n = 24) |
| Height (cm), mean (±SD) | 157.2 (±5.4) | 156.3 (±6.4) (n = 24) |
| Body mass index, mean (±SD) | 24.6 (±4.7) | 23.6 (±4.4) (n = 24) |
| Waist circumference (cm), mean (±SD) | 77.8 (±12.7), (n = 46) | not available |
| Hip circumference (cm), mean (±SD) | 97.2 (±9.3), (n = 48) | not available |
| Waist-Hip ratio, mean (±SD) | 0.79 (±0.08) (n = 46) | not available |

(Age and all anthropometric measurements had distributions that were not significantly different from the normal distribution using the Kolmogorov-Smirnov Goodness of Fit Test).

An intra-measurer variability study was carried out to assess the measurement error for the anthropometric measurements conducted by the researcher. In this study one female subject was measured for ten consecutive days at different times of the day.

**Table 4.5: Results of an intra-measurer variability study**

| | Weight (kg) | Height (cm) | Waist circumference (cm) | Hip circumference (cm) |
|---|---|---|---|---|
| Mean | 57.2 | 151.2 | 75.9 | 91.6 |
| Minimum | 56.7 | 150.1 | 75.0 | 90.6 |
| Maximum | 57.9 | 152.7 | 76.7 | 93.4 |
| SD | ±0.43 | ±0.75 | ±0.65 | ±0.86 |
| Coefficient of variation (%) | 0.8 | 0.5 | 0.9 | 0.9 |

The standard deviation from the variability study was smaller than that for measurement of subjects in the actual survey (table 4.5). Therefore the within-measurer error of the weight and height measurements was smaller than the between-subject variability in the study.

### 4.3.2 The activity diary

Out of 57 subjects who returned the dairy, fifty-one had completed the 7-day activity records. Two subjects completed only 6-day records, three subjects had 5-day records, and one subject had only 4-day records. Days that the subjects did not record were weekdays. The reason given for not recording was that the activities for those days not recorded were similar to the other weekdays. For those subjects whose records were less than seven days, their total energy expenditure was divided by the number of days recorded to obtain the mean daily energy expenditure, and this was multiplied by seven to obtain the weekly energy expenditure.

All subjects had recorded their activities in consecutive days. However, subjects had taken from two weeks to two months to begin their activity recording. The quality of the records varied. There were subjects who recorded their activity in detail and there were subjects who described their activities in one or two words only. Some subjects maintained the same quality of recording throughout the whole week. Some subjects who started with detailed records gradually recorded in less detail after a few days. Some had recorded several activities within one time period. These needed to be clarified with the subject later on. Most subjects reported that they could not record their activities as they were being performed. Thus the activities were recorded at a later time several times a day, or the whole days activity would be recorded at the end of the day, for example before going to bed at night.

Figure 6 shows the distribution of average daily expenditure from the diary. Two subjects had reported daily energy expenditure that was much higher than the group mean. One of the subjects was a postgraduate research student who was working in a laboratory-based project. In her working hours she spent most of her time standing and walking about. Everyday she walked about one mile from her house to the university. The other subject was working in a laboratory too, and during her working hours she spent most of her time standing and walking about.

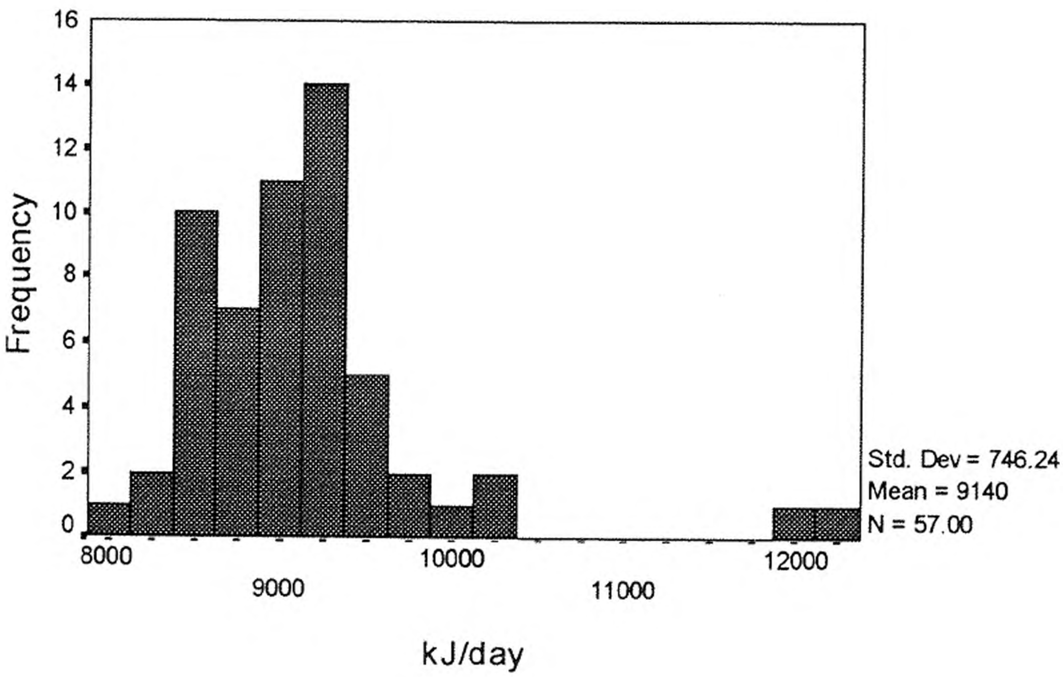
The energy expenditure during weekdays and weekends were compared. The mean energy expenditure during weekdays was transformed into the log (natural) scale to assume a symmetrical distribution. There seems to be no difference in mean daily energy expenditure during weekdays and weekends (table 4.6).

Table 4.6: **Mean energy expenditure from the diary, kJ/day**

| | Mean | (95% confidence interval) |
|---|---|---|
| Week days | *9145 | (8933 - 9363) |
| Weekend days | 9058 | (8857 - 9258) |
| Week days & weekends combined | 9140 | (8942 - 9338) |

* Geometric mean

**Figure 6: Distribution of energy expenditure from the diary**




The activities recorded by subjects were put into eight groups of increasing intensity using the PAR values as the cut off point (James & Schofield, 1990). Group 1 and 2 represent inactivities, group 3 represents low intensity standing activities, group 4,5 and 6 represent moderate intensity activities, and group 7 and 8 represent high intensity activities. Table 4.7 lists the types of activities in each group.

To give an indication of their physical activity patterns, the average time spent in each activity group from table 4.7 was calculated for week days and week end days (table 4.8). This represented their total activity time during work, at home and during leisure time as reported in the 7-day diary.

At weekends, subjects spent on average an extra forty minutes per day sleeping compared to weekdays. The time spent sitting down was less during weekends compared to weekdays. There was no difference in time-spent standing, preparing food, cooking, brisk walking, washing and dressing during weekdays and weekends. Subjects spent on average an extra 50 minutes per day shopping and walking about during weekends compared to weekdays.

**Table 4.7: Activity groups and their PAR values**

| Activity | PAR Value |
|---|---|
| **Group 1** | |
| Sleeping, lying down | 1.0 |
| **Group 2** | |
| Sitting at rest, | 1.09 |
| Sitting with activities | 1.33 |
| Sitting at work | 1.44 |
| Ironing | 1.46 |
| **Group 3** | |
| Standing and talking | 1.51 |
| Washing dishes | 1.54 |
| Preparing vegetables/sandwiches, making tea | 1.56 |
| Standing at work | 1.71 |
| Cooking | 1.80 |
| **Group 4** | |
| Walking on the level (1-2 km/h) | 2.23 |
| Standing doing laboratory work | 2.38 |
| **Group 5** | |
| Washing, taking a shower, dressing up | 2.69 |
| Walking briskly (3-4 km/h) | 2.87 |
| Hand washing clothes | 3.19 |
| Setting the table | 3.37 |
| **Group 6** | |
| Household chores | 3.91 |
| Walking fast (4-5 km/h) | 3.77 |
| Aerobic dancing - low intensity | 3.91 |
| **Group 7** | |
| Bed making | 4.57 |
| Gardening | 4.82 |
| Climbing stairs | 5.19 |
| Cycling | 5.50 |
| **Group 8** | |
| Moderate & high intensity exercises | 6.31 |
| Jogging | 8.21 |

At weekends subjects spent on average an extra fifteen minutes per day cleaning the house or fast walking, compared to weekdays. Very few subjects had reported doing high intensity activities such as gardening, cycling, swimming, jogging and exercises, thus the median for the group was zero. The time spent on other types of activities was similar during weekdays and weekends. On average, subjects spent seventy percent of their time in sitting activities and sleeping.

**Table 4.8:** **Average time spent at different activities from the diary**

| Activity group | Type of activity | Monday-Friday<br>Mean ±SD (min; max) | Saturday-Sunday<br>Mean ±SD (min; max) | All week<br>Mean ±SD (min; max) |
|---|---|---|---|---|
| | | **(hour/day)** | **(hour/day)** | **(hour/week)** |
| 1 | Sleeping, Lying down | 9.3 ±1.2<br>(5.9; 12.0) | 10.0 ±1.6<br>(6.5; 14.0) | 66.6 ±8.1<br>(42,7; 79.7) |
| 2 | Sitting Ironing | 8.3 ±2.7<br>(2.7;13.1) | 7.4 ±1.9<br>(2.8; 11.5) | 56.1 ±15.3<br>(19.0; 83.8) |
| 3 | Standing Preparing food Cooking | 3.1 ±1.9<br>(0.35; 7.6) | 2.8 ±1.8<br>(0.58; 8.04) | 20.8 ±12.3<br>(3.8; 54.1) |
| | | **(min/day)** | **(min/day)** | **(min/week)** |
| 4 | Shopping Walking about | 40± 21.0<br>(0.0; 55.3) | 92.8 ±66<br>(0.0; 252.5) | 579 ±522<br>(0.0; 3125) |
| 5 | Brisk walking Washing, Dressing | 72.9 ±30.6<br>(26; 172.5) | 72.9 ±33<br>(25; 197.5) | 510 ±186<br>(275; 1190) |
| 6 | Cleaning the house Fast walking | 44.5 ±40.8<br>(0.0; 172.5) | 60.6 ±51<br>(0.0; 207.5) | 341.5 ±264<br>(0.0; 995) |
| 7 | Stair climbing Gardening Cycling, Swimming | *0.0 (0.0, 0.0)<br>(0.0; 17) | *0.0 (0.0, 0.0)<br>(0.0; 50) | *0.0 (0.0; 27.5)<br>(0.0; 116.7) |
| 8 | Jogging Moderate & high intensity exercises | *0.0 (0.0, 24.5)<br>(0.0; 65) | *0.0 (0.0, 0.0)<br>(0.0; 30) | *0.0 (0.0, 0.0)<br>(0.0; 325) |

* Values are median (25th & 75th percentiles)

To calculate the number of days required by subjects to record their activity diary that will give an accurate measure of their normal activity the formula used was:-

$$D = \frac{r^2}{1-r^2} \times \frac{S^2_w}{S^2_b}$$

(Nelson *et al.* 1989)

Where D is the number of days of activity needed to obtain a given r between the unobservable correlation between the observed and the true physical activity of individuals over the study period. $S^2_w$ and $S^2_b$ are the observed within- and between-subject variances. Each variance component was computed using the variance component estimation procedure by the SAS software package (SAS Institute, Inc., Cary, North Carolina).

**To estimate D, where r = 0.9:**

$$D = \frac{0.9^2}{1 - 0.9^2} \times \frac{507878.48}{460909.95}$$

$$D = \frac{0.81}{0.19} \times 1.1019$$

$$D = 4.69$$

At r = 0.9, the proportion of subjects correctly classified into thirds is 0.86, and the proportion of subjects incorrectly classified is less than 0.001 (Nelson *et al.* 1989). Therefore the study needs to collect at least five days of recorded activity to obtain enough precision so that more than 80 percent of the subjects would be correctly classified.

### 4.3.3 The 24-hour activity recall

The time and date for the interviews were mainly determined by the subjects to suit their convenience. Due to the long duration anticipated for the interview, subjects had preferred to hold it during weekdays. For housewives, those were times when their children were at school. For the working women, those were the times when they could be available. For others, weekdays were the times the interviewer could meet them at the community centres, playgroups or at their study centres. Fridays and Saturdays have not been recalled by any subject (table 4.9). From the frequency of the energy distribution three subjects had recalled high activity levels (figure 7). Two of them were the same subjects who had reported the highest daily energy expenditure from the diary. They both had recalled on a weekday (their working day). The third subject was a house wife and part time support worker. She had recalled on weekday activities that involved cleaning the house, walking to the shops and looking after her baby. The median energy expenditure from the 24-hour recall was 9068 kJ, the 5th and 95th percentiles being 7926 and 10736 kJ, respectively. Similar to the diary, more than 70 percent of the subject's time on average was spent in sitting activities and sleeping (table 4.10).

**Table 4.9: Frequency of days covered in the 24-hour recall**

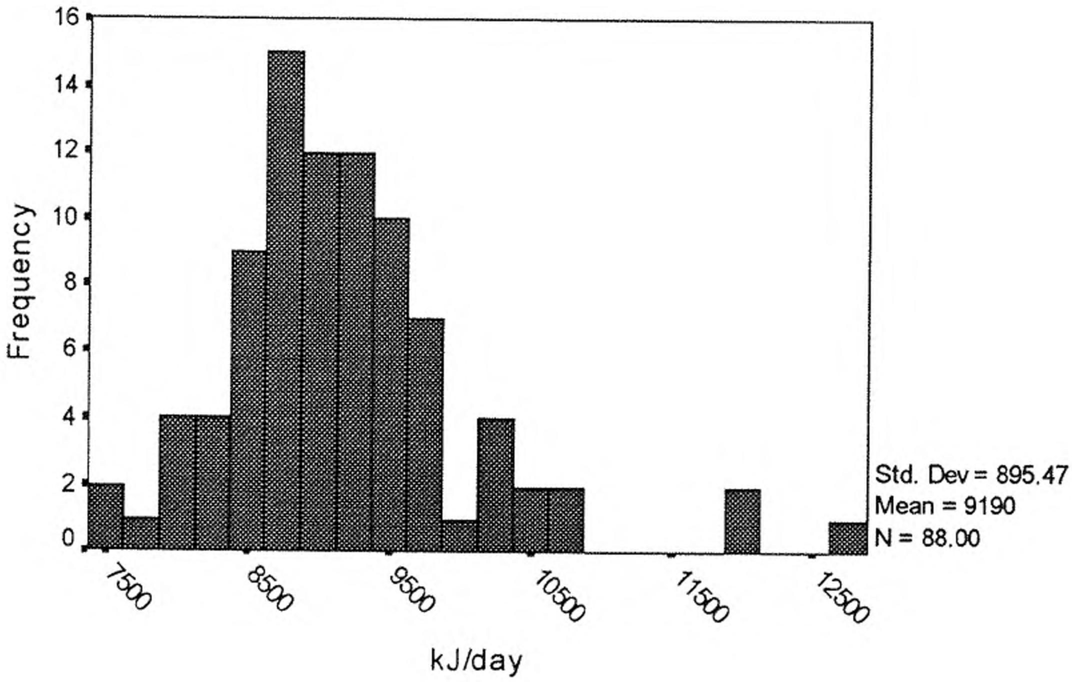
| | |
|---|---|
| Monday | 25 % |
| Tuesday | 25 % |
| Wednesday | 28 % |
| Thursday | 9 % |
| Friday | 0 % |
| Saturday | 0 % |
| Sunday | 13 % |

Table 4.10: Time spent at different activity groups, from the 24-hour recall

| Activity group | Type of activity | Average time spent, mean (95% confidence interval) |
|---|---|---|
| | | (hours/day |
| 1 | Sleeping, lying down | 9.2 (8.9 - 9.5) |
| 2 | Sitting, Ironing | 8.0 (7.4 - 8.6) |
| 3 | Standing, preparing food, cooking | 3.6 (3.1 - 4.2) |
| | | (min/day) |
| 4 | Walking about, shopping | *50 (10; 78) |
| 5 | Brisk walking, washing, dressing | *60 (36; 75) |
| 6 | Cleaning the house, fast walking | *28 (10; 89) |
| 7 | Stair climbing, gardening, cycling, swimming | *0.0 (0; 0) |
| 8 | Jogging, moderate-high intensity exercise | *0.0 (0; 0) |

*Median (25th & 75th percentiles)

**Figure 7: Distribution of energy expenditure from the 24-hr recall method (For 88 subjects)**



### 4.3.4 The Frequency of Activity Questionnaire (FAQ)

We have data for 89 subjects who answered the FAQ. The results for these subjects will be presented first to describe their habitual physical activity pattern. Their physical activity will be compared with the 24-hour recall. Later the results for only the 56 subjects who completed the FAQ, the 24-hour recall and the diary will be used to assess the relative validity of the FAQ.

From the FAQ, sleeping accounted for 33 percent of the subjects' total time (168 hours) in a week (table 4.11). For working women, the time spent at work took the second largest portion of their time. For non-working women, cooking, cleaning the house and washing dishes occupied the second largest portion of their time. Preparing food and cooking can be combined together because some subjects could not allocate separate times for these activities. Working women spent more time in doing exercises such as brisk walking, gardening, swimming or gym exercises compared to non-working women.

From the diary, the accumulated time spent in activities of moderate or high intensity activities (PAR > 3.0) ranged from 355 to 1885 minutes per week (50 to 270 minutes per day). Examples of these activities are dressing, cleaning the house, stair climbing, gardening, brisk and fast walking, sports and exercise. From the 24-hr recall, the total time spent in moderate or high intensity activities ranged from 30 to 410 minutes per day. The time spent in these activities from the FAQ was less (Table 4.12).

Table 4.11: **Average time spent at various activities, from the FAQ**

| Activity | Hours per week , median (25th; 75th percentiles) | | |
|---|---|---|---|
| | All subjects | Employed | Not employed |
| Number of subjects | 57 | 35 | 22 |
| Sleeping | 56 (49.0; 63.0) | 56 (49.0; 59.5) | 56 (55.0; 63.0) |
| At work | 36.0 (12.0; 40.0) | 36.0 (6.6, 63.2) | 0 |
| Ironing | 0.54 (0, 1.5) | 0.75 (0, 2.0) | 0.5 (0, 1.5) |
| Preparing food | 0.67 (0.0, 3.5) | 1.1 (0.0, 3.5) | 0.0 (0.0, 3.5) |
| Cooking | 4.0 (1.7; 8.6) | 4.0 (2.3; 7.0) | 6.5 (1.3; 10.3) |
| Washing dishes | 2.3 (1.1 , 5.2) | 1.8 (1.0, 5.3) | 2.9 (1.2, 4.6) |
| Leisurely walking | 0.67 (0.0, 2.5) | 0.5 (0.0, 2.3) | 0.75 (0.0, 3.1) |
| Shopping for food | 1.0 (0.5, 1.5) | 1.0 (0.5, 1.7) | 1.0 (0.1, 1.5) |
| Cleaning the house | 3.8 (1.8, 8.6) | 3.0 (1.8, 9.0) | 4.5 (2.1, 10.8) |
| Hand washing clothes | 0.1 (0.0, 0.5) | 0.2 (0.0, 0.5) | 0.1 (0, 0.5) |
| Moderate-high intensity exercise | 1.25 (0.0, 8.3) | 1.6 (0.0, 10.0) | 1.0 (0.0, 7.5) |
| Others e.g. DIY, home decorating, washing car | 0.0 (0.0, 2.0) | 0.0 (0.0, 3.0) | 0.0 (0.0, 1.5) |
| Percent of time accounted for in a 24-hour period | 59.0 % | 64.9 % | 51.0 % |

After computing the total time spent daily in sleeping, at work, doing household chores, leisure activities and stair climbing for each subject, the activities reported in the FAQ covered only 59 percent of the total 24-hour period. The average time unaccounted for in the group was 9.4 hours per day. In individual subjects it ranged from 2.2 hours to 15.0 hours per day. Subjects with occupations had reported more activity time than subjects who did not work.

Table 4.12: **Time spent in moderate-high intensity activities**

| **Method** | **Median** | **25th, 75th percentiles** |
|---|---|---|
| Diary, min/week | 880 | (638, 1038) |
| FAQ, min/week | 451 | (451, 891) |
| 24-hr recall, min/day | 110 | (61, 163) |

At the group level it was lower than their average BMR. These subjects may have under reported their activities performed during the previous twelve months. One possible explanation for this time deficit is that several activities performed regularly by the subjects have been left out from the questionnaire. As a result, the mean daily energy expenditure calculated was unreasonably low. Examples of these activities that have been excluded were taking care of children, social activities (sitting and talking), resting activities (watching TV or video), and student activities. These activities were part of the daily physical activity for some of the subjects. An adjustment to the daily energy expenditure for individual subject was then made.

**How the energy adjustment was done**

1. From the FAQ reported activities the average number of minutes per day spent in activities was calculated. This was called the FAQ activity time. The FAQ activity time was subtracted from 1440 minutes (24 hours) to obtain the time unaccounted for in the FAQ, which was called the "time deficit". To estimate the energy expenditure during this 'time deficit' each subject was assigned an energy-cost factor.
2. From the time deficit, it was found that unemployed subjects and postgraduates students had more time deficit than employed subjects and under graduate students.
3. Based on these, subjects were placed into four categories. First was for the students involved in laboratory research. Second was for the housewives with children. Third was for the other undergraduate and postgraduate students. Fourth was for the housewives without children, the unemployed and those with jobs. They had different activity patterns based on their activity diaries. This is shown in Table 4.13 below.

Table 4.13: **The energy adjustment for the FAQ**

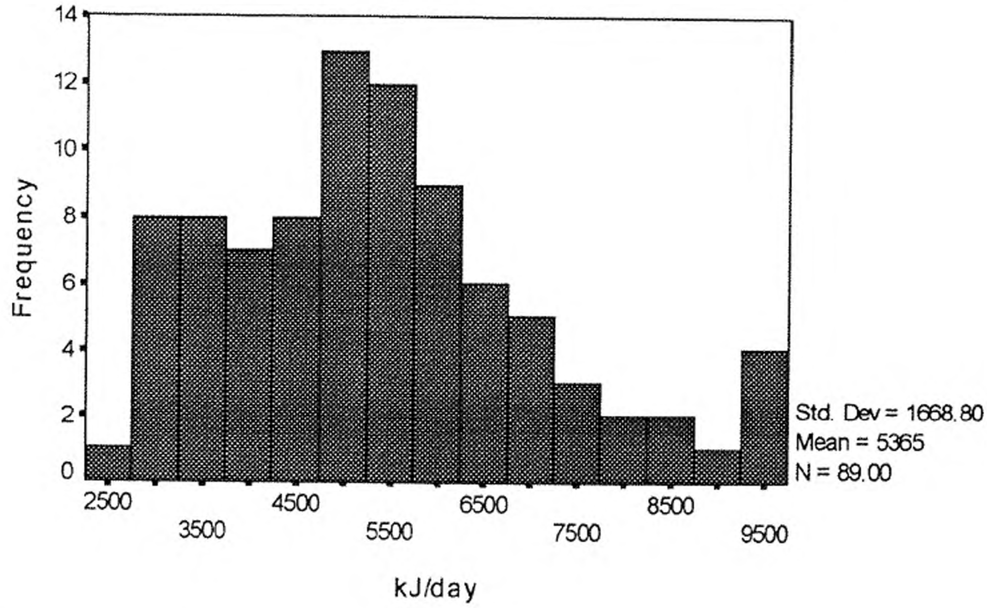
| Subject category | Energy cost factor, kJ/min | Assumed major activity component in time deficit |
|---|---|---|
| 1. Post graduate student involved in laboratory research | 14.32 | Laboratory work |
| 2. Housewife with children | 7.17 | Standing (unspecified activities) |
| 3. Students, mostly attending lectures | 6.44 | Sitting working |
| 4. Unemployed/employed/housewife without children | 5.50 | Sitting at rest |

4. The energy cost factor was multiplied with the time deficit, then added to the daily energy expenditure from the FAQ. This is called the adjusted FAQ daily energy expenditure.

5.. The adjustment used the researcher's personal knowledge about the subjects' activity patterns from the survey. There is a possibility that it has influenced the level of agreement between the FAQ and the diary and the FAQ and the 24-hour recall.

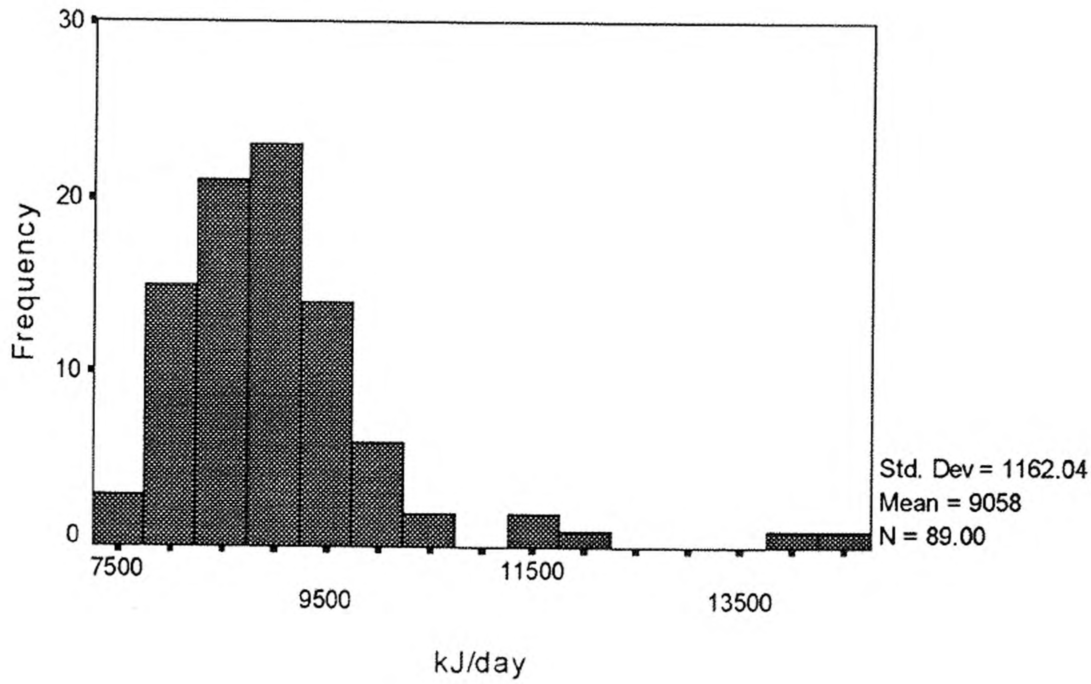
The level of agreement between the diary and the FAQ and between the 24-hr recall and the FAQ improved considerably after this adjustment was made. The physical activity measures from the FAQ will be presented without adjustments (unadjusted), and after adjustments (adjusted). Figures 8 and 9 show the frequency distribution the daily energy expenditure from the FAQ (unadjusted) and from the FAQ (adjusted), respectively. All subjects were adjusted to higher energy expenditure levels. After adjustment five subjects showed the highest energy expenditure level. Two of them were postgraduate research students who worked in the laboratory. Their energy cost factor for the

Figure 8: **Frequency distribution for energy expenditure from the unadjusted FAQ (for 89 subjects)**




adjustment was the largest compared to other subjects. Being students they reported themselves as unemployed. Thus their working hours, which involved mostly standing, and walking but were not included in the occupational activities, neither was it reported in

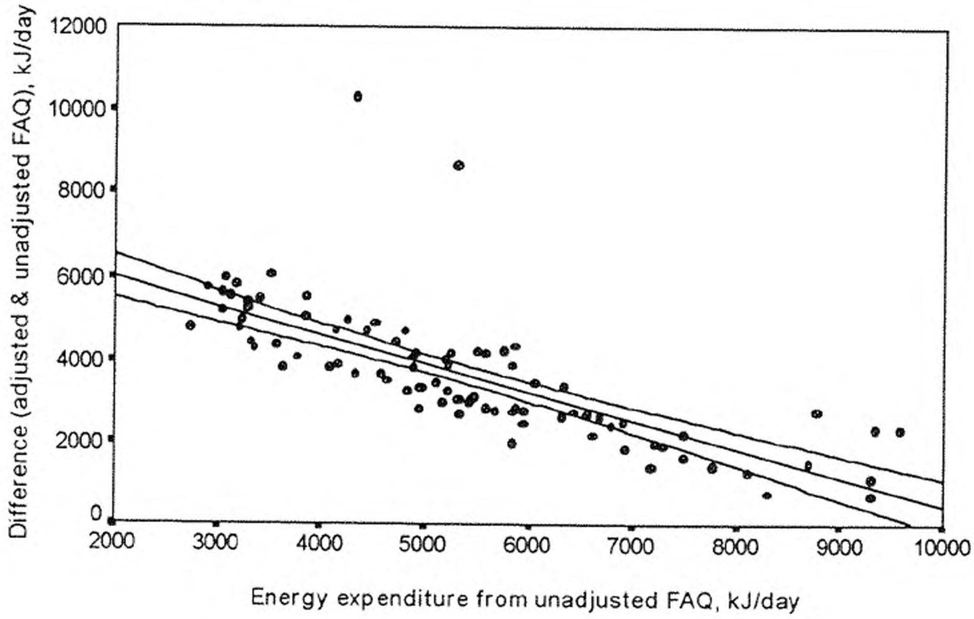
Figure 9: **Frequency distribution for energy expenditure from the adjusted FAQ (for 89 subjects)**



other activities. The other three subjects had reported high physical activity levels in the FAQ. A scatter diagram of the difference against the energy expenditure from the unadjusted FAQ shows that values from the two subjects (postgraduate research students) that fell outside of the group's cluster (Figure 10). The mean difference between energy expenditure from the unadjusted and adjusted FAQ was 3693 (±1564) kJ/day. The difference was negatively related to the energy expenditure from the unadjusted FAQ ($r = -0.87$, $p=0.000$)

After adjustment 6 subjects (6.7%) changed their ranking in thirds of the FAQ energy distribution by two tertiles (up or down), 46 subjects (51.7%) changed by one tertile, and 37 subjects (41.6%) remained in the same tertile. Energy expenditure from the adjusted FAQ and from the 24-hour recall were later transformed to log (natural) scale to assume a symmetrical distribution, and used for subsequent statistical analysis.

