UNIVERSITY OF SOUTHAMPTON

LOW BACK PAIN AND RISK FACTORS FOR LOW BACK PAIN IN CAR DRIVERS

LENKA GALLAIS

DOCTOR OF PHILOSOPHY

FACULTY OF ENGINEERING SCIENCE AND MATHEMATICS

INSTITUTE OF SOUND AND VIBRATION RESEARCH

MAY 2008

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF ENGINEERING SCIENCE AND MATHEMATICS

INSTITUTE OF SOUND AND VIBRATION RESEARCH

Doctor of Philosophy

LOW BACK PAIN AND RISK FACTORS FOR LOW BACK PAIN IN CAR DRIVERS

by Lenka Gallais

The cause of low back pain in populations of professional drivers is uncertain. A literature review revealed factors that seem to be associated with low back pain (e.g. physical factors: exposure to whole body-vibration, prolonged sitting posture, frequent lifting, pushing and pulling, lack of physical fitness; psychosocial factors: job satisfaction or stress; individual factors: age, gender, anthropometrics, tobacco, alcohol consumption, etc.).

This thesis investigates the occurrence of back pain in professional car drivers – a group found to be not focussed upon in previous epidemiological studies. The thesis seeks to advance understanding of response relationships between risk factors and low back pain in populations of car drivers (209 taxi drivers and 365 police drivers) and 485 non-drivers. A longitudinal study with cross-sectional baseline combined with field measurement of driving in selected vehicles was performed to investigate the occurrence of musculoskeletal problems (mainly low back pain) and the relationship between risk factors and low back pain experienced for at least one day during the past 12 months in the two populations of professional drivers (taxi drivers and police drivers) and professional non-drivers.

The cross-sectional baseline of the longitudinal study revealed that 45% (38.3-51.7%) of taxi drivers, 53% (48-58.6%)of police drivers and 46% (41-50.1%) of police non-drivers reported low back pain for at least one day during the past 12-months (p = 0.09). The prevalence of low back pain in the non-driving population of police employees fell within prevalence range reported by professional car drivers in this study and in previous epidemiological studies. The cross-sectional study revealed risk factors associated with the prevalence of low back pain (i.e., stature, previous physical demands, increased psychosomatic distress, daily and cumulative driving in taxi drivers; age, lifting, bending, increase psychosomatic distress in police drivers; stature, bending, increased psychosomatic distress in police non-drivers).

Measurements of whole-body vibration in selected taxi and police vehicles revealed frequency-weighted accelerations in the dominant vibration direction (i.e., z-axis) to be 0.47 ms^{-2} r.m.s. in taxi vehicles and 0.58 ms^{-2} r.m.s. in police vehicles.

A study of cumulative exposure to whole-body vibration in a group of taxi drivers pointed to a possible overestimation of their self-estimated duration of vibration exposure by 31% on average.

The longitudinal study revealed a lower incidence of low back pain in taxi drivers than in both police drivers and police non-drivers (p = 0.02). The difference might be attributed to a different approach to low back pain in taxi drivers who lose income if unable to work. An alternative explanation for increased low back pain among police employees could be that taxi drivers with low back pain leave their profession and were excluded from the follow-up study – a healthy worker effect.

The longitudinal study revealed that increased psychosomatic distress was a risk factor associated with the development of new episodes of low back pain in all three of the studied populations (i.e. taxi drivers and police drivers and non-drivers).

In police drivers, increased daily duration of driving was a risk factor for the development of low back pain. Although the results point to increased incidence of low back pain with increasing duration of daily driving, non-drivers were at a similar risk of developing of low back pain. Plausible explanations for this finding include ergonomic factors that were present for both the drivers and the non-drivers (e.g., the duration of sitting or duration in a constrained posture) and the presence of other risk factors not investigated in the study but associated with increased incidence of low back pain in non-drivers.

ACKNOWLEDGMENT

I would like to thank to Professor Mike Griffin who has introduced me to the science of whole-body vibration. Many thanks for his help and patience.

I would like to thank to all VIBRISKS participants from different part of Europe (France, Germany, Italy, Netherlands, and Sweden). Cooperation with such great researchers has allowed me to appreciate how important the science is.

I would like to thank to Keith Palmer, Issy Reading, Claire Harris, and Vanessa Cox from MRC who kindly helped me with my questions

A big thanks to all the taxi drivers and police employees who participated in this research. Without such brave people this study would have not been possible.

To my beloved person, my husband Cedric with whom we have together enjoyed the student life and with whom my life is so wonderful.

Special thanks to my parents and to all my family which supported me and always believed in me.

Thanks to all my new friends I have met in Southampton, who introduced me to different cultures and also thanks to all my old friends all around the world.

And finally thanks to all the people I have forgotten to mention ....

CONTENTS

CHAPTER ONE: INTRODUCTION

CHAPTER TWO: LITERATURE REVIEW

CHAPTER THREE: MATERIAL AND METHODS

CHAPTER FOUR: CROSS-SECTIONAL STUDY

CHAPTER FIVE: LONGITUDINAL STUDY

CHAPTER SIX: GENERAL DISCUSSION

CHAPTER SEVEN: GENERAL CONCLUSION

REFERENCES

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF ABREVATIONS

LBP	Low Back Pain
NP	Neck Pain
SP	Shoulder Pain
BMI	Body Mass Index
C1 – C7	Cervical vertebrae
T1-T12	Thoracic vertebrae
L1-L5	Lumbar vertebrae
MRC	Medical Research Council
VINET	Vibration Injury Network
ISVR	Institute of Sound and Vibration
VIBRISKS	European Commission FP5 Project No. QLK4-2002-02650
WBV	Whole Body Vibration
H*Vlab*	Data acquisition and analysis system
W_d, W_k, W_c	Frequency weightings required for the evaluation of whole-body vibration on health
VDV	Vibration Dose Value
eVDV	Estimated Vibration Dose Value
a_w	Frequency-weighted r.m.s. acceleration
T, T_0	Exposure duration in seconds
A(8)	8-h energy-equivalent frequency-weighted acceleration magnitude

CHAPTER ONE

INTRODUCTION

1.1. General introduction

Back pain is a common disease affecting almost all individuals at some point in their life. After headaches and tiredness, back pain is the third most common health problem reported by individuals (Waddell, 1999).

In a typical one-year period, approximately five million people suffering from low back pain consult their general practitioner. The cost of the primary care related to low back pain by GPs in 1998 has been estimated at £140.6 million, of which £108.2 million related to care at surgery and £32.4 million to formal care at home. The total annual estimated cost associated with care (in general practice, by private consultants, physiotherapists, osteopaths, etc.) and treatment (prescriptions, over the counter medication, etc.) of back pain in 1998 has been estimated at £1632 million (Maniadakis, 2000).

The cost of treating and the affects of back pain are high. Besides the direct cost of care and treatment of back pain, production losses due to work absence caused by back pain and the informal welfare cost can be estimated. Back pain is a common cause of disability. It was estimated that back pain in 1998 caused about 116 million lost working days. That number implies that £9090 million (as an upper estimate) was lost due to the disability caused by back pain preventing work. The cost of informal health care to an individual experiencing back pain was estimated at £1578 million in 1998 (Maniadakis, 2000).

Studies of disorders among professional drivers have reported musculoskeletal problems (low back pain, neck pain and shoulder pain), disorders of the digestive system, disorders of the reproductive system and disorders of the vestibular and visual system, abdominal pain, headaches, sleep disturbance, haemorrhoids and prostatitis (Griffin, 1982; Seidel and Heide, 1986; Wikström *et al.*, 1994). Reviews suggest that the most frequent health problems in drivers are low back pain, sciatic pain and degenerative changes in the spinal system (Seidel and Heide, 1986; Griffin, 1990; Wikström *et al.*, 1994; Bovenzi and Hulshof, 1999).

Low back pain is multi-factorial in origin. The cause of increased prevalence of low back pain in populations of professional drivers is often uncertain. The factors reported to be most strongly associated with low back pain are exposure to whole body-vibration, prolonged sitting posture, frequent lifting, and cigarette smoking. Other possible risk factors with weaker or inconsistent evidence for influencing low back problems are pushing and pulling, sedentary occupations and lack of physical fitness, psychosocial factors, such as job satisfaction or stress and individual factors (age, gender, anthropometrics, tobacco consumption, etc.) (Jayson, 1992).

Reviews of epidemiological studies of persons occupationally exposed to driving mostly conclude that long-term exposure to whole-body vibration is associated with increased risk of low back pain. The positive association between long-term exposure to whole-body vibration and low back pain has been reported in studies considering tractor drivers, truck drivers, bus drivers, helicopter pilots, and drivers of heavy off-road machines (e.g. earth moving machines, cranes, excavators) (Bongers *et al.*, 1990; Boshuizen *et al.*, 1990; Boshuizen *et al.*, 1992; Bovenzi and Betta, 1994; Bovenzi, 1996; Dupuis and Zerlett, 1987).

1.2. Objectives of research

Epidemiological studies of low back pain have been performed among general populations and professional drivers. As previously stated, the studies of professional drivers mostly considered drivers of trucks, tractors, busses and heavy machines. The number of epidemiological studies concerning the risk of low back pain among professional car drivers is low. Car drivers are exposed to lower levels of whole-body vibration than drivers of the other vehicles, but there may be still a risk of increased level of low back pain which may be affected by long durations of exposure or by other risk factors (individual risk factors, physical risk factors and psychosocial risk factors). Therefore the main objectives of this research are:

- To determine whether low back pain is more prevalent and incident episodes of low back pain are more frequent in car drivers than in workers who sit or walk for most of the day (after account is taken of other individual, physical and psychosocial risk factors)

- To improve knowledge of exposure-response relationship between exposure to driving expressed in different metrics and the development or persistence of low back pain
- To improve understanding of the risk factors (individual, physical and psychosocial risk factors) which may contribute to the development or progression of the symptoms of low back pain

1.3. Hypothesis of research

On the basis of the results from previous epidemiological studies it was hypothesised:

- Low back pain is more common among professional car drivers than among workers who sit or walk for most of the day but do not drive in their job.
- The higher risk of getting low back pain in professional car drivers can be related to the extent of exposure to driving (estimated by various metrics)
- The greater risk of getting low back pain persists after an account is taken of other individual, physical and psychosocial risk factors.

A few models, proposed by different authors, have sought to explain the relationship between risk factors and low back pain. For an example see Chapter two, paragraph 2.4. The real association between risk factors and low back pain is not clear and reciprocal associations between different risk factors are expected. For an elementary model of the research see Figure 1.1.

1.4. Milestones of the research

To fulfil the objectives and test the hypothesis, the following milestones had to be completed:

- A critical review to investigate the quality of previously published epidemiological studies of back pain among car drivers. For detailed information about previous research see Appendix A and Appendix B.
- To design a study involving the selection of an appropriate study population and create tools for the collection of information (self-administered questionnaire, system for measurement of exposure to whole-body vibration). For detailed information see Chapter 3.

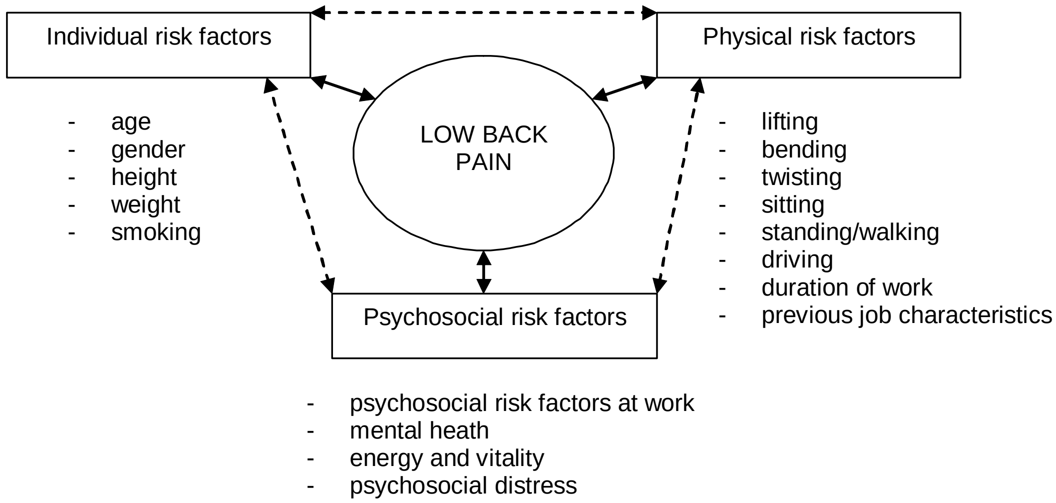


Figure 1.1. Associations between possible risk factors and low back pain

1.5. Organisation of thesis

The research is presented in the following eight chapters:

CHAPTER ONE: INTRODUCTION

The first chapter is an introduction presenting the general problem of low back pain in society and driving populations. This chapter also defines the general objectives and hypotheses of the research, and defines important milestones of the research such as performance of critical review of the present knowledge about risk of low back pain to car drivers.

CHAPTER TWO: LITERATURE REVIEW

Chapter two summarises fundamental knowledge about the anatomy of the spine, common causes of back pain and summarises the state of knowledge about possible risk factors for development and aggravation of low back pain. The fundamental principles of the epidemiological research are also presented in the Chapter two.

CHAPTER THREE: MATERIAL AND METHODS

Chapter three describes the study material (different type of occupational groups used in the research), measurement apparatus for the collection of information (self-administered questionnaire, equipment for measurement of exposure to whole-body vibration) and methods for analysing the collected information.

CHAPTER FOUR: CROSS-SECTIONAL STUDY

The results of the cross-sectional study such as prevalence of musculoskeletal problems in occupationally driving and non-driving population and the presence of possible risk factors for development of low back pain are presented in Chapter four.

Discussion of results and conclusion of the cross-sectional study are also presented in the Chapter four.

CHAPTER FIVE: LONGITUDINAL STUDY

Chapter five presents results of the whole longitudinal study such as incidence and persistence of musculoskeletal problems in the occupational driving and non-driving population and risk factors for development of low back pain.

Discussion of results and conclusion of the longitudinal study are also presented in the Chapter five.

CHAPTER SIX AND CHAPTER SEVEN: GENERAL DISCUSSION, GENERAL CONCLUSSION

Chapter six discusses the results of the cross-sectional and longitudinal study as a whole in relation to the current state of knowledge and presents possible model, characterising the relationship between low back pain and possible risk factors for the development. Chapter six also discusses the implication of the knowledge for minimising risk from whole-body vibration injuries in professional drivers.

A discussion of the implication of the study and the importance to future research is followed by the general conclusion in the Chapter seven.

APPENDICES

A summary of tables characterising the critical review of state knowledge about low back pain is presented in the Appendix A and Appendix B.

Self-administered questionnaire, accompanying letters used in the study are presented in the Appendix C and Appendix D.

Detailed and additional information and results of investigated populations are presented in the Appendix E.

CHAPTER TWO

LITERATURE REVIEW

2. 1. Introduction

Low back pain is called pain, muscle tension or stiffness which is felt below the costal margin (the lower edge of the chest formed by the bottom edge of the rib cage) and above the inferior gluteal folds (upper part of the buttocks), which is sometimes accompanied by pain radiating down to the legs, called sciatica.
The pain may vary from mild and short to severe and long episodes. Back pain could be classified as an upper back pain or a low back pain. Low back pain is the most common problem and it is reported that more than 70% of people in developed countries suffer from low back pain at some time in their lives (Chambers, 2001).

2.2. Anatomy of the spinal column

The anatomy of spinal column and common cause of low back pain are clearly explained in many anatomical textbooks (i.e. Jayson, 1992; Giles *et al*., 1993; Braggins, 1994; Waddell, 1999; Adams *et al.*, 2002).

The spinal column is one of the most important and one of the most difficult parts of the human skeleton. The human spine is strong and highly flexible.

The main functions of the spinal column are:

- Erected body posture of the human
- Realization of mobility
- Protection of spinal cord and nerve roots

The spine is a column of thirty-one to thirty-four bony vertebrae. Vertebrae are grouped into five main sections (See Figure 2.1.):

- The cervical spine (C1-C7) is made of seven cervical vertebrae that support the neck. These vertebrae enable the rotational and flexion movement of the head. Vertebrae which give the greatest degree of mobility for head movements are called atlas and axis.
- The thoracic spine (T1-T12) is composed of twelve thoracic vertebrae that are not designed for motion. The function of the vertebrae that are connected via rib cage to the sternum is to protect the compression of the important body organs (heart, lungs and major vessels).
- The lumbar spine (L1-L5); lumbar vertebrae are the five largest and toughest bones of the spinal column. The lumbar spine carries all the weight of torso and is responsible for the trunk twisting motion.
- Sacrum; triangle-shaped structure formed by five vertebrae that fused together. The sacrum connects the spine column to the lower part of the body.
- By fusion of two to four tiny vertebrae in the end of the spine was created Coccyx. Coccyx is more commonly known as a “tail bone”.