**Figure 10: A scatter plot for difference between energy expenditure from the unadjusted and adjusted FAQ (regression line with 95% confidence interval)**




The mean daily energy expenditure from the unadjusted FAQ was much lower than the mean daily energy expenditure from the adjusted FAQ and the 24-hour recall (table

4.14). The correlation between the mean daily energy expenditure from the unadjusted FAQ and the 24-hour recall was low. The correlation between the mean daily energy expenditure from the adjusted FAQ, and the 24-hour recall was moderate (table 4.15). The wide confidence interval indicates that estimate of sample correlation was not very precise.

**Table 4.14: Mean energy expenditure from the unadjusted FAQ, adjusted FAQ, and the 24-hour recall, kJ/day (n = 87)**

| | Mean (95% confidence interval) |
|---|---|
| FAQ (unadjusted) | 5365 (5013 - 5716) |
| FAQ (adjusted) | *9005 (8111 - 9228) |
| 24-hour recall | *9152 (8964 - 9330) |

* geometric mean

Figures 11 and 12 show the scatter plot of the mean daily energy expenditure from the unadjusted FAQ against the 24-hour recall, the mean daily energy expenditure from the adjusted FAQ against the 24-hour recall, respectively. At the group level there was moderate agreement between energy expenditure estimated by the unadjusted FAQ and by the 24-hour recall (figure 13). The mean difference between the two methods was 3823 kJ/day. The limits of two standard deviations below and above the mean difference were 461 kJ/day and 7185 kJ/day. This is called the 95 percent limits of agreement (Bland & Altman, 1986). This means that for 95 percent of the subjects the outcome of the unadjusted FAQ fell within an interval of 461 kJ below and 7185 kJ above the outcome of the 24-hour recall. The unadjusted FAQ had underestimated daily energy expenditure by 3823 kJ/day for the group. Only one subject had her unadjusted FAQ energy expenditure that was higher than the 24-hour recall.

**Figure 11:** **A scatter plot for energy expenditure from the unadjusted FAQ and 24-hr recall (For 87 subjects)**

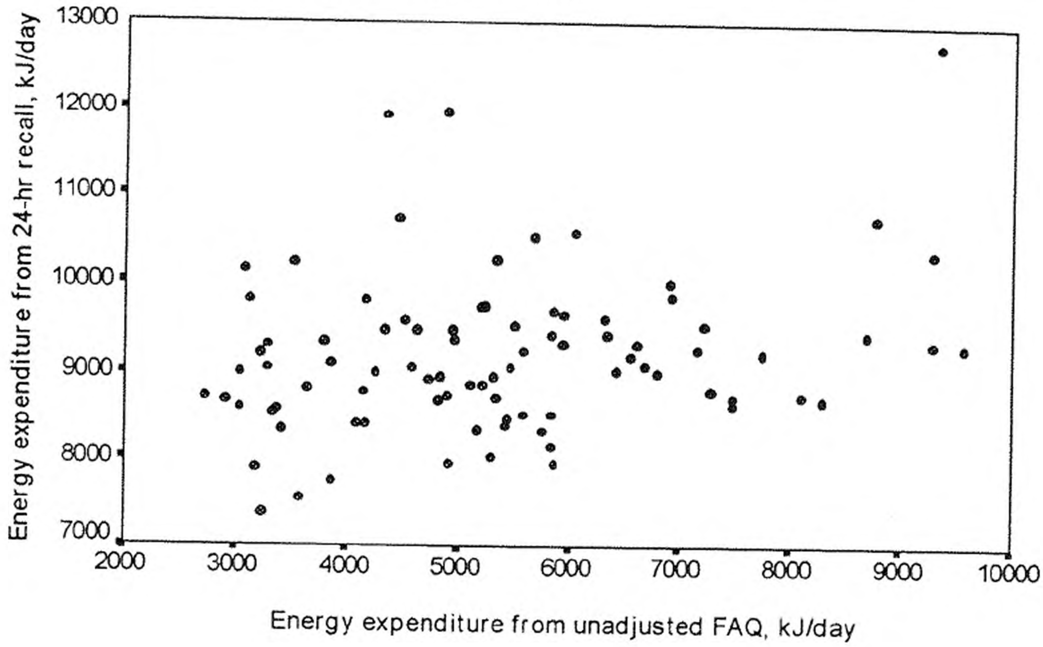



**Figure 12:** **A scatter plot for energy expenditure from the adjusted FAQ and 24-hr recall (For 87 subjects)**

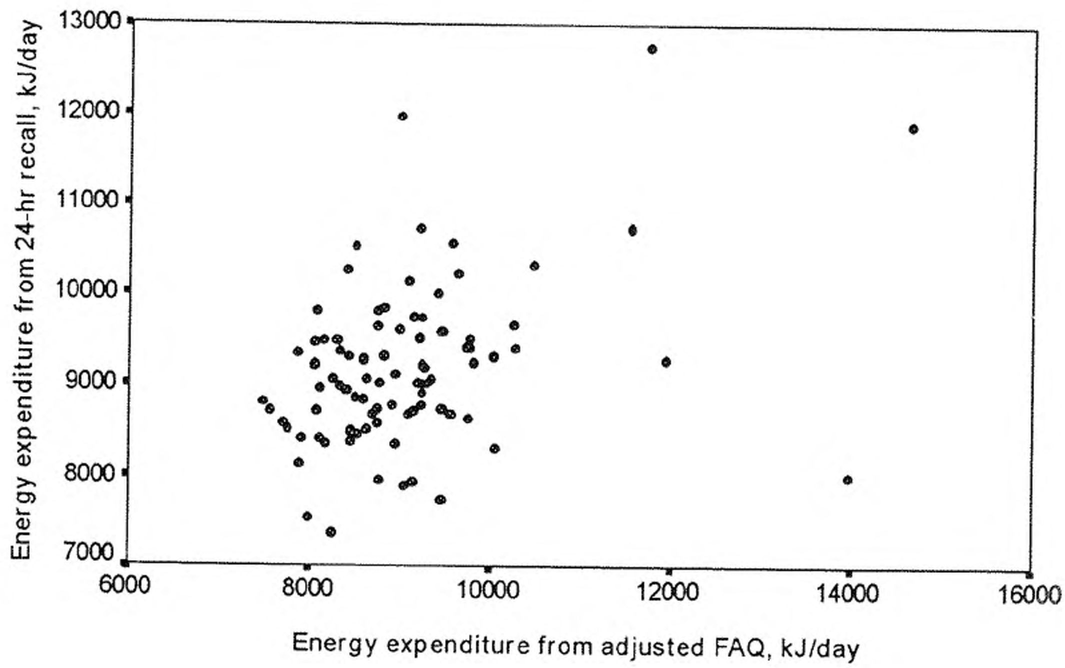


**Figure 13:** **A Bland-Altman plot for energy expenditure from 24-hr recall and unadjusted FAQ, (n = 87)**

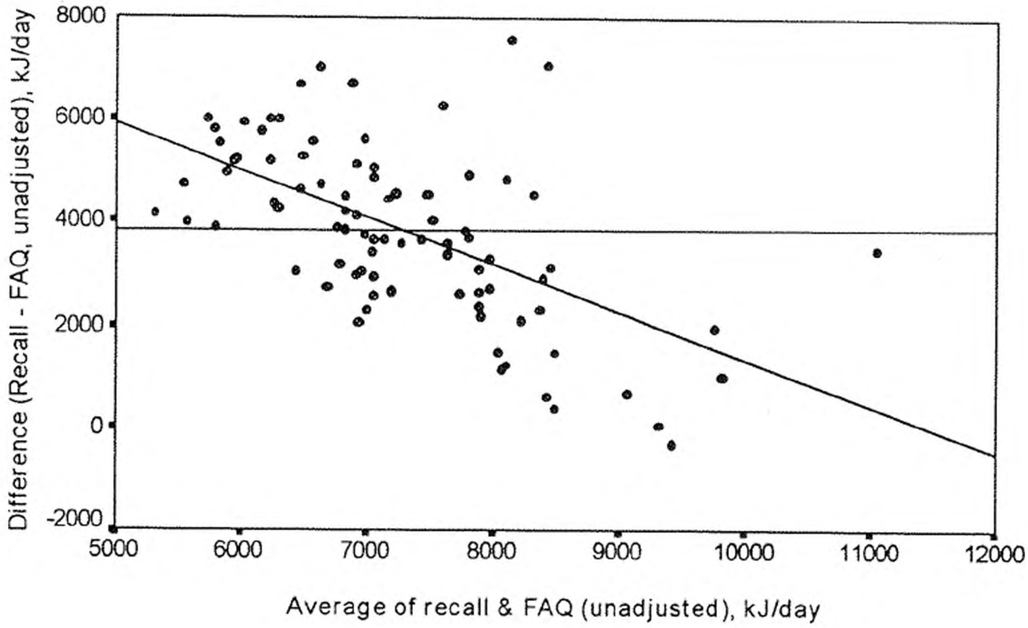



**Table 4.15:** **Spearman correlation coefficient ( r ) between energy expenditure from the FAQ and 24-hr recall (n=87)**

| | r | 95% CI | p-value |
|---|---|---|---|
| FAQ (unadjusted) vs. 24-hr recall | 0.24 | (0.03 - 0.43) | 0.025 |
| FAQ (adjusted) vs. 24-hr recall | 0.32 | (0.11 - 0.50) | 0.003 |

There was a negative correlation between the mean difference and the average of the two methods (r = -0.60, p = 0.000), as shown in table 4.16. This means that there was a

**Table 4.16:** **Mean difference and average of two methods (for 87 subjects)**

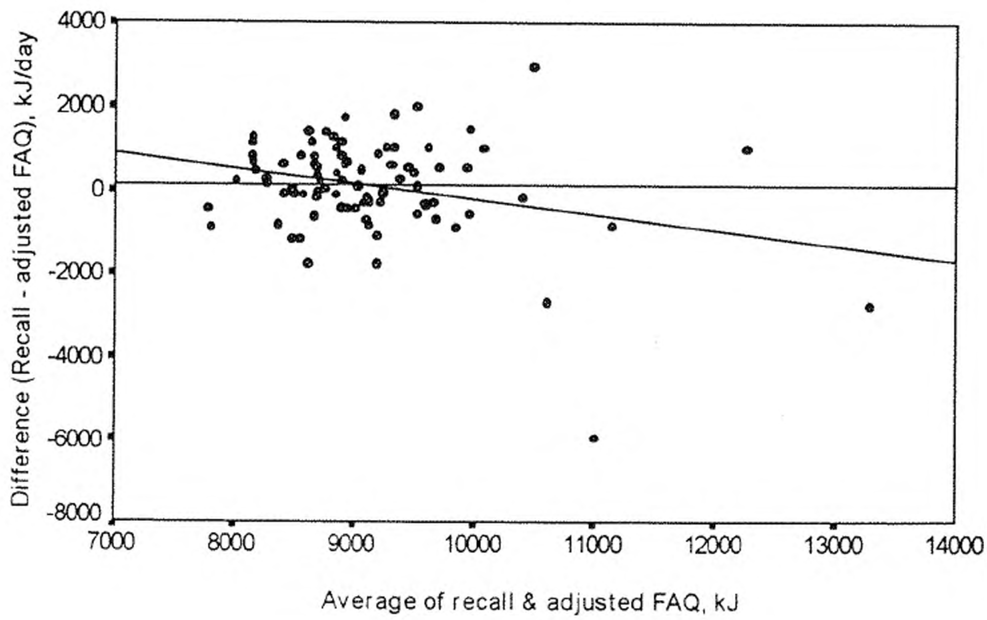
| | Average | ±SD | Difference | ±SD | Correlation between average and difference (p-value) |
|---|---|---|---|---|---|
| Recall - FAQ (unadjusted), kJ/day | 7282 | ±1059 | 3823 | ±1681 | -0.60 (0.000) |
| Recall - FAQ (adjusted), kJ/day | 9131 | ±867 | 126 | ±1156 | -0.09 (0.400) |

trend for the unadjusted FAQ to underestimate energy expenditure for subjects with lower physical activity levels, and to overestimate energy expenditure for subjects who had higher physical activity levels.

The adjusted FAQ also underestimated daily energy expenditure compared to the 24-hour recall, but not as large as the adjusted FAQ. For the group, the adjusted FAQ underestimated energy expenditure by 173 kJ (1.4 percent), as seen in Figure 14. However at the individual level the errors were large, it ranged from an underestimation of 5945 kJ (-74%) to an overestimation of 2989 kJ (+25%). The 95 percent limits of agreement were -1030 kJ and 1281 kJ. There was no significant correlation between the mean difference and the average energy expenditure of the two methods. Differences between two methods appeared to be randomly distributed.

The proportion of subjects correctly classified by both methods indicates the level of agreement between the FAQ and the 24-hour recall. Comparing the unadjusted FAQ with the 24-hour recall, thirty-eight percent of the subjects were correctly classified

**Figure 14: A Bland-Altman plot for energy expenditure from recall and adjusted FAQ (for 87 subjects)**



(**bold numbers**). Gross misclassification (underlined numbers) occurred in sixteen percent of the subjects (table 4.17). The Kappa statistics indicated that the level of agreement was poor and not significant. Chance alone could have accounted for the percent agreement between the two methods. Comparing the adjusted FAQ with the 24-hour recall, correct classification occurred in 44 percent of the subjects, and gross misclassification in fourteen percent (table 4.18). The Kappa statistics indicated that the agreement between the two methods was moderate.

**Table 4.17:** **Percent classification of subjects into thirds of their daily energy expenditure by the unadjusted FAQ and the 24-hour recall method (n = 87)**

| | | Classification by 24-hour recall | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| **Classification** | 1st | **13.8 (12)** | 10.3 (9) | 9.2 (8) |
| **by the FAQ** | 2nd | 12.6 (11) | **10.3 (9)** | 9.2 (8) |
| **(unadjusted)** | 3rd | 6.9 (6) | 12.6 (11) | **14.1 (13)** |

(Kappa = 0.086, significance = 0.255); (number of subjects in parenthesis)

**Table 4.18:** **Percent classification of subjects into thirds of their daily energy expenditure by the adjusted FAQ and the 24-hour recall method (n = 87)**

| | | Classification by 24-hour recall | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| **Classification** | 1st | **14.9 (13)** | 11.5 (10) | 6.9 (6) |
| **By the FAQ** | 2nd | 11.5 (10) | **12.6 (11)** | 10.3 (9) |
| **(adjusted)** | 3rd | 6.9 (6) | 9.2 (8) | **16.1 (14)** |

(Kappa = 0.155, significance = 0.041); (number of subjects in parenthesis)

### 4.3.5 Validity of the FAQ

To assess the validity of the FAQ as a method for measuring habitual physical activity among South Asian women, the mean daily energy expenditure from the FAQ, and the ranking of subjects in thirds of energy distribution were compared with the diary. The physical activity measurements by the FAQ were also compared with the 24-hour recall to evaluate the possibility of a 24-hour recall being used as reference method. The number of subjects included in this analysis was 56.

Results of the comparison between the unadjusted as well as the adjusted FAQ physical activity measures and the diary and the 24-hour recall are presented.

Figures 15 and 16 show the distribution of daily energy expenditure from the unadjusted FAQ and the adjusted FAQ respectively, for 56 subjects. After adjustment, two subjects had higher than the average daily energy expenditure from the FAQ. Both subjects were postgraduate research students who were described in section 4.3.3.

Figure 17 shows the distribution of daily energy expenditure from the 24-hour recall for 56 subjects. Two subjects who had the highest energy expenditure from the 24-hour recall have been described earlier in section 4.3.2. The daily energy expenditure from

**Figure 15: Distribution of energy expenditure from the unadjusted FAQ (For 56 subjects)**

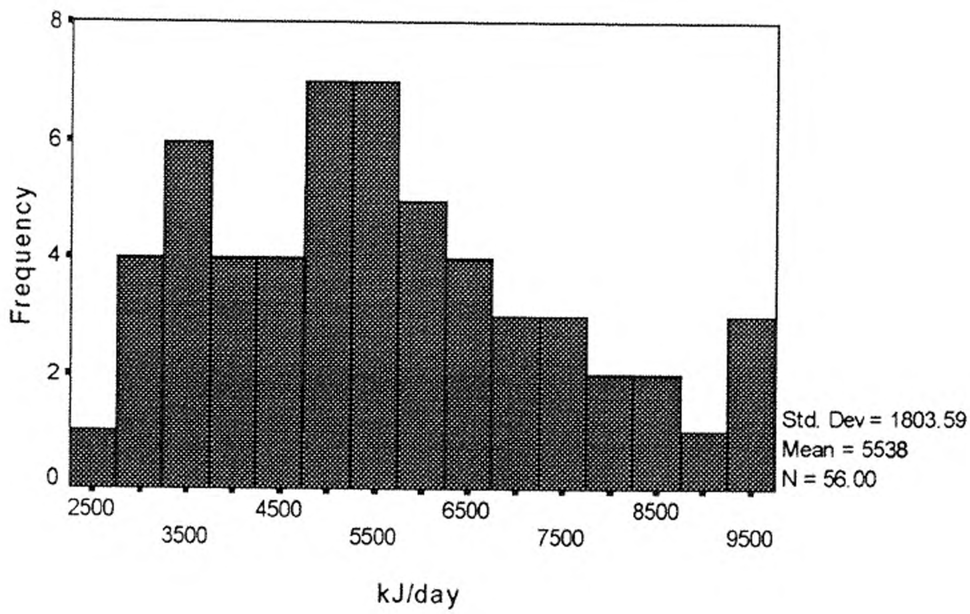


Figure 16: **Distribution of energy expenditure from the adjusted FAQ (For 56 subjects)**

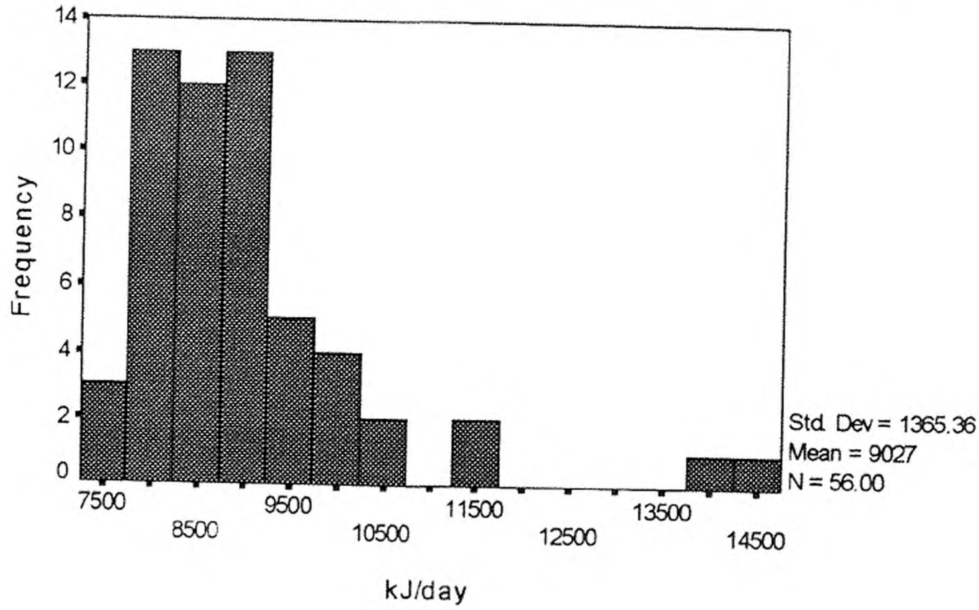
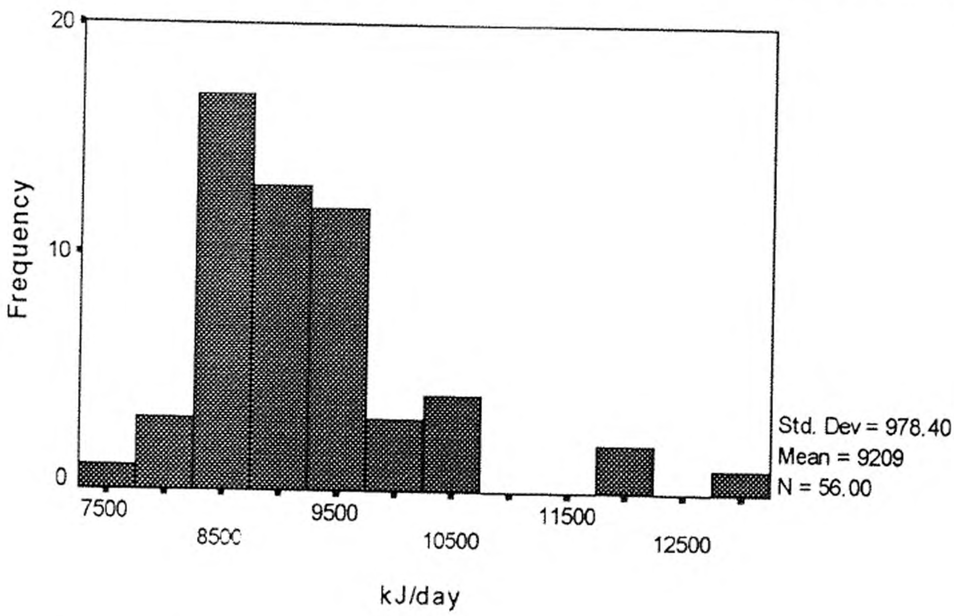



Figure 17: **Distribution of energy expenditure from 24-hr recall (For 56 subjects)**




the adjusted FAQ, the diary and the 24-hour recall were later transformed into the log (natural) scale to assume symmetrical distributions, and they were used for subsequent statistical analyses. The mean daily energy expenditure from the unadjusted FAQ was 39 percent and 40 percent lower than the mean daily energy expenditure from the dairy and the 24-hour recall, respectively (Table 4.19). The mean daily energy expenditure from the adjusted FAQ was two percent and three percent lower than the mean daily energy expenditure from the diary and the 24-hour recall respectively. There was no significant difference in energy expenditure estimated by the diary and the 24-hour recall.

**Table 4.19: Mean daily energy expenditure from three methods, kJ/day**

| Method | n | Mean, (95 % confidence interval) |
|---|---|---|
| 7-day diary | 57 | *9113 (8932 - 9298) |
| 24-hour recall | 56 | *9163 (8866 - 9405) |
| FAQ (unadjusted) | 56 | 5538 (5055 - 6021) |
| FAQ (adjusted) | 56 | *8942 (8627 - 9267) |

*geometric mean

Figures 18 and 19 show the scatter plot of the energy expenditure from the unadjusted FAQ against the diary, and the adjusted FAQ against the diary, respectively. There was no significant correlation between energy expenditure from the unadjusted FAQ and the diary, (Table 4.20).

**Table 4.20: Spearman rank correlation coefficients ( r ) between three methods of physical activity assessment**

| | n | r (95% confidence interval) | p - value |
|---|---|---|---|
| FAQ (unadjusted) vs. Diary | 56 | 0.25 (-0.01 - 0.48) | .063 |
| FAQ (adjusted) vs. Diary | 56 | 0.44 (0.19 - 0.63) | .001 |
| FAQ (unadjusted) vs. Recall | 55 | 0.26 (-0.01 - 0.40) | .060 |
| FAQ (adjusted) vs. Recall | 55 | 0.41 (0.16 - 0.61) | .002 |
| Recall vs. Diary | 56 | 0.62 (0.42 -0.76) | .000 |

Figures 20 and 21 show the scatter plot of the energy expenditure from the unadjusted FAQ against the 24-hour recall, and the adjusted FAQ against the 24-hour recall, respectively. The correlation between energy expenditure from the adjusted FAQ and the diary, and between the adjusted FAQ and the 24-hour recall was moderate and significant (table 4.20). The confidence intervals for the correlations were wide, indicating that it was a moderate estimate of the population correlation coefficient.

**Figure 18:** **A scatter plot for energy distribution from the unadjusted FAQ and diary (For 56 subjects)**

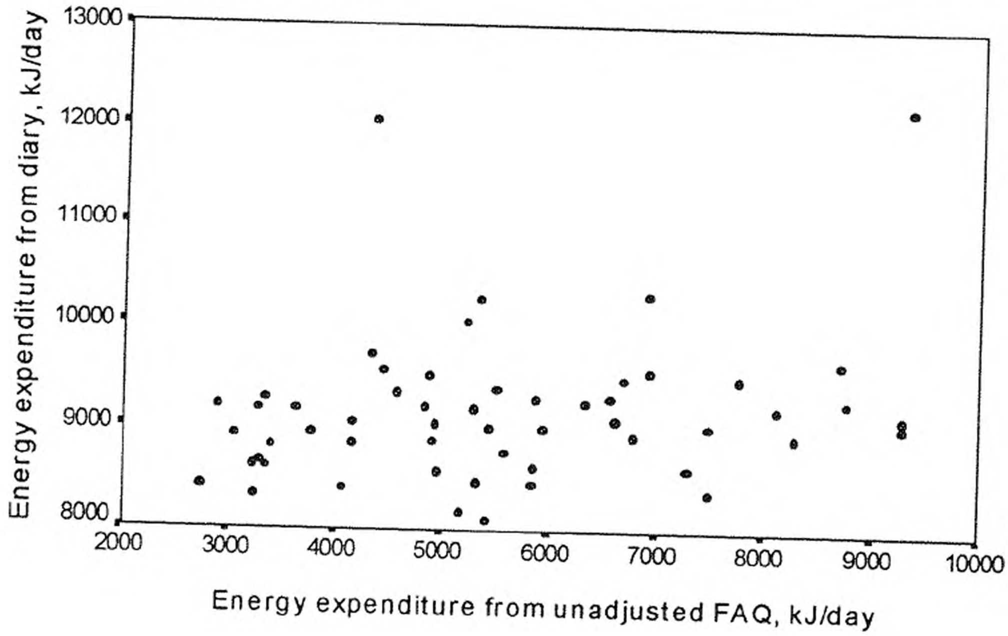



**Figure 19:** **A scatter plot for energy distribution from the adjusted FAQ and diary (For 56 subjects)**

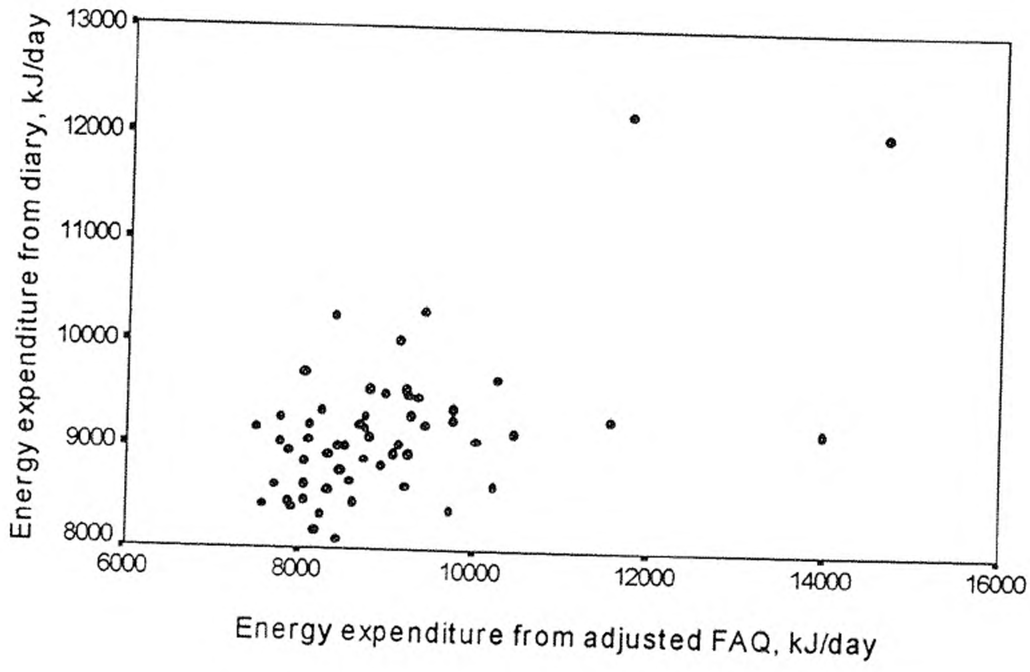
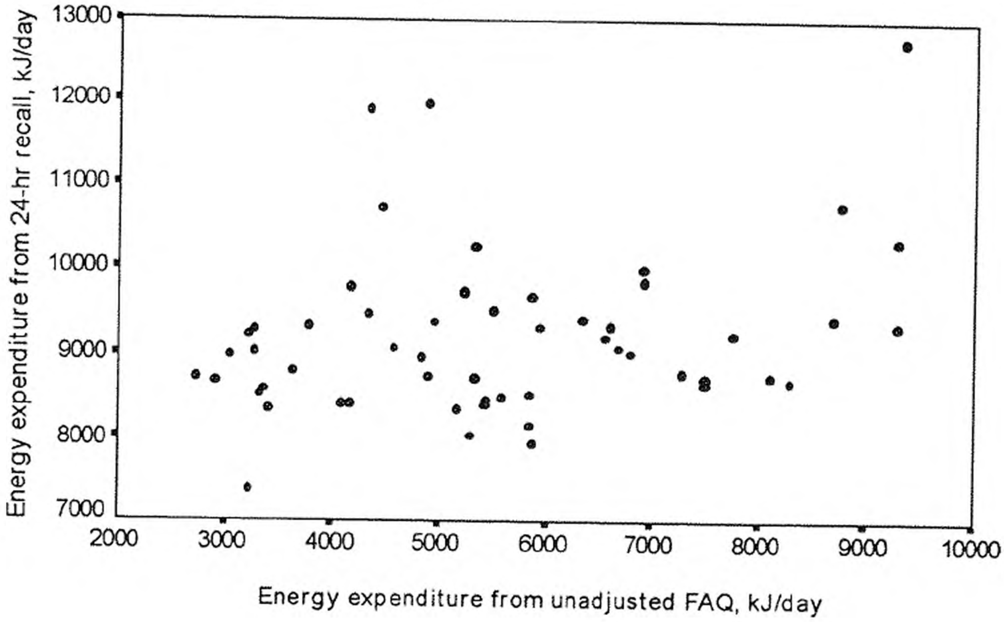


**Figure 20:** **A scatter plot for energy distribution from the unadjusted FAQ and 24-hr recall (For 56 subjects)**




Correlation between the adjusted FAQ and the 24-hour recall was higher among respondents compared to the total group (respondents and non-respondents), 0.32 versus 0.41.

**Figure 21:** **A scatter plot for energy distribution from the adjusted FAQ and 24-hr recall (For 56 subjects)**

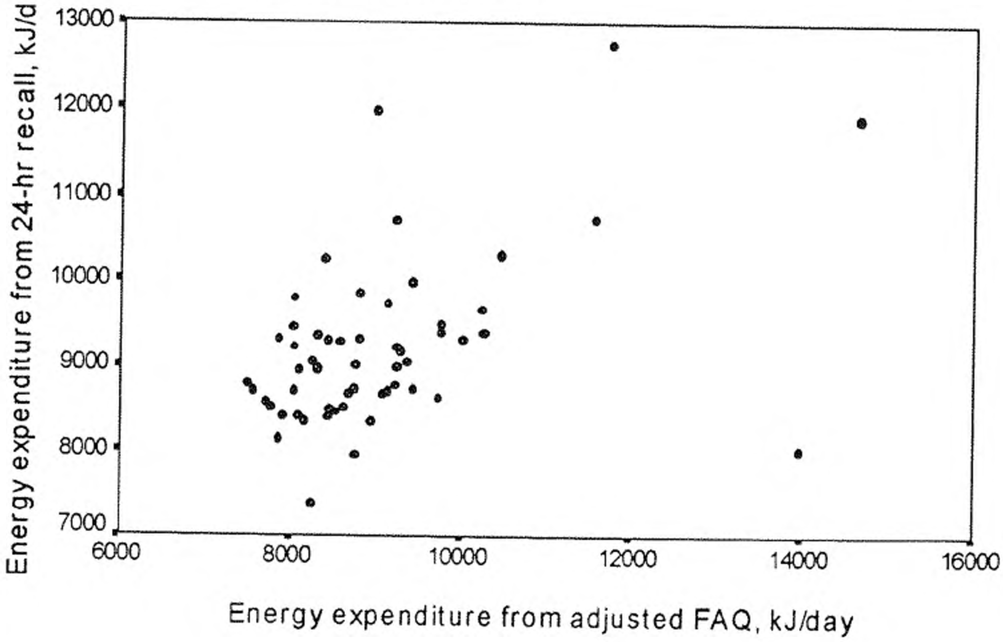


**Figure 22:** **A scatter plot for energy distribution from the diary and 24-hr recall (For 56 subjects)**

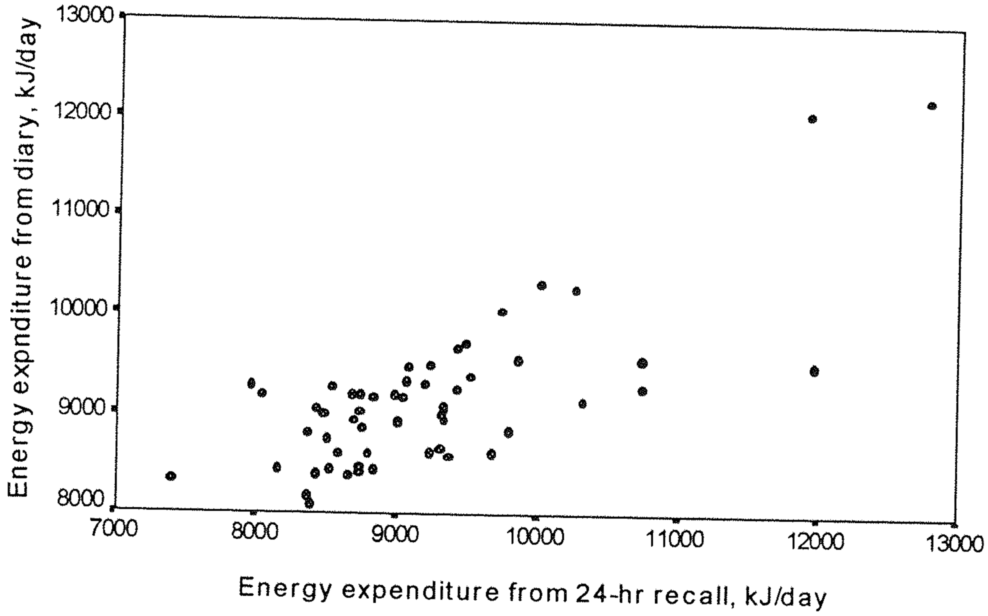



Figure 22 shows a scatter plot for the energy expenditure 24-hour recall and the diary. There was a high correlation coefficient between daily energy expenditure from the diary and recall. The diary and 24-hour recall showed better agreement than comparison with any other methods. The differences between daily energy expenditure from the unadjusted FAQ and the diary, and between the unadjusted FAQ and the 24-hour recall were large (table 4.21).

**Table 4.21:** **Average daily energy expenditure and mean differences of two methods (kJ)**

| Method | n | Average of two methods | ±SD | Difference between methods | ±SD | Correlation between difference and average |
|---|---|---|---|---|---|---|
| Diary - FAQ (unadjusted) | 56 | 7345 | ±1059 | 3605 | ±1771 | -0.77 (p = 0.000) |
| Diary - FAQ (adjusted) | 56 | 9090 | ±950 | 125 | ±1112 | -0.47 (p = 0.000) |
| Recall - FAQ (unadjusted) | 55 | 7382 | ±1151 | 3667 | ±1803 | -0.63 (p = 0.000) |
| Recall - FAQ (adjusted) | 55 | 9133 | ±1016 | 167 | ±1247 | -0.23 (p = 0.094) |
| Diary - Recall | 56 | 9176 | ±812 | -67 | ±640 | -0.29 (p = 0.033) |

The 95 percent limits of agreement between the unadjusted FAQ and the diary were 7158 kJ/day above and 70 kJ/day below the mean difference (Figure 23). This indicated that the unadjusted FAQ gave a poor estimate of subjects' energy expenditure, compared to the diary. It underestimated the group's daily energy expenditure by 49 percent, compared to the diary. The differences between the unadjusted FAQ and the diary were not randomly distributed. There was a negative trend between the difference and the average of the two methods. It means that there was a tendency for the unadjusted FAQ to underestimate energy expenditure for subjects with lower physical activity levels, and to overestimate energy expenditure for subjects with higher physical activity levels. A similar trend was also seen between the adjusted FAQ and the diary.

Energy expenditure from the adjusted FAQ had substantially smaller differences with the diary and with the 24-hour recall. Figure 24 shows the plot of difference against the average of energy expenditure from the diary and the adjusted FAQ. The limits of two standard deviations below and above the mean difference were -2099 kJ and 2349 kJ. This means that for 95 percent of the subjects, the outcome of the FAQ fell within an interval of 2099 kJ below and 2349 kJ above the outcome of the diary. At group level agreement between the adjusted FAQ and the diary appeared to be good. The mean difference between the adjusted FAQ estimated daily energy expenditure and the diary was small. However, at the individual levels the FAQ when compared with the diary can underestimate daily energy expenditure by as much as 52 percent or overestimate it by 18 percent.

Agreement between estimated energy expenditure from the unadjusted FAQ and the 24-hour recall was poor (Figure 25). The 95 percent limits of agreement were 7273 kJ/day above and 61 kJ/day below the mean difference. Again the unadjusted FAQ gave poor estimate of the subjects energy expenditure.

**Figure 23:** **A Bland-Altman plot for energy expenditure from the diary and unadjusted FAQ**

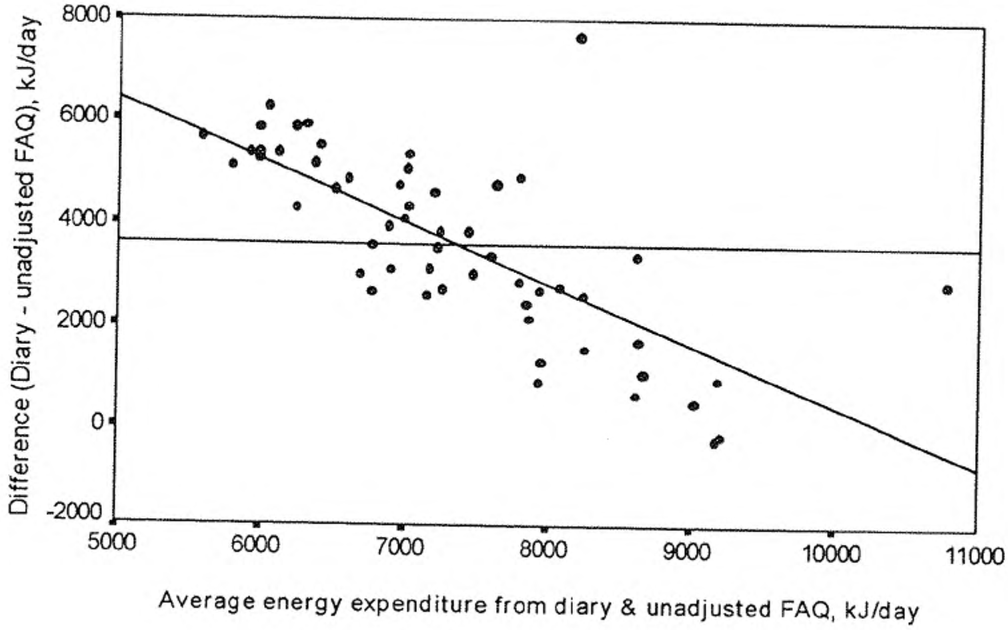
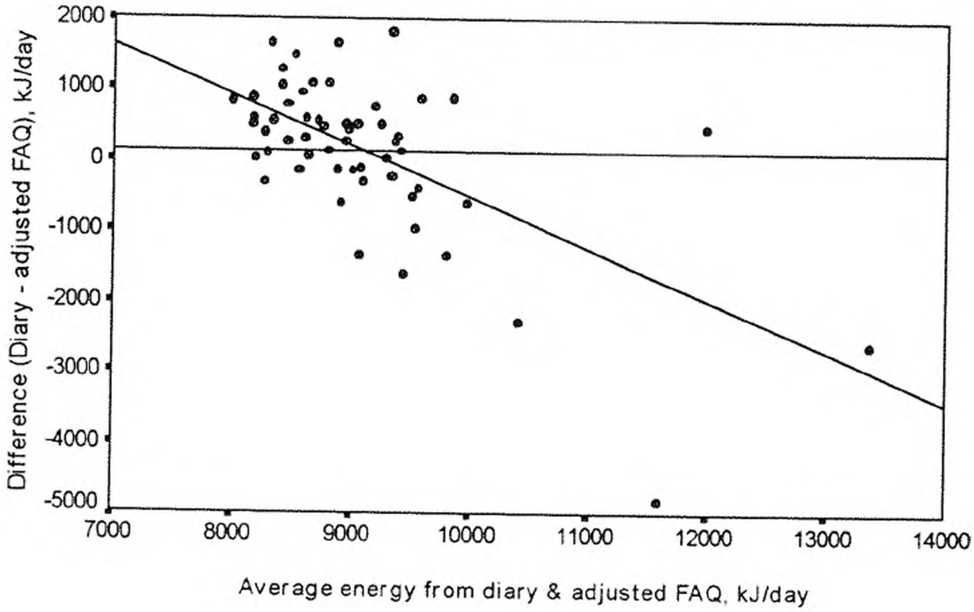



**Figure 24:** **A Bland-Altman plot for energy expenditure from the diary and the adjusted FAQ**



At the group level the unadjusted FAQ underestimated daily energy expenditure by 50 percent, compared to the 24-hr recall. Similarly, there was a negative relationship between the mean difference and the average of the two methods. The unadjusted FAQ tended to underestimate energy expenditure for subjects with lower physical activity

**Figure 25: A Bland-Altman plot for energy expenditure from the 24-hour recall and the unadjusted FAQ**

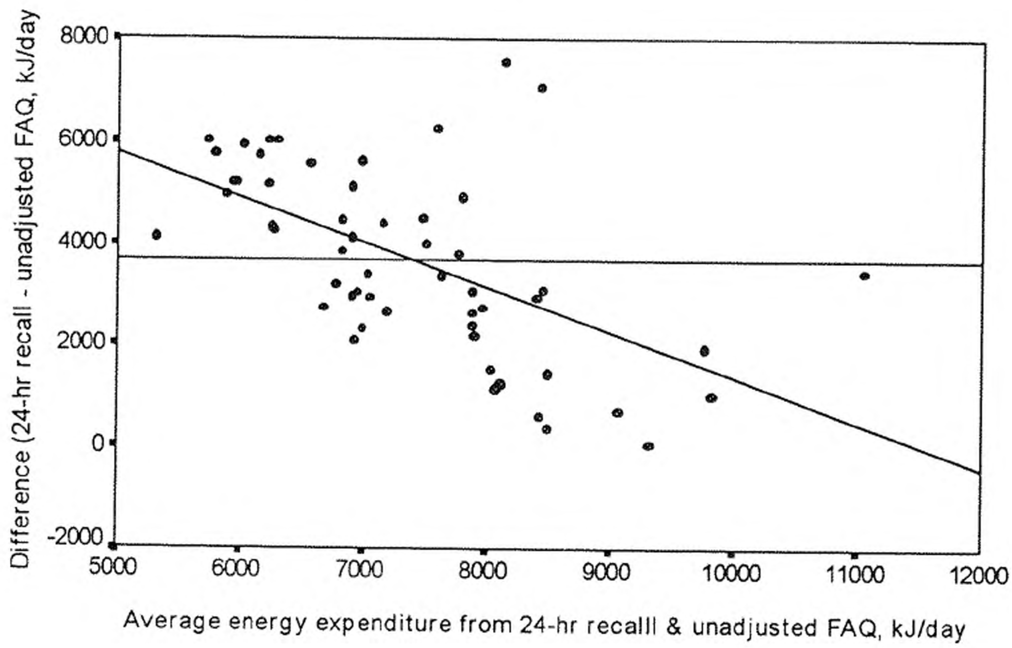
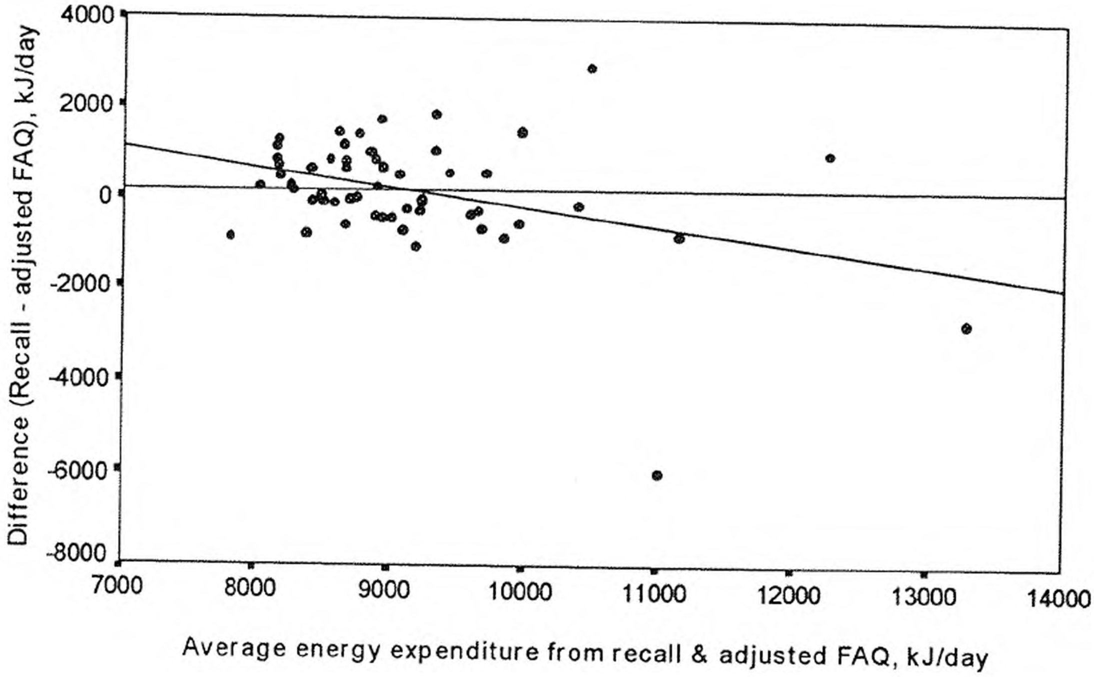
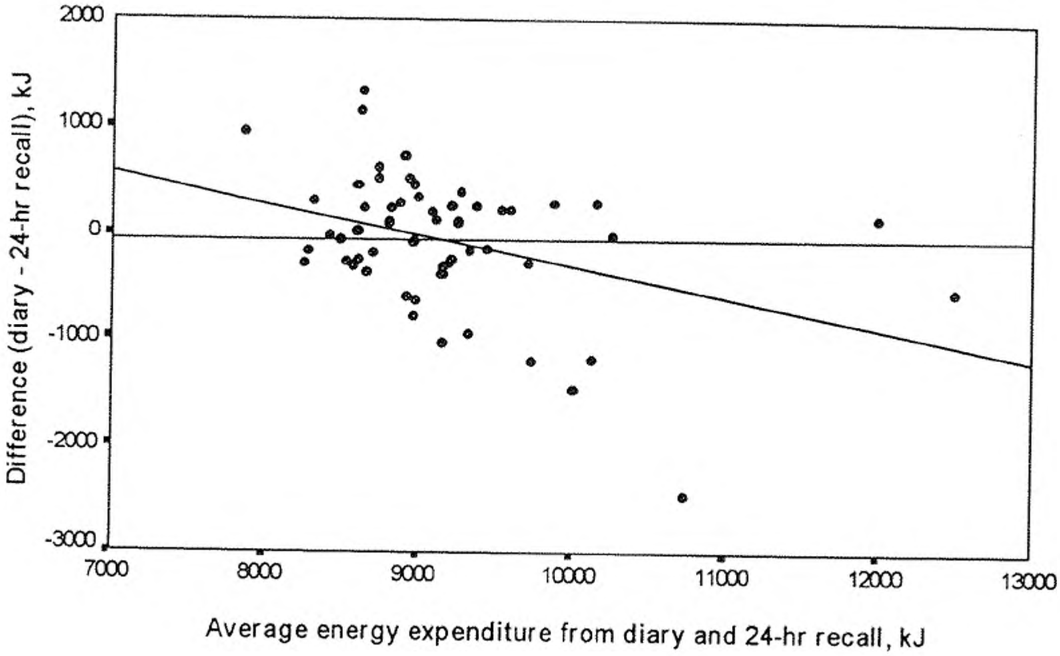


**Figure 26:** **A Bland-Altman plot for energy expenditure from the 24-hour recall and the adjusted FAQ**




levels, and to overestimate energy expenditure for subjects with higher physical activity levels. Agreement between the adjusted FAQ and the 24-hour recall was moderate, (Figure 26). The 95 percent limits of agreement between the adjusted FAQ and the 24-hour recall were -2328 kJ and 2661 kJ. The adjusted FAQ when compared to the 24-hour recall can underestimate an individual's daily energy expenditure by 74 percent and overestimated it by 25 percent. The difference between the two methods appeared to be randomly distributed.

**Figure 27:** **A Bland-Altman plot for energy expenditure from the diary and the 24-hr recall**




The mean difference between energy expenditure from the diary and 24-hour recall was small, and the 95 percent limits of confidence were narrower, 1213 kJ above and 1347 kJ below the mean (Figure 27). It means that the 24-hour recall was able to give a good estimate of the groups energy expenditure. There was a significant negative correlation between the difference and the average of two methods. This implies that the 24-hour recall tended to underestimate energy expenditure for subjects with lower physical activity levels, and to overestimate energy expenditure for subjects with higher physical activity levels. Lack of agreement between any two methods is likely to cause a high proportion of the subjects incorrectly classified.

Table 4.22 indicates how the subjects were ranked into thirds of energy expenditure by the diary and the unadjusted FAQ. Correct classification occurred in 39 percent of the subjects, and gross misclassification in eleven percent. The Kappa statistics indicated that there was no obvious pattern in the classification, which could have occurred by chance.

Comparing the adjusted FAQ with the diary, forty-three percent of the subjects were correctly classified by both methods, and eleven percent was put in the opposite thirds (table 4.23). Classification of subjects was more than expected by chance alone. Correct classification of subjects by the unadjusted FAQ and the 24-hour recall was 34 percent, and gross misclassification was 14 percent (table 4.24). However, subjects' classification was not significantly different from the occurrence by chance. Comparing the 24-hour recall and the adjusted FAQ 44 percent of the subjects were correctly classified, and 11 percent were grossly misclassified (table 4.25).

**Table 4.22:** **Percent classification of subjects into thirds of energy expenditure distribution ( n = 56)**

| | | Classification by the diary | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| **Classification** | 1st | **14.3 (8)** | 10.7(6) | 7.1 (4) |
| **by the FAQ** | 2nd | 14.3(8) | **8.9 (5)** | 10.7(6) |
| **(unadjusted)** | 3rd | 3.6 (2) | 14.3(8) | **16.1 (9)** |

(Kappa = 0.089; significance = 0.346); (number of subjects in parenthesis)

**Table 4.23:** **Percent classification of subjects into thirds of energy expenditure distribution (n = 56)**

| | | Classification by the diary method | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| **Classification** | 1st | **17.9 (10)** | 8.9 (5) | 5.4 (3) |
| **by the FAQ** | 2nd | 8.9 (5) | **16.1 (9)** | 8.9 (5) |
| **(adjusted)** | 3rd | 5.4 (3) | 8.9 (5) | **19.6 (11)** |

(Kappa = 0.303; significance = 0.001); (number of subjects in parenthesis)

**Table 4.24:** **Percent classification of subjects into thirds of energy expenditure distribution (n = 56)**

| | | Classification by the 24-hour recall | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| **Classification** | 1st | **12.7 (7)** | 10.9 (6) | 9.1(5) |
| **by the FAQ** | 2nd | 14.5 (8) | **7.3 (4)** | 10.9 (6) |
| **(unadjusted)** | 3rd | 5.5 (3) | 14.5 (8) | **14.5 (8)** |

(Kappa = 0.0179; significance = 0.851); (number of subjects in parenthesis)

Table 4.25: **Percent classification of subjects into thirds of energy expenditure distribution (n = 55)**

| | | **Classification by the 24-hour recall method** | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| **Classification by the FAQ (adjusted)** | 1st | **12.7 (7)** | 10.9 (6) | 7.3 (4) |
| | 2nd | 16.4 (9) | **10.9 (6)** | 7.3 (4) |
| | 3rd | 3.6 (2) | 10.9 (6) | **20.0 (11)** |

(Kappa = 0.155; significance = 0.1056); (number of subjects in parenthesis)

Table 4.26: **Percent classification of subjects into thirds of energy expenditure distribution ( n = 56)**

| | | **Classification by the diary** | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| **Classification by the 24-hour Recall** | 1st | **17.9 (10)** | 10.7 (6) | 3.6 (2) |
| | 2nd | 10.7 (6) | **16.1 (9)** | 7.1 (4) |
| | 3rd | 5.4 (3) | 5.4 (3) | **23.2 (13)** |

(Kappa = 0.357; significance = 0.00016); (number of subjects in parenthesis)

Comparing the diary and recall method fifty-one percent of the subjects were correctly classified and nine percent were grossly misclassified (Table 4.26). Subjects' classification was significant.

### 4.3.6 The effect of body weight on physical activity reporting

To assess if there was any relationship between body size and how subjects reported their physical activity, subjects were placed into two categories of BMI. Thirty-eight subjects belonged to the normal weight group (BMI $\leq$ 25), and seventeen were in the overweight group (BMI > 25). The average BMI for the normal weight subjects was 21.5 ($\pm$2.3), and that for the overweight subjects was 29.7 ($\pm$3.8).

Table 4.27: **Energy expenditure by subject's BMI**

| **Energy expenditure (kJ/day)** | **BMI ≤ 25 (n = 38)** | | **BMI > 25 (n = 17)** | |
|---|---|---|---|---|
| | **mean** | **(95% CI)** | **mean** | **(95% CI)** |
| Diary | *9146 | (8907 - 9392) | *9181 | (8814 - 9388) |
| 24-hour recall | *9173 | (8874 - 9481) | *9291 | (8863 - 9719) |
| FAQ (unadjusted) | 5363 | (4776 - 5950) | 6065 | (5159 - 6970) |
| FAQ (adjusted) | *8915 | (8502 - 9394) | *9098 | (8562 - 9635) |
| Basal metabolic rate | 5370 | (5230 - 5510) | 6260 | (5950 - 6570) |

*geometric mean

Table 4.27 illustrates that the mean basal metabolic rate for the normal weight subjects was lower than the overweight subjects. Energy expenditure from the diary, 24-hour recall and the adjusted FAQ were similar for both groups of subjects. Energy expenditure from the unadjusted FAQ appeared to be slightly higher among overweight compared to normal weight subjects.

Table 4.28: **Physical activity ratios (reported energy expenditure/basal metabolic rate) by BMI**

| **Method** | **n** | **BMI ≤25** | **(95% CI)** | **n** | **BMI >25** | **(95% CI)** |
|---|---|---|---|---|---|---|
| Diary | 39 | 1.72 | (1.65 - 1.79) | 17 | 1.47 | (1.38 - 1.56) |
| 24-hr recall | 38 | 1.73 | (1.65 - 1.80) | 17 | 1.50 | (1.40 - 1.60) |
| FAQ (unadjusted) | 38 | 1.01 | (0.89 - 1.12) | 17 | 0.98 | (0.82 - 1.14) |
| FAQ (adjusted) | 38 | 1.69 | (1.58 - 1.79) | 17 | 1.47 | (1.35 - 1.59) |

The mean physical activity ratio from the diary, 24-hour recall, the unadjusted FAQ and the adjusted FAQ was lower among overweight subjects compared to normal weight subjects (table 4.28). Calculating the activity ratio using the Henry & Rees' formula increased the values slightly (Henry & Rees, 1991). There was no significant correlation between BMI and energy expenditure estimated by the diary, 24-hour recall and the FAQ. However, correlation between energy expenditure from any two methods increased slightly after controlling for BMI (table 4.29). It seems that variations in BMI could account for some of the correlations observed

Table 4.29 Spearman rank correlation ( r ) between methods after controlling for BMI

| Method | n | r | 95% CI | p-value |
|---|---|---|---|---|
| Diary vs. FAQ (adjusted) | 52 | 0.56 | (0.33 - 0.72) | 0.000 |
| 24-hr recall vs. FAQ (adjusted) | 51 | 0.47 | (0.22 - 0.66) | 0.000 |
| Diary vs. 24-hr recall | 52 | 0.73 | (0.58 - 0.84) | 0.000 |

between any two methods. It is likely that due to the small number of subjects, any effects that BMI might have on reported physical activity may not have been detected. Similar trends were also seen in the correlations between any two methods after controlling for waist-hip ratio (data not shown). The mean waist-hip ratio for normal weight subjects was significantly lower than that for the overweight subjects (0.76; 95% confidence interval, 0.74 - 0.78 and 0.87; 95% confidence interval, 0.83 - 0.90, respectively).