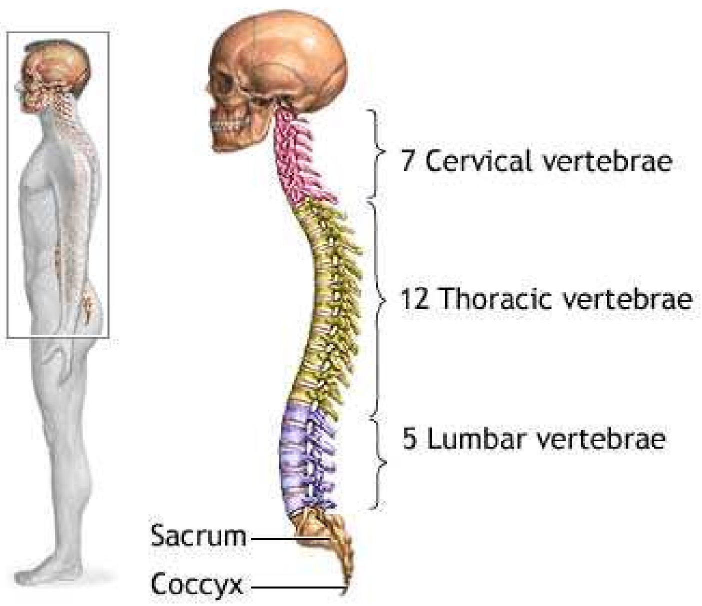


Figure 2.1. Spinal column (www.nlm.nih.gov)

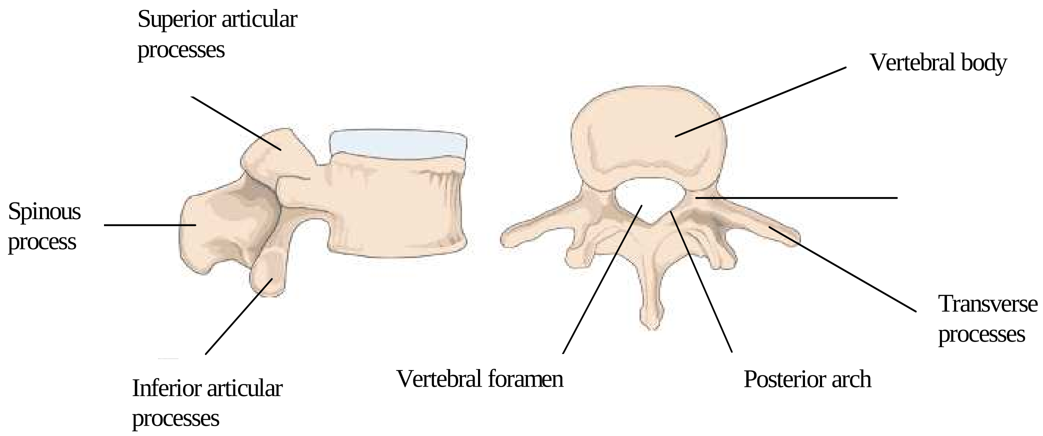


Figure 2.2. Spinal vertebrae (www.backkrack.co.uk)

2.2.1. The vertebrae

The vertebral body has a kidney shape and is designed to sustain great vertical load from the whole weight of the trunk. Vertebrae from the cervical, thoracic and lumbar spine have got the same basic shape (See Figure 2.2.).

From the vertebral body are growing two pedicles which together create the posterior arch and divide the vertebra into anterior and posterior elements. The hole between the vertebral body and posterior arch is known as the vertebral foramen. The vertebral foramina of all the vertebrae line up to form a canal known as the spinal canal, which gives a solid protection to all sensitive structures coming through. The spinal cord then traverses the spinal canal and ends up on the level of the second lumbar vertebrae. From the pedicles ray two superior and two inferior articular processes whose function is to form the joints that connect vertebrae together and fortify the spine. Two transverse processes and spinous process, which ray from pedicles, form the attachment for muscles in the back.

Vertebrae are stacked on top of each other with an intervertebral disc in between each one.

2.2.2. Intervertebral disc

There are twenty-three intervertebral discs in the human spinal column. Intervertebral discs are responsible for the curvatures of the spine known as lordosis and kyphosis (See Figure 2.3.).

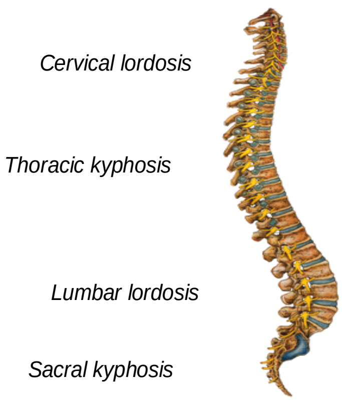


Figure 2.3. Spinal curves (www.cviceni.net)

Intervertebral discs are located between two vertebral bodies. One of the main functions of the intervertebral disc is to absorb and eliminate the shocks of weight-bearing from all activities going down through the vertebral bodies.

The healthy intervertebral disc has a kidney shape and is about 1cm thick. The disc consists of three main parts (See Figure 2.4.):

- Annulus fibrosus
- Nucleus pulposus
- Vertebral endplates

The annulus fibrosus is composed of 10-20 concentric sheets of tough collagen fibres

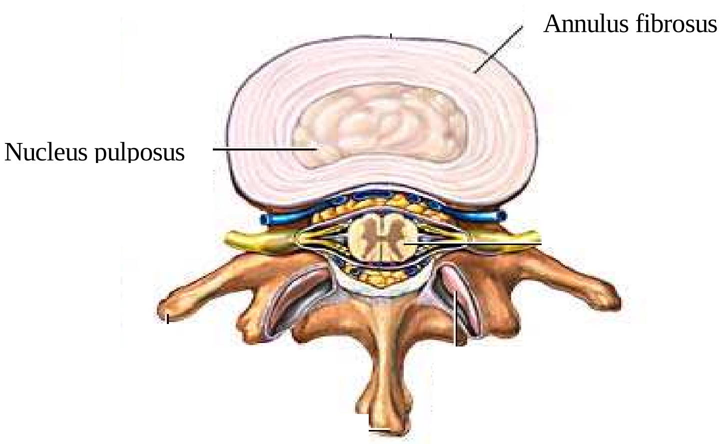


Figure 2.4. Intervertebral disc (www.nlm.nih.gov)

(lamellae) that are tightly packed together and surround the nucleus pulposus. The water amount of the structure is between 60 to 70% of its weight.

The nucleus pulposus is a semifluid mucoprotein gel located in the centre of each disc. Under pressure the nucleus can be deformed without a loss of the volume. This deformation is then resisted by the surrounding annulus fibrosus.

The function of the vertebral endplates is to separate the intervertebral disc from the vertebral bodies. Vertebral endplates have got an important function for the transport of water and nutrition of the disc. In addition they are also important for the prevention of the nucleus bulging into the vertebral body.

2.2.3. Spinal cord and spinal nerve roots

The spinal cord is coming from the brain through the cervical spine and stops at the lower level of the spine. Pairs of nerve roots emerge from either side of the spinal cord at appropriate level (See Figure 2.5.). Nerve roots (Cauda equina) coming from the spinal cord fill the rest of the spinal column and then exit the spine.

There are together thirty-one pairs of spinal nerves, which can be divided into five groups:

- 8 cervical nerves
- 12 thoracic nerves
- 5 lumbar nerves
- 5 sacral nerves
- 1 coccygeal nerves

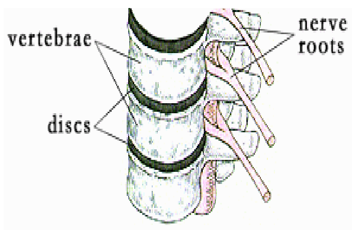


Figure 2.5. Spine segment (www.energycenter.com)

2.2.4. Back muscles

There is a large number of muscles that work together as a complex to support the spine. The spinal muscles help hold the spine in an erect posture and allow the trunk to move, twist and bend in many directions.

The three main types of back muscles that help to maintain the spine are:

- Extensor muscles that enable standing and lifting objects
- Flexor muscles enable flexing, bending forward, lifting and arching the lower back
- Oblique muscles help rotate the spine and maintain the proper posture

The flexibility and strength of these back muscles are essential to maintaining the neutral spine position.

2.3. Back pain and the common causes of back pain

Any part of the spinal column could be a source of back pain. Pain can arise from, intervertebral discs, ligaments, joints, muscles, nerves, etc.

2.3.1. Non specific back pain vs. specific back pain

There are two common groups of back pain:

1. Non specific back pain also called mechanical back pain or simple back pain of musculoskeletal origin. The most common cause of back pain where no pathology can be clearly identified. Simple back pain may be related to mechanical strain or dysfunction and often it develops spontaneously.
2. Specific back pain which is caused by pathologically known causes such as: spinal tumour, infection, inflammatory disease, etc.

<u>Non specific back pain</u>

Back pain is common and almost everybody experiences back pain at some point in time. However, between 85 to 90% of the back pain episodes do not have a definable cause and are non-specific in nature.
Mostly the causes of most cases of back pain are diagnosed to be a sprain or, small tear, to a ligament or muscle. The source of pain may also in small part originate from the spinal joints and spinal vertebrae. To diagnose the real cause of the pain is very difficult and the exact site and cause of the pain is often not clear.
The onset of non specific back pain affects especially lower back and is often sudden. The pain may also radiate to the buttocks, thighs and spread down to the legs and feet. The pain may range from mild to severe and is worsen by moving of back, sneezing or coughing. Non specific back pain does not lead usually to a surgery and the symptoms of back pain usually abate or are greatly eased within four to six weeks.

The onset of non specific back pain is often associated with mechanical work such as heavy lifting or inappropriate bending and twisting or bad posture held while sitting.

2.3.2. Common causes of low back pain

The main causes for low back pain are the following mechanical disorders of the lumbosacral spine:

1. Muscle strain or lumbar sprain
2. Disc degeneration
3. Intervertebral disc prolapse
4. Sciatica
5. Spinal stenosis
6. Spondylolisthesis
7. Other less common causes of low back pain

2.3.2.1. Muscle strain or lumbar sprain

Back strain is the most common cause of low back pain. A low back strain appears when the muscle fibres are abnormally stretched or torn. A lumbar sprain appears when the ligaments are torn from their attachments.

Micro tears in the annulus fibrosus is also one of the common cause of back pain (See Figure 2.6.). A decline in water content with age (from 90% in young people to 65% in older people) reduces the tension in the annulus and contributes to development of tears

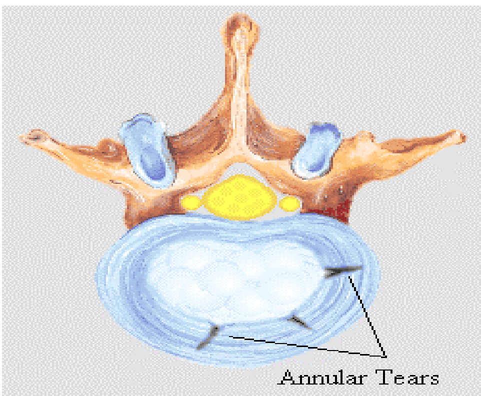


Figure 2.6. Annual tears (www.ilchiro.org)

in the annulus. As annular tears progress, the nucleus can prolapse through the tear. Acute tears of the annulus can also occur with twisting movements, particularly in flexion.

All these injuries show similar symptoms and therefore it is difficult to distinguish between them. The common symptom of muscular strain and lumbar sprain is inflammation of the soft tissue.

2.3.2.2. Disc degeneration

Intervertebral discs are prone to degeneration changes. It is difficult to distinguish which changes are due to the ageing process and which are due to the degeneration.

The structure and chemical composition of the discs change with their age. In the early stage, the disc has a low collagen level and high water content. With increasing age the collagen level increases, the water level decreases and the elastic contents of the disc falls. In older age, the water content decreases to about 70%. The annulus looks dry and has a more solid structure. It is difficult to see boundaries between the nucleus and the annulus of the disc. The nucleus looses its role as a pressure protector. At this stage discs are more vulnerable to disc prolapse and may explain the acute back pain among elderly people.

Disc degeneration that ends with changes in disc composition and the loss of the boundaries between the annulus and the nucleus may be related to the changes in biochemical and mechanical factors. Typical changes in the disc structure are:

- Concentric and radial tears in the annulus
- Inwards buckling of the inner annulus
- Increased radial bulging of the outer annulus
- Reduced disc height
- Endplates defects
- Vertical bulging of the endplates into the adjacent vertebral bodies

Disc degeneration occurs mostly at the lower level of the lumbar spine. The most affected discs are L4-5 and L5-S1 (See Figure 2.7.).

2.3.2.3. Intervertebral disc prolapse

Intervertebral discs are under constant pressure. With degenerative changes and the weak state of the disc, the annulus can bulge or be pushed into the space containing the spinal cord or a nerve root, causing pain. There are three types disc prolapse (See Figure 2.8.):

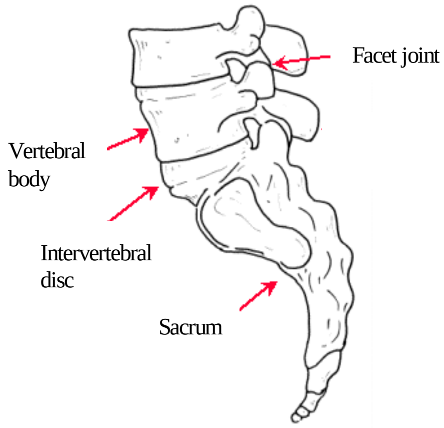


Figure 2.7. Lower level of the lumbar spine (www.spine.com.au)

1. Disc protrusion is the type of prolapse when the annulus bulges but is not ruptured. There is no contact between the nucleus and extra-discal space.
2. Disc extrusion also called disc herniation is a prolapse in which the annulus is ruptured but expelled nucleus is not separated from the disc.
3. Disc sequestration is the type of prolapse when the expelled nucleus is no longer attached to the disc. Complication of a ruptured disc is cauda equina syndrome, which occurs when disc material is pushed into the spinal canal and compresses the bundle of lumbar and sacral nerve roots.

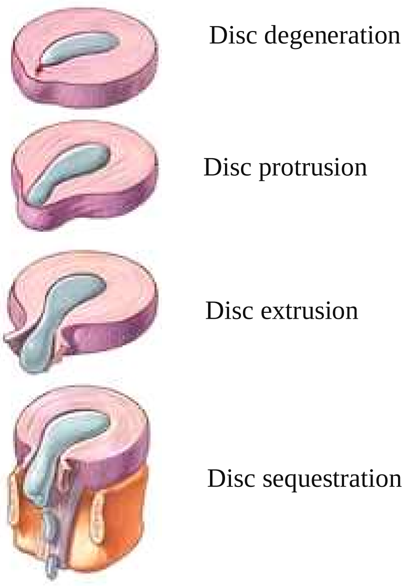


Figure 2.8. Intervertebral disc prolapse (www.wvneuro.com)

2.3.2.4. Sciatica

A herniated or ruptured disc may directly press on to the sciatic nerve and cause an irritation of a sciatic nerve. The sciatic nerve is the largest nerve in the human body that begins in the lumbar part of the spine and extends through the buttock area down to the lower legs (See Figure 2.9.). The persistent pain radiating along the sciatic pain is then called sciatica. Main symptoms of sciatica are:

- Radiating pain from lumbar spine to the buttock and down to the legs
- Burning or tingling sensations in the leg
- Muscle weakness, numbness or difficulty moving the leg
- Shooting pain that makes it difficult to stand up
- Pain in the rear or leg which worsens when sitting
- Constant pain on one side of the rear

There are a few conditions that may cause pressure on the sciatic nerve and cause sciatica. The common causes are herniated disc, spinal stenosis, degenerative disc disease, spondylolisthesis, spinal tumours, infections, trauma, etc.

2.3.2.5. Spinal stenosis

Spinal stenosis is a condition which is defined by a narrowing of the spinal canal and is caused mainly by degenerative changes of the spine and affect individual over the age of 50 years (See Figure 2.10.).

The narrowing of the canal can cause compression of the spinal cord or compression of

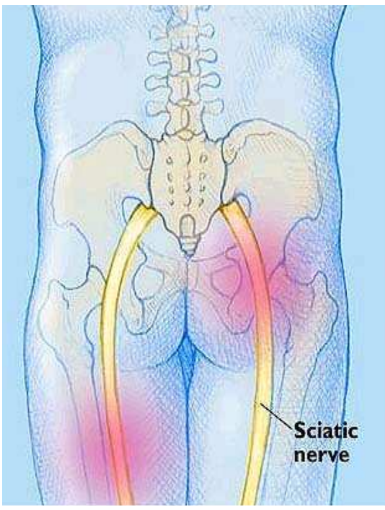


Figure 2.9. Sciatic nerve (www.mayoclinic.com)

the nerve roots. The common symptoms are generalized pain, weakness and numbness in the affected region.

2.3.2.6. Spondylolisthesis

Spondylolisthesis occurs when one vertebra slips forward on the vertebra bellow (See Figure 2.11.). The main cause of the slippage is the structural defect of the vertebrae. The lumbosacral region is particularly vulnerable to mechanical stress because the mobile spine moves on a fixed pelvis. Spinal cord or the exciting spinal nerves become trapped by the slipping vertebrae and therefore the symptoms are similar as symptoms of herniated intervertebral disc. Pain is often localised, and is worse with extension and rotation. The common symptoms are leg pain, burning travelling down the leg, numbness or tingling in the legs and feet, muscle weakness of the legs.

2.3.2.7. Other less common causes of low back pain

Arthritis is the inflammation of the joints of the spine sometimes causes back pain, swelling, and difficulty in body movement.

Spondylitis is a rheumatic disease that causes inflamed joints in the spine and adjacent joints which causes pain and stiffness in the spine, neck, hips, jaw and rib cage. Spondylitis occurs in young adults.

Other various uncommon bone disorders are tumours, infections or pressure from structures near to the spine occasionally cause back pain. However, these disorders affect individuals only 1 in 100 cases of back pain.

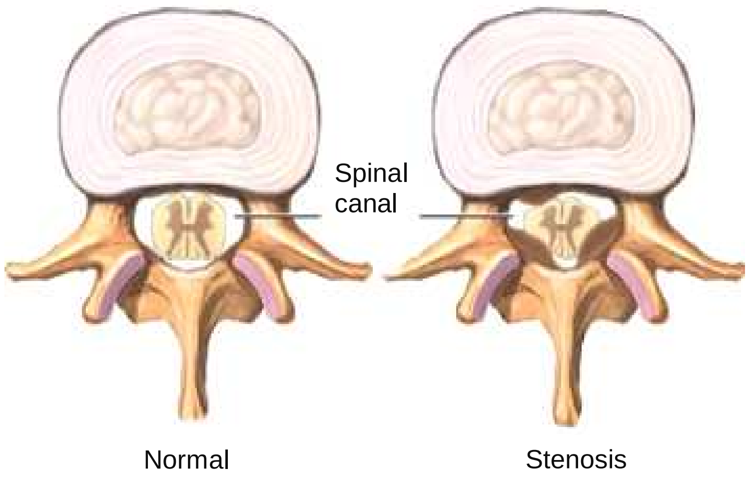


Figure 2.10. Spinal stenosis (www.nlm.nih.gov)

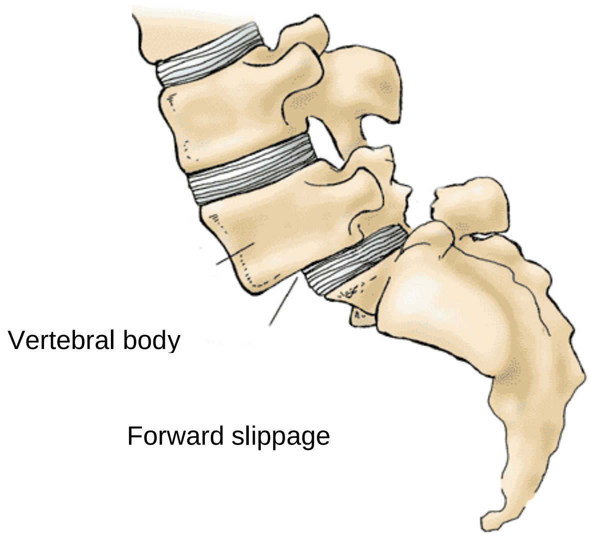


Figure 2.11. Forward slippage of the vertebrae (www.med.umich.edu)

2.4. Risk factors influencing low back pain

There are different ways of grouping risk factors, which can lead to low back problems. Adams *et al*. (2002) divided factors into four main groups, which are indicated in Figure 2.12.

- Genetic risk factors arise when specific genes are inherited from biological parents
- Individual risk factors such as body height, body weight, spinal mobility, etc. are easy to quantify and identify if there are risks for low back trouble
- Under environmental risk factors come risk factors concerning physical environments (occupation, sport activities) but also personal habits such as smoking, alcohol consumption, etc.
- Psychosocial risk factors include factors such as stress, depression, occupational psychosocial interactions, etc.

Waddell (2004) divided potential risk factors for back pain into two main groups. The first group of factors is named the individual risk factors. The second group is named the environmental factors and is divided into two subgroups: physical risk factors and psychosocial factors (See Figure 2.13.)

Some of the mentioned factors are generally accepted as risk factors leading to low back problems. These strongly associated factors are strained sitting posture, exposure to whole body-vibration, frequent lifting and cigarette smoking. Possible risk factors, which

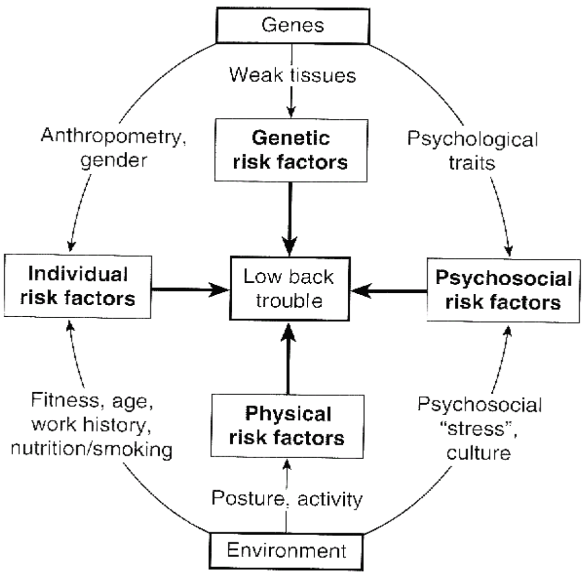


Figure 2.12. Risk factors for low back trouble and the relationship between them (Adams *et al.*, 2002)

show weaker or inconsistent evidence for influencing back problems, are pushing and pulling on the job, sedentary occupations and lack of physical fitness, (Jayson, 1992).

Selection of the studies included in the literature review, part risk factors influencing low back pain.

Most of the reviewed studies were found in the Human Response to Vibration Literature Collection at the Institute of the Sound and Vibration Research at the University of Southampton, United Kingdom. A search for related papers was also carried out on the Internet and in the Medline database (National Library of Medicine, United States of America). Electronic searches used various combinations of following terms: individual risk factors (e.g. age, gender, height, weight, etc.), physical risk factors (e.g. lifting, sitting, walking, driving, whole-body vibration, etc.), psychosocial risk factors (e.g. distress, anxiety, depression, satisfaction, etc.), and health outcomes (e.g. low back pain, herniated lumbar disc, sciatica, etc.).

Studies relevant to selected search terms were examined but only studies that fulfilled the criterion of investigation of occurrence of low back pain or sciatica were chosen for review. The selection criterion was based on the nature of the studies and not the quality of the studies.

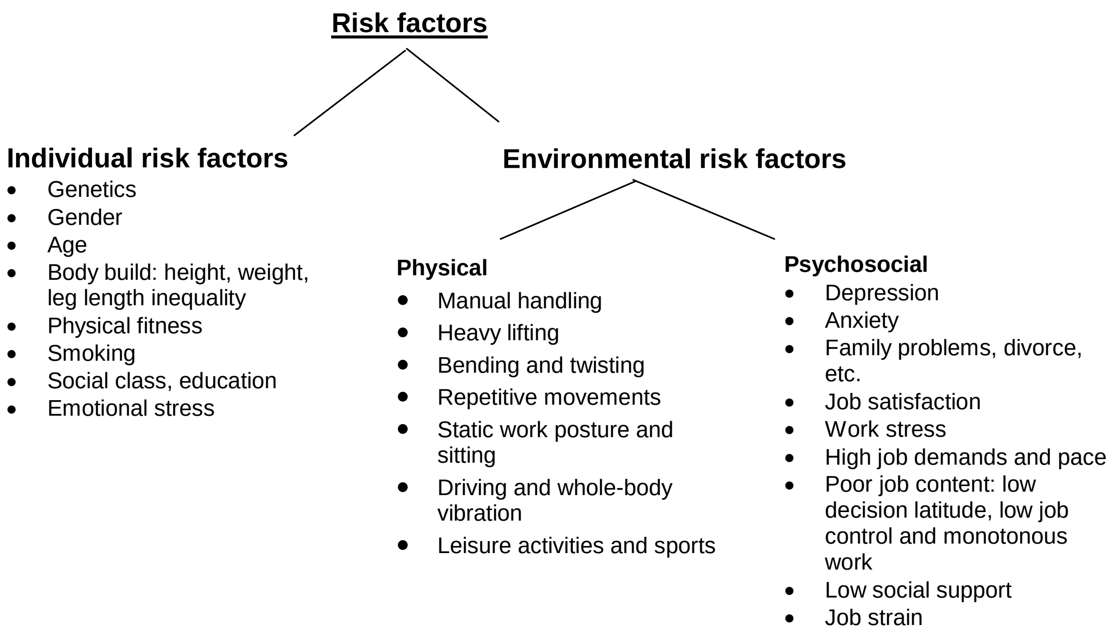


Figure 2.13. Potential risk for back pain

2.4.1. Individual factors

Commonly investigated individual factors for back problems are age, gender, anthropometry (such as height and weight), smoking and sport. Age and smoking are known as important risk factors for low back pain.

2.4.1.1. Age

Studies have shown that the prevalence of back problems increases with increasing age of individuals. The prevalence of low back pain increase with the age but the increasing risk of problems stops and declines at the age of about 55 years.

Bovenzi and Betta (1994) in a study of agricultural tractor drivers exposed to whole-body vibration pointed an association between back problems and age. The lifetime prevalence of low back pain, sciatic pain and acute low back pain increased with the increasing age for tractor drivers and also for the control subjects. In a study performed by Bovenzi (1996) the prevalence of chronic low back pain was found to increase with increasing age for professional drivers such as bus drivers and tractor drivers also well for the control subjects.

The influence of age is likely to be a complex. In 1990, Bongers *et al.* found in a study of back problems among helicopter pilots that prevalence of back pain was relatively high for a young group of subjects. A possible explanation for increased prevalence of low back pain among young individuals could be that individuals with back problems change profession and do not get accounted for. The health-based selection of a population because of the tendency to leave the job resulting in damage or injury to workers is named “the healthy worker effect”. Boshuizen *et al.* (1992) observed this effect in his study of back pain in fork-lift truck and freight-container drivers. Their results showed that with age, the prevalence of back pain increase in the control group and decrease in the group of drivers. Also Biering-Sørensen (1982) pointed on healthy worker effect when found decreasing tendency of low back pain among male population at the age of 40, while the female population had increasing prevalence with increasing age.

Some studies failed to find an age dependency. In the study of bus drivers Anderson (1992) concluded that the relationship between age and occurrence of back problems did not exist. This is consistent with other studies such as Miyamoto *et al*. (2000), who did not find any statistical differences among age and back problems in truck drivers with and without low back pain. Other studies supporting the lack of correlation between age and back problems are by Gyntelberg (1974) investigating low back pain among male population and by Porter and Gyi (2002) investigating large group of car drivers. They all found that the effect of age low back pain was minimal.

2.4.1.2. Gender

There are not many studies investigating the relationship between low back problems and the gender. The occurrence of low back pain seems to be as frequent in females as in males and they tend to be affected equally, (Anderson, 1992; Ozguler, 2000; Porter and Gyi, 2002)

Somme studies reported differences but these differences were very small. Reisbord and Greenland (1985), Xu *et al.* (1997) in their studies found that women had a higher prevalence of low back pain than men. Although it should be taken in account that women report slightly higher level of most symptoms (Waddell, 1999).

2.4.1.3. Anthropometry

Studies have investigated how weight, height or BMI[1] may influence the occurrence of low back problems. Although anthropometric data are conflicting but in general there is minimal risk for development of back problems.

Heliövaara (1987) studied the body height, obesity and the risk of herniated lumbar intervertebral disc. She found that the body mass index is an independent risk factor in men and that height and heavy body mass may be important contributors for disc herniation. Also Gyntelberg (1974) suggested that taller individuals are at greater risk for low back pain when compared with shorter people.

Many studies show that height and weight (even obesity) are not risk factors for low back pain (Levangie, 1999; Miyamoto, 2000; Porter and Gyi, 2002).

2.4.1.4. Smoking

Many epidemiological studies associate low back pain with smoking. The mechanisms for the association of low back problems with smoking are not clear.

One of the possible explanations is that smoking may cause chronic coughing which in turn puts more pressure on the intervertebral disc and influence disc prolapse and sciatica (Frymoyer *et al.*, 1980; Kelsey *et al*., 1984).

Another explanation is that smoking causes changes in the disc nutrition and reduces bone mineral content. This can make the disc vulnerable to osteoporosis and microfracture (Frymoyer *et al*., 1980, 1983).

Smoking may reflect a complex of psychosocial and lifestyle factors. Smokers tend to have a lower physical and mental health status and thus show more depressive symptoms. Smoking also may vary with social class, education and occupation (Waddell 1999).

[1] BMI is the measurement of the relative percentage of fat and muscle mass in the body. BMI is the weight in kilograms divided by height in meters

Frymoyer *et al*. (1980) performed a study on 3920 patients and found that subjects who smoked suffered more from low back pain than subjects who did not smoke. In a later study (1983) he confirmed that subjects who smoked were more prone to back problems. Other authors who found smoking to be one of the aggravating factors for back problems were: Kelsey *et al*. (1984), Pietri *et al*. (1992), Liira *et al*. (1996), Levangie (1999).
Despite studies showing a relationship between low back pain and smoking some studies have shown that the relation between smoking and back problems is weak and inconsistent (Porter and Gyi, 2002).

2.4.1.5. <u>Sport</u>

There is no clear evidence that leisure sports activities are risk factors for development of back problems.
Barnekow-Berkvist *et al.* (1998) did not find any association between leisure time (especially sport) and back pain symptoms in subjects chosen from a population of students. Oorter and Gyi (2002) also concluded in their study of musculoskeletal troubles among car drivers that sport activity has a minimal impact on low back pain.
Other reported individual factors not much investigated in the literature are genetics, social class and education and also previously reported back injuries.

2.4.2. Physical risk factors

From the number of epidemiological studies can be linked out following five physical, mainly job related factors: heavy manual handling, lifting, twisting and bending, sitting and driving and exposure to whole-body vibration.

2.4.2.1. <u>Heavy manual work</u>

A difference in low back pain prevalence among different occupational groups was demonstrated in the study of Riihimäki *et a*l. (1989). They found that low back pain caused trouble for more people in physically strenuous work (machine operators) than those in sedentary work.

When comparing the prevalence of low back pain between different occupational groups major emphasis should be maid to this possible source of bias (especially healthy worker effect). The selection of observed population (mainly white-collar workers versus blue-collar workers) can be assumed to underestimate the true values. An example is the study of Liira *et al.* (1996). They reported higher prevalence of back pain among blue-collar workers (service, primary occupations and industry workers) and among people who were not working than among white-collar workers (professional, clerical and sales employees).

The high prevalence of low back pain among people who were not working was explained by healthy worker effect when people suffering by back pain are leaving the profession causing the injuries.

Several studies have found no association between heavy manual work and increased level of low back pain. Masset and Malchaire (1994) in their study of workers in steel industry did not find increased level of low back pain with heavy physical workload. Damkot *et al.* (1984) in their study of different occupations found that greater manual work is increasing the prevalence of low back pain. However, no specific occupation was identified to be at particular risk. In the case of both studies, an important fact of healthy worker effect should be considered.

2.4.2.2. <u>Lifting</u>

Lifting as a risk factor for low back pain is one of the most investigating working task, partly because almost all professions have to perform lifting at some point of the time.

There are several studies investigating the role of frequent and heavy lifting over a long period of time on low back pain. Some studies reported increased prevalence of low back pain connected with the task of heavy and frequent lifting while some studies did not find any relationship.

Chaffin and Park (1973) pointed to the importance of postural stress which is induced by weight of lifting object and the method of lifting which can lead to low back pain. The high forces generated by low-back muscles while heavy lifting were identified as a possible cause of the compression on the lumbar intervertebral disc causing low back pain.

Statistics about industrial accidents and injuries show that heavy lifting, lifting objects which are bulky or must be held away from body, lifting from the floor and frequent lifting are the most common cause of back injuries (Waddell, 1999).

Frequent lifting of heavy objects was found to be associated with increased prevalence of low back pain in studies of Magora (1974), Frymoyer *et al.* (1983), Damkot *et al.* (1984), Svensson *et al*. (1989), Walsh *et al*. (1989).

Kelsey *et al.* (1984), Liira *et al.* (1996), Magnusson *et al.* (1996) presented studies in which showed the association between frequent lifting and low back pain among vehicle drivers. Kelsey *et al.* (1984) found that lifting objects more than twenty-five per day of loads greater than 11.3 kg (25 lbs) while twisting back is associated with increased risk of acute prolapsed lumbar intervertebral disc among car drivers.