Among normal weight subjects, correct classification by the diary and adjusted FAQ was 52.6 percent and gross misclassification was 13 percent (table 4.30). The Kappa

Table 4.30: Percent classification into thirds of energy expenditure distribution for normal weight subjects (n =38)

| | | Classification by the diary | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| Classification | 1st | **15.8 (6)** | 10.5(4) | 7.9 (3) |
| by the FAQ | 2nd | 10.5(4) | **18.4 (7)** | 7.9 (3) |
| (adjusted) | 3rd | 5.3 (2) | 5.3 (2) | **18.4 (7)** |

(Kappa = 0.289; significance = 0.011); (number of subjects in parenthesis)

statistics indicated that classification was significantly different from a chance distribution. Comparing the adjusted FAQ with the 24-hour recall, correct classification occurred in 35 percent of the subjects, and gross misclassification in 16 percent (table 4.31). The classification was not significant, which could have occurred by chance.

When the 24-hour recall was compared with the diary, 50 percent of the subjects were correctly classified, and 10.6 percent were grossly misclassified (table 4.32).

**Table 4.31:** **Percent classification into thirds of energy expenditure distribution for normal weight subjects ( n = 37)**

| | | Classification by the 24-hour recall | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| **Classification by the FAQ (adjusted)** | 1st | **5.4 (2)** | 16.2 (6) | 10.8 (4) |
| | 2nd | 18.9 (7) | **13.5 (5)** | 5.4 (2) |
| | 3rd | 5.4 (2) | 8.1(3) | **16.2 (6)** |

(Kappa = 0.023; significance = 0.842); (number of subjects in parenthesis)

The percent classification was significantly different from a chance distribution. Among over weight subjects, correct classification by the diary and adjusted FAQ was 53 percent and gross misclassification was 6 percent (table 4.33). The percent classification was not significantly different from a random distribution.

**Table 4.32** **Percent classification into thirds of energy expenditure distribution for normal weight subjects (n = 38)**

| | | Classification by the diary | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| **Classification by the 24-hour Recall** | 1st | **13.2 (5)** | 10.5(4) | 5.3 (2) |
| | 2nd | 15.8 (6) | **15.8 (6)** | 7.9 (3) |
| | 3rd | 5.3 (2) | 5.3 (2) | **21.1 (8)** |

(Kappa = 0.251; significance = 0.026); (number of subjects in parenthesis)

Comparing the adjusted FAQ with the 24-hour recall, correct classification occurred in 59 percent of the subjects, and no gross misclassification occurred, (tables 4.34). The percent classification was significant, therefore not a random distribution. When the 24-hour recall was compared with the diary, 70.5 percent of the subjects were correctly classified, and 6 percent were grossly misclassified (table 4.35). The percent classification was significant. Classifications of subjects by the diary and recall method were found to be significant for the normal weight and overweight groups. Correct classification was higher among the overweight subjects than the normal weight subjects. This suggests that overweight subjects tended to report more similar activities

Table 4.33 **Percent classification into thirds of energy expenditure distribution for overweight subjects (n =17)**

| | | Classification by the diary | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| Classification | 1st | **17.6 (3)** | 5.9 (1) | 0 |
| by the FAQ | 2nd | 5.9 (1) | **11.8 (2)** | 11.8 (2) |
| (adjusted) | 3rd | 5.9 (1) | 17.6 (3) | **23.5 (4)** |

(Kappa = 0.288; significance = 0.089); (number of subjects in parenthesis)

Table 4.34 **Percent classification into thirds of energy expenditure distribution for overweight subjects ( n = 17)**

| | | Classification by the 24-hour recall | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| Classification | 1st | **23.5 (4)** | 0 | 0 |
| by the FAQ | 2nd | 11.8 (2) | **5.9 (1)** | 11.8 (2) |
| (adjusted) | 3rd | 0 | 17.6 (3) | **29.4 (5)** |

(Kappa = 0.370; significance = 0.029); (number of subjects in parenthesis)

Table 4.35: **Percent classification into thirds of energy expenditure distribution for overweight subjects (n = 17)**

| | | Classification by the diary | | |
|---|---|---|---|---|
| | | 1st | 2nd | 3rd |
| Classification | 1st | **23.5 (4)** | 11.8 (2) | 0 |
| by 24-hour | 2nd | 0 | **17.6 (3)** | 5.9 (1) |
| recall | 3rd | 5.9 (1) | 5.9 (1) | **29.4 (5)** |

(Kappa = 0.559; significance = 0.001); (number of subjects in parenthesis)

in the 24-hour recall and the diary than the normal weight subjects. The validity of the questionnaire compared to the diary among overweight subjects could not be assessed because their percent classification was not significant. Among normal weight subjects correct classification by the FAQ and the diary was similar to that found for the whole group.

### 4.3.7 The Step Test

Forty-nine subjects took part in the 'Step Test'. Their average resting pulse rate was 14 beats per ten seconds (84 beats per minute). The pulse rate after stepping and the change in pulse rate from resting to after stepping for three minutes (1st stage), and to stepping for six minutes (2nd stage) is shown in table 4.36. Pulse rate after stepping was used to categorised subjects into three fitness levels (Shephard *et al.* 1976). Forty subjects (82 %) had the minimum level of fitness, six subjects (12 %) were categorised as having less than the recommended level of fitness, and three subjects had undesirable fitness level. Two of these latter subjects stopped after the first three minutes of stepping.

**Table 4.36: Pulse rate before and after exercise**

| | Pulse rate (beats/10 seconds) | | |
|---|---|---|---|
| | mean | ±SD | (minimum; maximum) |
| Resting | 14 | ±2 | (11; 19) |
| 3 minute stepping | 20 | ±3 | (14; 26) |
| 6 minutes stepping | 22 | ±3 | (15; 29) |
| Change after 1st stage | 6 | ±2 | (2; 11) |
| Change after 2nd stage | 8 | ±3 | (2; 16) |

Energy expenditure had a negative correlation with the resting pulse rate (table 4.37). This suggests that subjects with lower resting pulse rate were likely to report higher physical activity levels than subjects who had higher resting pulse rate. The adjusted FAQ too had a negative correlation with resting pulse rate, but with a borderline significant level. The diary energy expenditure was not related to resting pulse rate. Pulse rate after stepping and the change in pulse rate after stepping was not related to physical activity measures by any method. Subjects' BMI was positively related to the change in pulse rate after stepping (table 4.37). This implies that subjects who were fatter had a larger increase in pulse rate after stepping than subjects who were thinner.

Table 4.37 Spearman rank correlation ( r ) between pulse rate and physical activity measures, and with BMI

| | n | r | 95% CI | p-value |
|---|---|---|---|---|
| 24-hr recall vs. resting pulse rate | 49 | -0.36 | (-0.08 to -0.58) | 0.013 |
| FAQ (adjusted) vs. resting pulse rate | 48 | -0.27 | (-0.27 to -0.70) | 0.060 |
| BMI vs. change in pulse rate (1st stage) | 49 | 0.39 | (0.12 to 0.60) | 0.006 |
| BMI vs. change in pulse rate (2nd stage) | 46 | 0.34 | (0.06 to 0.58) | 0.019 |

### 4.3.8 A summary of the results

1. South Asian women in the study sample spent a large proportion of their time in doing low and moderate level activities. The average time spent in moderate to high intensity activities was higher than the recommended levels.
2. The average time spent daily in activities recalled by the subjects in the FAQ was less than 24 hours. This resulted in very low values for the estimated daily energy expenditure of all subjects. Subjects have under-reported on activities that they performed regularly on a daily basis. Subsequently, every subject was assigned a correction factor (energy cost factor) based on their occupation and family status. This factor was multiplied with the time difference between 24 hours and the total time from recalled activities.
3. The mean daily energy expenditure estimated by the questionnaire (after adjustment) was lower than the mean daily energy expenditure estimated by the dairy and the 24-hour recall.
4. The 24-hour recall estimated daily energy expenditure was not different from the diary estimated energy expenditure.
5. There was no significant correlation between energy expenditure from the unadjusted FAQ with the diary or the 24-hour recall.
6. The correlation between the mean energy expenditure from the questionnaire (after adjustment) and the diary was moderate ($r = 0.44$). This was statistically significant

despite not getting the required sample size of 84 subjects, because the correlation obtained was higher than our predetermined level.

7. The correlation between the mean daily energy expenditure from the questionnaire (adjusted) and the 24-hour recall was moderate (r = 0.41).
8. The correlation between the mean daily energy expenditure from the 24-hour recall and the diary was higher (r = 0.62).
9. The mean difference between the daily energy expenditure from the diary and the adjusted questionnaire was 125 kJ/day, with large 95% limits of agreement, 2349 kJ above and 2099 kJ below the mean.
10. The mean difference between the daily energy expenditure from the 24-hour recall and the adjusted questionnaire was 167 kJ/day, with large 95% limits of agreement, 2661 kJ above and 2327 kJ below the mean.
11. The mean difference between the daily energy expenditure from the diary and the 24-hour recall was -67 kJ/day, with narrower limits of agreement, 1213 kJ above and 1347 kJ below the mean.
12. Using the diary as the reference method, correct classification of subjects into thirds of their daily energy expenditure by the questionnaire was 54 percent, and gross misclassification was 11 percent.
13. Using the 24-hour recall as the reference method, correct classification of subjects into thirds of their daily energy expenditure by the questionnaire was 44 percent, and gross misclassification was 11 percent.
14. Using the diary as the reference method, correct classification of subjects into thirds of the daily energy expenditure by the 24-hour recall was 57 percent, and gross misclassification was 9 percent.
15. Correlation between energy expenditure estimated by the questionnaire and the 24-hour recall for subjects who completed the study was higher than correlation for all subjects (those who completed the diary and those who did not).

16. There was no significant correlation between BMI and energy expenditure estimated by the diary, adjusted FAQ, and the 24-hour recall. However, correlation between any two methods increased slightly after controlling for BMI.
17. Results of the 'Step Test' did not show any significant correlation with the physical activity measures by the diary, 24-hour recall and the questionnaire methods.
18. Subjects with lower resting heart rate had higher energy expenditure from the 24-hour recall and from the adjusted FAQ.
19. Results from the 'Step Test' indicated that about 80 percent of the subjects as having the minimum level of fitness.

## 4.4 DISCUSSION

### 4.4.1 Introduction

The general objective of this part of the research project was to develop and assess the validity of a method of assessing physical activity among South Asian women. Specifically, we wanted to design a questionnaire that would enable us to describe and assess the activity patterns of subjects at the group level so that we could divide them into low, medium or high levels of physical activity. If the questionnaire was shown to be valid it would enable other investigators in future work to study the effect of physical activity on energy balance and its relationship with birth outcomes among a larger sample of South Asian women. This is because previous studies have suggested that South Asian women's maternal size, that is height, prepregnant weight, and weight gain during pregnancy have an influence on birth weight. They are on average shorter and lighter than the Caucasian women and tend to have smaller and lighter babies.

### 4.4.2 The study sample

The study required at least 84 subjects to have 80 percent power at 5 percent significance level to detect a correlation coefficient of 0.3 between physical activity measures by the FAQ and by the diary (Machin & Campbell, 1987). With a sample size of 56 and a correlation coefficient of 0.44, at 5 percent significance level, the study power had increased to 90 percent. A 90 percent power implies the study has a 10 percent probability of making a type II error, that is, failing to detect a relationship between the FAQ and the diary measures when there was one.

*Problems encountered*

The problems encountered with recruiting subjects to take part in the study have been highlighted in the methods and results section (4.2.6 & 4.3.1). The reasons for the low response rate of the subjects could only be speculated, based on our experience of working in the South Asian community. It is possible that subjects did not receive the letters because they had changed addresses. Another reason is probably due to the impersonal approach taken by sending letters of invitation to the subjects, instead of using the community approach. Traditional beliefs about food, nutrition, health and exercise may have influenced their attitudes and behaviour towards health oriented programmes (Greenhalgh *et al.* 1998).

To overcome the problem of low response rate it may be necessary in future to involve the local GP's. For example the recruitment can be done by the GP's. Health education to increase the community's awareness on health and physical activity could increase their motivation to take part in future studies. Leaders from the respective ethnic groups of the South Asian community could become their motivators.

The burden that the study imposed on the subjects could have discouraged them from taking part. They were required to record their daily activities starting from the time they got out of bed in the morning until the time they go to sleep at night, for one week. It would be a hard task, especially for subjects who have young children to look after, or subjects who have to go out to work as well as take care of the household chores. Moreover, it would be more difficult for subjects who do not speak or write in English well enough to be interviewed and record their activities. They are mostly people who have come to this country only recently. Other reference methods, which will not interfere with the subject's daily activities, such as the triaxial accelerometer, could be used instead of the diary.

More subjects were willing to take part in the study if they were contacted through their friends or relatives. Subjects who took part in this study were conscious of their health and wanted to learn more about their physical activity and health status. Information about their weight, height, body mass index and fitness status created an interest for them to take part. The subjects in the present study were self-selected, well educated and probably highly motivated. Most subjects were able to speak and write in English fluently. Therefore the study sample is not likely to be representative of the South Asian women population in Southampton. The FAQ developed in the present study would not be expected to produce higher correlations if it was administered to the general South Asian community. Little information is available for subjects who did not respond to the postal questionnaire.

Agreement between the FAQ and recall was better when the analysis included only 57 subjects (they completed the validation study) than when analysis included all subjects (those who completed and did not complete the validation study). This suggests that the subjects who completed the study were more reliable in answering the questions than those who did not complete the study.

### 4.4.3 Development of the FAQ, the activity diary, the 24-hour activity recall

In the present study, the FAQ was developed to measure the long-term physical activity patterns of the South Asian women, and to detect differences in their physical activity. The measure, in terms of their total daily energy expenditure would enable us to place subjects into thirds of the energy expenditure distribution. In order to evaluate the accuracy of the physical activity measurement by the questionnaire we compared it with the physical activity measurement from a seven-day activity diary. Comparison of the questionnaire measurement with the diary, presumed to be a superior method, would enable us to detect any bias due to measurement error incurred in the questionnaire. This is assuming that the diary is correct. The questionnaire may underestimate energy expenditure if certain activities that are performed by all subjects have not been included. There may be tendencies for groups of subjects in the study sample to under-report or over-report their activities.

The FAQ was developed based on current knowledge available at that time. Most questionnaires developed earlier had focused only on occupational, or leisure time activities or both. The FAQ in the present study contains questions on occupation, housework, leisure, stair climbing (at home and at work), and sleep to assess all components of subjects' physical activity. Questions on frequency and duration of physical activity during the past twelve months was adapted from the Minnesota Leisure Time Physical Activity Questionnaire (MLTPAQ), (Taylor *et al.* 1978). However, the present questionnaire contains more activity components than that of the MLTPAQ. In an evaluation of the MLTPAQ, the total activity measure had a high correlation with the total activity measure from a 4-week leisure-time physical activity history (Jacobs *et al.* 1993). Recommendations made by previous investigators who evaluated the MLTPAQ advised a better assessment of light and moderate intensity activities such as household chores and occupational activities (Jacobs *et al.* 1993; Eloshua *et al.* 1994).

The present FAQ has listed in detail leisure activities, household chores and other activities that are likely to be performed by South Asian women. This is probably an appropriate approach for the subjects in the target group. In the traditional South Asian community women are responsible for day-to-day care of the family and household (Henley, 1979). This includes looking after children and the elderly, cooking and cleaning the house. From the subjects' responses this tradition still holds among the South Asian community in Southampton. Assessment of physical activity at work was based on questions about stair climbing and the type of activity they spent most time engaged in at work.

Seasonal variations in physical activity have been considered by having the frequency and duration of activity into the four segments representing seasons of the year. Some activities may be performed only in the summer or winter season. This has helped subjects to recall their activity more precisely. Activities like gardening, swimming or walking as an exercise were not likely to be performed during the winter. Seasonal divisions helped subjects to recall specific periods for example the summer and winter school holidays when their activities were likely to be different.

The aim of the questionnaire was to assess subjects' habitual physical activity. By asking subjects to recall their activity during the previous one year we assume that it represents their long-term physical activity pattern. This assumption may not be entirely true. There were subjects who had changed their physical activity pattern during the previous five years. For example, their activities might have changed since coming to England from India, Pakistan or Bangladesh, since leaving school, college or university, after being married, or after having children.

It appears that physical activity patterns of individuals in the long term do not remain static. There are variations at specific time periods during their lifetime. To determine the correct physical activity exposure for an individual the questionnaire might have to ask subjects about their physical activity pattern at critical points throughout their life (Friedenreich *et al.* 1998).

The format for the activity diary and the 24-hour recall was modelled from the weighed food records and the 24-hour dietary recall. In dietary records, subjects would have to describe the food that they have eaten and its weight. In the activity diary and 24-hour activity recall subjects were asked to describe the activity they had performed and the duration for which that activity was performed. A description of the activity enabled us to estimate the energy cost intensities. Some activities may have a different energy cost depending on the position in which it is performed. For example, the energy cost for standing activities can vary from 5.96 kJ/min (for standing at rest) to 7.46 kJ/min (for standing and working).

A self-administered questionnaire in the English language may not be appropriate for all the South Asian people. Newcomers to this country may not have good command of the language and it may be necessary to produce the questionnaire in several languages. An interview method would be more appropriate because then subjects can choose their preferred language. It may be necessary to hire interviewers who are proficient in English and one or two of the South Asian languages, for example Urdu, or Gujarati, or Hindi.

### 4.4.4 Measurement errors in the FAQ

The level of precision and validity of the FAQ as an instrument to assess habitual physical activity is affected by errors associated with its structure, design and the subjects who answered the questionnaire. In epidemiology this is referred to as measurement error. Precision in measurement and estimation is improved when random error is minimised. On the other hand, validity of an instrument is improved when systematic error is reduced (Rothman & Greenland, 1998).

#### 4.4.4.1 *Random error*

Possible sources of random error in the present study include the study sample and the questionnaire being administered only once and not repeated. In a randomly selected sample we assume that variations in their physical activities and other characteristics that influence their answers to the questionnaire are randomly distributed. The present study subjects have not been randomly sampled from the possible target population. The sampling error may have contributed to inaccuracies in the physical activity measurements. One way to reduce the sampling error and increase precision of the measurement is to increase the number of subjects, and to ensure that they are randomly selected from the target population.

Validity of the FAQ implies accurate measurements of habitual physical activity in South Asian women. Subjects in the study were all volunteers, so they had a personal interest in or were more motivated to take part in the study. Being self-selected, they were likely to be different from women who did not take part, in relation to their physical activity, or their ability to recall past physical activity. Because most of the subjects were well educated and conscious of their health, this bias might cause the questionnaire to appear more accurate than it would if used in a random sample of the target population.

Because physical activity of every individual varies on a daily, weekly and seasonal basis, a measurement at any one time is bound to be different from their 'true' habitual physical activity. We assume that these variations occur at random. Thus when the activity diary was recorded for seven days, it was likely to reduce the random errors due to short-term true within-subject variability in their physical activity. If the diary were repeated several times a year, say in different seasons, the average of the repeat measure would be a better estimate of the subject's long-term habitual physical activity.

#### 4.4.4.2 *Systematic error*

The FAQ has attempted to obtain information on activity components that were thought to be important to our target population. In the interview, subjects were shown a list of household, exercise, sport and leisure activities that would help in their recall. However, several types of activities that most subjects had recorded in the diary had not been listed in the questionnaire. Therefore they were seldom recalled. These include social activities (sitting and talking, serving guests, travel to visit relatives); religious activities (daily prayers at home or at the temple, weekly prayers at the temple, community work at the temple); looking after young children; travel to and from work or getting about; sitting and watching the video or TV, and studying or sitting in lectures. Because these activities were frequently performed by the subjects, the questionnaire underestimated their total physical activity and this underestimation affected subjects differently. The systematic error associated with it may have caused the FAQ to underestimate the daily energy expenditure in most subjects, when compared with the diary. To improve the questionnaire's validity, it should be modified so that the subject's total physical activity is assessed.

We would expect subjects to be able to recall their work-related activities better than other types of activities because they are probably more structured than other activities. One questionnaire that has focused on energy expenditure during work and transportation to and from work has been found to be reliable because it had a high correlation with their occupation record (Ainsworth *et al.* 1993a). Another occupational physical activity questionnaire that assessed only types of activity and duration spent at each activity at work had poor correlation with the 7-day activity recall. It did not include questions about transportation to and from work (Lakka & Salonen, 1992).

Bernstein *et al.* (1998) developed a self-administered physical activity frequency questionnaire that had listed 70 activities. Subjects had to recall the number of days and the number of hours per day they performed the activity during the previous week. The list of activities was developed based on the same principles for the food frequency questionnaire. Data obtained from 24-hour recalls in a representative sample of the population in Geneva were used to get a list of the major activities that contributed to 95 percent of the total daily energy expenditure by the sample. They found that about fifty percent of the energy expenditure were from activities of low and moderate intensities. Their 24-hour recall of activity was obtained through telephone interviews. This procedure may be feasible in highly developed societies where it is possible to get a high response rate by using telephone interviews. To develop that type of physical activity in other populations, similar principles can be applied, for example, by using focus group discussions among samples of the community.

Their questionnaire's estimate of daily energy expenditure was highly correlated with the estimate by the heart rate monitoring method. More useful information would be the proportion of subjects placed in the same distribution of energy expenditure by both methods. Their questionnaires need to be re-tested among the same population to evaluate its reproducibility.

Other than activities that have been left out, error in the estimation of the duration of each activity by the subjects may have contributed to the discrepancy between the two measures. There is a possibility that subjects were not able to recall accurately the frequency and duration of activities that are not performed regularly. Other activities for example, cooking, washing the dishes and cleaning the kitchen were often performed within the same time period and many subjects could not estimate a specified time period for each activity. As these activities have different energy costs, an error in their duration is likely to result in underestimation or overestimation of an individual's total energy expenditure. For example, if a subject had underestimated or over estimated the time spent in cleaning the house (energy cost 13.68 kJ/min) by 15 minutes per day, this would result in an over or underestimation of 74898 kJ in twelve months (13.68 kJ/min x 15 min x 365 days). As cleaning the house is performed almost daily it will contribute to a large proportion of the total year's energy expenditure (data not shown). Thus a small error in its daily estimation would cause a large error in the long-term energy expenditure.

The energy cost values used for conversion of activity into energy expenditure were based on the data by James & Schofield (1990). In the reference table the energy costs for many of the activities were based on experiments with very few subjects. For some activities the energy costs were derived from the study of one subject. By studying a small number of subjects there are likely to be errors in estimating energy cost due to variability between subjects in performing the activity. The reference tables did not give information about the proportion of males and females involved in the experiments. If the subjects had been young healthy males, they would probably have performed the activities more vigorously and used more energy per minute of activity than female subjects. This would imply that subject's energy expenditure has been overestimated, and it would not reflect their true energy expenditure. However, since the same reference values have been used to estimate the energy expenditure for all the methods, this will probably cause them to be more alike than different.

The same energy cost per activity was applied to all subjects, regardless of possible differences in energy expenditure per activity due different body weights. This is likely to make heavier subjects appear to expend less energy than they actually did, and lighter subjects appear to expend more energy than they actually did. However the same method of calculation was used to estimate energy expenditure for the diary, the 24-hour recall and the FAQ. Therefore estimation of energy expenditure was probably valid for internal comparisons only.

Poor measurement of the exposure may obscure a true relationship. In the EPIC-project study among Dutch women aged 49-70, walking was not significantly related to any of the cardiovascular disease risk factors (Pols *et al.* 1997c). This is in contrast to the body of evidence available. One of the recommendations by the US Department of Health was that every American should engage daily in 30 minutes of moderate level physical activity, example brisk walking (US Department of Health & Human Services, 1996). One reason for the lack of association shown between walking and CVD risk in the Dutch EPIC study is probably the poor measurement of walking in their subjects. In the validation study of the questionnaire, walking had the lowest correlation coefficient of energy expenditure compared with the activity diary (Pols *et al.* 1997b). It is likely that many subjects were misclassified in their walking component.

In dietary studies, overweight subjects tend to under report their food intake (Bingham & Nelson, 1997). Lavienja *et al.* (1998) found that increasing under reporting of energy intake occurred with increasing degree of overweight among Dutch men and women. Part of their under reporting was explained by subjects dieting during the survey, smoking habits, education level and physical activity.

It is not clear whether weight can influence the way subjects report their physical activity. The present study, subject's BMI did not show any relationship with physical activity level. The sample size may be too small to have sufficient number of subjects in subgroups by their BMI. Analysis of their energy expenditure to BMI ratio showed that overweight subjects had lower energy ratio than normal weight subjects. This could be an artefact of using the same energy cost of activity for all the subjects irrespective of their basal metabolic rate.

### 4.4.5 The diary as a reference method for physical activity assessment

In the present study the 7-day activity diary has been used as a reference method to measure physical activity. The total daily energy expenditure based on the average of a 7-day activity record was compared with the average daily energy expenditure estimated by the FAQ and the correlation between the two measures was moderate. The activity diary has been used as a reference method for the assessment of physical activity by many investigators.

The errors in recording of an activity as it is performed are not likely to be correlated with the errors in the FAQ, which is based on recall of their past physical activity. Thus recording of current activity would not be affected by their ability to recall. In this aspect the diary is justified to be used as a reference method. On the other hand, the same reference table for energy cost of activities has been used to estimate energy expenditure from the FAQ. Errors in the estimate of energy expenditure by both methods might be correlated, thus the level of agreement between the two methods might be an over estimate of their true relationship.

The diary can give a good estimate of the daily energy expenditure when compared with the doubly labelled water method (section 2.2.2), with an error of not more than seven percent at group level. This might be sufficient to tolerate considering the diary is used to rank subjects into thirds or fourths of the energy expenditure distribution. Among adolescents the level of agreement was found to be better for boys than girls. Correct classification of total energy expenditure by the diary compared with the doubly labelled water method was lower among girls (about 55 %) than among boys (about 70 %), (Bratteby *et al.* 1997). We do not know the size of error in the estimated daily energy expenditure from the diary among the South Asian women. This has never been evaluated before.

Seven days of activity records have been collected from the study subjects. This was two days more than the minimum required based on our estimation of 5 days. It is presumed this is adequate in estimating the average energy expenditure that takes into account of the day-to-day variations in subject's activity and the variations between weekdays and weekend days.

The diary as a reference method is the preferred method for many investigators, over other methods such as the doubly labelled water, heart rate monitoring or motion sensor methods, due to its low cost. This is an important consideration when the validation studies involve a large number of subjects. Due to budget constraints most investigators will have no other alternatives except to use the diary method. However, the diary should be validated with a more accurate method such as the doubly labelled water or the heart-rate monitoring method, in a small sub-study among the target population.

Several studies have used the activity diary as a reference method to compare with the questionnaire. Their correlations between the questionnaire physical activity measures and the diary were similar to findings in the present study. The Minnesota Leisure Time Physical Activity Questionnaire (MLTPAQ) total physical activity score and heavy activity score had moderate correlations with the physical activity record and level of fitness, $VO_2$peak. Moderate and light household physical activity scores were poorly correlated with the reference measures (Richardson *et al.* 1994). It is probable that moderate and light activities were not accurately assessed among the Caucasian subjects, in their study.

The Dutch pre EPIC physical activity questionnaire had moderate correlations with the diary for women. Correlations among men were higher (Pols *et al.* 1997a). They suggested that older women in their study might find it difficult to make correct estimates of the time they spent on various activities. Although the subjects in the present study belonged to the younger age group, similar problems were encountered. They were not able to give correct estimates of the time in various activities. Richardson *et al.* (1995) too found that the correlations between physical activity from the questionnaire and the diary was lower among women than men. They explained that daily miscellaneous activities that involved walking (i.e. household-related activities) were not assessed by the questionnaire. Household activities are considered an important component of the daily physical activity, particularly among women. Our physical activity questionnaire has included questions on household-related activities.

The Baecke physical activity questionnaire has been validated in Dutch men and women. The correlations between the questionnaire measures of physical activity and the diary were lower among women than men (Pols *et al.* 1995). The percentage agreement between the classification in thirds according to the questionnaire and the diary too was lower for the female than male subjects. The Baecke questionnaire is short and user-friendly. However there are no questions on activities related to housework. This activity would be expected to contribute a higher proportion of the total activity among women than among men. This might explain the poorer measure of physical activity among women than men.

The physical activity which was used in the Nurses' Health Study showed higher correlations between activity scores as assessed by the physical activity questionnaire and the diary than for inactivity scores (Wolf *et al.* 1994). The questionnaire had underestimated physical activity by 20 percent. It had poor measures of sedentary activities such as sitting and resting. Activity scores from the questionnaire and the diary had a higher correlation for subjects in a representative sample of the population compared to the African-American sample. Subjects in the two samples differed in their participation rate in two types of activities, that is, 'jogging' and 'other activities'. The reduced rate of participation among African-American subjects in these activities may have led to the lower correlations in physical activity measures between the questionnaire and the diary.

Vooripps *et al.* (1991) had validated the modified Baecke physical activity questionnaire among a group of elderly Dutch men and women, using the 24-hour activity recall as a reference method. They had included additional questions on household activities as they considered this to be relatively important in the elderly. The correlation coefficient between activity scores from the questionnaire and the 24-hour recall was high, 71 percent of the subjects were classified consistently in the same tertile. They have shown that a questionnaire can be a valid measure of physical activity by including activities that are relevant to their target population.