In contrast, there are other studies that support the fact that lifting is likely to be an explanation of low back pain. Masset and Malchaire (1994), Levangie (1999), Battié *et al.*

(2002) in their studies of general population and Kelsey (1975) and Jensen *et al.* (1996) in their studies of professional drivers did not find any evidence of increased risk of low back pain among subjects who did lifting as a part of their job.

2.4.2.3. <u>Bending and twisting</u>

Bending and twisting are both associated with lifting and to separate and analyse the impact of these non-neutral trunk movements on low back pain is complicated.

Several studies reported increased prevalence of low back pain associated with bending or twisting, (Magora, 1974; Riihimäki *et al.*, 1989; Svensson and Andersson, 1989; Liira *et al.*, 1996; Xu *et al*., 1997; Ozguler *et al*., 2000).

Twisting or bending alone along may not produce increased risk of low back pain. However the risk of low back pain can increase in combination of twisting or bending with other motions, especially lifting, (Kelsey and Golden, 1987).

The unlikely cause of low back pain, by twisting or bending without any other motion was found in studies of Boshuizen *et al.* (1992), Battié *et al.* (2002) and Chen *et al.* (2004).

2.4.2.4. <u>Sitting</u>

When seated, the pelvis rotates backward and the lumbar lordosis decreases (See Figure 2.14.). The reduced lumbar lordosis, which increases the load movement and the disc

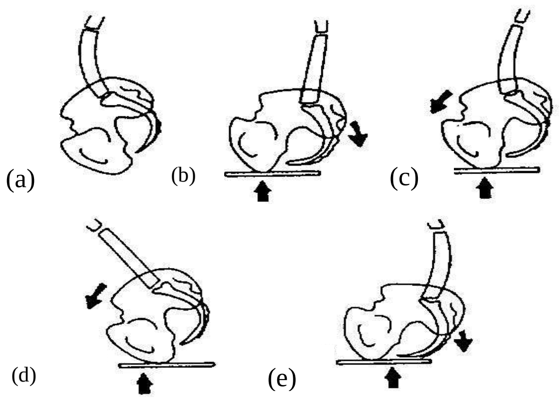


Figure 2.14. Posture of the pelvis and the lumbar spine when:

(a) standing
(b) sitting relaxed
(c) sitting erect
(d) anterior sitting
(e) posterior sitting

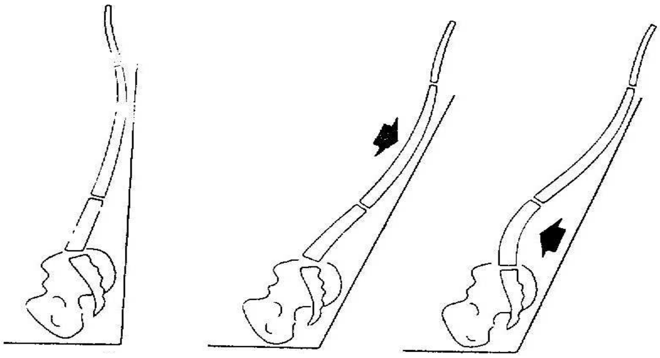


Figure 2.15. Posture of the pelvis and the spine when:

(a) sitting with the backrest inclined to 90°
(b) sitting with the backrest inclined to 110°
(c) sitting with the backrest inclined to 110° and with support for the lumbar spine

(Andersson *et al*., 1984)

deformation caused by the lumbar spine are contributing factor for the increased disc pressure in the spine which may lead to low back pain. The disc pressure can be influenced by the backrest inclination or by using of lumbar support (See Figure 2.15.). An efficient way of reducing the pressure is by using armrest (Magnusson and Pope, 1998).

In 1974, Anderssson *et al.* investigated a lumbar disc pressure and myeoelectric back muscle activity during sitting. Their study strengthened the finding that the pressure in the lumbar intervertebral disc is higher in unsupported sitting than in standing or lying. They also presented the finding that supported sitting with forward inclination of backrest is resulting in the reduced disc pressure. Increase of lumbar support and use of arm rest also help to reduce the disc pressure. When considering the back muscle activity, the muscle activity was about the same when considering standing and unsupported sitting with increasing activity when sitting and leaning forward. The muscle activity decreased with the increased backrest inclination.

Wikström *et al.* (1994) published a review of epidemiological studies concerning health effects of occupational long-term exposure to whole body vibration. Aside from increase disc pressure and back muscle activity the author presented possible explanations for the effects of prolonged sitting to the low back. One of them is that the prolonged sitting and lack of motion means inactivity in the bone tissue which may disturbs the nutrition supply to the intervertebral disc. Another explanation is a lack of motion which leads to accumulation of metabolites, which can accelerate the degeneration of the disks.

Some epidemiologic studies indicated possible risk of sitting on increase prevalence of low back pain. In the study of Magora (1972), high prevalence of low back pain was reported in occupation which reported sitting for longer than four hours every working day when compared with occupation sitting for less than four hours. Kelsey (1975) in her study of the general population found that the increased risk of acute herniated lumbar intervertebral disc is higher among those individuals who reported five years of sedentary occupation and is increasing with each year in the work. A weak association between sitting for more than two hours per day and prolonged sitting was found in the study of Walsh et al. (1989). However, the study reported strong relation among low back pain and prolonged exposure to sitting among women.

There are also studies which do not find sitting to be important risk factor for low back pain (Riihimäki *et al*., 1989; Xu *et al*., 1997; Masset and Malchaire, 1994; Levangie, 1999).Also the systematic, critical literature review performed by Hartvigsen *et al.*, 2000 does not support opinion that sitting while at work is associated with LPB. Hartvigsen *et al.* in their review referred to thirty-five studies dealing with sitting-while-working and sedentary occupations. All but one of the studies failed to find a positive association between professional sitting and low back pain.

2.4.2.5. <u>Whole-body vibration and driving</u>

The possibility that prolonged exposure to whole-body vibration may cause disorders of the spine has been the subject of many studies.

The exact mechanism of a negative effect of whole-body vibration is not clear, although some hypotheses have been proposed. The first hypothesis is that the compressive loading of the intervertebral joint leads to fatigue which induces microfractures or fractures in the vertebra endplate which may cause reduction of blood flow and nutrition diffusion. A second hypothesis is that the loading is accelerating the muscular fatigue of the spinal muscles. Both hypotheses are known as “tissue fatigue failure” (Hulshof *et al*., 2007). A model of work-load due to whole-body vibration at the spine can be seen on the Figure 2.16.

Palmer *et al.* (2000) studied the prevalence and pattern of exposure to whole-body vibration and estimated that nine million men and women in Great Britain are exposed to whole-body vibration at work. Common reported sources of occupational exposures were cars, vans, fork-lifts, lorries, tractors, buses and loaders. In both men and women, there were significant trends for increased low back pain in those most exposed compared with those least exposed.

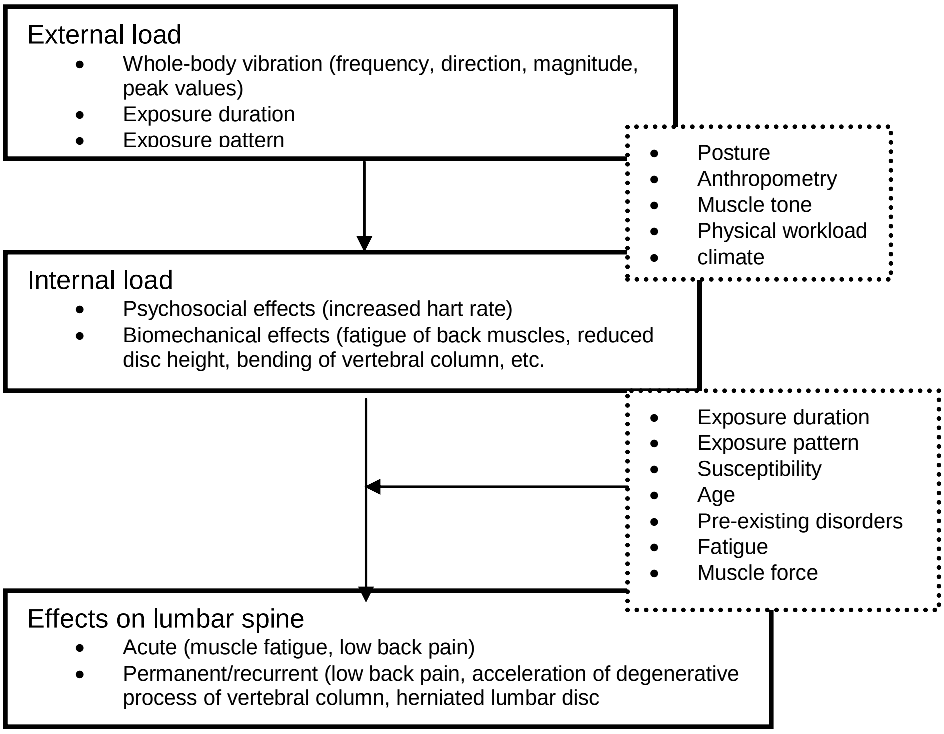


Figure 2.16**.** Model of work-load due to whole-body vibration at the spine (based on the figure from Hulshof *et al.*, 2007)

Experimental studies indicated that maximum strain occurs in the seated lumbar region at the presence of the resonance of the spine within a band of 4.5 – 5.5 Hz (similar resonances are also defined at range 9.4-13.1 Hz) (Andersson *et al*., 1984; Wilder and Pope, 1996; Pope *et al*., 1998; Magnusson and Pope, 1998). The 4.5-5.5 Hz resonance is due to biological systems between the lumbar vertebrae L3 and the surface of the seat. This frequency may be responsible for the increased frequency of back problems among drivers. Many studies concluded that many years of exposure to whole-body vibration that occurs in vehicles could accelerate the degeneration of the spine. Spine degeneration can then affect the disc degeneration and lead to disorders and injuries of lower back.

Analysis of epidemiological studies among persons occupationally exposed to whole-body vibration led by Seidel and Heide (1986) concluded that long-term exposure increased spine and peripheral nervous system disorder, with the digestive system, the peripheral veins, reproductive organs and vestibular system affected with a lower probability.

From a review of 135 epidemiological studies (mostly among tractor drivers, truck drivers, bus drivers, helicopter pilots and drivers of heavy machinery- earth moving operators, crane operators, excavator operators, etc.) Griffin (1990) found that the back problems (degeneration of spinal vertebrae, herniated disc, osteoarthritis, etc.) were most frequently reported disorders, followed by stomach and reproductive system disorders and vestibular and visual problems.

Wikström *et al.* (1994) reviewed 45 studies of the health effects of exposure to whole-body vibration in populations of professional drivers and concluded that many years of exposure to whole-body vibration might contribute to injuries and disorders of the lower back. However, because the exposure-response-relationship was weak, a causal role of whole-body vibration could not be defined.

Bovenzi and Hulshof (1999) reviewed 45 studies of the effect of whole-body vibration on the spinal system among occupational drivers (mainly truck drivers, tractors drivers, bus drivers and crane operators). Their review of selected studies suggested that occupational exposure to whole-body vibration is associated with an increased risk of low back pain, sciatic pain and degenerative changes in the spinal system including intervertebral disc disorders.

In a critical review published in 2000, Lings and Leboeuf-Yde identified 24 epidemiological studies concerning the association between whole-body vibration and low back pain and concluded that there is probably an association between vibration and low back pain. However, they concluded that it was not possible to decide whether exposure to whole-body vibration alone or in combination with other factors (such as prolonged sitting, certain work postures, etc.) were the cause of low back pain.

There are also some studies, which do not support the affirmation that driving and its associated whole-body vibration is a significant cause of back problems. In 2002, Battié *et al.* performed a study of lumbar disc degeneration among 45 pairs of monozygotic twins. Their results did not provide any evidence of increased risk of disc degeneration in occupational drivers and their twin brothers who were not exposed to high levels of vehicular vibration. That exposure to whole-body vibration does not have harmful effect on low back was affirmed also in a study by Frymoyer *et al*. (1980) and Videman (2000).

<u>Car driving</u>

Critical reviews of epidemiological studies of groups exposed to whole-body vibration have mostly considered tractor drivers, truck drivers, bus drivers, helicopter pilots, and drivers of heavy off-road machines. Car drivers are sometimes considered as a control group in epidemiological studies. Although car drivers are usually exposed to a lower level of whole-body vibration than drivers of some other vehicles, long durations of exposure of vibration, prolonged sitting, and other factors common to car driving might be associated with low back pain.

During the past 30 years there have been published studies investigating the role of car driving on development of low back pain. The studies have mainly investigated the duration of driving (e.g. driving for more than two hours per day, driving for more than half of the working day, more than five years of driving, etc.), driving distance (e.g. annual mileage, weekly mileage, annual kilometres) and also driving speed and quality of roads or the effect of the model of car and car features as potentially influencing factors for low back problems.

There have been studies concluding that drivers with increased duration to driving exposure had increased risk of low back pain (Kelsey and Hardy, 1975; Pietri *et al.*, 1992; Chen *et al*., 2004; Tubach *et al*., 2004). On the other hand, there are also studies that did not find association among increased duration of driving and occurrence of low back pain, such as studies of Battié *et al*. (2002) and Porter and Gyi (2002).

Information on the relationship between low back pain and whole-body vibration in the past studies is mainly unsatisfactory and consideration of a dose-response relationship minimal. One of the studies investigating the real exposure to whole-body vibration experienced in car was study of Porter and Gyi (2002). They investigated the lifetime occupational driving hours and the frequency-weighted vibration driving hours (number of hours spent in driving jobs multiplied by an estimate of the frequency-weighted vibration magnitude for the corresponding vehicle type as measured according to an International Standard). However, this study found no tendency towards increased risk of low back pain in drivers compared with non-drivers, even though the drivers experienced greater levels of whole-body vibration.

Driving of vehicles is not only associated with exposure to whole-body vibration. There are also many ergonomic factors which may influence back pain while driving. Back pain in car drivers might be also associated with prolonged sitting in a constrained posture and factors related to car design (e.g. back posture during driving, forces at the feet when operating foot pedals, load from the arms, head posture, back movement, twisting to look rearward while reversing, forces during entry and exit from a car). Some of these factors (e.g. sitting posture) are likely to be important for both car drivers and car passengers. The more constrained posture of drivers than passengers might influence the risks of low back. In each driving profession and in each individual driver there are different risk factors so some may be at high risk and others at no measurable risk. Some driving occupation such as bus drivers, delivery drivers also report frequent heavy lifting as a part of driving profession.

Studies that have considered physical risks to the back (such as frequent lifting, carrying heavy loads, twisting and bending) have clearly demonstrated increased risk of low back

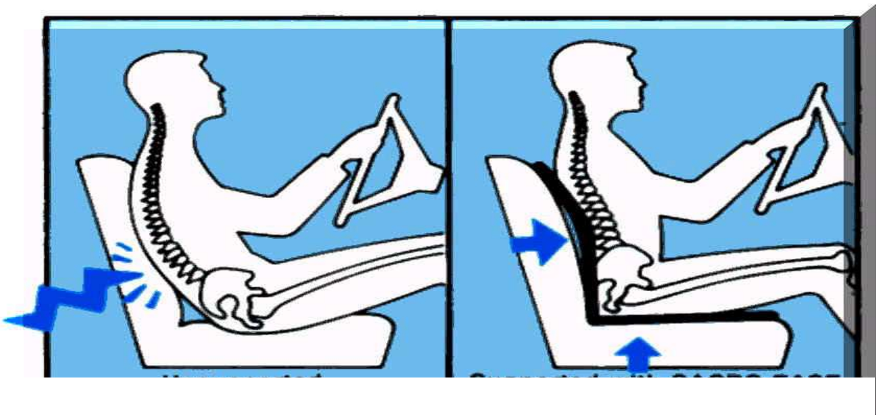


Figure 2.17. Unsupported and supported sitting posture while driving (www.backsupport.com)

pain. Also some individual factors and psychosocial factors are recognized as important factors influencing low back pain.

2.4.3. Psychosocial factors

It is difficult to assess psychosocial factors that result in low back pain. There are various theories where the prevalence of low back pain has been associated with distress, depression, psychosocial stress, dissatisfaction with work and low social support. However there is no convincing evidence that there is a direct link between the two. Psychosocial changes may affect variously different individual factors and it might influence the reporting of low back pain (Bongers *et al.*, 1993).

Psychosocial effects may have more indirect effects on the biomechanics of the back:

1. Psychosocial factors could influence spinal loading by changes in muscles, trunk movement and the forces exerted
2. The muscle changes or the neurohormonal changes that occur with stress could influence metabolic activity in various tissues in the back
3. Psychosocial factors could influence the neurophysiology of pain in various ways
4. Psychosocial factors might influence the reporting of low back pain

At present there is limited evidence for any of these mechanisms. Much more research is needed (Waddell, 2004).