*Problems encountered*

The diary is not an objective method in physical activity measurement. It is subject to errors in the recording of activities, and requires subjects to be conscientious and highly motivated. In the present study, subjects were instructed to record the time at the start of each activity, and to describe the activity in brief. Not all subjects followed this procedure. Some subjects recorded their activity at times when they were free, for example during their lunch break, or before going to bed at night. This is likely to cause error in the estimate of the duration of each activity, or they might leave out an activity that was performed on that day. By writing the activity at a later time subjects might have forgotten to record a trivial activity which lasted long enough to influence total daily energy expenditure. There was a tendency for subjects to round up the duration of activity to the nearest 15 or 30 minutes.

Due to its structure and format every activity recorded has to be identified and coded before calculating its energy costs. If the activity is not listed in the reference tables, its energy cost per minute has to be determined by using values from similar activities. There is no computerised physical activity database available similar to the food tables, or a computer program similar to that for the analysis of food frequency questionnaires. This has made to the task of analysing the activity diary and questionnaire a tedious and time-consuming process.

### 4.4.6 The 24-hour activity recall as a reference method for physical activity assessment

The 24-hour recall was easy to administer because it only requires the subjects to remember what they had done on the previous day. Subjects found it easy to answer if they started from the time they got out of bed and ended with the time they went to sleep. As the activities were recalled in sequence, they could probably remember most of the activities. Some subjects could only approximate the time taken for each activity, but some subjects could give the correct time when certain activities started and when another activity ended. Examples of these activities include sending children to school and collecting them back, a meeting at the office, or watching a particular programme on TV. Activities in which subjects had difficulties in estimating their duration included vacuuming and cleaning the house, preparing foods and cooking. We can say that the 24-hour recall is able to identify nearly all the activities that subjects had done on the previous day. How long each activity lasted could not be estimated as accurately as the diary, except for certain types of activities.

The FAQ in the present study had underestimated the time spent for each activity. As explained earlier, one of the reasons is probably due to poor memory recall of past activities. To improve the precision in recall it may be necessary to shorten the period of recall, say the past week, or the past 24 hours. Correlation between energy expenditure measured from the 24-hour recall and the diary was moderate ($r = 0.62$, $p = .000$). The period of recall was followed immediately by the recording of activity. It is likely that the subject's activity will remain unchanged during that period and this could have overestimated their true relationship. On the other hand, this also indicates that the 24-hour recall can probably be used as proxy for the diary. The 24-hour recall has an advantage over the diary because it is easier to administer and does not impose a heavy burden on the subjects. The structure of the 24-hour recall makes it possible for subjects to account for all 1440 minutes in a day.

One 24-hour recall of activity would not give an accurate estimate of an individual's usual physical activity because it has covered activities that were performed in one day. It probably would not have included some activities, which the subjects carry out once or twice a week. Data in the present study confirmed this because the correlation between estimated energy expenditure by the FAQ compared with 24-hour recall was lower than when the FAQ was compared to the 7-day diary. Because an individual's physical activity varies from day to day, in different weeks or months of the year, it would be necessary to repeat the 24-hour recalls say, every month for one year. The repeat 24-hour recalls should maintain a balance between the days of the week. This method has been conducted in the dietary survey for the EPIC Project (Boeing *et al.* 1997). They found correlation coefficients (unadjusted) that ranged from 0.22 to 0.61 between the food frequency questionnaire and the 24-hour dietary recalls for retinol, carotenoids, tocopherols and ascorbic acid.

### 4.4.7 The Step Test as a marker for physical activity level

The FAQ in the present study was not developed to assess subject's level of fitness. The Step test was used as a measure of subject's long-term physical activity independent of recall. The step test is a submaximum exercise test that was developed for the general population, so that an individual can do the test at home by using the domestic steps (Shephard *et al.* 1976). The 3-minute "warm-up" stepping rate was equivalent to 65 to 70 percent of the average aerobic power anticipated in a person in the next older 10-year age group. The second 3-minute stepping rate was at 65 to 70 percent of the average aerobic power in a sedentary person of her own age.

The physical activity questionnaire used in the Male Health Professionals study found an inverse relationship between vigorous activity scores and the resting pulse rate and the pulse rate after stepping (Chasan-Taber *et al.* 1996). Correlations for non-vigorous activity scores were very low. The subjects in the present study were mostly engaged in moderate and low level physical activities. That may explain the lack of relationship between heart rate and the physical activity measures. The pulse rate in the study may have been poorly measured, thus any relationship between the two measures could have been obscured. Even in the laboratory setting the correlation between the MLTPAQ physical activity scores and submaximal heart rate was poor (DeBacker *et al.* 1981).

### 4.4.8 Validity of the FAQ

This is the first time that a physical activity questionnaire has been evaluated among the South Asian community in the UK. Findings from the present study can only be compared with validation studies that have been conducted among other populations (Table 4.38). The correlation between physical activity measures from the questionnaire and the reference measure varied from very low (Leon *et al.* 1981) to higher (Westerterp *et al.* 1992). The types of physical activities assessed and the physical activities measures used as the reference were more likely to have a large influence on their validity. Maximum oxygen consumption may not be an appropriate reference to assess moderate intensity (Jacobs *et al.* 1993, Richardson *et al.* 1994, Ainsworth *et al.* 1993). Body fat did not appear to be an appropriate validation criteria (Jacobs *et al.* 1993, Richardson *et al.* 1994).

*Precision in the ranking of subjects*

The FAQ was developed to assess subjects' long-term physical activity and place them into three categories of physical activity that is low, medium, and high. Ranking of subjects by the FAQ was compared with ranking by the diary. More than forty percent of the subjects did not fall into the same physical activity level by both methods. Measurement errors in the FAQ as already explained have probably contributed to the lack of precision in its physical activity assessment. The diary too may have its own measurement error in the assessment of subjects' physical activity.

Although the activity record is considered to be more accurate in measuring physical activity than past recall, using the average of a one-week dairy may not be representative of long-term physical activity. Random weekly, monthly or seasonal variability of individuals physical activity could reduce the accuracy of physical activity measurements by the diary. This too could account for the moderate level of agreement between the FAQ and the diary. One way to minimise this type of error in physical activity measurements is to ask subjects to repeat their one-week activity record several times a year at intervals. The average of several recordings is more likely to be representative of their long-term physical activity than a single recording.

Validity of the FAQ was also assessed by the proportion of subjects correctly classified compared to the diary or the 24-hr recall. Subject misclassification in their exposure measurement (in this case physical activity) has serious implications if the questionnaires were to be used in an epidemiological study. For example, in a study to assess disease in relation to physical activity level, the questionnaire was able to correctly classify only 50 percent of the subjects. Let us assume that the true relative risk of disease for people who are least active compared to those most active is 3. Because some of the subjects who were truly active were placed in the less active group and vice versa (the 50 percent of subjects misclassified), they have varying relative risks. The average relative risk for this group is less than the true value. In this example the observed relative risk is reduced to about 1.4 (Clayton & Gill, 1997).

It is now possible to estimate correct classification of subjects using data from validation studies by using mathematical models. However, investigators have been cautioned on the use of correction methods because these methods usually assume the validation standard is measured without error (Rothman & Greenland, 1998). This is not always the case. If validation measurement taken as the truth is itself subject to error, then the corrected estimate will also be biased. This is likely to be the case with a 7-day diary,

**Table 4.38: Results from other physical activity questionnaire validation studies**

| Reference | Method | Summary of results | | Subjects |
|---|---|---|---|---|
| Leon *et al.* 1994 | Relationship between HIP occupational score and treadmill time (correlation coefficients) | All classifications<br>Light to moderate vs. heavy | 0.07<br>0.03 | |
| Taylor *et al.* 1984 | Relationship between 7-Day Recall score and self-report log for weekend (WEND) and weekday (WDAY) (correlation coefficients) | <br>Moderate activity<br>Hard/very heavy activity | WEND WDAY<br>0.70* 0.75*<br>0.66* 0.39* | 30 men between ages 34 & 69 yr. |
| Westerterp *et al. 1992* | Relationship between monthly total hours of activity and physical activity index expressed as the total energy expenditure measured with doubly labelled water divided by resting metabolic rate (correlation coefficient). | | 0.61* | 21 Dutch men aged between 70 & 89 years |
| Ainsworth *et al.*1993 | Relationships between the Paffenbarger total index and specific activity indices (PAI), Caltrac activity monitor (CAL), maximal oxygen capacity ($VO_2$max) and % body fat (BF) (correlation coefficients) | Heavy PAI (MET-min/wk)<br>Light PAI (MET-min/wk)<br>CAL (METs/day)<br>$VO_2$max<br>BF (%) | 0.69*<br>0.08<br>0.29<br>0.60*<br>-0.44* | 28 men & 50 women aged between 21 & 59 years. |
| DiPietro *et al.*1993 | Relationship between energy expenditure (kcal/wk) from activities checklist compared to $VO_2$max and Caltrac counts | Estimated $VO_2$max<br>Caltrac counts | 0.20<br>0.14 | 14 men & 11 women aged between 60 & 86 years with variable economic status. |
| Jacobs *et al.* 1993 | Relationships between moderate and heavy intensity activity units and maximum oxygen consumption | <br>Moderate<br>Heavy | $VO_2$max BF CAL FWH<br>0.08 -0.09 0.11 0.08<br>0.63* -0.35 0.31* 0.54 | 28 men & 50 women aged between 20 & 59years; predominantly |

| | | | | |
|---|---|---|---|---|
| | ($VO_2$max), % body fat (BF), Caltrac counts (CAL; MET-min/d), & total 4-wk activity history (FWH: MET-min/d) (Spearman correlation). (The CARDIA physical activity history) | | | Caucasian. |
| Lakka *et al.* 1994 | Relationships between duration and intensity of activity from the KIHD 12-month History and duration and intensity of leisure activity from the KIHD Seven-Day Recall and BMI (Pearson correlations adjusted for age and exam year) | Duration of 12-m recall<br>Duration of 7-d recall<br>Intensity<br>BMI<br>Frequency o f 12-m recall<br>Duration of 7-d recall<br>Frequency<br>BMI | <br>0.57*<br>0.49<br>-0.01<br><br>0.11*<br>0.06<br>-0.12 | 1743 men from a population-based sample aged between 42 & 60 years at baseline. |
| Richardson *et al.* 1994 | Relationships between physical activity sub-scores and physical activity record (PA; MET-min/d), Caltrac (CAL; MET-min/d), peak oxygen consumption ($VO_2$peak), & % body fat (BF) (Correlation coefficients). | <br>Total<br>Heavy<br>Moderate<br>Light<br>Household | $VO_2$peak / BF / CAL / PA<br>0.47* / -0.24* / 0.21 / 0.47*<br>0.43 / -0.24* / 0.22 / 0.39*<br>.014 / -0.01 / 0.23* / 0.19<br>0.27* / -0.15 / 0.15 / 0.16<br>0.14 / -0.01 / -0.02 / 0.21 | 78 men and women aged between 21 & 59 years. |

HIP - Health Insurance Plan of New York
KIHD - Kuopio Ischaemic Heart Disease Study
* $p < 0.05$

because people might overestimate socially desirable activities or underestimate other activities.

'True' habitual physical activity is not measurable. Some researchers have used data from a validation study to estimate the relationship between physical activity as measured by a field method and the 'true' physical activity, by using mathematical models. Kaaks (1997) described the method of triads to quantify the validity of a questionnaire method to assess habitual dietary intake. It requires the questionnaire method to be compared with two objective methods (one is a biomarker). We could not use a biomarker such as the doubly labelled water method to compare with the FAQ because it is too costly.

Result from the studies mentioned suggest that the same physical activity questionnaire may perform differently in assessing habitual physical activity in men and in women. Household-related activities are likely to be performed more frequently by women than by men. On the other hand strenuous physical activities may be performed more frequently by men than by women. Thus questionnaires that have left out household-related tasks tend to measure physical activities less accurately among women compared to in men. Our FAQ is targeted for the South Asian women. Most of the household-related tasks we would expect the South Asian women to be involved in have been included, except for child-care activities.

One questionnaire that is appropriate for a population may not perform equally well if applied to a different population or ethnic group. Most physical activity questionnaires currently available have been developed for use among the Caucasian populations. Our study is the first to validate a physical activity questionnaire appropriate for the South Asian community.

*Repeatability of the FAQ*

Within the time available it was not possible to repeat the FAQ interview on the same subjects. Repeat administration of the FAQ would enable us to estimate how reliable it is as an instrument to assess a subject's habitual physical activity by recall. If the instrument was reliable, physical activity measure between the first and the repeat administration should be closely related. If there was a long gap between the first and the repeat administration, the individual's physical activity might truly have changed, such that the two measures were different. Validity of a questionnaire includes evaluation of its performance when administered to the same population more than once. This is represented by the correlation coefficient between first and repeat measurement (intra-class correlation).

### 4.4.9 Physical activity level of the South Asian women in Southampton

The amount of time spent daily on activities of moderate and high intensity activities were on average more than that recommended. The South Asian women in the study were not likely to participate in sporting or vigorous exercises. This is similar to findings of a survey among the ethnic minority in the UK (Rudat, 1994). On the other hand they were not highly sedentary. Reported activities from the diary suggest that all of the subjects had accumulated on average 880 minutes of moderate to high intensity activities per week. This was more than what was recommended by the National Institute of Health for the American people (NIH, 1996). The accumulated time per week from the FAQ was less, but 75 percent of the subjects met the minimum level of 30 minutes per day spent in moderate activities for most days of the week, (or 210 minutes per week). Previous surveys of the South Asian community have not measured this component of their daily physical activities.

# CHAPTER FIVE

## 5 OVERALL DISCUSSION

This section integrates the two studies conducted for the thesis. The research aim, objectives and hypothesis are restated below: -

### *Aim*

To study the effects of maternal anthropometry, medical and socio-demographic characteristics, on size at birth among South Asian babies born in Southampton

### *Objectives*

1. To explore maternal factors during pregnancy associated with birth outcome among South Asian babies born in Southampton between 1957 and 1996.
2. To asses whether increased maternal weight associated with migration from the Indian Subcontinent to the UK is associated with increased birth weight in South Asian babies born in the UK, taking into account of the effects of other maternal characteristics.
3. To assess whether the higher maternal weight in South Asian women in the UK can be explained by changes in levels of physical activity associated with migration to the UK, leading to a more positive energy balance.
4. To develop a valid method of assessing physical activity among South Asian women in Southampton in order to assess the effect of physical activity on maternal size.

### *Hypothesis*

1. The higher birth weight of South Asian babies born in the UK compared with those born in the Indian Subcontinent is explained by higher maternal weight of South Asian mothers in the UK.
2. Changes in levels of physical activity, as a result of migrating from the Indian subcontinent to the UK, leads to increased body weight as a consequence of a more positive energy balance.

Comparison of the South Asian birth records with the population census figures for UK born South Asians indicated an under-reporting for the Indian population. However, since the difference was small it is not likely to bias the results. The census figures for Pakistanis and Bangladeshis born in the UK were similar to the birth records. This is the first retrospective study of South Asian birth in the UK covering a period of more than thirty years. The strength of the study is the exposure data were measured before the babies were born. Thus the outcomes were not likely to be biased by the exposure.

The data were taken from routine clinic records, thus its quality could not be checked. The size of measurement error in the data could not be assessed. Systematic errors in the anthropometric measurements and in the estimation of gestational age could have caused subjects to be misclassified, and obscure any relationship that existed. Although there were many cases that had missing data, there were no differences in the mean birth weight between cases that were included and cases that were excluded in the regression analysis. Thus, the results of the analysis are not likely to be biased.

The prevalence of low birth weight in the South Asian babies was higher than the UK population, but lower than the prevalence in India, Pakistan and Bangladesh. The average birth weight of South Asian babies in Southampton was higher than that of the babies in India, Pakistan and Bangladesh. Improved nutritional status due to improved socio-economic status of the South Asian community and the utilization of better pre-natal care in the UK may be the contributing factors.

Factors that were found to have an effect on the birth measurements of South Asian infants were consistent with studies in other population groups. These factors include gestational age, parity, infant sex, maternal weight, and height and body mass index. Maternal weight and body mass index at the beginning and end of pregnancy both influence fetal size. However, the size of the effect could not be quantified. While other studies found that weight gain during pregnancy had a significant effect on birth weight, our study did not. This could be because the average weight gain among the South Asian women was small. There was a relatively small number of subjects with weight records. With a difference of 69 g in birth weight between babies from the highest and the lowest weight gain distribution, this study did not have enough power to be confident in making the conclusion that weight gain did not have a significant effect on birth weight. A study that has a larger sample size and more precise birth weight measurements might be able to detect a statistical difference.

Very low levels of haemoglobin in late pregnancy was associated with babies who had shorter gestation, lower birth weight, placental weight, a smaller head circumference and a higher placental to birth weight ratio. Almost forty percent of the mothers were diagnosed to have anaemia at some stage of their pregnancy. Considering that this data were collected over a long period, it could be recording the same individual who had repeated anaemia in several pregnancies. It could also mean that a large proportion of the South Asian women suffer from anaemia. In both circumstances, this situation is considered a public health problem that requires urgent attention by the community as well as the health services providers.

Female South Asian babies born with lower birth weight are likely to be at risk of becoming anaemic during adolescence and probably during motherhood. Subsequently they themselves will produce lower birth weight babies. The Barker hypothesis of *in-utero* programming of adult diseases may have public health implications for future South Asian adults. Improving the birth outcomes of the South Asian women may have to begin by improving their nutritional status before they reach childbearing age that is during adolescence. The prevention of anaemia during pregnancy may help to break the vicious cycle of being born small that increases their risk of being anaemic and later producing small babies. There is a need to educate the South Asian community on how to improve their dietary intakes especially with foods that have a high availability for iron. We could not assess the effect of haemoglobin levels in early pregnancy. Future studies need to monitor the haemoglobin levels among South Asian women in order to develop appropriate guidelines to monitor their iron status.

The South Asians are a heterogeneous group. The present study has shown that four ethnic sub-groups showed differences in maternal size and the size of their babies. Pakistani-Muslim women, who had better nutritional status at the beginning and end of pregnancy, had heavier and longer babies than Hindu-Indian and Sikh-Indian women. The Bangladeshi women were shorter but had similar BMI to the Pakistani-Muslim women. Their babies' birth weights were similar. This suggests that maternal weight had a greater influence on birth weight than height. Sikh-Indian babies were the smallest. Their lower maternal weight, BMI and poor iron status could explain their poorer birth outcomes compared to other groups. The differences in weight, height and haemoglobin levels between the four subgroups suggest that current maternal nutritional status and growth in early life are contributing factors for differences in their baby's birth weight. Thus future studies should consider the ethnic differences within the South Asian community.

South Asians in the UK are probably living in an environment of improved socio-economic conditions, and received better pre-natal care. It may take several generations of South Asians in the UK before its impact on birth weight can be observed. Differences in their diets too could have contributed to differences in their birth outcomes. Future studies need to assess if the differences between the ethnic groups could be explained by the differences in their maternal iron status, gestational age or body mass index.

There were several negative and unexpected findings in the present study, contrary to the findings of previous studies. There was a lack of relationship between maternal height and baby's birth length. The relationship between haemoglobin and birth weight was linear instead of U-shaped, and there seems to be no improvement in the birth weight of babies born by second generation South Asian women. Measurement errors due to non-standardized method of taking heights and measuring birth length could have caused subject's misclassification. Subsequently this could have masked any association between maternal height and birth length if there was any. Moreover the relatively small number of births with data on birth length was may have contributed to the lack of relationship.

Low haemoglobin during the third trimester may be too late to have a favourable effect on fetal growth. It is probably the reason for lack of a U-shaped relationship between haemoglobin and birth weight. On the other hand, low haemoglobin in late pregnancy may be an indicator of poor nutritional status that leads to reduce fetal growth. It is not known what is the optimal haemoglobin level during pregnancy and at which stage of pregnancy it can enhance fetal growth in the South Asian community. It is necessary to monitor maternal haemoglobin levels throughout pregnancy to study its effects on birth weight of the South Asian babies.

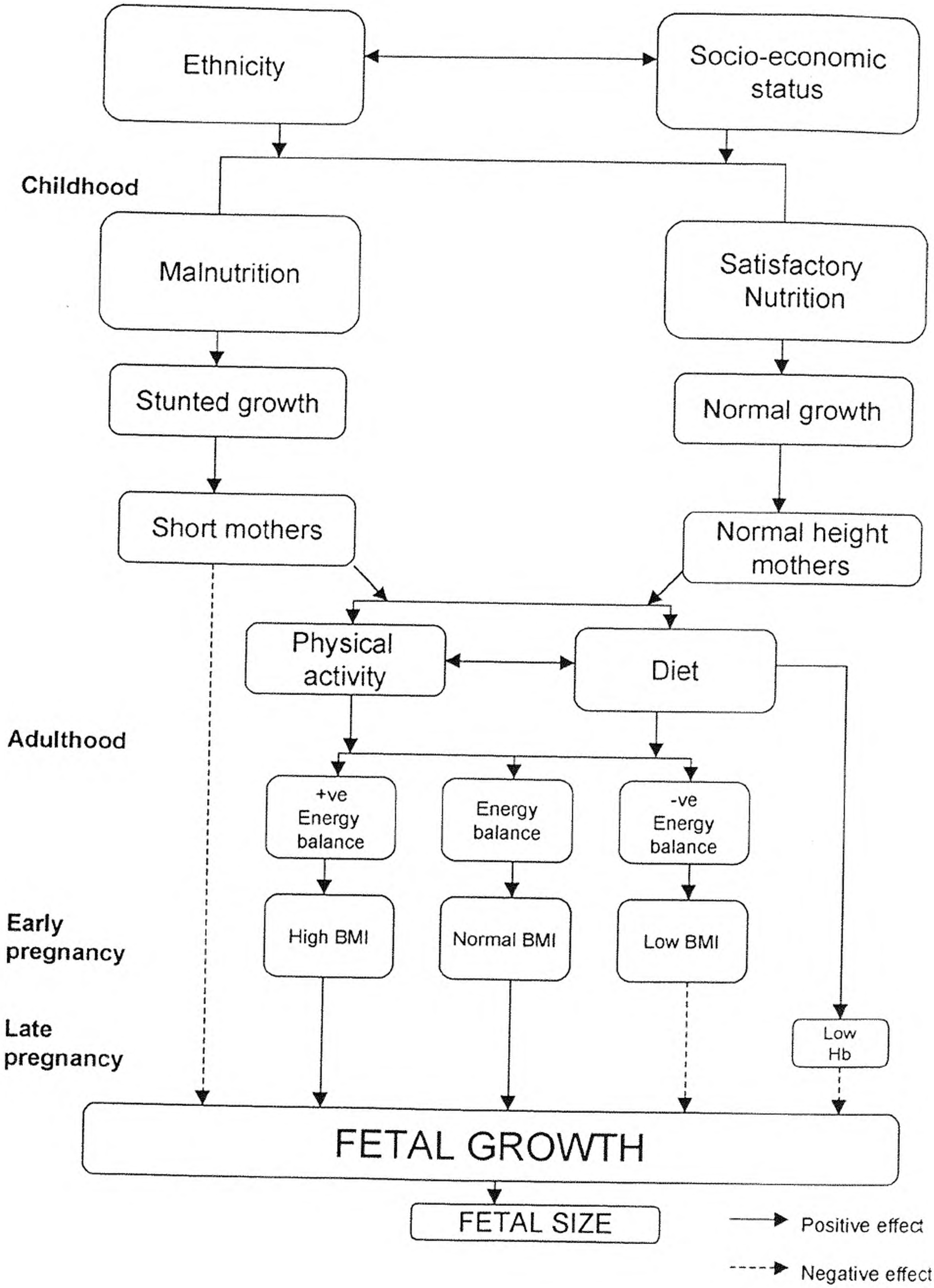
The lack of improvement in the birth weight of babies by second generation South Asian women was probably due to the relatively young second-generation women. They were lighter and shorter compared to the first generation women, this is probably because the former were still growing and had not reached their full adult size. Some of them had poor nutritional status as indicated by their low haemoglobin levels. There is a need to create awareness among the South Asian community about this situation and its implications on the health of their future generation. Members of the community should be consulted in the development of any nutrition education programme targeted to the young girls so that it will be acceptable to their community.

In this study, the South Asian women had lower birth weight babies than Caucasian women. The South Asian women were shorter and lighter than the Caucasian women. On the other hand, South Asian babies in Southampton were heavier compared to babies in India, Pakistan and Bangladesh. Maternal weight, BMI and height are probably some of the factors that contribute to these differences. However, this needs to be confirmed with a better-designed study.

The results of the study suggest that maternal nutritional status before the South Asian women become pregnant and during pregnancy have an influence on fetal growth and the fetal size at birth (Figure 28). Improving dietary intakes during pregnancy may improve the iron status and weight gain, and consequently baby's birth weight. At the same time improving their nutritional status before they become pregnant are equally important.

Socio-economic status during childhood has an influence on their growth. Women from poor families may have experienced malnutrition are likely to have suffered stunted growth. They were short. Short women were more likely to produce lighter babies than tall women. The nutritional status of adult South Asian women may have been

**Figure 28: A causal model showing factors that influence fetal growth among South Asian babies**



influenced by their current lifestyles too. Physical activity and diet are probably two important factors that determine their energy balance. Women whose energy intakes were in excess of their energy expenditure are likely to become fat mothers and were likely to produce heavier babies. There was a trend in increasing body weight and BMI as the women get older. This study suggests that as the women become older, they become heavier and have a higher BMI. Some South Asian women who have migrated to the UK may not have changed their diets, particularly energy intakes. Due to their lifestyles and environment in the UK they have become physically less active than before migration. Thus they are more likely to become fatter compared to women who stayed in the Indian subcontinent.

There is a lack of information on energy balance in South Asian people who have immigrated to the UK. Follow up and comparative studies would be able to determine if changes in their diet and physical activity patterns have contributed to changes in maternal size. This would be able to determine what impact these changes would have on the birth weight and other birth outcomes of the South Asian babies.

It is therefore important that physical activity of the South Asian women be studied. A study on the birth outcomes of South Asian women would need to look into their physical activity levels before and during pregnancy. Previous studies on birth weights have not considered physical activity of the mothers as a determining factor. Among South Asian women who have migrated to the UK, this could be an important factor that influences the birth weight of their babies. Thus there is a need to assess their physical activity levels before and during pregnancy. Since there is no instrument available to measure physical activity among the South Asians it has to be developed and validated before any study can be conducted. The second part of the thesis addresses this issue.

Community surveys in the UK suggest that the South Asian women are sedentary. They are not likely to be involved in sports activities or strenuous exercises. A majority of the South Asian women who gave birth in Southampton were housewives, and more likely to live in extended families. Thus housework and taking care of young children or other family members may have been a major component of their daily activities. Previous studies did not look into household-related activities. Therefore there is a need to include this type of activity in any study assess their physical activity.

Methods of physical activity assessment have been developed and validated for other populations. Currently there is no instrument available, which has been developed and validated for the South Asian community. Therefore it is thought necessary to develop a valid physical activity questionnaire appropriate for the South Asian people before the third objective of the thesis can be addressed. The present study did not intend to address objective three but stated to indicate the logical sequence of events that should follow.

In the second part of the thesis a physical activity questionnaire was designed to assess the levels of physical activity among South Asian women. It is a questionnaire that asks the subjects to recall their physical activity during the last twelve months by using face-to-face interview. The questionnaire contains questions on the subject's housework, sleep, stair climbing, leisure time activities, and activity at work. Housework has been itemised into eight major activities. They were vacuuming, cleaning the bathroom, cleaning the kitchen, preparing vegetables, cooking, washing dishes, hand washing of clothes, and shopping for food.

The FAQ was validated against a 7-day activity diary, which may not have been a perfect method for measuring habitual physical activity. The level of correlation between the diary and the FAQ after adjustment was similar to several other studies among Caucasian subjects. The diary itself is not considered a 'gold standard' for measuring habitual physical activity. The FAQ should have used a more objective validation criteria such as the accelerometer, the heart rate monitoring, and if the budget allows, doubly labelled water method.

The FAQ in the present study lacked details on the amount of time during work spent on sitting, standing or walking about, and transportation to and from work. The list of activities subjects were required to recall was not comprehensive and left out commonly undertaken activities such as religious and social activities, and caring for children. The exclusion of these activities could have reduced the validity of the FAQ.

The FAQ was able to detect different housework related activities that were important to the South Asian women. Housework has different intensities, of which activities such as vacuuming, cleaning the house and mopping the floor had a moderate intensity. It is important to identify the low and moderate activities that the South Asian women are frequently engaged in. The current FAQ was able to do that. However, to improve its precision the list of activities needs to be expanded to include activities that are important for the South Asian community.

A 24-hr recall questionnaire was also administered to obtain a complete account of the subject's activity during the previous day. The reference method that was used to validate the FAQ and the 24-hr recall was a 7-day activity diary. The physical activity measurements by the 24-hr recall were highly correlated with the diary. Future studies could use repeated 24-hr recall to assess the subject's long-term physical activity instead of the diary to improve compliance.

Although a majority of the South Asian women in the study did not take part in sporting activities or strenuous exercises, the time they spent in moderate activities were more than the current recommended level. This is because moderate intensity household chores, for example cleaning and vacuuming, occupied at least 30 minutes of subjects' time every day. They would not be considered as sedentary. There have not been studies to compare the physical activity levels of South Asian people in the Indian Subcontinent and the UK. This is the first time that a physical activity questionnaire has been developed and validated for the South Asian community. It may not very perfect and precise in its measurements but it could form a basis for future methods to assess physical activity in the South Asian community.