Frymoyer *et al.* (1980) found more complaints of low back pain among patients reporting episodes of anxiety, depression and stressful events. As a possible mechanism was offered the fact that patients who are more anxious or depressed have greater difficulty to cope with pain and that is why they seek more medical attention. Psychosocial factors (such as satisfaction at job, mental stress at job, fatigue after work, distress) were found to

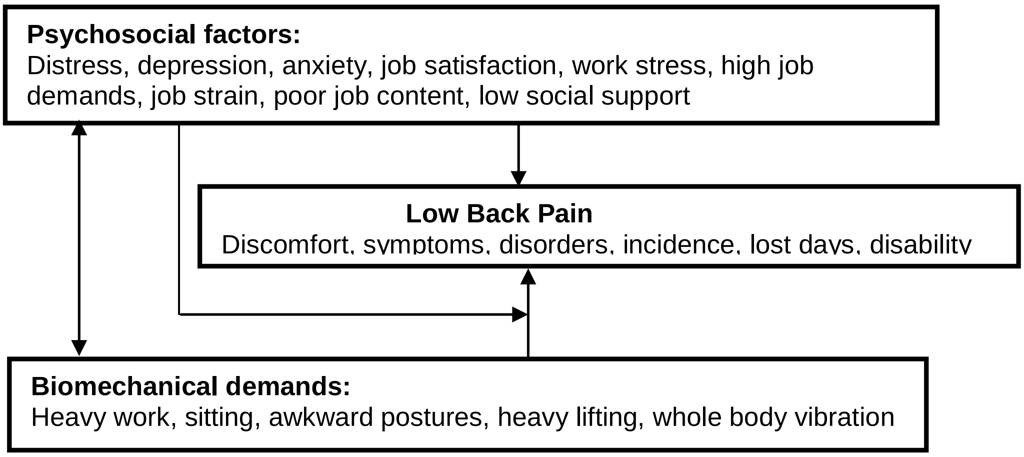


Figure 2.18. Possible relationship between biomechanical demands and psychosocial risk factors and back pain (based on figure from Waddell, 2004)

be associated with low back pain in following studies: Gyntelberg (1974), Biering-Sørensen *et al.* (1989), Svensson and Andersson (1989), Heliövaara *et al.* (1991), Pietri *et al.* (1992) and Barnekow-Bergkvist *et al*. (1998). Barnekow-Bergkvist showed that there was little influence of psychosocial factors and social support at work on musculoskeletal symptoms in the general population. Higher presence of musculoskeletal problems was captured among women. An explanation was that women might react differently to different problems.

On the other hand Masset and Malchaire (1994) and Porter and Gyi (2002) found that there was no significant relationship between job satisfaction or negative perception of working environment and increased prevalence of low back pain.

Interpretation of association of psychological factors and low back pain is difficult because they are generally summing up more factors. It is difficult to decide if psychosocial problems are the cause of low back pain or if they are caused by low back pain.

2.5. Epidemiology

Using the definition of Last (2001), epidemiology is the study of diseases as they affect populations (including the frequency and distribution of the disease and determinants of health-related states or events in specified human population), the factors (e.g. age, sex, occupation, economic status, etc.) and the application of this study to control health problems. The ideal scientific method in epidemiology is shown diagrammatically in Figure 2.19.

When summarised, the main aims of epidemiological research are:

1. Describe the health status (the extent of the disease) of the selected population which is affected by the disease
2. Explain the cause of disease and determine the risk factors which may cause or aggravate the disease
3. Predict the occurrences and distribution of the disease in the population
4. Control and prevent the distribution of the disease in the population

2.5.1. Causal inference in epidemiology

To develop a theory that a disease is attributed to one or more risk factors is based on many observations and a series of arguments. To help to determine if there is causal inference between a disease and possible factors, the following criteria of association offered by Bradford Hill (1971), as summarised by Kleinbaum *et al.* (1982) and Rothman

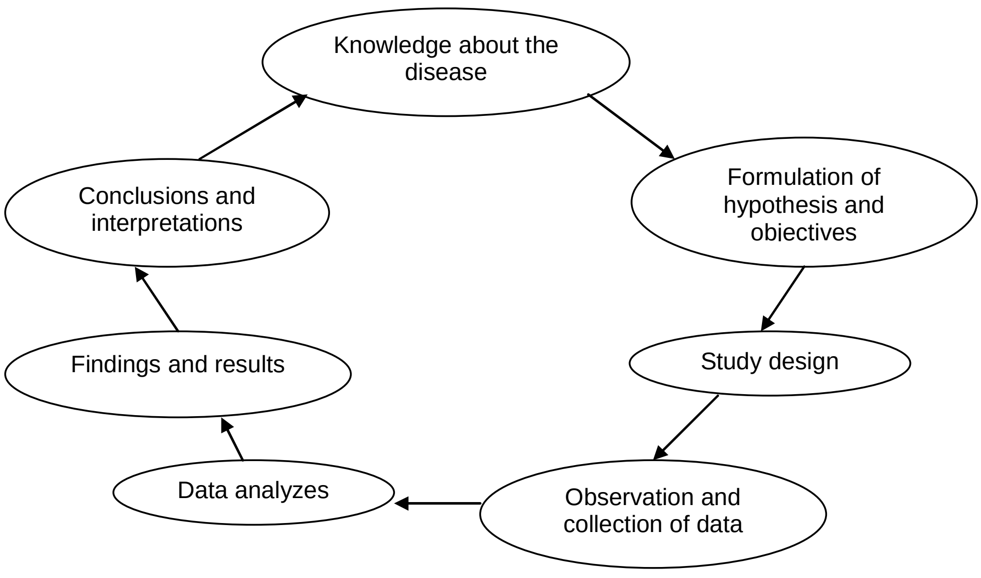


Figure 2.19. Ideal scientific method in epidemiology (based on Kleinbaum *et al.*, 1982)

and Greenland (1998) have to be considered:

1. Strength of the association. Weaker associations between the disease and possible risk factors are explained by various sources of errors (biases). On the other hand, a stronger observed association between the disease and risk factor shows that the association is not due to a source of error.

2. Consistency of the findings. The consistency of the findings is based on the repeating of observations in different populations. An inconsistency can also help to better understanding of the disease. Lack of consistency points to the causal association, because some effects are aggravated only in some environments. Consistency suggests that the disease is attributed to some risk factor that varies across the observations.

3. Specificity of the association. A causal association can be defined if the factor is found to be the only one risk factor for the disease after the series of observation (or the disease is associated with only one risk factor). However, this criterion can be indicated as invalid, because studies showed that many risk factors have multiple disease effect (or almost all disease are multifactorial in their origin).

4. Temporality. It is important that the hypothesised cause precede the occurrence of the disease.

5. Dose-response effect (biologic gradient). The presence of a monotonic dose-response curve which increases with the dose of exposure usually leads to causal interpretation. However, there is also case when the observed dose-response relationship is caused by some source of bias.

6. Biological plausibility of the study. A causal interpretation is more acceptable when the hypothesised factor-disease effect makes sense in the current biological knowledge.

7. Coherence of the evidence. A causal interpretation is more acceptable when the finding is not conflicting with what is known about the disease in the current biological knowledge.

The application of previously reported criteria is complicated. As mentioned by Kleinbaum *et al.* (1982), none of the criteria are either necessary or sufficient for making a causal interoperation and strict adherence to any of them without the consideration of others could result in incorrect conclusions.

2.5.2. Measures of disease frequency in epidemiology

The presence of a disease is generally investigated in groups of individuals (population at risk) with particular characteristics which are representative for the whole population in interest.

There are two main possibilities how to measure the disease frequency in the selected population.

2.5.2.1. Incidence

The incidence of the disease is defined as the number of new cases of the disease that occurs during a specified period of time in the observed population (Gordis, 1996).

The incidence of the disease is measuring how people (who did not have the disease previously) in the selected population are developing the disease and is expressed by following rate:

$$\text{Incidence} = \frac{\text{Number of people who develop the disease in the selected population during the specified period of time}}{\text{Total number of people in the selected population during the specified period of the time}}$$

For the measurement of incidence it is important to know about all individuals of the selected population and also to know the period of time they will be followed.

The incidence calculated using a period of time during which all of the individuals in the population are considered to be at risk for the outcome is called cumulative incidence, (Gordis, 1996).

2.5.2.2. Prevalence

The prevalence of the disease is defined as the proportion of the population that has the disease at the specific point of the time (Webb *et al*., 2005).

The prevalence of the disease measures the amount of the disease in the population at the given time and is expressed as following rate:

The prevalence is often expressed in two ways: point prevalence and period prevalence.

$$\text{Prevalence} = \frac{\text{Number of people with disease in the selected population at given point in time}}{\text{Total number of people in the selected population}}$$

Point prevalence is used in community health surveys investigating presence of disease at the point of the time of the survey.

Period prevalence is specifying how many people had the disease at any time during a certain period (Gordis, 1996).

2.5.3. Measures of association

Measures of association describe if there is an association between exposure to possible risk factors suspected to cause the disease and health outcome. The association is acquired by comparison of frequency of disease in group of people who have been exposed to possible cause of the disease and a group of people who have not been exposed (Webb *et al.*, 2005).

Measures of association are also largely used to compare disease rates between subgroups of individuals with different levels of exposure to possible risk factors.

2.5.3.1. Ratio measures (Relative risk)

Measurements of association ratios are used for finding the strength of association between the exposure to possible risk factors and development of the disease. The calculation of these ratios show how many times more likely the individual exposed to possible risk factors for the disease will develop the disease or health outcomes connected with the disease than an individual who is not exposed to these factors or an individual experiencing lower levels of exposure. The ratio is calculated by following Equation 2.1.

$$\text{Ratio} = \frac{\text{Disease risk in exposed individuals}}{\text{Disease risk in unexposed individuals}} \qquad \text{(eq. 1)}$$

The results may be interpreted in following ways:

- If the ratio is equal to 1, it means that the risk of development of the disease in both populations is equal. This value also shows that there is no any association between the exposure to possible risk factor and the development of the disease.
- If the value of the ratio is greater than 1, it means that the risk of development of the disease is greater among the individuals who are exposed to the possible risk factor. A value greater than 1 shows evidence of a positive association between the risk factor and development of the disease.

- If the ratio is less than 1, it means that the risk of the development of the disease is smaller among the individuals who are not exposed to risk factor. A value smaller than one is shows a negative association between the risk factor and the development of the disease. A value less than one can also indicated a protective effect of the factor from the disease.

The calculations of ratios are widely used in all designs of epidemiological studies. Some calculations of ratios are indicated in following equations (Equation 2.2-2.4):

1. Rate ratio is calculated by dividing the incidence rate of the disease in the group of individuals who are exposed to possible risk factors for the disease by the incidence rate of the disease in group of individuals who are not exposed to the same factors or are experiencing lower level of exposure.

$$\text{Rate ratio (RR)} = \frac{\text{Incidence rate in exposed individuals}}{\text{Incidence rate in unexposed individuals}} \qquad \text{(eq. 2)}$$

2. Risk ratio (also called Relative risk) is calculated by dividing the cumulative incidence or risk of disease in the group of individuals who are exposed to possible risk factors for the disease by the cumulative incidence of the disease in group of individuals who are not exposed to the same factors or

$$\text{Risk ratio (RR)} = \frac{\text{Cumulative incidence in exposed individuals}}{\text{Cumulative incidence in unexposed individuals}} \qquad \text{(eq. 3)}$$

are experiencing lower level of exposure.

3. Prevalence ratio is using for the calculation the measures of prevalence. This ratio is calculated by dividing the prevalence or risk of disease in the group of individuals who are exposed to possible risk factors for the disease by the prevalence of the disease in group of individuals who are not exposed to the same factors or are experiencing lower level of exposure.

$$\text{Prevalence ratio (PR)} = \frac{\text{Prevalence in exposed individuals}}{\text{Prevalence in unexposed individuals}} \qquad \text{(eq. 4)}$$

2.5.3.2. Ratio measures (Odds ratio)

Another measure of association that is widely used in epidemiology is the calculation of odds ratios. The calculation of odds ratio is used in studies where the calculation of the incidence of the disease is limited. Instead of exposed and unexposed individuals who developed the disease, individuals with disease (cases) and individual without disease (controls) are compared.

The calculation of odds ratios has to fulfil the following steps of data organisation:

	Cases	Controls	Total
Exposed group	a	b	a+b
Unexposed group	c	d	c+d
Total	a+c	b+d	

The odds ratio is then defined as (Equation 2.5.):

$$\text{Odds ratio (OR)} = \frac{a \times d}{b \times c} \qquad \text{(eq. 5)}$$

The results of the calculation may be interpreted similarly as the results of relative risk calculation:

- If the ratio is equal to 1, it means there is no association between the exposure to possible risk factor and the development of the disease.
- A value greater than 1 is shows evidence of a positive association between the risk factor and development of the disease.

- A value smaller than one is shows a negative association between the risk factor and the development of the disease. A small value can also indicate a protective effect of the factor from the disease.

2.5.4. Study design

There are two main types of epidemiologic studies: experimental and nonexperimental studies.

Among nonexperimental studies are counted descriptive studies and analytical studies (cohort studies, case-control studies, cross-sectional studies, proportional mortality studies, ecologic studies, etc.). The following paragraphs explain the main principles of the most used nonexperimental studies in epidemiology.

2.5.4.1. Cohort study

A cohort study is the most straightforward type of epidemiologic study involving less statistical problems and generally produces more reliable answers (Rothman and Greenland, 1998).

In a cohort study (also called longitudinal study or prospective study) subjects (the cohort) are followed over time with continuous or repeated monitoring of possible risk factors or health outcomes of the disease or both (Coggon *et al*,. 1993).

In a cohort study, subjects exposed to a certain risk factors are followed over time with the measurement of the incidence of the disease and compared with a group of subjects which is not exposed to these factors or are experiencing lower level of the risk exposure (control group). For graphical illustration see Figure 2.20.

Cohort study designs give the best information about the cause of the disease and also the best measurement of the risk of developing this disease. The longitudinal design of the study allows the calculation of incidence rates.

The size of each longitudinal study may differ. There are large population studies which follow a population over decades as well as studies of small population groups followed over few days or weeks.

The biggest disadvantages of most longitudinal studies are the long time to prepare and perform the study and the consequent high cost of the study. Sometimes, the whole population has to be followed for a long time period to wait for the development of the disease symptoms which is resulting in high expense.

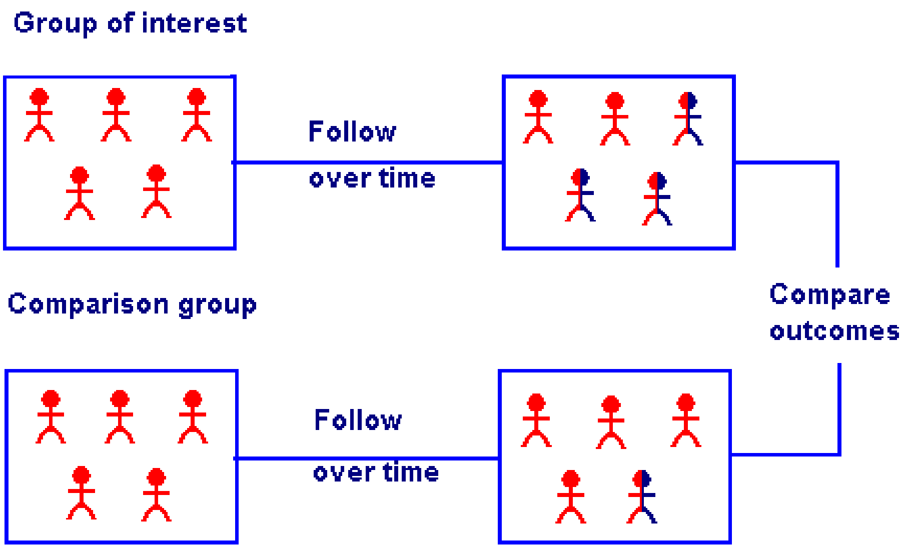


Figure 2.20. Schema of cohort study (www.servers.medlib.hscbklyn.edu) (bicolour individual-individual who developed the disease)

2.5.4.2. Case-control study

In a case-controlled study (also called case-referent or retrospective study) a group of subjects who have already developed the disease is compared with group of subjects who do not have the disease (controls) and account is taken possible risk factors which may cause the disease occurrence (Coggon *et al*., 1993).

Figure 2.21. presents a basic schema of how case-control study may be performed.

The case-control design of the study is allowing the calculation of odds ratios which express the association of the risk exposure and the disease in interest.

Usually there are no problems to find a case population. On the other hand there may be a problem to find the right matching control population for the study. The control population has to meet some criteria: the exposure of the controls to possible risk factors and possible confounders of the disease should be similar as the exposure to risk factors and confounders in the case population. The control population is commonly chosen from the general population or by using patients with other types of disease where the measurement of exposure can be more clear (Coggon *et al*., 1993).

The design of the study easily allows investigation of the role of potential risk factors for the development of the disease by matching cases and controls for existing exposure to confounders. The matching can be either group matching (the control group has the similar age distribution, gender distribution, etc. as the case group) or individual matching (each case is matched with one or more individual with the same age, gender, etc.).