# CHAPTER SIX

## 6 CONCLUSIONS AND RECOMMENDATIONS

This is the first time that a study on a large sample of South Asian births covering a period of more thirty years has been done in the UK. Similar to findings of studies in other populations we have shown that in the South Asian community maternal size, iron status, length of gestation, maternal age, parity and infant sex have an influence on fetal growth. Our data shows that haemoglobin levels during the third trimester has a negative effect on fetal growth of the South Asian babies, as anaemic mothers had babies with a smaller head circumference, and a lower birth weight. Very low haemoglobin level during late pregnancy is associated with lighter birth weight babies and higher ratios of placenta weight to birth weight. These outcomes are associated with coronary heart disease and hypertension in adult life. Lower birth weight has been associated with anaemia in adolescent girls. If their iron status is not corrected they will enter motherhood with poor iron status, which will subsequently produce lower birth weight babies. Improving the nutrition of adolescent girls and women of childbearing age should break this cycle among the South Asian community.

The present study did not indicate any trend of increasing birth weight of babies born by the second generation South Asian women as found in a previous study elsewhere. The second-generation South Asian women, being younger mothers were lighter, had lower haemoglobin status, and had lighter weight babies compared to the first generation women. It is important to inform their community about the health status of their young women and its effects on the health status of their future generations. Targeted nutrition_education programmes that are culturally appropriate and acceptable to the community would help to improve their health and nutritional status.

We propose that fetal growth among the South Asians be influenced by maternal nutritional factors that prevail before pregnancy and during pregnancy. Before pregnancy, dietary energy intakes and energy expenditure determine the maternal weight, which will have an influence on fetal growth. Higher maternal BMI is associated with higher birth weight babies. During pregnancy, dietary macronutrient and micronutrient intakes determine maternal weight gain and haemoglobin levels. Both have an influence fetal growth.

The South Asians are not a homogeneous group. There are differences in their weight, height, nutritional status and probably early life experiences that may have resulted in the differences in their babies' sizes. These differences existed even after taking into account the effect of gestation, parity, infant sex, maternal BMI, maternal height and haemoglobin levels. Thus future studies should consider factors such as maternal nutrition status before and during pregnancy.

South Asian women showed a trend in increasing BMI from the 1960's to the 1990's. This applies to all ethnic groups. This suggests that duration of stay in the UK is associated with increase in BMI, or the South Asian women in general anywhere have increased BMI compared to previously.

Little is known about what causes South Asian women to increase weight as they get older. Increase in maternal weight before pregnancy is the result of a positive energy balance. This is the consequence of dietary energy intakes, which are in excess of the body's requirements for metabolism and for physical activity. Lifestyles and environment may be one of the underlying factors that cause the South Asian women who lived in the UK to have increased BMI. There is need to assess their physical activity patterns and to study its effects on the birth weight of their babies. Currently there is no valid tool available to measure the physical activity of the South Asian people. Thus there is a need to develop and validate a method that is appropriate for use among the South Asian community before any study to assess their physical activity is conducted.

This is the first time that a physical activity questionnaire has been developed and validated in a South Asian community. We conclude that the FAQ has shown moderate validity by correlating with physical activity measures from the diary and the 24-hour recall. The FAQ needs to add several components of activities such as child care, religious and social activities, and inactivity such as watching TV, sitting and talking, to improve its precision. Questions on activity at work should include transportation to and from work, and the time spent at different types of activities.

South Asian women may not be involved in vigorous activities for example in sports or exercise. However, in their daily living, household chores and child-care activities involve moderate intensity physical activity. Among subjects in our study moderate and low intensity activities contribute to a large proportion of their usual physical activities. Sports and exercise activities do not contribute to a substantial proportion of their physical activity. Due to family obligations, social-cultural and religious restrictions, some women in our study were 'house-bound'. This needs to be studied further because of its public health implications. Any type of public health recommendation to increase their physical activity level may have to take into account the social and cultural barriers that prevent some South Asian women from becoming more active.

In order to determine what activities should be included in the FAQ for the South Asian people, it is suggested that a 24-hr recall to be conducted among a representative sample of the population. Activities that contribute to 95 percent of the total daily energy expenditure should be itemised and listed in the FAQ. This is using the principles in the development of the food frequency questionnaire. A community approach to obtain a representative sample of the South Asian population needs to be developed so that their participation rate in future studies can be increased.

Ideally, a longitudinal study on pregnancy and birth outcome in the future should have a large study sample and obtain more detailed information on important factors. These factors include prepregnant weight, weight gain during pregnancy, maternal body composition, dietary intakes, physical activity and socio-economic factors.

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# Appendix 1

## A critical review on validity studies of physical activity questionnaires: a checklist

1. Study name :
2. Reference:
3. Organisation conducting study:
4. Country of study:
5. What is the exposure being measured?:
6. Time frame for the relevant exposure:
7. What is the test method?:
8. What is the reference method:
9. Subjects:

    -response rate: -sample size: -age:

    -is sample size based on power calculation?:

    -is the sample representative of the population?:

10. Is the instrument administered before or after the reference method?:
11. Is there any auto-correlation between the test measure and the reference measure?:

    -are errors in the test measure and the reference measure independent?:

12. Number of activities listed:.

    -are there any major activities being omitted?

    -are activities that are performed less frequently included?

13. How many times was the instrument administered to the same subject?

    -test-retest correlation?

14. How many data collectors were used?

    -inter-rater reliability

15. How was validity of the test measure being presented?

    -comparison of means:

    -correlation between means;

    -Bland-Altman plot:

    -Ranking of subjects- into 3rds, fourths, quintiles etc.:

    - % subjects correctly classified:

    -% subjects grossly misclassified:

16. Any report of bias in the study?
17. Sources of measurement errors
18. The implications if this questionnaire were used in an epidemiological study
19. Other comments.

# Appendix 2

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# SOUTHAMPTON GROUP HOSPITAL MANAGEMENT COMMITTEE

E.P.I. to H.U. ~~PROFESSOR~~ UNIT D. G. MILLAR

## ANTE-NATAL RECORD

NAME

M.P. AGE 22 yr. CLINIC No. C 6600

ADDRESS

CIRCUMSTANCES DOCTOR NURSE

Husband - Machinist - 36 yrs. Religion Moslem. Flat

PREGNANCY PUERPERIUM

LABOUR INFANT

GRAVIDA II L.M.P. 1.5.69 EXP. DATE 8.2.70 MENSTRUATION

PREVIOUS PREGNANCIES 1968 ✓ Sheffield.

COMPLICATIONS NO

BIRTH WEIGHTS M 6lbs 7oz

MISCARRIAGES

PAST ILLNESSES

OPERATIONS

Scarlet Fever, Diphtheria, Measles, Rheumatic Fever, Tonsilitis

Twins } NIL
Trans }
T.B. - H. Chest Hosp.
Diabetes } NIL

Had treatment Sheffield Hosp 1968 ??

PRESENT COMPLAINT

### EXAMINATION

HS' 2"

GENERAL CONDITION TEMP. PULSE RESPIRATION

HEART LUNGS TEETH

BREASTS DISCHARGE OEDEMA

SPECIAL REPORTS

X-RAY V.C. Negative Rh Factor Positive Blood Group

### MEASUREMENTS

| INTERSPINOUS | INTERCRISTAL | EXTERNAL CONJUGATE | DIAG CONJUGATE | OUTLET | REMARKS | HEIGHT | DEFORMITY |
|---|---|---|---|---|---|---|---|
| | | H.U.H. 8 day | | | | | |

| DATE | HEIGHT OF FUNDUS | Presentation and Position of Foetus | ENGAGEMENT OF HEAD | FOETAL HEART | BLOOD PRESSURE | WEIGHT | URINE | T.C.A. | NOTES AND TREATMENT |
|---|---|---|---|---|---|---|---|---|---|
| 2.10.69 | D. 22 F | | | | 120/80 | 51.500 | NIL | 4 | Iron tablets from G.P. Bloods taken |
| | | | | | | | | | HB 65% ABS NIL 3.10.69 |
| 6.11.69 | D = 26 F = 24 | Vertex | Free | H | 80/50 | 52.600 | NIL | 3 | For 10 day course of Jectofer |
| 27.11.69 | F = 26 D = 29 | Vertex | Free | H | 90/60 | 57.500 | NIL | | Well HB. |
| 11.12.69 | D = 32 F = 29 | Vertex | Free | H. | 110/60 | 58.600 | NIL | | Well HB ?% Small Baby |
| | | | | | | | | 1 | [illegible] |
| 1.1.70 | D = 35 F = 33 | Vertex | Free | H. | 80/50 | 59.700 | NIL | 1 | Well HB 72% 1.1.70 |
| 15.1.70 | D = 36 F = 34 | Transverse → Vertex | | H. | 90/50 | 60.550 | NIL | [illegible] | Well. Transverse lie. → Vertex. |
| [illegible] | D = 38 F = 36 | Ceph. | free | H | 55/50 | 61.900 | [illegible] | 1 | Well High head |
| | | | | | | | | | TCI. Cosford 22.2.70 if not before |

No. HO 102/2

# LYING-IN REPORT

DATE OF ADMISSION 23.2.70 AT 3.45 p.m. DATE OF DISCHARGE 5.3.70

| LABOUR | COMMENCED | MEMBRANES RUPTURED | CERVIX FULLY DILATED | CHILD BORN | PLACENTA EXPELLED | DURATION OF LABOUR |
|---|---|---|---|---|---|---|
| DATE | 25 2 70 | 25 2 70 | 25 2 70 | 25 2 70 | 25 2 70 | 1st STAGE 4 HRS. 5 MIN.; 2nd STAGE 5; 3rd STAGE 5 |
| HOUR | 6 55pm | 10 55pm | 10 55pm | 11pm | 11.5pm | TOTAL 4 10/60 |

CONDITION ON ADMISSION ______ CHARACTER OF PAINS nil

EXAMINATION TEMPERATURE 98° PULSE 72 RESPIRATIONS Reg URINE NAD B.P. 115/75

PRESENTATION ______ FOETAL HEART 144 Reg.

CONDITION OF MEMBRANES Intact CERVIX ______ PRESENTING PART ______

PROGRESS OF LABOUR (EVERY TWO HOURS) ANAESTHETICS ______

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | | | | | | | | | | | | | | |
| TIME | | | | | | | | | | | | | | |
| PULSE | | | | | | | | | | | | | | |
| TEMP. | | | | | | | | | | | | | | |
| FOETAL HEART | | | | | | | | | | | | | | |
| PAINS | | | | | | | | | | | | | | |
| URINE | | | | | | | | | | | | | | |
| BOWELS | | | | | | | | | | | | | | |
| VAGINAL EXAM. | | | | | | | | | | | | | | |
| RECTAL EXAM. | | | | | | | | | | | | | | |
| DRUGS | | | | | | | | | | | | | | |

PLACENTA and MEMBRANES: TYPE Healthy Complete WEIGHT 1 lb 2 oz LENGTH OF CORD 55 cm 3 vess.

METHOD OF EXPULSION Brandt Andrews MEMBRANES ______ (~~INTACT, IMPERFECT, RETAINED~~)

HAEMORRHAGE QUANTITY minimal SOURCE uterine TREATMENT I V Ergot

LACERATIONS CERVIX ______ VAGINA ______ PERINEUM small Epis DEGREE ______ SUTURE MATERIAL Catgut

CONDITION AFTER DELIVERY ______ PULSE 88 TEMPERATURE 98[4] BP 130/80

CHILD (Alive / ~~Still Born~~) Sex (~~Male~~ / Female) MATURITY 42 Wks.

MALFORMATIONS Nil apparent STILLBORN (~~Fresh~~ / ~~Macerated~~)

Treatment to Establish Respiration Airways cleared

WEIGHT 2 Lbs. 8 Ozs. 2250 LENGTH 49 cm MOULDING ______

HEAD MEASUREMENTS S.O.B. ______ O.M. ______ B.P. ______ S.M.V. ______ V.M. ______

CIRCUMFERENCE 34 cm Ins. S.O.F. ______ O.F. ______ B.T. ______ S.M.B. ______

CAUSE OF DEATH ______ P.M. FINDINGS ______

DELIVERED ______ STATUS ______

VAGINAL EXAMINATIONS BY ______ NUMBER OF Vaginal Examinations 1 Rectal Examinations ______

Breast feeding.

**ANTE-NATAL**

| | | | |
|---|---|---|---|
| L.M.P. 26.2.82. | Certain ✓ / Uncertain / Approx. | PILL: USED ✓ / NEVER | From 1977 – To 1979 |
| E.D.D. 5.12.82 | | | |

| Usual Cycle | Rhythm | Loss | Duration |
|---|---|---|---|
| 4/28-34 | Regul ✓ / Irreg | usual ✓ / lighter / heavier | usual ✓ / shorter / longer |

Other Contraceptive Measures: none.

Bleeding since L.M.P: 2/6/82. sl. pv. loss. Admitted none.

Med Offic. Comment on M.C./contraception:

General Exam at First Visit: HS [illegible] Rest Clear.

Phys. Grade: V Good / Good ✓ / Fair / Poor

Pelvic Exam.: Not done.

| Date | Weight (kgs) | Urine Alb | Urine Sug | B P | Wks. Preg | FUNDAL HEIGHT | OEDEMA | POSITION & MOBILITY | F. H SOUNDS |
|---|---|---|---|---|---|---|---|---|---|
| 14.5.82 | Routine U/S Obtained | | | | | | | | |
| 19 5 82 | 59-50 | Nil | Nil | 110/70 | (12) | just felt | | | |
| | Admitted 2/8/82 ċ P.V. bleeding | | | | | | | | |
| 16 6 82 | 60 450 | Nil | Nil | 129/80. | 16 | 16. | | | |
| 14 7 82 | 63.400 | Nil | Nil | 120/70 | 20. | 20. | | No pain Tenderness. | |
| | U/S Not visit placenta | | | | | | | | |
| 8.9.82 | 69.650 | Nil | Nil | 105/60 | 27½ | 27 | nil | ceph. | ✓ |
| 6 10 82 | 70 500 | Nil | Nil | 120/80. | 31½ | 32 | nil. | Ceph. | FHH. |
| 3 11 82 | 73.650 | Nil | Nil | 130/80 | 35½ | 35 | nil | Ceph. NE | FH |

HMR 1 (Mat) 2

11939 SCP

| | | | |
|---|---|---|---|
| 1 HOSPITAL | D 2 2 1 1 | 14 SURNAME | Date of Birth: E 02 10 56 |
| 2. UNIT NUMBER | 00882307 | 15 FIRST NAME(S) | |
| 3 ANTENATAL COMPLICATIONS (R C O G CODE) Up to 6 Items | 41 | | |

**16. PRESENTATION AT DELIVERY**
1 Vertex OA; 2 Vertex OP or OT; 3 Face; 4 Breech; 5 Brow; 6 Shoulder; 7 Compound; 8 Other; 9 Not Known
1st Infant: 1 — 2nd Infant: — 3rd Infant:

**4 BLOOD PRESSURE**

| | Maximum Systolic | Maximum Diastolic |
|---|---|---|
| Before 20 Weeks | 110 | 070 |
| After 20 Weeks | 140 | 090 |

**17 METHOD OF DELIVERY**
0 Spontaneous; 1 Manipulation No Instruments; 2 Forceps; 3 Ventouse; 4 Caesarean – Classical; 5 Caesarean – Lower Seg; 6 Other Surgical Instrm.; 7 Unspecified
1st Infant: 0 — 2nd Infant: — 3rd Infant:

**5 ANTENATAL X-RAYS**: 5
0 None; 1 ABD & PEL 1st Trimester; 2 ABD & PEL 2nd Trimester; 3 ABD & PEL 3rd Trimester; 7 Multiple; 9 Chest; 8 Other

**6 COMPLICATIONS OF LABOUR** (Up to 8 – R C O G Code): 9
POST PARTUM BLOOD LOSS ml 0300

**18 ANAESTHESIA FOR LABOUR AND DELIVERY**: 0
0 Nil; 1 General; 2 Epidural; 3 Caudal; 4 Pudendal Block; 5. Paracervical Block; 6. Perineal; 8. Other; 9. Not Known

ANALGESIA: 1
0 Nil; 1 Pethidine; 2 Other drug; 3 Trilene; 4 Gas + Air; 5 Gas + $O_2$; 6. Other inhalent; 7 Other analgesia

**7 ONSET OF LABOUR**: 6
0 Spontaneous; 1 Elective C S; 2 Other Surgical; 3 i.v. Oxytocin; 4 i.m. nasal, buccal oxytocin; 5 Other oxytocic agent; 6 Surgical and oxytocic; 7 Other induction

**8 LABOUR**

| | Hrs | Mins |
|---|---|---|
| Duration of 1st Stage | 02 | 20 |
| Duration of 2nd Stage | 0 | 04 |
| Duration of 3rd Stage | 0 | 06 |

**19 PLACENTAL DELIVERY**: 2
1 Simple; 2 Controlled Cord Traction; 3 Manual
PLACENTA: Complete; Incomplete; Uncertain — 1

**9 DATE OF DELIVERY**: 29 09 86

**20 BLOOD TRANSFUSION** Amount ml 0000

**10 TIME OF DELIVERY (24 HOUR CLOCK)**: 12 54

**11 DELIVERY BY**: 7 — SUPERVISED BY:
1 Cons Obs; 2 Asst Obs; 3 Registrar; 4 Clin Asst; 5 G P; 6 House Surg; 7 Midwife; 8 Med Stud; 9 Pupil M.W; 0 Not known

**21**
0 Uncomplicated: 0
1 Genital Infection
2 Urinary Infection
3 Mastitis
4 Other infection
9 Psychiatric
5 Superficial Thrombophlebitis
6 Deepvein Thrombosis
7 Pulmonary Embolus
8 Anaemia
X Other

**12 OTHER OPERATIVE PROCEDURE**

**13 TEAR**: 1 N/L
1 First degree; 2 Second degree; 3 Third degree; 4 Episiotomy; 9 Nil

**22 STERILISATION**: 2 — Date: N/L
1 Yes; 2 No

| INFANT | 1 | 2 | 3 |
|---|---|---|---|
| 1 1 Alive 2 Fresh S B 3 Macerated S B | G 1 | H | J |
| 2 Maturity in Weeks PAEDIATRIC ASSESSMENT | 38 | | |
| 3 SEX 1 Male 2 Female 3 Indeterminate | 2 | | |
| 4 LENGTH CMS (CROWN TO RUMP) | | | |
| 5 BIRTH WEIGHT GMS | 287 | | |
| 6 ONSET REG RESP AFTER MINS | 01 | | |
| 7 RESUSCITATION | 1 | | |
| 8 MALFORMATIONS CODE (Specify below) | | | |
| 9 OUTCOME (COMPLETE AT 28 DAYS) 1 Live at 29 days 2 Stillborn 3 Died within 24 hrs 4 Died 1-7 days 5 Died after 7 days 6 Abortion thera 7 Abortion other 8 Ectopic 9 Hydatidiform Mole | N/L | Time of Delivery; N/L | Time of Delivery; N/L |
| 10 TRANSFER TO SPECIAL CARE BABY UNIT 1 No discharged home 2 Yes this hospital 3 Yes other hospital 4 Yes, born or more than one hospital 5 Yes, other care but not spec care baby unit | 1 | | |

PLEASE SPECIFY MALFORMATIONS

ADDITIONAL COMPLICATIONS NOT RECORDED ELSEWHERE (ICD): K ... N/L

DATE 29.9.86

SIGNED [signature]

# LABOUR SUMMARY

## MODE OF DELIVERY

Normal

## PRESENTATION AT DELIVERY

vertex

| STAGE | DATE | TIME | LENGTH (HRS) |
|---|---|---|---|
| First | 29.9.86 | 10.30 | 2 20/60 |
| Second | " | 12.50 | 4/60 |
| Third | " | 12.54 | 6/60 |
| End of Third | " | 13.00 | 2 30/60 |

### FETAL DISTRESS

| | 1st STAGE | 2nd STAGE |
|---|---|---|
| Meconium | ☐ | ☐ |
| Bradycardia: Baseline | ☐ | ☐ |
| Type I | ☑ | ☑ |
| Type II | ☐ | ☐ |
| Tachycardia | ☐ | ☐ |
| Irregularity | ☐ | ☐ |

### PLACENTA

Weight 550 g

| | |
|---|---|
| Retroplacental Clot | ☐ |
| Calcification | ☑ |
| Infarction | ☑ |
| Other | ☐ |

halved
pale.

Membranes

| | |
|---|---|
| Complete | ☑ |
| Incomplete | ☐ |
| Doubtful | ☐ |

Nearest point of rupture to placenta ........... cm

### CORD

Length ........ cm.

No. of Vessels: 3

Insertion Type: Central

[illegible]: normal

Round Neck:
- Not ☐
- Loose ☑
- Tight ☐

Clamping at Del:
- Before ☐
- After ☑

3rd Stage Oxytocic Drugs:
- Ergometrine i.v. ☐
- Ergometrine i.m. ☐
- Syntometrine i.m. ☑
- Syntocinon ☑

## SUMMARY OF COMPLICATIONS

none.

## INFANT SUMMARY

| INFANTS | 1 | | 2 | |
|---|---|---|---|---|
| SEX | Female | | | |
| WEIGHT (g) | 2870g. | | | |
| APGAR | 1 | 5 | 1 | 5 |
| Heart Rate | 2 | 2 | | |
| Respiration | 2 | 2 | | |
| Muscle Tone | 2 | 2 | | |
| Reflexes | 2 | 2 | | |
| Colour | 1 | 1 | | |
| Total | 9 | 9 | | |
| Time 1st Resp | stat. | | | |
| Time sust Resp | 01. | | | |

### RESUSCITATION

| | 1 | 2 |
|---|---|---|
| Nil (incl. clearing airway) | ☑ | ☐ |
| Mask and IPPV | ☐ | ☐ |
| Intub and IPPV (no drugs) | ☐ | ☐ |
| Intub and IPPV (with drugs) | ☐ | ☐ |
| Other | ☐ | ☐ |
| Transfer to Ward | ☑ | ☐ |
| Transfer to Special Nursery | ☐ | ☐ |

Remarks on Resuscitation or Delivery:

T 36.5°

HC 33cm.

| STAFF | SIGNATURE | RANK |
|---|---|---|
| Accoucheur | | midwife. |
| Supervised by: | | |
| Resuscitator | | Sister |

Suture Material:

No. for removal:

Sutured by:

# APPENDIX 3

**Formula for conversion into metric measures**

1 stone = 6.35 kg

1 pound = 0.4536 kg

1 ounce = 0.002835 kg

1 foot = 30.48 cm

1 inch = 2.54 cm

100 percent haemoglobin = 12 g/dl

# Appendix 4

Test for normality of distribution for variables in their log transformed scale (full term birth))

| | Variable name | Valid cases | K- S sample test | | Normal or not |
|---|---|---|---|---|---|
| | | | K-S Z statistics | significance | |
| 1 | Birth weight | 2429 | 1.7045 | .0060 | No |
| 2 | Placental weight | 2358 | 3.3914 | .0000 | No |
| 3 | Placental/birth wt. ratio | 2355 | 0.9328 | .3491 | Yes |
| 4 | Head circumference | 2182 | 4.5456 | .0000 | No |
| 5 | Birth length | 323 | 2.0957 | .0003 | No |
| 6 | Ponderal index | 323 | 2.1838 | .0001 | No |
| 7 | Gestational age | 2432 | 9.1919 | .0000 | No |
| 8 | Maternal height | 2219 | 2.2985 | .0001 | No |
| 9 | Maternal age | 2427 | 3.5828 | .0000 | No |
| 10 | Gravida | 2430 | 8.5288 | .0000 | No |
| 11 | Parity | 2057 | 9.3265 | .0000 | No |
| 12 | Weight at booking | 1408 | 1.8649 | .0019 | No |
| 13 | Weight gain | 941 | 3.8533 | .0000 | No |
| 14 | Weight at delivery | 1195 | 1.4148 | .0365 | No |
| 15 | BMI at delivery | 1174 | 1.4825 | .0247 | No |
| 16 | Hb in 2nd trimester | 1142 | 2.2499 | .0001 | No |
| 17 | MCV in 2nd trimester | 603 | 2.5117 | .0000 | No |
| 18 | MCV in 3rd trimester | 1218 | 2.9204 | .0000 | No |
| 19 | MCH in 2nd trimester | 601 | 2.4339 | .0000 | No |
| 20 | MCH in 3rd trimester | 1221 | 2.8644 | .0000 | No |
| 21 | MCHC in 1st trimester | 151 | 1.7171 | .0055 | No |
| 22 | MCHC in 2nd trimester | 602 | 2.0230 | .0006 | No |
| 23 | MCHC in 3rd trimester | 1224 | 2.7197 | .0000 | No |

Test for normality of distribution for variables in their reciprocal transformed scale (full term birth)

| | Variable name | Valid cases | K- S sample test | | Normal or not |
|---|---|---|---|---|---|
| | | | K-S Z statistics | significance | |
| 1 | Birth weight | 2429 | 1.1124 | .0000 | No |
| 2 | Placental weight | 2358 | 5.0626 | .0000 | No |
| 3 | Head circumference | 2182 | 4.9250 | .0000 | No |
| 4 | Birth length | 323 | 1.7899 | .0033 | No |
| 5 | Ponderal index | 323 | 4.4975 | .0000 | No |
| 6 | Gestational age | 2432 | 9.4425 | .0000 | No |
| 7 | Maternal height | 2219 | 2.5877 | .0000 | No |
| 8 | Maternal age | 2427 | 2.9945 | .0000 | No |
| 9 | Gravida | 2430 | 12.1467 | .0000 | No |
| 10 | Parity | 2057 | 11.5038 | .0000 | No |
| 11 | Weight at booking | 1408 | 2.8592 | .0000 | No |
| 12 | Weight gain | 941 | 11.3617 | .0000 | No |
| 13 | Weight at delivery | 1195 | 2.2642 | .0001 | No |
| 14 | BMI at delivery | 1174 | 2.0357 | .0005 | No |
| 15 | Hb in 2nd trimester | 1142 | 3.2993 | .0000 | No |
| 16 | MCV in 2nd trimester | 603 | 2.8884 | .0000 | No |
| 17 | MCV in 3rd trimester | 1218 | 3.4910 | .0000 | No |
| 18 | MCH in 2nd trimester | 601 | 2.9977 | .0000 | No |
| 19 | MCH in 3rd trimester | 1221 | 3.4393 | .0000 | No |
| 20 | MCHC in 1st trimester | 151 | 1.6315 | .0097 | No |
| 21 | MCHC in 2nd trimester | 602 | 2.2696 | .0001 | No |
| 22 | MCHC in 3rd trimester | 1224 | 3.0574 | .0000 | No |

Test for normality of distribution for variables in their square root transformed scale (full term birth))

| | Variable name | Valid cases | K- S sample test | | Normal or not |
|---|---|---|---|---|---|
| | | | K-S Z statistics | significance | |
| 1 | Birth weight | 2429 | 1.2912 | .0713 | Yes |
| 2 | Placental weight | 2358 | 3.0670 | .0000 | No |
| 3 | Head circumference | 2182 | 4.4038 | .0000 | No |
| 4 | Birth length | 323 | 2.3023 | .0000 | No |
| 5 | Ponderal index | 323 | 1.6018 | .0112 | No |
| 6 | Gestational age | 2432 | 9.0627 | .0000 | No |
| 7 | Maternal height | 2219 | 2.1571 | .0002 | No |
| 8 | Maternal age | 2427 | 4.1368 | .0000 | No |
| 9 | Gravida | 2430 | 8.2380 | .0000 | No |
| 10 | Parity | 2057 | 8.2998 | .0000 | No |
| 11 | Weight at booking | 1408 | 1.3695 | .0470 | No |
| 12 | Weight gain | 940 | 2.8012 | .0000 | No |
| 13 | Weight at delivery | 1195 | 1.5014 | .0220 | No |
| 14 | BMI at delivery | 1174 | 1.3725 | .0462 | No |
| 15 | Hb in 2nd trimester | 1142 | 1.8897 | .0016 | No |
| 16 | MCV in 2nd trimester | 603 | 2.3140 | .0000 | No |
| 17 | MCV in 3rd trimester | 1218 | 2.6262 | .0000 | No |
| 18 | MCH in 2nd trimester | 601 | 2.1589 | .0002 | No |
| 19 | MCH in 3rd trimester | 1221 | 2.5591 | .0000 | No |
| 20 | MCHC in 1st trimester | 151 | 1.8023 | .0030 | No |
| 21 | MCHC in 2nd trimester | 602 | 1.9056 | .0014 | No |
| 22 | MCHC in 3rd trimester | 1224 | 2.5683 | .0000 | No |