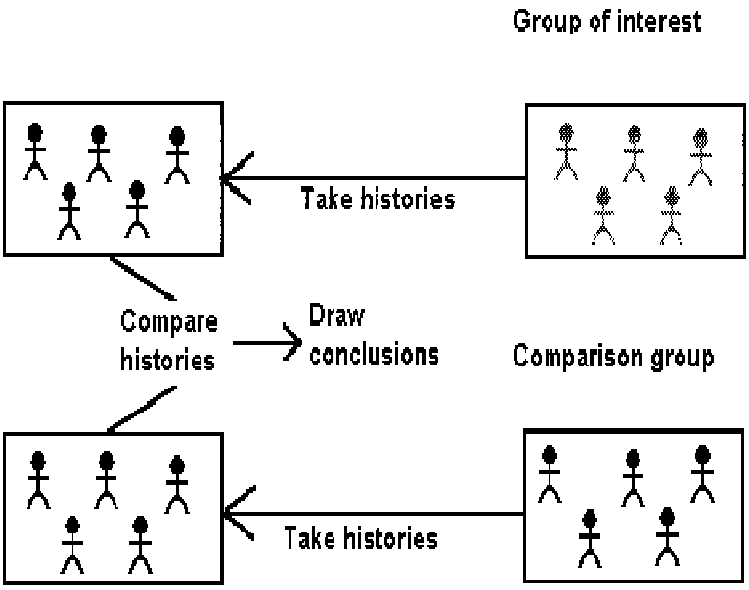


Figure 2.21. Schema case-control study (www.servers.medlib.hscbklyn.edu) (group of interest – group with developed disease, comparison group – controls without disease)

The main advantage of the case-control study is that it is a less time consuming design and therefore incurs less cost than cohort studies.

2.5.4.3. Nested case-control study

Studies combining the case-control and longitudinal study design are called nested case-control studies. At the start of the study are obtained the baseline information of individuals. The group is then followed for specified period of time. After that period, the case-control type of study is carried out when individuals who developed the disease are used as cases and individual who did not develop the disease are used as controls. For graphical illustration see Figure 2.22.

The advantage of this study type is that the information about an individual is collected at the beginning of the study before the disease develops. Therefore any presence of changes may be diagnosed to be potential risk factors of the investigated disease. On the other hand, in a case-control study it is not possible to decide if the change preceded the disease or was the result of the disease. The low cost of the nested case-control study is one of the advantages.

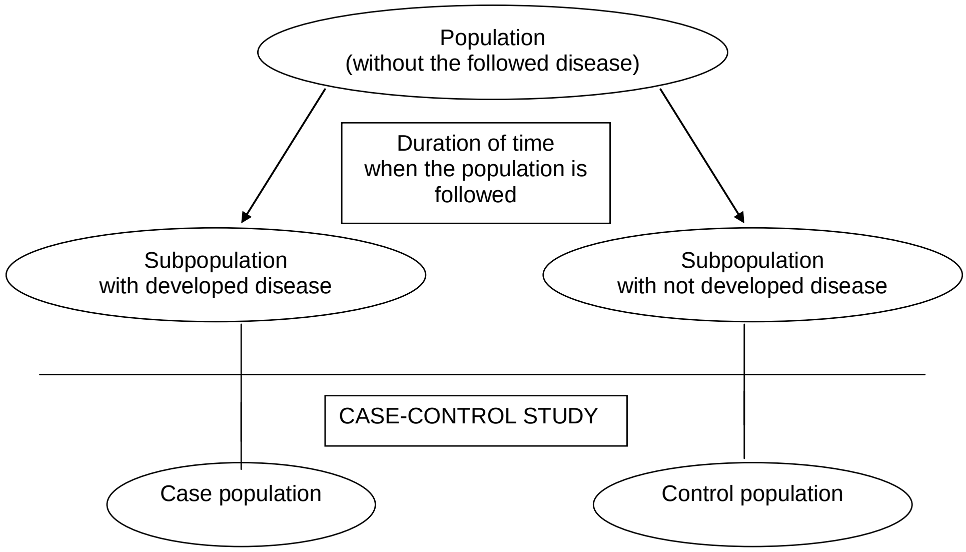


Figure 2.22. Schema of nested case-control study (based on Gordis, 1996)

2.5.4.4. Cross-sectional study

The design of cross-sectional study (also called prevalence study) allows measuring the prevalence of health outcomes or determinants of health, or both in a group of individuals at a point in time or over a short period.

Figure 2.23 presents a basic schema of how cross-sectional study may be performed.

Because the lack of follow-up, the cross-sectional study design is often used to build up hypothesis for health survey regarding the role of risk factors for the development of the disease. The role of possible risk factors which were found to be factors for the investigated disease has to be interpreted with limitations. The cross-sectional study design makes it difficult to establish what the cause is and what the effect of the disease is. For establishment of the relationship between risk factors and disease cohort and case-control studies are more suitable.

2.5.4.5. Ecological study

Ecological studies, which are also frequently used in epidemiology, are using different study units when comparing with previously reported study designs. For ecological study it is typical to follow populations or groups of people rather than individuals (Beaglehole *et al*., 1993).

The interpretation of the findings of ecologic studies is quite difficult. Often the data are representing characteristics of more than one population which are collected for different reason and the difference in risks exposure information do not allow establishing the exposure effect on the disease.

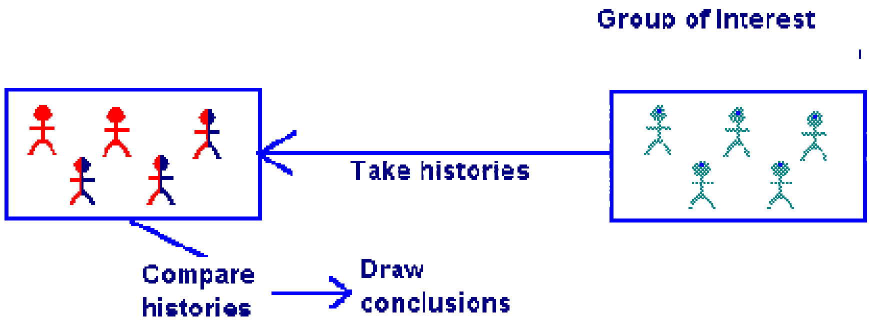


Figure 2.23. Schema of cross-sectional study (www.servers.medlib.hscbklyn.edu) (bicolour individual-individual who developed the disease)

2.5.4.6. Descriptive study

Descriptive studies are informing about the general health status of the community. This description of the health status is based on the data which are obtained from previously performed investigation. There is no need of investigation of the relationship between the risk factor and the health outcome. Very often the descriptive study is a base for a larger epidemiologic survey (Beaglehole *et al*., 1993).

2.5.5. Potential bias in epidemiology

Bias is a systematic tendency to underestimate or overestimate the parameter of interest because of a deficiency in the design or realization of the study (Coggon *et al*., 1993). There are various types of bias that may occur in epidemiological studies. The three main types of bias are: selection bias, information bias and confounding bias.

2.5.5.1. Selection bias

Selection bias may arise from inappropriate selection of investigated individuals, which are not a representative sample of the target population. Selection bias may also arise from applying of different criteria when choosing of sample and control population for the study (Webb *et al*., 2005).

There are number of factors which may be the cause of selection bias.

- One of them is recruitment of individuals who voluntarily agreed to participate in the study. The choice of volunteers may results in selection of healthier individuals than the average of general population. In this case the prevalence of the investigated disease may differ from the general population

- Other problem is low response rates. A low response rate may be arising due to the low motivation of healthy people which are recruited in the study. It is generally known that people affected by some disease are highly interested to take part in health studies and the lack of controls (healthy people) then seriously affect the results
- The healthy-worker effect is a well known type of selection bias. When people are suffering by some disease they tend to leave the profession which may cause the disease or injuries. As a result the followed occupational group is healthier in comparison with general population.
- Loss of follow-up, mainly in cohort designed studies is also a possible source of selection bias. It arises from the loss of the follow-up or from the non-response of individuals (from different exposure group of individuals) during the data collection

Selection bias is one of the most important biases for all main designs of epidemiological studies. In cohort, case-control and cross-sectional study design the presence of selection bias may lead to the biased measures of associations such as odds ratios and relative risk values and all the results of the study may be wrong. Mainly case-control design, where the cases and controls are recruited separately has to be aware of the bias. Both subgroups should be selected from the same identifiable group to prevent the occurrence of this bias.

2.5.5.2. Information (measurement) bias

The measurement of exposure to risk factors and also the measurement to outcomes which may be aggravated by them are prone to many types of errors. These errors then lead to results bias in the study.
Main sources of measurement errors are following:

- The use of different materials and methods how to analyse the samples and information from selected individuals (statistical analysis, different interview methods, etc.) are the most common sources of bias.
- Another type of bias, called recall bias may arise from the fact that the study requires the recalling of past exposures to risk factors from selected individuals. The overestimation or underestimation of exposure to possible factors may lead to misclassification of the effect of possible risk factors on the disease. It is generally known, that it is complicated to eliminate this type of bias from the study.
- Possible errors which may be the cause of bias is inappropriate collection of information from selected individuals. The errors are mainly applicable in interviews when the observer knows who the potential individual with developed

disease of interest is. The interviewer may then more deeply investigate the exposure data which may lead to misclassification of data.

2.5.5.3. Confounding bias

Confounding bias may arise from a mixing of effects which occurs when the relationship between a risk factor and the disease is confused by the effect of something else. The confounding effect of other risk factors can sometimes change the direction of association between the followed risk factor and the disease or the presence of the confounder could show a cause-effect relationship which does not exist (Beaglehole *et al*., 1993).
Confounding bias may be eliminated by the choice of suitable study design or can be eliminated by statistical analysis.

It is not simple to eliminate presence of bias in any epidemiological study design. Good epidemiological study should be aware of the presence of possible bias and should be able to minimize their presence at the study or consider them when interpreting the results of the research.

CHAPTER THREE

MATERIAL AND METHODS

3.1. Study design

The performed survey had a cohort design (also called longitudinal design). Selected groups of subjects (also called baseline population) exposed to low levels of whole-body vibration were followed over the time with repeated measurement of the incidence of possible health outcomes and possible risk factors (variables) for these outcomes after the duration of minimum twelve months.

3.1.1. Cross-sectional baseline study

The initial results from the first monitoring (baseline) reflected a single examination of the relationship between health outcomes and investigated risk factors (i.e. dependent and the independent variables). The investigated variables measured the prevalence of health outcomes or determinants of health, or both. To accept a risk factor as being important for low back pain, it has been suggested that the strong association between the risk factor and low back pain should exist and the association should be repeatedly observed (Rey, 1979). The factors identified as statistically significant in a cross-sectional study cannot be assumed to be predictive of low back pain, but a cross-sectional study can help to identify the risk factors to be considered in a follow-up epidemiological study. The results from the first monitoring of the relationships between low back pain outcomes and risk factors possibly causing these health problems will be examined and reported as an independent part of the study and is called the cross-sectional baseline study. The design of the baseline was dependent on the type of selected population.
In the case of the population of taxi drivers, the baseline had a cross-sectional design.

The population of police employees were divided into a subpopulation of police drivers and a non-driving subpopulation. In both subpopulations the baseline also had the cross-sectional design.

3.1.2. Longitudinal study

The follow-up examination of the populations was carried out 12 months after the initial monitoring. The design of the longitudinal study allowed the estimation of incidence and persistence rate and the relationship between risk factors and health problems. The design of the study is illustrated in the Figure 3.1.

3.2 Study population

Simple size of the of the study was determined so as to be able to detect a relative risk of 2.0 with a power of 90% using a two-sided significance level of 5%. Based on the anticipated incidence, about 200 responding participants from each study population were necessary to use in the study in order to satisfy this requirement. As the drop of the response rate was presumed for the follow-up of the study, one of the important task was to ensure the high response rate in the cross-sectional study.

3.2.1. Taxi drivers

The target population was taxi drivers located in the City of Southampton. In total 861 taxi drivers were contacted in the cross-sectional baseline study and 209 of taxi drivers were contacted during the follow-up study.

The nature of the work of taxi drivers is to help passengers to get from one place to another in a short period of time without any complication. The professional requirement for a taxi driver is to posse up-to-date knowledge of the city area.

The work schedule of taxi drivers may include full-time, part-time, night and evening shift and weekend work. The majority of the taxi drivers in the survey were self-employed and worked full-time. Full-time drivers usually work 8 to 12 hours per day. Part-time drivers work less hours per day or work 8 to 12 hours once or twice a week. Working hours can change from day to day depending on seasonal changes, weekends and holidays.

Taxi drivers can be subjected to potentially stressful situations. Drivers may encounter many different types of people and may also be in higher risk of robbery. They must be patient to deal with rude passengers and be tolerant. Drivers must be alert to conditions on the road and driving for long periods can be tiring and uncomfortable. In addition they may be required to load and unload heavy luggage and packages.

Taxi drivers pick up passengers in three different ways: by being "waved down" by passengers, by picking up a passenger who prearranged travel or by picking up passengers waiting at taxi lines at highly populated areas such as transport stations and entertainment centres.

Some taxi vehicles are adapted for transport of individuals with special needs such as people with disabilities and elderly people. The vehicle design is improved to reduce the stress and discomfort of drivers. Modern vehicles have available amenities such as air conditioning, tracking devices and dispatching equipments.

3.2.2. Police employees

The target population were persons employed by the Grampian Police. The information about the number and contact information were provided by the Service Centre of Aberdeen Police Station. In total 2105 police employees were contacted in the cross-sectional baseline study and 850 of police employees were contacted during the follow-up study.

Most of the police employees used cars. However, some individuals had no or little use of motor vehicles. By using information about the duration of walking or standing, sitting and driving, it was possible to separate police employees into two main subgroups. Police

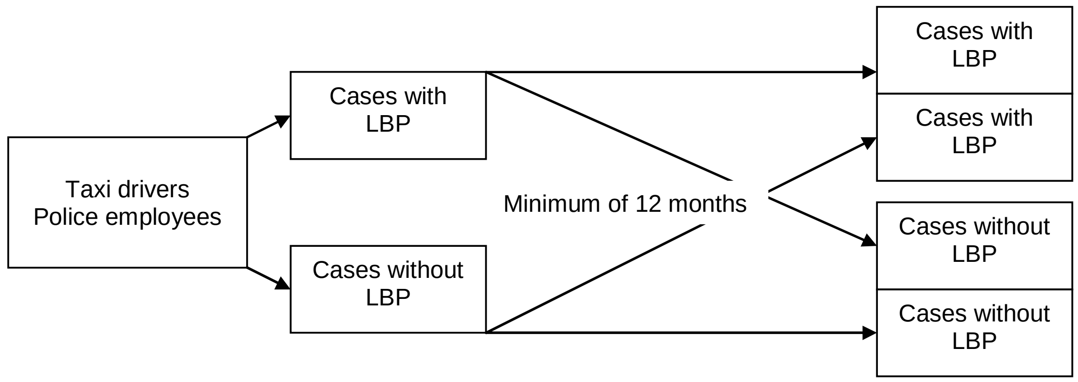


Figure 3.1. Design of performed cohort study

employees who reported driving for more than 5 hours per week during their working shift were marked as drivers and the rest of the employees were marked as non-drivers. The cutting point of 5 driving hours per week was used in order to obtain two equal sub-groups of police drivers and police non-drivers. In total 43% of police employees were drivers and 57% of police employees were non-drivers of a population of 850.

<u>Drivers</u>

- Squad drivers who drive general purpose patrol vehicles (e.g. Vauxhall Astra, Ford Focus) or unmarked vehicles
- Drivers of high-speed traffic vehicles (e.g. Vauxhall Omega, Volvo, Range Rover)

Police vehicles, mainly high-speed traffic vehicles, are supplied with special features such as seat suspensions providing better comfort, gear box modifications which allow smooth change of speed or better brakes for rapid deceleration. Vehicles are regularly changed after four years of servicing or after completing 100,000 miles in service.

All police drivers are also trained to operate any kind of police vehicles such as lorries, vans and special purpose vehicles for operation in mountains terrain, water, etc.

<u>Non-drivers</u>

Sitters

- Employees of the force control centre. The job involves 8-hours sitting shifts when operators are looking at computer screens, using a mouse, keyboard and radio. Operators can move around when they need but they sit for about 95% of the working time
- Employees of the Service Centre who perform a similar job as operators of the Force Control Centre
- Support staff who spend much of their working time sitting
- Others: Various police jobs and practices resulting in little use of cars and more sitting

Walkers

- Traffic wardens who are provided with a police car but spend most of their working time walking
- Community workers who spend most of the time walking but may use private cars for occasional journeys
- Community police officers working in the town and walking for the entire shift
- Others: Different police jobs and practices resulting in little use of cars and more of the time walking

3.3. Questionnaire

Information on risk factors and health outcomes were collected using a self-completed postal questionnaire. The use of self-administered questionnaires is one of the most common and efficient methods of collecting information, allowing a greater study size. It is generally the easiest and cheapest method for collection of information and involves minimal involvement for subjects and researchers. However, the response and completion rate of questionnaires tend to be lower compared with other methods such as interviews (Nieuwenhuijsen, 2005).

The postal survey has several limits such as a loss of deliveries or replies or false address delivering. To obtain a good response rate a repeated re-mailing was encouraged. Also the length of the questionnaire is an important point of the postal study. It was recommended that the questionnaire could be completed between 30 and 60 minutes, preferably less (Nieuwenhuijsen, 2005). Another disadvantage of the self administered questionnaire is the lack of clarity in the answers supplied on the forms. The questions should be short, clear and easy to answer to eliminate inappropriate answers or missing information. Questions should not go into too much detail and should not require a long recall time for the answers. In both cases the subject cannot provide good quality information which will be included in the final statistical analysis. It is widely recommended to use the questionnaire which was already tested in previous studies or base the questionnaire on studies that have been performed. The same or improved types of questionnaire also allow easy comparison with previous results (Nieuwenhuijsen, 2005).

The questionnaire used in this epidemiological study was based on the VIBRISKS whole-body vibration questionnaire for longitudinal epidemiological studies. The questionnaire was originally developed within the European project VINET (Vibration Injury Network).

The questionnaire was enriched by a set of health questions selected from existing models used and validated in earlier MRC community surveys in the UK. These questions permit an assessment of the severity and frequency of symptoms. The final version of the questionnaire was consistent with the VIBRISKS questionnaire. The similar structure to the questionnaire will enable comparisons with data collected by other VIBRISKS partners.

3.3.1. Structure of the questionnaire

Baseline questionnaire

The questionnaire compiled a maximum of 70 questions which were structured and had mainly binary or multiple choice answers. The questionnaire required approximately 30 minutes to be completed. The questionnaire was divided into the five following parts:

PERSONAL AND GENERAL INFORMATION

The first section <u>"About yourself"</u> included questions about personal and general characteristics and the driver's details such as age, gender, anthropometrics details, smoking habits, sport and activity.

For further analysis, information such as age, height and weight were classified into three bands (approximate thirds of all investigated populations added together).

Information about smoking and practising of sport was treated as dichotomous variables (YES/NO).

PRESENT OCCUPATIONAL HISTORY

The second section named <u>"Your current job"</u> focused on information about the current job such as working activities (i.e. lifting, bending, twisting and other working posture such as walking or standing, sitting, etc.) Working activities were assessed by using the frequency or duration of the working tasks per one working day.

For further analysis, the working activities were classified as categorical variables. Answers to these questions were treated by the following:

Lifting/bending/twisting:

not at all (NO)

1-10 times, more than 10 times per day (YES)

Walking or standing:

none, less than one hour (NO)

1-3 hours, more than 3 hours (YES)

Sitting other than driving:

less than one hour, 1-3 hours (NO)

more than 3 hours (YES)

The section about occupational history provided information about the vehicle being driven (i.e. vehicle type, time spent driving per working week, experience of discomfort and mechanical vibration or shock). Information about the duration of driving exposure and type of vehicle were used for calculation of different metrics of whole-body vibration exposure.

The sections on professional driving between the two questionnaires for the two selected populations (taxi drivers, police employees) were different. Each population chose from different options characterising the different vehicles used.

The last part of the second section was concerned with psychosocial risk factors at work. Participants were asked about the support and satisfaction at work. The set of questions also asked about the possibility of decision how to perform various working tasks. The questions were based on the Karasek demand-control support model that predicts the mental strain resulting from the interaction of job demands and job decision latitude (Karasek, 1979). In this model the work related psychosocial risk factors were measured on a 4-point scale.

For further analysis, subjects were classified into two groups according to their responses. The answers to these questions were treated in the following:

Job decision and job support:

Often, sometimes (YES)

Seldom, never/almost never (NO)

Job satisfaction:

Very satisfied, satisfied (YES)

Dissatisfied, very dissatisfied (NO)

For the case of taxi drivers, ‘not applicable’ was added to the questionnaire for the question about support decision as taxi drivers are often self-employed and work alone.

PREVIOUS OCCUPATIONAL HISTORY

The third section, <u>“Other jobs you may have held”,</u> focused on jobs that participants may have held in their past. Special attention was paid to different type of driven vehicles in the past, previous seating and physical demands (i.e. frequent heavy lifting) at work.

Information was treated as categorical variables:

Previous driving: (YES/NO)

Previous prolonged sitting:

No previous job, no sitting, sitting less than one hour a day (NO)

Sitting for 1-3 hours, more than 3 hours a day (YES)

Previous physical demand: (YES/NO)

PERSONAL MEDICAL HISTORY

The fourth part of the questionnaire was titled <u>“Your health: Aches and pains”.</u> This part of questionnaire was inspired by the widely used and validated Standardised Nordic questionnaire for the analysis of musculoskeletal symptoms proposed by Kuorinka *et al*. (1987). The study concerned aches and pains that may have occurred in different parts of the body (pain in the low back, pain in the neck, pain in the shoulders) and at different times (during the past 12 months, 4 weeks or last 7 days).

Low back pain was defined as pain in the area shown in the diagram (see Figure 3.2.), which lasted more than one day during the past 12 months, 4 weeks or 7 days. All participants experiencing low back pain during the past 12 months were required to answer additional questions about the low back pain symptoms. Additional information was provided on:

- The duration of low back pain episodes,
- The number of visits to doctor due to low back pain,
- Days off from work due to low back pain,
- Pain spreading down to leg which may signal the presence of sciatica,
- Disability due to the episode of low back pain using the Rolland and Morris disability scale. The short questionnaire (24 questions) focused on activity limitations which are related to low back pain (such as walking, working, dressing up, standing, sitting, etc.). The higher level of disability is reflected by higher score of the 24 scale (Brouwer *et al.*, 2004). The questionnaire is used also for reporting of improvement of activities over the time,
- Rating of pain intensity for the most recent occurrence of low back pain on 0-10 point scale proposed by Von Korff *et al.* (1992), where 0 is 'no pain' and 10 is 'worst pain you can imagine', etc.

OTHER SYMPTOMS AND FEELINGS

The last section "Other symptoms and feelings" explored the feelings about health

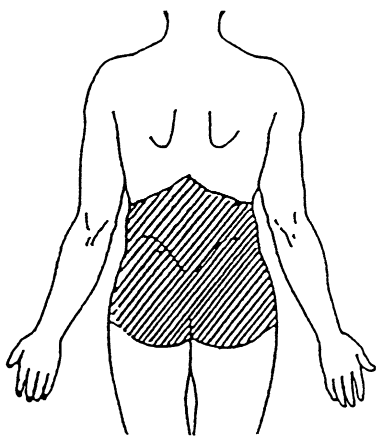


Figure 3.2. Definition of low back pain (shaded region) in self-administered questionnaire

symptoms. The section contained information about feeling of stress and low morale.

The first part was a set of nine questions which came from the SF-36 health questionnaire (SF-short form of questionnaire measuring health status). The questionnaire SF-36 is the commonly used for measuring health status and is classified into questions about: physical functioning, social functioning, role limitations due to physical problems, role limitations due to emotional problems, mental health, energy and vitality, bodily pain and general health perception (Reulen *et al.*, 2006). The actual question in the questionnaire consists of five questions designed to assess the mental health of the respondent and four to assess the energy and vitality of the respondent. Answers to these questions were scored and added together (five for mental health and four for energy and vitality). Scores were then divided into three subgroups characterising the health status of the respondent (approximate thirds based on the distribution of scores). Participants with a high score on questions regarding mental health were identified as mentally healthy (27 points and more), drivers with a lower score were grouped as medium mentally healthy 23 to 26 points), and drivers who had a low score were identified as having a poor mental health (22 points and less). The same procedure was carried out with the total score from responses on energy and vitality questions, giving three subgroups: energy and vitality healthy respondents (19 points and more), energy and vitality medium (15 to 18 points), and energy and vitality poor respondents (14 points and less).

Another important question is describing the psychosomatic distress caused by possible daily problems. To determine the level of psychosomatic distress of the drivers, 10 sub-questions were used to assess how different problems distressed or bothered the respondent (i.e. nausea, faintness, dizziness, weakness, numbness in the body, chest pain and breathing difficulties during the past 7 days). After the summation of scores, three subgroups (approximate thirds based on the distribution of scores) were formed characterising the different stages of psychosocial distress among participants. The first group was formed from participants who were not distressed or bothered by any of the possible problems. The remaining drivers were then equally distributed into the second and third group. The second group contained participants with a ‘medium distress status’ (participants reporting 1 or 2 points from the total summation of scores), and third group contained participants who reported a ‘high distress status’ (participants reporting 3 and more points from the total summation of scores).

<u>Pilot study</u>

A pilot test, where the consistency of the questionnaire and time needed for the completion was checked. This was performed using a small sample of researchers that were introduced to the fundamental principle of the study. Testing of small sample of researchers brought few advantages: fast results, direct contact with participants and flow of the questions (the right word using and right interpretation of the question). All replies were carefully explored and possible which may lead to inaccurate analysis or missing information from ambiguous questions were corrected. Performance of pilot study directly in selected population (mainly in police employees) was limited by the confidentiality rules. As the similar questionnaire was used in previous studies performed by Medical Research Council in the City of Southampton, there was presumed no need to perform pilot test directly in he population of taxi drivers and police employees.

Follow-up

The follow-up questionnaires were distributed 12 months after the initial questionnaire. In the follow-up, all participants who had replied in the first year of the study were followed.
The follow-up questionnaire was based on the structure of the questionnaire used in the baseline. Questions from the initial questionnaire were excluded if they would not bring new information about the participant (such as some anthropometric information, leisure activities, information about previous jobs, etc.) and some irrelevant questions (such as information about direction of vibration).
The follow-up questionnaire consisted of 48 questions and was divided into five main parts as explained above. The questionnaire required up to 20 minutes to be completed.
Examples of the baseline and follow-up questionnaires are provided in Appendix C.

3.3.2. Distribution of questionnaire

Each questionnaire with accompanying letters and pre-paid sealed envelope with the address of MRC in Southampton was sent (by mail to the population of taxi drivers and by internal post to the population of police employees) to each participant on two occasions (baseline and follow-up).

Each questionnaire package contained two accompanying letters: one letter from the researchers and the other from the Legal & democratic Services (in the case of taxi population) or from the Chief Superintendent of Grampian Police Force (in the case of police employees). The accompanying letters were designed to enhance the motivation to answer the questionnaire and briefly explained the purpose of the study. Copies of accompanying letters are provided in Appendix D.

To enhance the response rate of participants a financial bonus was proposed. In the case of taxi drivers, a small cash reward was offered to five randomly selected drivers that answered both questionnaires (baseline and follow-up). In the case of police employees a small financial amount was donated to the Diced Cap Charitable Trust for each completed questionnaire.

The questionnaire package did not identify the name or address of each participant except for a reference number. The coding system, which was based on matching the reference number to the names and addresses of subjects (created and printed by the Licensing officer from the Southampton City Council and by the Service Centre of Aberdeen Police Station), was securely stored for our use in the event of losing of the original coding.

<u>Baseline</u>

For the case of taxi drivers, a list of reference numbers was assembled to identify participants that did not send their responses. A new copy of the original questionnaire and two reminding letters were sent to all participants that did not respond within one month of the initial issue of the first questionnaire.

For the case of police employees, to avoid the feeling of loss of confidentiality the reminder questionnaire was omitted. Instead a reminder letter was published on the internal website of the Grampian Police Force.

<u>Follow-up</u>

The follow-up study needed a high response rate from participants who had replied in the baseline. Three reminder rounds where each participant received a new copy of the questionnaire and reminder letters were sent in the case of taxi drivers and one reminder was published on the internal website of the Grampian Police Force in the case of police employees.

3.3.3. Data processing and coding

<u>Baseline</u>

All the responses from the taxi drivers were double entered to computer by using Microsoft's Access database. A cross-comparison test was used to identify errors, inconsistencies or improbable values in both data entries. All inconsistencies were then corrected by reading the true information from the questionnaire.

Responses from police employees were entered into the computer database. As the number of police employees participating in the study was more than four times higher, only one entry of data were performed. Random checks for errors, inconsistencies and improbable values and their corrections were performed in 25% cases of all replies. In the case of wrong values entered in the database, ten questionnaires bellow and ten questionnaires above the serial number of the questionnaires were checked.

Follow-up

All responses from taxi drivers and police employees were entered to the computer database and random check of errors, inconsistencies and improbable and impossible values and their corrections were performed in all replies from taxi drivers and in all replies from police employees.

In the case that the error was not possible to correct the information were treated as missing.

3.4. Statistical methods used for analysis of results

Further analysis of taxi drivers and police employees was carried out using SPSS 13.0 for Windows. SPSS statistical program provides a majority of techniques and tools for statistical analysis broadly used for epidemiological studies.

3.4.1. Preliminary statistics - Descriptive statistics

Information from the questionnaires was entered as categorical (nominal or ordinal) variables or continuous variables.

All individuals were allocated to each category by using categorical type variables (gender, smoking, practising of sport, leisure and working activities, psychosocial variables and some of the health outcomes).

In further analysis (logistic regression), continuous variables (i.e. age, anthropometric information, duration of employment and main part of driving information were transformed to categorical values and were divided into three different categories (approximate thirds).

Descriptive statistics were obtained using different approaches depending on the type of variables (i.e. categorical variables - frequency distributions, percentage distributions; continuous variables - maximum and minimum values, standard deviations or inter-quartile ranges) and the distribution of data (i.e. normal distribution – mean values; non-normal distribution – median values).

3.4.2. Exploring the relationship among variables and different study groups

3.4.2.1. Relationship among variables

Different statistical techniques were used for exploring the relationship among different variables. The choice of different techniques depended on the type of investigated variables and outcomes of interest. The following statistical techniques were used:

Correlation (Pearson correlation test or *Spearman's rank order correlation test)* - this type of test was used for exploring relationships between continuous variables. The calculation of correlation coefficient was used to indicate the positive or negative correlation and the strength of the association between the two investigated variables.

Logistic regression – this type of statistical test was used to explore the relationship between one dichotomous dependent variable and a number of independent variables (adjustment of the linear combination during the stepwise procedure explained bellow). The binary dependent variable is then explained as linear combination of the independent variable or set of independent variables:

$$z = b_0 + b_1x_1 + b_2x_2 + ... + b_nx_n ,$$

where, the variable *z* is a measure of the total contribution of all the risk factors used in the model and is known as the logit, b_0 is the constant of the equation and $x_1, ...x_n$ are the coefficients of the predictor variables.

A dependent variable in logistic regression was treated as dichotomous (low back pain outcome: YES/NO). The independent variables were considered to be the cause of a dependent variable and were treated as dichotomous (smoking: YES/NO) or categorical (e.g. age groups, height groups, driving characteristics, whole-body vibration measurements, etc.).

Two main types of logistic regression were used: simple logistic regression and multiple logistic regression. Associations of independent variables with dependent variable which were examined using a logistic regression were expressed as Odds Ratio (OR) and 95% Confidence Interval (95% CI).

Dependent variable – as the dependent variable for the main analysis of relationship between the health outcome and different risk factors was used low back pain experienced at least for one day during the past 12 months. Choice of this dependent variable was in accordance with previous epidemiological studies performed in professional drivers and allowed comparison of the results considering the same health outcome. As there have not been many epidemiological studies considering low back pain in professional car drivers, the design was focused on the main characteristics of low back pain presence.

Simple logistic regression

Simple logistic regression (univariate analysis) analysed the relationship between a dependent variable (health outcome) and one other independent variable. All variables, of known biologic importance, for which the univariate test had a *p*-value less than 0.05 were considered for the subsequent multivariate logistic regression analysis. Using a larger level of *p*-value has the disadvantage that variables with less importance are included in the model. On the other hand, using a lower *p*-value often fails to identify important variables. (Hosmer and Lemeshow, 1989)

For multiple logistic regression care is needed for the selection of variables. The reason is that a greater number of variables that are included in a model increases the estimated standard errors and the dependence of the model on the observed data.

Multiple logistic regression

Multiple logistic regression (multivariate analysis) was used to analyse the relationship between a dependent variable with more than one independent variable.

There are two types of multiple regression techniques used for analysing the results:

1. Standard multiple regression: this was used to evaluate the relationship between the dependent variable (low back pain outcome) and a set of independent variables (variables selected by univariate analysis). In this type of regression all independent variables were entered in the model at the same time. This type of regression was used to show how much the presence of dependent variable (health outcome) is explained by the set of independent variables.
2. Stepwise multiple regression was used to identify the subset of independent variables that had the strongest relationship to the dependent variable. The stepwise method is based on the addition of variables, starting with the highest significance level, one at time to the model.

.

3.4.2.2. Exploring the relationship among variables in the cross-sectional baseline

In the cross-sectional study a univariate logistic regression was used to determine the relationship between low back pain and one other independent variable. All variables which were found to be significant with the health outcome, together with variables of known biological importance for low back pain were entered into multivariate analysis.