Test for normality of distribution for variables squared (full term birth)

| | Variable name | Valid cases | K- S sample test | | Normal or not |
|---|---|---|---|---|---|
| | | | K-S Z statistics | significance | |
| 1 | Placental weight | 2358 | 6.07 | .0000 | No |
| 2 | Head circumference | 2182 | 4.99 | .0000 | No |
| 3 | Birth length | 323 | 2.13 | .0002 | No |
| 4 | Ponderal index | 323 | 1.23 | .0931 | Yes |
| 5 | Gestational age | 2432 | 8.66 | .0000 | No |
| 6 | Maternal height | 2219 | 2.15 | .0002 | No |
| 7 | Maternal age | 2427 | 6.56 | .0000 | No |
| 8 | Gravida | 2430 | 12.99 | .0000 | No |
| 9 | Parity | 2057 | 12.41 | .0000 | No |
| 10 | Weight gain | 941 | 5.45 | .0000 | No |
| 11 | Weight at delivery | 1195 | 2.69 | .0000 | No |
| 12 | Hb in 2nd trimester | 1142 | .93 | .3487 | Yes |
| 13 | MCV in 2nd trimester | 603 | 1.70 | .0063 | No |
| 14 | MCV in 3rd trimester | 1218 | 1.77 | .0038 | No |
| 15 | MCH in 2nd trimester | 601 | 1.46 | .0274 | Yes |
| 16 | MCH in 3rd trimester | 1221 | 1.63 | .0100 | No |
| 17 | MCHC in 1st trimester | 151 | 2.17 | .0002 | No |
| 18 | MCHC in 2nd trimester | 602 | 1.58 | .0138 | No |
| 19 | MCHC in 3rd trimester | 1224 | 2.1883 | .0002 | No |

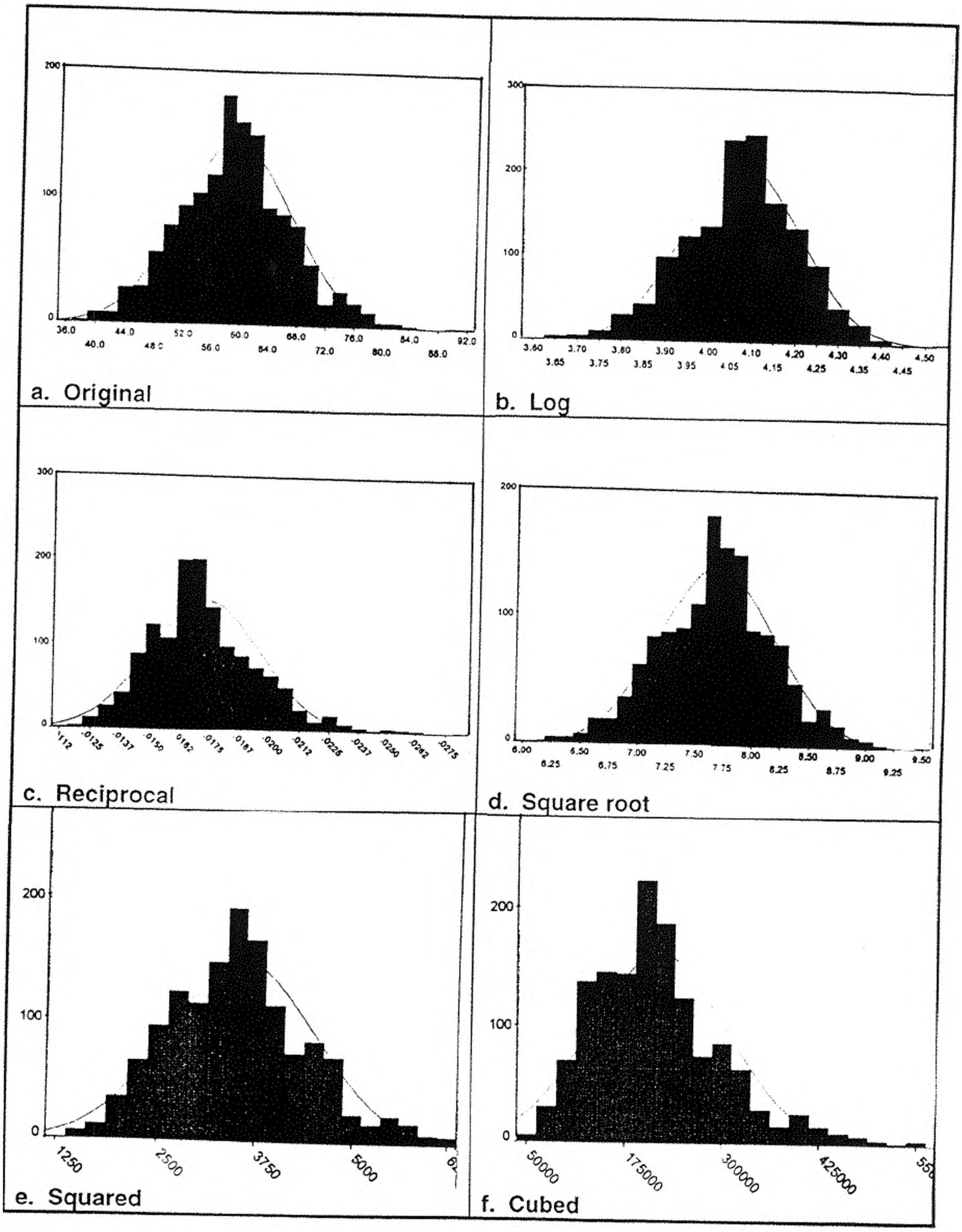
Test for normality of distribution for variables <u>cubed</u>

(full term birth)

| | Variable name | Valid cases | K- S sample test | | Normal or not |
|---|---|---|---|---|---|
| | | | K-S Z statistics | significance | |
| 1 | Placental weight | 2358 | 7.78 | .0000 | No |
| 2 | Head cicumference | 2182 | 5.40 | .0000 | No |
| 3 | Birth length | 323 | 2.30 | .0000 | No |
| 4 | Gestational age | 2432 | 8.38 | .0000 | No |
| 5 | Maternal height | 2219 | 2.42 | .0000 | No |
| 6 | Maternal age | 2427 | 8.28 | .0000 | No |
| 7 | Gravida | 2430 | 15.29 | .0000 | No |
| 8 | Parity | 2057 | 14.90 | .0000 | No |
| 9 | Weight gain | 941 | 7.52 | .0000 | No |
| 10 | Weight at delivery | 1195 | 3.56 | .0000 | No |
| 11 | MCV in 2nd trimester | 603 | 1.28 | .0774 | <u>Yes</u> |
| 12 | MCV in 3rd trimester | 1218 | 1.20 | .1101 | <u>Yes</u> |
| 13 | MCH in 3rd trimester | 1221 | 1.01 | .2609 | <u>yes</u> |
| 14 | MCHC in 1st trimester | 151 | 2.49 | .0000 | No |
| 15 | MCHC in 2nd trimester | 602 | 1.38 | .0450 | No |
| 16 | MCHC in 3rd trimester | 1224 | 1.96 | .0009 | No |

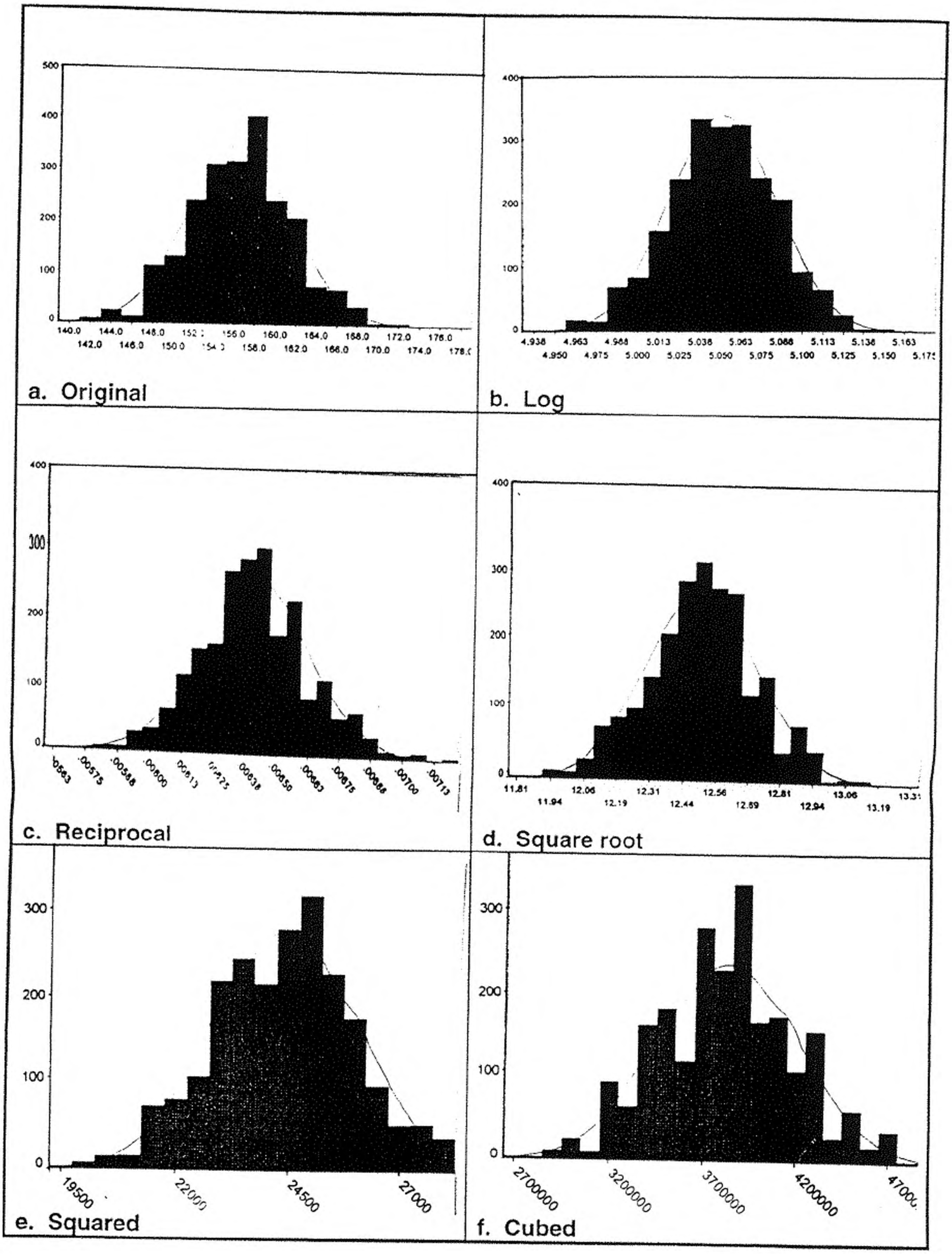
# Appendix 5

Histograms of the variable in its original and transformed scales



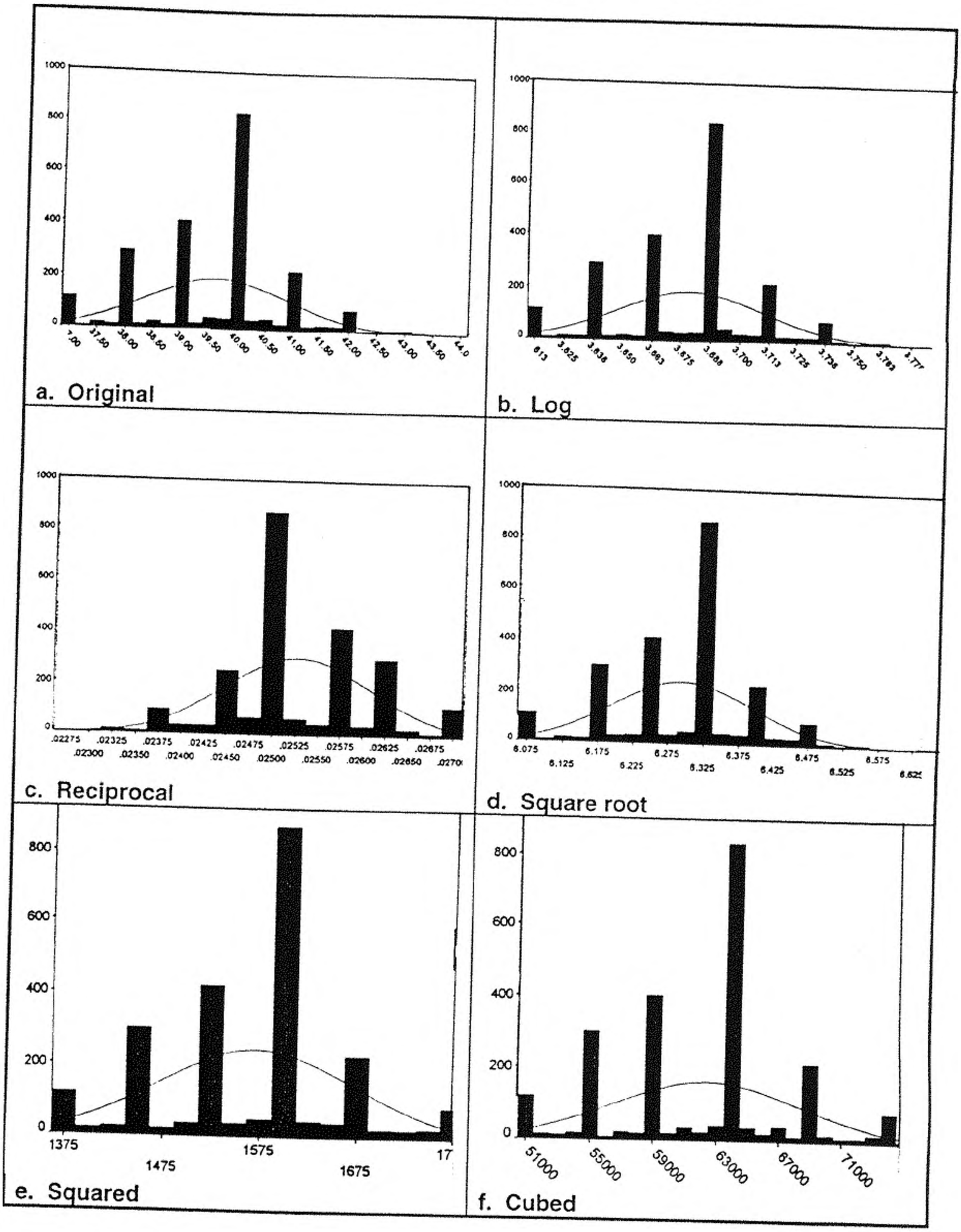

Maternal weight at booking

Histograms of the variable in its original and transformed scales



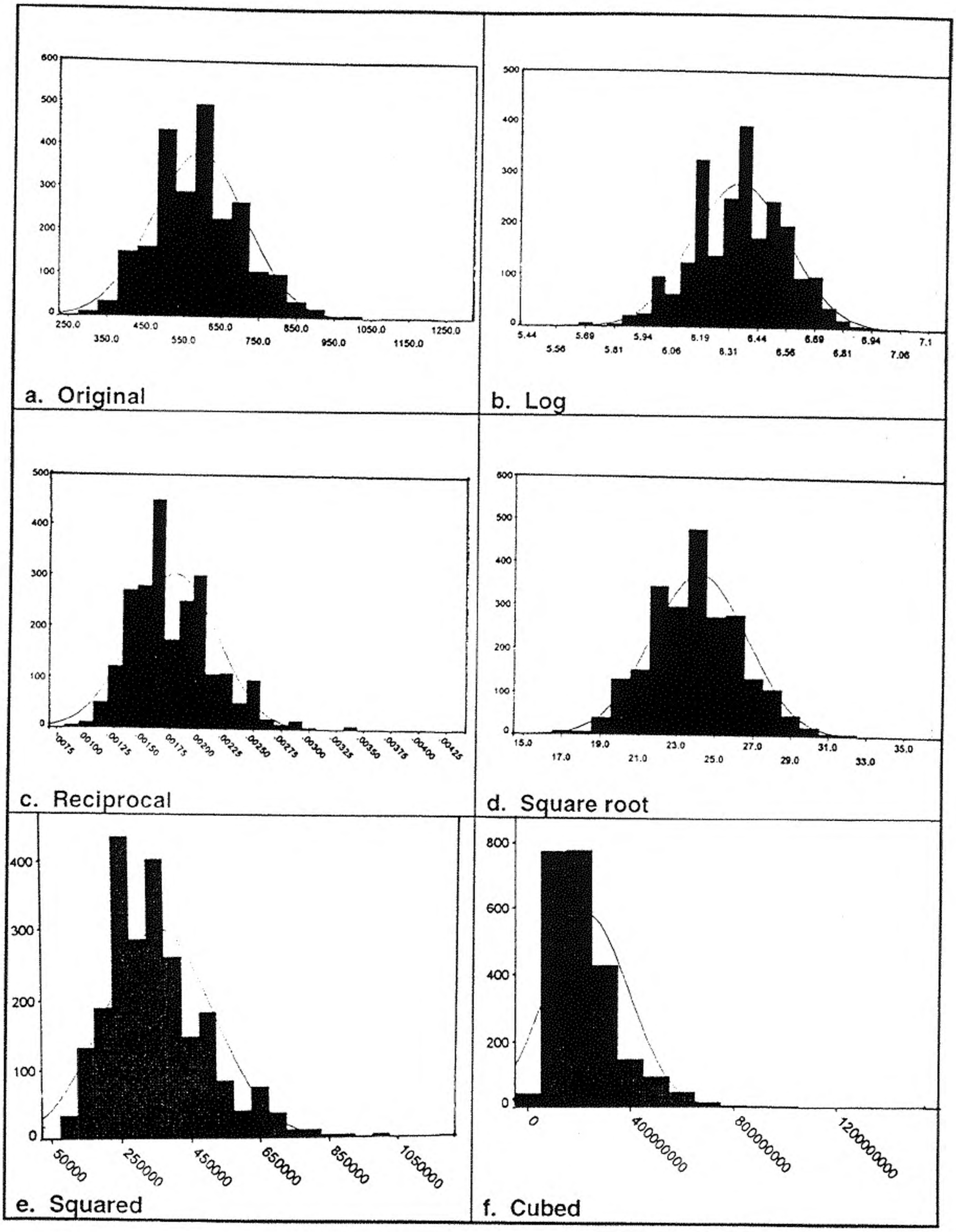

**Maternal height**

Histograms of the variable in its original and transformed scales




<u>Gestational age</u>

Histograms of the variable in its original and transformed scales




Placental weight

# Appendix 6

**A correlation matrix for birth outcomes and maternal characteristics**

| **Variable name r (n); p-value** | Placental weight | Placental to birth weight ratio | Head circumference | Birth length | Ponderal index | Infant sex | Gestation | Maternal height |
|---|---|---|---|---|---|---|---|---|
| Placental to birth weight ratio | 0.70 (2355); .000 | | | | | | | |
| Head circumference | 0.36 (2133); .000 | -0.5 (2133); .034 | | | | | | |
| Birth length | 0.37 (312); .000 | -.0013 (312); .982 | 0.40 (313); .000 | | | | | |
| Ponderal index | .11 (312); .050 | -0.10 (312); .061 | 0.06 (313); .252 | -0.59 (320); .000 | | | | |
| Infant sex | -.0232 (2356); .261 | 0.08 (2355); .000 | -0.18 (2180); .000 | -0.15 (320); .006 | 0.05 (320); .353 | | | |
| Gestational age | 0.10 (2358); .000 | -0.02 (2355); .162 | 0.26 (2182); .000 | 0.13 (320); .018 | -.0188 (320); .737 | 0.02 (2430); .290 | | |
| Maternal height | 0.08 (2152); .000 | -.0140 (2149); .517 | 0.07 (2010); .003 | .0687 (215); .316 | .0186 (215); .787 | -.0129 (2217); .543 | .0015 (2219); .942 | |
| Maternal age | 0.13 (354); .000 | -.0059 (2351); .776 | 0.15 (2178); .000 | 0.16 (316); .004 | -.0774 (316); .170 | .0052 (2405; .799 | -.0204 (2427); .315 | 0.13 (2217); .000 |

| **Variable name r (n); p-value** | Gravida | Parity | BMI at 12 weeks | BMI before delivery | Weight at booking | Weight gain | RBC 3 | Hb 3 |
|---|---|---|---|---|---|---|---|---|
| Parity | 0.93 (2057); .000 | | | | | | | |
| BMI at 12 wk. | .44 (453); .000 | 0.44 (453); .000 | | | | | | |
| BMI before delivery | 0.33 (1174); .000 | 0.32 (1174); .000 | 0.95 (331); .000 | | | | | |
| Weight at booking | 0.32 (1408); .000 | 0.31 (1408); .000 | 0.87 (453); .000 | 0.81 (936); .000 | | | | |
| Weight gain | -.0657 (941); .044 | -.0661 (941); .043 | -0.17 (331); .001 | 0.09 (936); .004 | -0.16 (941); .000 | | | |
| RBC 3rd trimester | -.0135 (1219); .637 | -.0204 (1219); .478 | .0447 (410); .373 | .0026 (877); .939 | .0018 (877); .952 | .0123 (776); .731 | | |
| Hb 3rd trimester | -.0106 (1703); .663 | -.0128 (1614); .608 | .0124 (421); .799 | -.0391 (1049); .206 | -.0540 (1212); .060 | .0025 (848); .943 | 0.54 (1219); .000 | |
| Maternal age | 0.60 (2425); .000 | 0.55 (2055); .000 | 0.48 (453); .000 | 0.40 (1173); .000 | 0.44 (1407); .000 | -.0655 (940); .045 | -.0029 (1218); .920 | .0207 (1700); .393 |

| **Variable name r (n); p-value** | Gravida | Parity | BMI at 12 weeks | BMI before delivery | Weight at booking | Weight gain | RBC 3 | Hb 3 |
|---|---|---|---|---|---|---|---|---|
| Placental weight | 0.13 (2356); .000 | 0.13 (2004); .000 | 0.23 (449); .000 | 0.14 (1153); .000 | 0.16 (1379); .000 | .0206 (924); .531 | 0.16 (1208); .000 | 0.11 (1673); .000 |
| Placental to birth weight ratio | -.0058 (2353); .778 | -.0030 (2001); .892 | 0.11 (449); .025 | .0051 (1153); .862 | .0067 (1377); .804 | -.0511 (924); .121 | .0188 (1280); .514 | -.0497 (1672); .042 |
| Head circumference | 0.10 (2353); .000 | 0.11 (1866); .000 | 0.12 (443); .013 | 0.12 (1104); .000 | 0.08 (1320); .004 | 0.12 (905); .000 | 0.25 (1100); .000 | 0.19 (1560); .000 |
| Birth length | 0.15 (320); .009 | 0.17 (147); .040 | .0000 (10); 1.000 | 0.30 (74); .011 | .1516 (62); .240 | .0073 (31); .969 | .0134 (27); .947 | -.0706 (156); .381 |
| Ponderal index | .0073 (320); .896 | .0268 (147); .748 | -.1636 (10); .651 | .1500 (74); .202 | .0957 (62); .459 | 0.49 (31); .005 | -.0177 (27); .930 | .0270 (156); .738 |
| Infant sex | .0131 (2428); .518 | .0189 (452); .688 | .0189 (452); .688 | .0162 (1173); .579 | -.0009 (1406); .973 | -.0520 (940); .111 | 0.09 (1217); .001 | -0.07 (1701); .007 |
| Gestation | .0309 (2430); .128 | 0.05 (2057); .035 | .0469 (453); .320 | -.0057 (1174); .846 | -.0210 (1408); .432 | 0.10 (941); .002 | .011 (1219); .000 | 0.10 (1703); .000 |
| Maternal height | -.0338 (2219); .111 | -0.05 (1982); .031 | .0668 (453); .156 | -.0387 (1174); .185 | 0.40 (1385); .000 | .0601 (936); .066 | .0486 (1207); .091 | .0179 (1619); .472 |

# Appendix 7

THE ASIAN WOMEN STUDY

INSTITUTE OF HUMAN NUTRITION

UNIVERSITY OF SOUTHAMPTON

Name:______________________________

Date of birth:_____/_____/_____

Address:______________________________

Tel:____________________

ID #: | | | | | |

Date of interview:__________

Name:..................................................... Date:..........................

Frequency of physical activities for the past 12 months - refer to list of physical activities

ID # : ☐☐☐☐☐☐

| ACTIVITY | SPRING (March-April-May) | | | SUMMER (June-July-August) | | | AUTUMN (Sept-Oct-Nov) | | | WINTER (Dec-Jan-Feb) | | | PAR (for office use only) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No.of times per week | Duration per occasion | | No.of times per week | Duration per occasion | | No.of times per week | Duration per occasion | | No.of times per week | Duration per occasion | | |
| | | hour | min. | | hour | min. | | hour | min. | | hour | min. | |
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Has there been any change in your physical activities since the last five years?
If yes, were you less active or more active than now?

**List of physical activities**

-Cycling

-Dancing

-Exercises e.g. aerobics, gym workouts, yoga.

-Home repair / Do-It-Yourself

-Housework

a) cleaning the house (bathroom, kitchen, vacuuming, mopping)

b) preparing foods/vegetables

c) cooking

d) washing dishes

e) hand washing of clothes (includes hanging of clothes)

f) shopping for food

g) ironing.

-Gardening

-Jogging

-Running

-Swimming

-Walking

-Others :please tell me what else................

## Physical activity at work and at home

Name: ______________________ ID # ☐☐☐☐☐☐

### OCCUPATION

Now I would like to ask about your activity at work.

1. Do you have a paid job, either full or part time at present

   Yes ☐ No ☐

2. **If YES**, what is your job title? ______________________
3. Briefly describe what do you do in your job: ______________________
4. How many hours do you work each week (on average) ? ____________ hours
5. When at work, are you most of the time

   Sitting down ☐ Walking about ☐

   Standing up ☐ Doing more vigorous work ☐

6. Do you climb stairs at work ?

   Yes ☐ No ☐

7. How long have you had this job?
   (If less than one year , go to Q10)
8. **If NO** (to question 1), how would you describe yourself ?

   Housewife ☐

   Unemployed ☐

   Retired ☐

   Student ☐

   Other ☐

   Describe : ______________________

9. When did you last work ? No. of months ☐☐
10. What did you do in your last job? ______________________
11. How many hours did you work each week ? ............... Hours
12. Do you climb stairs at home ?

    Yes ☐ No ☐

13. How many hours do you sleep everyday, on average ? .................Hours

**Coding sheet for the 24-hour activity recall / the 7-day activity diary**

Surname:…………………First name:………………………ID:……………Subject no.:………

Date:………………………Day:………………………………Day no.:……..

| Time | PAR | KJ/ min | Total EE | Time | PAR | KJ/ min | Total EE | Time | PAR | KJ/ min | Total EE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 00.00 | | | | 02.00 | | | | 04.00 | | | |
| 00.05 | | | | 02.05 | | | | 04.05 | | | |
| 00.10 | | | | 02.10 | | | | 04.10 | | | |
| 00.15 | | | | 02.15 | | | | 04.15 | | | |
| 00.20 | | | | 02.20 | | | | 04.20 | | | |
| 00.25 | | | | 02.25 | | | | 04.25 | | | |
| 00.30 | | | | 02.30 | | | | 04.30 | | | |
| 00.35 | | | | 02.35 | | | | 04.35 | | | |
| 00.40 | | | | 02.40 | | | | 04.40 | | | |
| 00.45 | | | | 02.45 | | | | 04.45 | | | |
| 00.50 | | | | 02.50 | | | | 04.50 | | | |
| 00.55 | | | | 02.55 | | | | 04.55 | | | |
| 01.00 | | | | 03.00 | | | | 05.00 | | | |
| 01.05 | | | | 03.05 | | | | 05.05 | | | |
| 01.10 | | | | 03.10 | | | | 05.10 | | | |
| 01.15 | | | | 03.15 | | | | 05.15 | | | |
| 01.20 | | | | 03.20 | | | | 05.20 | | | |
| 01.25 | | | | 03.25 | | | | 05.25 | | | |
| 01.30 | | | | 03.30 | | | | 05.30 | | | |
| 01.35 | | | | 03.35 | | | | 05.35 | | | |
| 01.40 | | | | 03.40 | | | | 05.40 | | | |
| 01.45 | | | | 03.45 | | | | 05.45 | | | |
| 01.50 | | | | 03.50 | | | | 05.50 | | | |
| 01.55 | | | | 03.55 | | | | 05.55 | | | |

Remarks:

**Coding sheet for the 24-hour activity recall / the 7-day activity diary**

Surname:....................First name:.........................ID:..............Subject no.:.........

Date:.........................Day:.................................Day no.:........

| Time | PAR | KJ/ min | Total EE | Time | PAR | KJ/ min | Total EE | Time | PAR | KJ/ min | Total EE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 06.00 | | | | 08.00 | | | | 10.00 | | | |
| 06.05 | | | | 08.05 | | | | 10.05 | | | |
| 06.10 | | | | 08.10 | | | | 10.10 | | | |
| 06.15 | | | | 08.15 | | | | 10.15 | | | |
| 06.20 | | | | 08.20 | | | | 10.20 | | | |
| 06.25 | | | | 08.25 | | | | 10.25 | | | |
| 06.30 | | | | 08.30 | | | | 10.30 | | | |
| 06.35 | | | | 08.35 | | | | 10.35 | | | |
| 06.40 | | | | 08.40 | | | | 10.40 | | | |
| 06.45 | | | | 08.45 | | | | 10.45 | | | |
| 06.50 | | | | 08.50 | | | | 10.50 | | | |
| 06.55 | | | | 08.55 | | | | 10.55 | | | |
| 07.00 | | | | 09.00 | | | | 11.00 | | | |
| 07.05 | | | | 09.05 | | | | 11.05 | | | |
| 07.10 | | | | 09.10 | | | | 11.10 | | | |
| 07.15 | | | | 09.15 | | | | 11.15 | | | |
| 07.20 | | | | 09.20 | | | | 11.20 | | | |
| 07.25 | | | | 09.25 | | | | 11.25 | | | |
| 07.30 | | | | 09.30 | | | | 11.30 | | | |
| 07.35 | | | | 09.35 | | | | 11.35 | | | |
| 07.40 | | | | 09.40 | | | | 11.40 | | | |
| 07.45 | | | | 09.45 | | | | 11.45 | | | |
| 07.50 | | | | 09.50 | | | | 11.50 | | | |
| 07.55 | | | | 09.55 | | | | 11.55 | | | |

Remarks:

**Coding sheet for the 24-hour activity recall / the 7-day activity diary**

Surname:....................First name:..........................ID:..............Subject no.:.........

Date:..........................Day:..................................Day no.:........

| Time | PAR | KJ/ min | Total EE | Time | PAR | KJ/ min | Total EE | Time | PAR | KJ/ min | Total EE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12.00 | | | | 14.00 | | | | 16.00 | | | |
| 12.05 | | | | 14.05 | | | | 16.05 | | | |
| 12.10 | | | | 14.10 | | | | 16.10 | | | |
| 12.15 | | | | 14.15 | | | | 16.15 | | | |
| 12.20 | | | | 14.20 | | | | 16.20 | | | |
| 12.25 | | | | 14.25 | | | | 16.25 | | | |
| 12.30 | | | | 14.30 | | | | 16.30 | | | |
| 12.35 | | | | 14.35 | | | | 16.35 | | | |
| 12.40 | | | | 14.40 | | | | 16.40 | | | |
| 12.45 | | | | 14.45 | | | | 16.45 | | | |
| 12.50 | | | | 14.50 | | | | 16.50 | | | |
| 12.55 | | | | 14.55 | | | | 16.55 | | | |
| 13.00 | | | | 15.00 | | | | 17.00 | | | |
| 13.05 | | | | 15.05 | | | | 17.05 | | | |
| 13.10 | | | | 15.10 | | | | 17.10 | | | |
| 13.15 | | | | 15.15 | | | | 17.15 | | | |
| 13.20 | | | | 15.20 | | | | 17.20 | | | |
| 13.25 | | | | 15.25 | | | | 17.25 | | | |
| 13.30 | | | | 15.30 | | | | 17.30 | | | |
| 13.35 | | | | 15.35 | | | | 17.35 | | | |
| 13.40 | | | | 15.40 | | | | 17.40 | | | |
| 13.45 | | | | 15.45 | | | | 17.45 | | | |
| 13.50 | | | | 15.50 | | | | 17.50 | | | |
| 13.55 | | | | 15.55 | | | | 17.55 | | | |

Remarks:

**Coding sheet for the 24-hour activity recall / the 7-day activity diary**

Surname:....................First name:..........................ID:...............Subject no.:.........

Date:..........................Day:..................................Day no.:........

| Time | PAR | KJ/ min | Total EE | Time | PAR | KJ/ min | Total EE | Time | PAR | KJ/ min | Total EE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 18.00 | | | | 20.00 | | | | 22.00 | | | |
| 18.05 | | | | 20.05 | | | | 22.05 | | | |
| 18.10 | | | | 20.10 | | | | 22.10 | | | |
| 18.15 | | | | 20.15 | | | | 22.15 | | | |
| 18.20 | | | | 20.20 | | | | 22.20 | | | |
| 18.25 | | | | 20.25 | | | | 22.25 | | | |
| 18.30 | | | | 20.30 | | | | 22.30 | | | |
| 18.35 | | | | 20.35 | | | | 22.35 | | | |
| 18.40 | | | | 20.40 | | | | 22.40 | | | |
| 18.45 | | | | 20.45 | | | | 22.45 | | | |
| 18.50 | | | | 20.50 | | | | 22.50 | | | |
| 18.55 | | | | 20.55 | | | | 22.55 | | | |
| 19.00 | | | | 21.00 | | | | 23.00 | | | |
| 19.05 | | | | 21.05 | | | | 23.05 | | | |
| 19.10 | | | | 21.10 | | | | 23.10 | | | |
| 19.15 | | | | 21.15 | | | | 23.15 | | | |
| 19.20 | | | | 21.20 | | | | 23.20 | | | |
| 19.25 | | | | 21.25 | | | | 23.25 | | | |
| 19.30 | | | | 21.30 | | | | 23.30 | | | |
| 19.35 | | | | 21.35 | | | | 23.35 | | | |
| 19.40 | | | | 21.40 | | | | 23.40 | | | |
| 19.45 | | | | 21.45 | | | | 23.45 | | | |
| 19.50 | | | | 21.50 | | | | 23.50 | | | |
| 19.55 | | | | 21.55 | | | | 23.55 | | | |

Remarks:

Summary sheet for the 24-hr recall of activity

| Level | PAR value | Subject number/ Number of minutes | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| 1 | <1.10 | | | | | | | | |
| 2 | 1.1 - 1.4 | | | | | | | | |
| 3 | 1.5 - 1.8 | | | | | | | | |
| 4 | 1.9 - 2.4 | | | | | | | | |
| 5 | 2.5 - 3.3 | | | | | | | | |
| 6 | 3.4 - 4.4 | | | | | | | | |
| 7 | 4.5 - 5.9 | | | | | | | | |
| 8 | 6.0 - 10.9 | | | | | | | | |
| **Total EE kJ** | | | | | | | | | |

**INSTITUTE OF HUMAN NUTRITION**

**UNIVERSITY OF SOUTHAMPTON**

## ACTIVITY DIARY

1.This is a record of all the activities that you normally do everyday, for seven consecutive days.

2. Take this diary with you, together with a watch and a pen, during the whole seven days.

3. Do not change your activity pattern.

4. Please record everything that you do from the moment you get out of bed until the time you go to sleep.

5. Write the time you when you start to do anything.

6. Refer to the example diary on the next page to write the codes for the type activity that you are doing.

**NAME:** ______________________________

**ADDRESS:** ______________________________

**TEL:** __________

**ID # :** __________

Please contact Safiah Mohd.Yusof at 796539 (day time) or at 679705 (evenings) if you have any problem regarding this activity diary. Thank you for your cooperation.

Example of an activity diary

Date:____ /____ /____ ID #: ☐☐☐☐☐☐

| Time | Activity | Code |
|---|---|---|
| *9.30 am* | *Woke up & bathed* | *ST* |
| *9.45* | *Washed & bathed baby* | *ST* |
| *10.00* | *Had breakfast* | *S* |
| *10.10* | *Cleared up dishes* | *ST* |
| *10.20* | *Cleaned table* | *ST* |
| *10.30* | *Got ready to go out* | *ST* |
| *10.40* | *Walked to the shops* | *W2* |
| *10.45* | *Shopping* | *W1* |
| *12.00 pm* | *Walked home* | *W2* |
| *12.05* | *Cooked lunch* | *ST* |

CODES for activities:

C - climbing stairs
L- lying down
S- sitting down
ST- standing

W1- walking at normal pace
W2- walking briskly

Others- please specify other codes which you have used but not in the list:-

________________________________________

Date:____ /____ /____ ID # : ☐☐☐☐☐☐

| Time | Activity | Code |
|---|---|---|
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Summary sheet for the 7d activity diary

Name:....................ID:................Subject no.:..................Diary date:........................Diary day:.........................BMR:.....................MJ/day.

| Level | PAR value | Number of minutes | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | D1- Mon | D2- Tues | D3- Wed | D4- Thur | D5- Fri | D6- Sat | D7- Sun | Total |
| 1 | <1.10 | | | | | | | | |
| 2 | 1.1 - 1.4 | | | | | | | | |
| 3 | 1.5 - 1.8 | | | | | | | | |
| 4 | 1.9 - 2.4 | | | | | | | | |
| 5 | 2.5 - 3.3 | | | | | | | | |
| 6 | 3.4 - 4.4 | | | | | | | | |
| 7 | 4.5 - 5.9 | | | | | | | | |
| 8 | 6.0 - 10.9 | | | | | | | | |
| **Total EE kJ** | | | | | | | | | |

/summary2

**Protocol for the 'Step Test'**

1. Welcome the subject and give her a brief explanation of what the test involves. It consists of two 3-minutes stages of stepping sequences up and down two steps to the beats of a metronome on a tape recorder.
2. Stage 1 is a "arm-up" stage. It the subject's heart rate does not go above the specified for her age then the subject continues on to Stage 2.
3. Stage 2 is carried out at a slightly faster rate than Stage 1.
4. Heart rate is measured by counting subject's pulse at the radial artery.
5. Pulse rate is counted before the test, at the end of Stage 1 and 2.
6. Remind the subject that the test can stop if at any time she feels uncomfortable.
7. Demonstrate to the subjects how she should be stepping.
8. The sequence of stepping is: -
   - a- both feet on the floor in front of the steps.
   - b- start with the right foot going up to the first step, and
   - c- left foot follows up to the first step, and both feet together.
   - d- left foot goes up to the second step, and
   - e- right foot follows up to the second step, and both feet together.
   - f- right foot down to the first step, and
   - g- left foot down to the first step, and both feet together.
   - h- left foot down, and right foot follows down, and
   - i- both feet together, and repeat.
9. Once the subject seems capable of stepping the correct way, start the tape.
10. The tape gives clear instructions on what to do and when to do it. The tape will instruct when the pulse rate should be counted (10 seconds after stopping).
11. Once counted, the pulse rate should be recorded immediately on the record sheet.
12. Throughout the test it is important to check that the subject is doing the test as required. Any help needed should be given.
13. If after Stage 1 the pulse rate is higher than specified for her age, then the test must be stopped.
14. Refer to the table for maximum allowable pulse rate at the end of Stage 1 and Stage 2 for the various age groups.

**The age-specific beats per minute (BPM) used in the two-stage Step Test**

| Age (years) | Stage 1 (BPM) | Stage 2 (BPM) |
|---|---|---|
| Women | | |
| 20-29 | 114 | 114 |
| 30-39 | 102 | 114 |
| 40-49 | 84 | 102 |
| 50-59 | 84 | 84 |
| 60-69 | 66 | 84 |

**Pulse rate at which the Step Test should be stopped, after Stage 1**

| | Beats per 10 seconds |
|---|---|
| Age (year) | |
| 20-29 | >28 |
| 30-39 | >27 |
| 40-49 | >25 |
| 50-59 | >24 |
| 60-69 | >23 |

These values are based on the expected pulse rates at 80 percent of $Vo_2$ max for the next youngest age group, and 75 percent of $Vo_2$ max for people over 40 years old. The Step Test should not be continued if the pulse rate is more than those specified above!

(From "Measuring the nation's exercise habits", by J. Kelly, a research project for a degree in M.Phil. at the Department of Human Nutrition, University of Southampton, 1995)

# Appendix 9

Appointments
Tel: (01703) 223330

**DR. N .K DESAI**
**DR. S. P. PAL**

131, St. Mary's Roac
Southampton SO14 OBI
Tel: (01703) 33515
Fax: (01703) 33967

Dear Patient

Re: The Study of South Asian Women Born in Southampton

Your name has been put forward for the above study with the blessing of Dr Pal and Dr Desai. If you feel able to participate in this study, you can be assured of the confidentiality promised.

Yours faithfully

[redacted]

Dr N K Desai

Dr C S Thaker
Dr B P Dave
Dr H Bhatt

230 Burgess Road
Bassett
Southampton
SO16 3AY

Tel: 01703 676233
Fax: 01703 672909

Mrs S Yusof
The Institute of Human Nutrition
University of Southampton
Bassett Crescent East
Southampton
SO16 7PX

12th January 1996

Dear Mrs. Yusof

Study of South Asian women born in Southampton

Having read the letter you intend to send to our patients the doct
confirm that they are in agreement for you to carry out this study

Yours sincerely,

[redacted]

June Conklin
Practice Manager

# Appendix 10

1~
2~

Dear 3~

**Re: A Health Survey of South Asians in Southampton**

I am a student at the University of Southampton. Part of my study project is to carry out a health survey among South Asians in Southampton. Dr Margetts who is a lecturer at the University is my supervisor in this project.

We are working closely with the local Health Services, your General Practitioner and the Community Workers. We also enclose a letter of support from your General Practitioner.

Surveys in some parts of the United Kingdom (UK) have shown that diabetes and coronary heart disease are very common among the South Asian community.

**To ensure that we get the right information we would ask you to complete the questionnaire enclosed and return it in the prepaid envelope.**

We regard this as an important study as it will give information about the current lifestyles and health of the South Asian in Southampton. It will help towards developing future educational messages for the Asians and improving the health care that you receive here.

If you have any questions to ask about the study please do not hesitate to call Mrs Safiah Mohd Yusof at (01703) 796530 (day time) or (01703) 346223 (evenings).

**Please note that all the information that we obtain from you will remain strictly confidential.**

I thank you in advance for your help.

Yours sincerely

Safiah Mohd Yusof
**PhD Student**

Dr B M Margetts
**Senior Lecturer in Public Health Nutrition**

Encs

University
of Southampton

## *A Survey on the Health and Lifestyles of South Asians in Southampton*

### *An Important Message Regarding You and Your Community*

* *Studies in the United Kingdom have shown that the South Asians have a higher tendency to get diabetes or heart disease than the general population.*
* *There are many reasons why this could happen. For example, the diet, family history of the disease, lifestyles and also their weight at birth !*

*The aim of this survey is to:*

> ***Find the relationship between weight at birth, current lifestyles and the risk of getting diabetes or heart disease among South Asians.***

*We want to make sure that future health advice or education are made suitable for you and your community.*

***To ensure that we get the right information we would like to ask you to complete the questionnaire enclosed and return it in the prepaid envelope.***

*Please note that all the information that we obtain from you will remain strictly confidential.*

**The results of this survey will appear only in the form of general statistics from which it will be impossible to identify you as an individual.**

*Before we ask any questions about your health and activities, we need to check some more details about yourself.*

Q1a **Your surname:**......................................................................

Q1b **Your forename(s):**..................................................................

Q1c **Your address:**......................................................................

Q1d **Postcode:**.................................

Q2 **Your date of birth:** ☐☐ / ☐☐ / ☐☐

Q3 **Were you born in Southampton?**

Yes ☐ No ☐

If not in Southampton, where?

Town...................................... Country.......................

Q4a **What is the highest educational qualification that you have obtained in this country?**

| | | |
|---|---|---|
| 01 | CSE/GCE 'O' level/GCSE | ☐ |
| 02 | GCE 'A' level | ☐ |
| 03 | City and Guilds Certificates | ☐ |
| 04 | Nursing, Polytechnic, University or Professional qualifications | ☐ |
| 05 | Other (describe)................................... | ☐ |
| 06 | No formal qualifications | ☐ |
| 07 | Don't know | ☐ |
| 08 | Education outside this country.................. | ☐ |

Q15 Where was your father born?

The state............................. The country....................................

Q16 Does your mother have any of the following?

| | Yes | No | Don't know |
|---|---|---|---|
| Diabetes | ☐ | ☐ | ☐ |
| Heart disease | ☐ | ☐ | ☐ |
| High blood pressure | ☐ | ☐ | ☐ |

*Details about your mother*

Q17 Where was your mother born?

The state.............................. The country...................................

Q18 a **Your mother's maiden surname:**.......................................

b **Your mother's married surname:**.......................................

c **Your mother's forename(s):**..................................................

d **Your mother's hospital maternity number:**.......................

Thank you for taking the time to complete this questionnaire

We may want to invite you to participate in an in depth study of the South Asian community in Southampton. If you agree that we contact please give your phone number or a place where we can contact you.

Tel. number:......................./ place to be contacted..........................................

If you do not wish us to contact you further please put a tick in the box.

☐

**Q9c If NO job, how would you describe yourself?**

Housewife ☐ Student ☐

Unemployed ☐

Other (describe)................................... ☐

**Q10a During week days how much time per day, on average, would you spend doing the following?**

i Sitting down (e.g. watching TV / video, eating, talking, studying, working or others)

☐☐ hours / day

ii Lying down or sleeping

☐☐ hours / day

**Q10b During weekends how much time per day, on average, would you spend doing the following?**

i Sitting down (e.g. watching TV / video, eating, talking, studying, working or others)

☐☐ hours / day

ii Lying down or sleeping

☐☐ hours / day

**Q11 During the last week have you done any of the following activities, if YES please write the number of times you have done it and for how long ?**

*If NO, put '00' for number of times.*

a Long walks ( 2 miles or more ) at brisk or fast pace

number of times ☐☐

duration each time ☐ hours ☐☐ min

b Heavy housework ( e.g. spring cleaning, moving furniture, polishing)

number of times ☐☐

duration each time ☐ hours ☐☐ min

c Heavy gardening (e.g. digging )

number of times ☐☐

duration each time ☐ hours ☐☐ min

d Heavy Do-It-Yourself ( e.g. mixing cement)

number of times ☐☐

duration each time ☐ hours ☐☐ min

e Sports or exercise ( e.g. football, swimming, tennis or aerobics)

number of times ☐☐

duration each time ☐ hours ☐☐ min

*Diet*

**Q12a During an average week how many times would you have the following foods?**

| | x per week | | x per week |
|---|---|---|---|
| Chappati | ☐ | Paratha | ☐ |
| Rice | ☐ | Breads | ☐ |
| Meat curry | ☐ | Vegetable curry | ☐ |
| Milk & dairy products | ☐ | Breakfast cereals | ☐ |
| Sugar in tea / coffee | ☐ | Fruits/fruit juices | ☐ |
| Indian sweets & biscuits | ☐ | | |

Q12b What do you usually use for cooking?

Ghee ☐ Oil ☐

Q12c Do you usually spread ghee , margarine or butter on your chappati/paratha?

Yes ☐ No ☐

*Q12d Are you a vegetarian-*

*All the time* ☐ *Most of the time* ☐

*Sometimes* ☐ *Not a vegetarian* ☐

*Current health status*

Q13 Have you ever been told to have any of the following ?

| | Yes | No | Don't know |
|---|---|---|---|
| Diabetes | ☐ | ☐ | ☐ |
| Heart disease | ☐ | ☐ | ☐ |
| High blood pressure | ☐ | ☐ | ☐ |

*Family history of certain diseases*

Q14 Does your father have any of the following?

| | Yes | No | Don't know |
|---|---|---|---|
| Diabetes | ☐ | ☐ | ☐ |
| Heart disease | ☐ | ☐ | ☐ |
| High blood pressure | ☐ | ☐ | ☐ |

Q4b If you have been educated in another country, what is the highest qualifications you have received?..........................................................................

Q5a Can you remember what was your weight at birth ?

Yes ☐ , it was.........lbs........oz /............grams

No ☐ ( go to Q5b)

Q5b If NO, can your mother remember your weight at birth?

Yes ☐ , it was.........lbs........oz /............grams

No ☐

Q6 What is your weight now ( lightly dressed )?

............lbs........oz /...........stones / ..............kg

Q7 What is your height now ( without shoes )?

...........feet........inches / .............centimetres

*Smoking*

*We would like to ask you a few questions about smoking. While we are aware that smoking may be offensive to you or against your religion please understand it is important we ask everyone this question.*

Q8a Have you ever been a cigarette smoker?

No ☐ Yes ☐

Q8b IF YES, do you still smoke cigarettes now?

No ☐ Yes ☐

*Activity at work and at home*

Q9a Do you have a paid job, either full or part time at present ?

No ☐ ....go to Q9c Yes ☐

Q9b IF YES, what is the name or title of your occupation?..................................................................

# Appendix 11

The Wessex Institute
for Health Research & Development
incorporating Public Health Medicine

The Wessex Institute
for Health Research and
Development

Level B, South Acad
Southampton Genera
Southampton
SO16 6YD

Telephone 01703 79
01703 796
Fax 01703 796529
Email wi@soton.ac.uk

# WANTED

Volunteers for a study on the health and lifestyles

Asian women in Southampton (age 18+)

**What you have to do:**

* Answer questions about your normal diet and daily activities

* Keep a diary of your daily activities for 1 week

* Do a simple fitness test

We will measure your weight, height, and waist and h

circumference.

If you are interested please contact:

**Dr Barrie Margetts**

**Public Health Nutrition ext: 4776 or 6539**

University
of Southam

# WANTED

Volunteers for a study on the health and lifestyles of Asian women in Southampton

**What you have to do:**

* Answer questions about your normal diet and daily activities
* Keep a diary of your daily activities for 1 week
* Do a simple exercise to test your fitness level

We will measure your weight, height, and waist and hip circumference.

If you are interested please contact:
**Safiah Mohd Yusof**
**Tel: (01703) 679705 (evenings) or (01703) 796539 (daytime)**

The Wessex Institute for Health Research & Development
*incorporating Public Health Medicine*

**The Wessex Institute for Health Research and Development**

*Level B, South Aca*
*Southampton Gene*
*Southampton*
*SO16 6YD*

*Telephone 01703 79*
*01703 79*
*Fax 01703 796529*
*Email wi@soton.ac.*

Dear student

I am a research student studying for a PhD in nutrition at the University of Southampton. My research is on the health and lifestyles of South Asian women in Southampton, age 18 years or more. South Asians are those who have origins in India, Pakistan or Bangladesh.

This study is done in two parts:

1. A general survey by a postal questionnaire.
2. A personal interview. (This is explained in the leaflet attached).

To take part in this study it is important that you first answer the questionnaire enclosed. If you would like me carry out the interview study, please write your telephone number at the end of the questionnaire. Your participation will make the findings of my study more meaningful.

Thank you for your cooperation. Please return your questionnaire in the reply-paid envelope.

Yours sincerely

[redacted]

(Safiah Mohd Yusof)

The Wessex Institute
for Health Research & Development
*incorporating Public Health Medicine*

**The Wessex Institute for Health Research and Development**

*Level B, South Academic B*
*Southampton General Hosp*
*Southampton*
*SO16 6YD*

*Telephone 01703 79*
*01703 796530*
*Fax 01703 796529*
*Email wi@soton.ac.uk*
smy@.soton.ac.u
*Extension 653*

Mr J Heyword
Head Teacher
Mount Pleasant Junior School
Mount Pleasant Road
Southampton
SO14 OUZ

4 February 1997

Dear Mr Heyword

Further to our telephone conversation this morning, I am enclosing copies of the introduction letter about my study. Could you please distribute to all female Asian teachers and mothers of Asian children in your school.

After filling in the slip they should return it to you and I will get in touch with you to find out about the response.

Many thanks.

Yours sincerely

[redacted]

Safiah Mohd Yusof
**PhD Student**

Encs

University
of Southampton

The Wessex Institute
for Health Research & Development
incorporating Public Health Medicine

**The Wessex Institute for Health Research and Development**

*Level B, South Academic Bl*
*Southampton General Hosp*
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*Telephone 01703 79*
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*Fax 01703 796529*
*Email wi@soton.ac.uk*

21.2.97

Mrs. Manju Tank
Tauntons College
Hill Lane, Southampton
SO15 5RI

I'm a PhD student at the University of Southampton. My research is focussed on the health and lifestyles of Asian women in Southampton. I have spoken on the telephone to the college Principal Mr Rodney Lyons. He has agreed that if you are able to help me, you could get students at the college , females aged more than 17 years to become subjects in my study.

What they have to do:
* Answer questions about their normal diet and daily activities
* Keep a diary of their daily activities for 1 week
* Do a simple fitness test
We will measure their weights, heights, and waist and hip circumferences. We would also like to ask them to allow us to do some more tests, for which they will need parental consent.

I can be contacted at these telephone numbers: 796539 (daytime) and 679705 (evenings).

Your help is much appreciated.

Thank you.

Yours sincerely

[redacted]

The Wessex Institute
for Health Research & Development
incorporating Public Health Medicine

The Wessex Institute for Health Research and Development

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Southampton
SO16 6YD

Telephone 01703 79
01703 796530
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Email wi@soton.ac.uk

Mr Harjap Singh
Secretary of
The Gurdwara, Peterborough Road
Southampton

26 February 1997

Dear Sir

We were pleased to meet you last Sunday afternoon at the Gurdwara. We are both students at the University of Southampton. We are studying for our PhDs in Nutrition by doing studies on the Asian community in Southampton. Let us explain about each of our studies.

**Mrs. Safiah:-**

My study is on the health and lifestyles of Asian women in Southampton, age 18 years or more. I'm interested to know about what they eat, their daily activities, whether they have diabetes, heart disease or blood pressure. For this study I need as many volunteers as possible to make sure that what we report is helpful to the whole community. I'm enclosing an information sheet to explain about the study.

**Mr. Zuhair:-**

My study is on the health of young girls (born in Southampton), age 10- 16 years. I'm interested to know what they eat and their daily activities. I also would like them to do a small blood test to see if they are suffering from anaemia or not. I'm enclosing an information sheet to explain about the study.

We would really appreciate it if you could help us in recruiting as many volunteers as possible. We are grateful to our friend Mrs. Bindu Bala Thathgar who brought us to the Gurdwara and who has been kind enough to give this letter to you.

Thank you. If you require more information please contact either of us (Mrs Safiah 679705 or 796539; Mr Zuhair 678397 or 796539)

Your sincerely

[redacted]

(Mrs. Safiah Mohd Yusof)

[redacted]

(Mr. Zuhair Majid)

University
of Southampton

# Appendix 12

## Job titles for study subjects

Administrative Assistant
Administrator
Assistant Librarian
Assistant Women Officer
Bank Clerk
Bilingual Assistant
Book Seller
Care Assistant
Catering Assistant
Clerk
Day-Care Co-ordinator
Dinner Lady
Domestic Cleaner
Health Visitor
Housing Adviser
Lab Manager
Lecturer
Machine Operator
Medical Doctor
Mental Health Development Worker
Newsagent
Non-Teaching Assistant
Pharmacist
Playgroup Supervisor
Project Worker
Receptionist
Research Assistant
Secretary
Shoe-Shop Assistant
Social Services Adviser
Social Worker
Special Needs Assistant
Supermarket Assistant / counter checkout
Supervisor at bakery
Support Worker
Take-Away Shop Assistant
Teacher
Trainee Solicitor

**If unemployed:**

Student
House wife

# Appendix 13

Energy cost of physical activity

| Activity description in reference | Similar activities recorded or recalled by subjects | Cost kJ/min | Physical activity ratio (PAR) |
|---|---|---|---|
| Aerobic dancing - low intensity (equivalent to walking) | Yoga/stretching exercises, sit ups | 16.98 | 3.91 |
| Aerobic dancing - medium intensity (equivalent to jogging) | Jogging, gym work | 27.50 | 6.31 |
| Aerobic dancing - high intensity (equivalent to running) | Running | 35.94 | 8.21 |
| Bed making | | 20.42 | 4.57 |
| | DIY (e.g. Carpentry) | 9.60 | 2.4 |
| Cleaning windows | Washing the car | 12.36 | 2.72 |
| Cleaning and drying | Cleaning a fish tank | 19.79 | 5.13 |
| Cooking activities (general) | | 6.73 | 1.80 |
| Cycling (on flat ground, 'own' speed) | | 26.27 | 5.50 |
| | Dancing (at a party) | 20.40 | 5.10 |
| Gardening | | 22.47 | 4.82 |
| Household chores (unspecified) | Vacuuming, cleaning and mopping the kitchen, bathroom & floor; polishing; putting shopping away; | 13.68 | 3.65 |
| Ironing | | 5.97 | 1.46 |
| Laboratory work (general) | | 14.32 | 2.38 |
| Laundry (washing, rinsing, hanging on the line) | | 12.78 | 3.19 |
| Lying at rest | | 4.96 | 1.05 |
| Operating electric sewing machine | | 5.07 | 1.06 |
| Preparing vegetables | Making sandwiches/ tea, prepare baby's milk etc. | 5.93 | 1.56 |
| Setting the table | | 13.51 | 3.37 |
| Sewing by hand | | 4.93 | 1.11 |
| Sitting at rest | Watching TV, reading, sitting in a car/bus | 5.50 | 1.19 |
| Sitting working (according to occupation) | Studying, sitting in lectures, typing | 6.44 | 1.44 |
| Sitting activities (cooking, washing etc.) | Playing with child, fold clothes | 8.69 | 2.13 |
| Sitting (typing) | | 6.76 | 1.69 |
| Sitting (unspecified activities) | Sitting and talking, eating, drinking, driving, bathing. | 6.56 | 1.33 |
| Sleeping | | 4.00 | 1.00 |
| | Spring cleaning | 16.00 | 4.00 |
| Standing at rest | Waiting for a bus | 5.96 | 1.26 |
| Standing working (according to occupation) | | 7.46 | 1.71 |

| | | | |
|---|---|---|---|
| Standing (unspecified activities) | Standing and talking, getting ready to go out, praying, serving guests, putting children to bed, changing baby's nappy, dressing baby | 7.17 | 1.51 |
| Sweeping floor | | 7.01 | 1.71 |
| | Swimming | 20.4 | 5.10 |
| Walking on level (1-2 km/h) | Shopping | 9.47 | 2.23 |
| Walking on level (3-4 km/h) | | 12.68 | 2.87 |
| Walking on level (4-5 km/h) | | 17.87 | 3.77 |
| Walking and carrying | | 16.32 | 3.98 |
| Walking downstairs (rate unspecified) carrying 'light' load/basket of clothes | Walking downstairs carrying a baby | 16.74 | 3.36 |
| Walking up and down stairs | | 15.2 | 3.36 |
| Washing, dressing, shaving, etc. | Taking a shower, washing hair | 13.47 | 2.69 |
| Washing dishes | | 6.32 | 1.54 |

Reference: James & Schofield, 1990