At this point in the statistical analysis the multicollinearity of independent variables was checked. For the case of high colinearity of two or more independent variables only one of the variables was chosen for the multivariate analysis. The singularity of independent variables (the possibility that the independent variable is a combination of other tested independent variable) was tested before a selected variable is entered into multivariate analysis.

Multivariate analysis was performed using variables from the univariate analysis which were not collinear or singular with other selected variables. The first type of multivariate analysis performed was a standard multiple logistic regression. To see the influence of different whole-body vibration metrics on health outcome, separate multivariate models were used for each metric of the whole body vibration exposure.

The final cross-sectional analysis of the baseline study was a forward stepwise logistic regression. In the stepwise method, the variables with highest statistical significance were added to the model one at time. Stepwise logistic regression was used to select possible risk factors (the factors remaining significantly associated with the prevalence of low back pain in the stepwise regression model) to be investigated as predictive risk factors of low back pain in the follow-up of the longitudinal study. The factors identified as statistically significant in a cross-sectional study cannot be assumed to be predictive of low back pain, but a cross-sectional study can help to identify the risk factors to be considered in a follow-up epidemiological study.

3.4.2.3. <u>Exploring of relationship among variables in the longitudinal study</u>

Longitudinal study design (cohort study design) provides the best information about the cause of low back pain and also the best measurement of the risk of developing this disease.

Statistical analysis used to find variables which may cause low back pain were based on the multivariate logistic regressions that were carried out for the group of interest. Possible groups of interest were an incidence group and a persistence group. The incidence group includes the group of participants who replied to have no low back pain in the cross-sectional baseline and still participating in the follow-up study. The persistence group is includes the group of participants who replied to have low back pain in the cross-sectional baseline and still participating in the study.

In the follow-up of the longitudinal study, variables entered into the regression models were the same as variables found to be significant risk factors for low back pain. As with the cross-sectional study, variables of known biological importance for low back pain were entered into the multivariate analysis.

For each value of whole-body vibration exposure, final statistical models were formed for the incidence group and the persistence group to investigate associations between risk factors and low back pain experienced for at least one day during the past 12 months.

3.4.2.4. Statistical techniques for comparing different populations

Different statistical techniques were used for exploring the relationship between different populations. The following statistical techniques were used:

To compare the mean scores of continuous variables within different populations an *independent-sample t-test* was used (in the case of comparison of two populations) and *one-way between group ANOVA* (in the case of comparison three different populations). Using the independent-sample t-test and the one-way between group ANOVA was suitable in exploring the relationship between variables which were normally distributed. In the case of non-normal distribution of variables, non-parametric *Mann-Whitney U test* (for two populations) or *Kruskal-Wallis test* (for more than two populations) were used to explore the relationship.

The differences between categorical data for two or more different populations (i.e. smoking, exercise, physical risk factors, psychosocial risk factors, health outcomes) were investigated by *Chi-square statistic*. If the value of the test is $p<0.05$, than the investigated population differ in selected variable.

To assess normality of data distribution was used the *Kolmogorov –Smirnov test.* Kolmogorov-Smirnov test compares selected data to a normal distribution. If the value of the test is $p<0.05$, than the null hypothesis can be rejected and it could be concluded that data do differ from a normal distribution.

3.5. Whole-body vibration measurements and assessment of vibration exposure

3.5.1. Measurement equipment

3.5.1.1. Measurement of whole-body vibration exposure in a representative sample of vehicles

The acceleration in selected vehicles was measured by using piezoresistive accelerometers (Entran EGCS-DO-10 and Entran EGCSY-240D-10). Fore-and-aft acceleration (*x*-axis), lateral acceleration (*y*-axis) and vertical acceleration (*z*-axis) was measured on the driver's seat pan using three accelerometers in a SIT-pad. A SIT-pad containing one accelerometer was used to measure fore-and-aft vibration between the backrest and the driver. The vertical floor vibration was measured by an accelerometer secured to the front seat rail of the driver's seat.

The signals from the five accelerometers were acquired to a portable digital computer-based data acquisition and analysis system, *HVLab* (version 3.81). The computer system was connected to a 12-volt rechargeable battery in the cabin of the vehicle. The acceleration was low-pass filtered by 80Hz and then digitized at 200 samples per second. The equipment setup to perform the measurements is shown in Figure 3.3 and Figure 3.4.

The same journey was used to test all vehicles: vehicles were driven over surfaces appropriate to normal daily driving. The measurement of vibration commenced at a predetermined location and lasted for 20 minutes.

Figure 3.3. Measurement system (placement of SIT on the driver's seat)

Figure 3.4. Measurement system (portable digital computer-based data acquisition and analysing system, *HVLab* (version 3.81) and 12-volt rechargeable battery

3.5.1.2. <u>Estimation of real duration of exposure to whole-body vibration in taxi drivers</u>

Cumulative exposure to whole-body vibration was recorded in 12 separate taxi vehicles using a similar measurement set-up as used for the 20-minutes measurements. Five accelerometers (the positions of which accelerometers are defined in the section 3.5.1.1.) continuously acquired data to a computer-based data acquisition and analysis system (in Matlab) during the entire driving shift which lasted up to 8 hours. The acceleration waveforms were low-pass filtered at 80 Hz and then digitized at 400 samples per second. The computer system was connected to a 12-volt rechargeable battery placed in the boot of the vehicle; all wires connecting accelerometers and battery were attached to the vehicle floor to eliminate the possibility of interference with the driver or passengers. For the equipment used in the measurements see Figure 3.5.

All the drivers were asked to drive the vehicles as they normally would during a work shift and return after 8 hours so that the measurement system could be removed from the vehicle.

The data was transferred to the data acquisition and analysis system, *HVLab* (version 3.81).

After the measurement period, drivers were asked to complete a simple questionnaire regarding the characteristics of the ride and the duration. Information about the duration of driving was then compared with the duration the engine of the vehicle was running and

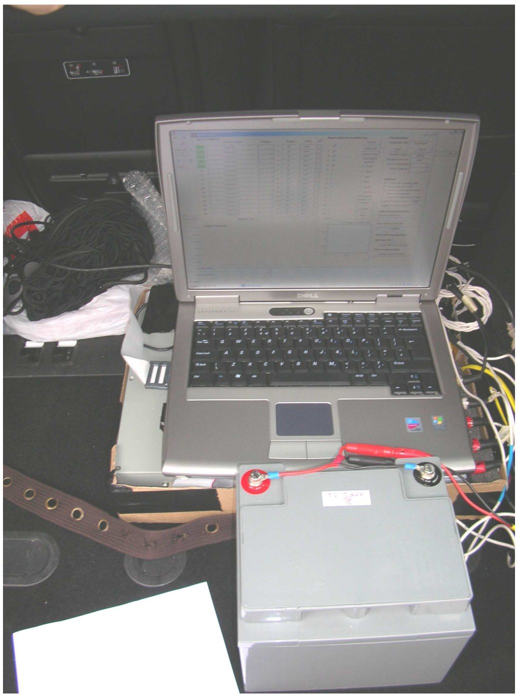


Figure 3.5. Measurement system (portable digital computer-based data acquisition and analysis system, *Matlab* and 12-volt rechargeable battery

the vehicle moving (obtained from the measured vibration data) to quantify the accuracy of the driver's estimate for his duration of driving.

3.5.2. Data analysis

3.5.2.1. Frequency weightings of vibration

The acceleration was frequency-weighted using frequency weightings defined by the International Standard 2631-1 (1997). As stated in the standard, the frequency weightings and their coefficients are required for different axes of vibration and the effects of different vibrations on the body. In the International Standard 2631; the frequency weightings required for the evaluation of whole-body vibration on health are W_d and W_k. In addition, the measurement of the vibrations from the backrest was frequency weighted using frequency weightings W_c. The evidence of the negative effect on the fore-and-aft vibration on health was insufficient therefore the measurement on the x-axis on the backrest was not included in the assessment of the whole-body vibration with respect to health. Frequency weightings and coefficients recommended for the evaluation of whole-body vibration with respect to health are shown in Table 3.1.

3.5.2.2. Calculation of vibration dose values in different types of tested vehicles

The vibration dose value may be expressed as:

$$VDV = \left[\int_{t=0}^{t=T} a_w^{\;4}(t)dt\right]^{1/4} \quad (ms^{-1.75}) \qquad \text{(eq. 3.1.)}$$

where a_w is the frequency-weighted acceleration r.m.s.and T is period (in seconds) during which the vibration is measured.

Alternative method of estimating vibration dose value

Standards suggest that the "estimated vibration dose value" should be used when the vibration exposure is continuous and of low crest factor:

$$eVDV = 1.4a_{w.}\ t^{1/4}\ (ms^{-1.75}) \qquad \text{(eq. 3.2.)}$$

where a_{ws} is the frequency-weighted r.m.s. acceleration and T is period (in seconds) during which the vibration is measured.

Multi-axis vibration

For the evaluation of vibration in more than one direction with respect to health, International Standards 2631 (1997) suggests that the assessment of the vibration shall be made with regard to the highest frequency-weighted acceleration measured in any axis of the seat pan. In addition, International Standards also suggest that the calculation of the root-sums-of squares of the r.m.s. values of the weighted accelerations measured in the *x, y and z*-axis of the seat. The total vibration value is used only for the evaluation with respect to health if no dominant axis of vibration exists. The value for the root-sum-of

Table 3.1. Frequency weightings and multiplying factors as specified in International Standards 2631 (1997)

Location of the measurement	Weighting ISO (2631)	Multiplying factor ISO (2631)
Seat		
fore-and-aft acceleration (x-axis)	W_d	1.4
lateral acceleration (y-axis)	W_d	1.4
vertical accelertion (*z* -axis)	W_k	1
Backrest		
fore-and-aft acceleration (x-axis)	W_c	0.8

squares (also called 'vector sum' or 'total value') is calculated from the following equation:

$$a_{ws} = [(1.4a_{wx})^2 + (1.4a_{wy})^2 + (a_{wy})^2]^{1/2} \quad (ms^{-2}) \qquad \text{(eq. 3.3.)}$$

where a_{xs}, a_{ys} and a_{zs} are the frequency-weighted r.m.s. accelerations in each axis of the seat. Measurements in the x-axis on the backrest were not included in the calculations.

3.5.2.3. Calculation of exposure periods required to reach action values

The EU Directive specifies 'daily exposure action values' and 'daily exposure limit values' (Table 3.2.)

Therefore, the exposure period (T expresed in seconds) required for the vibration to reach a 9.1 $ms^{-1.75}$ daily action value and a 21 $ms^{-1.75}$ daily exposure limit value specified in EU Directives are calculated from the following:

$$T_{9.1} = \left[\frac{9.1}{VDV_{\text{total}}}\right]^4 t \qquad \text{(eq. 3.4.)}$$

$$T_{21} = \left[\frac{21}{VDV_{\text{total}}}\right]^4 t \qquad \text{(eq. 3.5.)}$$

where VDV_{total} is the multi-axis vibration dose value calculated over all three axis (x-axis, y-axis and z-axis on the seat pan) and T is period (in seconds) during which the vibration is measured.

3.5.2.3. Calculation of daily and cumulative vibration exposure for each driver

Daily vibration exposure

For each driver the questionnaire (duration of exposure and type of driven vehicle) and vibration measurements were used to estimate the daily exposure to whole-body vibration.

The daily exposure to whole-body vibration expressed in driving hours was calculated for each driver.

Daily vibration was also expressed in terms of the 8-h energy-equivalent frequency-weighted acceleration magnitude (A(8)) according to the EU Directive 2002/44/EC on mechanical vibration:

$$A(8) = a_w (T/T_0)^{1/2} \quad (ms^{-2} \text{ r.m.s.}) \qquad \text{(eq. 3.6.)}$$

where a_w was included as the highest (dominant) value of the frequency-weighted r.m.s. accelerations, T is the total daily duration of exposure to the vibration a_w and T_0 is a reference duration of 8 hours (expressed in seconds).
Estimated daily vibration exposure was also expressed in terms of the vibration dose value using the expression Eq. 3.2.

Cumulative vibration exposure

The total life-time cumulative exposure to whole-body vibration expressed in years and total hours of driving was calculated for each driver taking part in the measurements. For the calculations of the total number of hours driven per profession was used number of hours reported to be driven per one working week, 40 working weeks in the year and number of years working as the driver.
The estimated total life-time vibration exposure was also expressed in terms of vibration dose value using the expression Eq. 3.2.

3.6. Safety of the study The Human Experimentation Safety and Ethics Committee

All details about the study (i.e. design of the study, selected populations for the study, self-administered questionnaire, description of the whole-body vibration measurement and measurement apparatus) were submitted to the Human Experimentation Safety and Ethics Committee of the Institute of Sound and Vibration Research at the University of Southampton as a request for approval of ethical, safety and insurance aspects of an experiment involving human subjects. All the potential risks such as vibration exposure, physical hazards, intrusion of privacy and confidentiality were identified as usual.
The questionnaire study design and vibration measurements in selected vehicles were approved by the Human Experimentation Safety and Ethics Committee of the Institute of Sound and Vibration Research at the University of Southampton.

Table 3.2. Daily exposure action value and daily exposure limit value for whole-body vibration according to the European Directives 2002/44/EC.

Daily exposure values for whole-body vibration		
Daily exposure action value	A(8) = 0.5 ms^{-2} (r.m.s.)	VDV = 9.1 $ms^{-1.75}$
Daily exposure limit value	A(8) = 1.15 ms^{-2} (r.m.s.)	VDV = 21 $ms^{-1.75}$

CHAPTER FOUR

CROSS-SECTIONAL STUDY

4.1. Cross-sectional baseline of taxi drivers

4.1.1. Description of the population

The target population was 861 taxi drivers located in the City of Southampton. Information about the number and contact details of the taxi drivers operating in the City of Southampton were provided by the Legal and Democratic Services of the Southampton City Council.

4.1.1.1. Response rate

From the total of 861 posted questionnaires, 222 responses were returned, giving an overall response rate of 26%. One hundred and thirty one responses were obtained at the first round and further 91 responses were obtained after the reminder. From the total of 222 responses, 13 cases were excluded because they did not wish to participate in the study or they were no longer taxi drivers.

In total, 209 questionnaires from taxi drivers were used in the cross-sectional baseline study of taxi drivers from the City of Southampton.

4.1.1.2. Individual information

One hundred and ninety-nine respondents (95%) were males and 10 of the respondents (5%) were females. The median age of taxi drivers was 51 years old with age range from

23 to 78 years. The majority of taxi drivers reported white (European) ethnic origin (90% of respondents). Other commonly reported ethnic origins were Pakistani, Indian, black-African and Bangladeshi. The median height of the taxi drivers was 175 centimetres with range from 158 centimetres to 196 centimetres and the median weight of the taxi drivers was 85 kilograms with range from 54 kilograms to134 kilograms. Sixty-one percent of taxi drivers reported smoking or past smoking at least once a day for a month or longer and 27% of drivers reported current smoking. Forty-one percent of taxi driver reported regularly practising sport.

The principal individual characteristics of the population of taxi drivers are listed in Table 4.1. Individual characteristics are presented as median value and inter-quartile ranges as the main part of characteristics was not normally distributed (Kolmogonov-Smirnov test: age p = 0.2; BMI p= 0.04; height p= 0.02; weight p = 0.04).

Complete individual information on the taxi drivers is listed in Appendix E (Table E1). The age and anthropometric information (height, weight, BMI) in Table E1 are divided into equal subgroups of taxi drivers as they were used in the statistical analysis.

4.1.1.3. Physical activities at present and in previous jobs

From the total of 209 taxi drivers, more than half (51%) reported that they had been taxi drivers for more than 10 years.

Table 4.1. Individual characteristics of taxi drivers (cross-sectional baseline study). Data are given as medians and inter-quartile ranges for age and anthropometric characteristics and as frequency (*n*) and percentage (%) for smoking, and physical activity

Individual risk factors	Taxi drivers (n=209)
Age (yr)	51 (41-58)
Height (cm)	175.3 (170.2-177.8)
Weight (kg)	84.6 (76.4-97.5)
Body mass index (kg/m^2)	27 (25-30.8)
Smoking:	
non-smokers	80 (38)
ex-smokers/smokers	127 (61)
Physical activity	
no	123 (59)
yes	86 (41)

Taxi drivers were asked how many times on average working day they lift loads greater than 15 kilograms (such as suitcases with belongings), lifting while their back is in a bent position, lifting while their back is in a twisted position and lifting while their back is bent and twisted. Eighty-five percent of taxi drivers reported lifting in their job, while 10% of the taxi drivers reported lifting a load more than 10 times per day.

Taxi drivers were also asked about the frequency of bending (other than while lifting) and twisting (other than while lifting) during an average working day. From the 209 drivers, 75% of drivers reported not bending at work and 77% of drivers not twisting at work.

From questionnaire information was possible to determine that 45% of taxi drivers walked or stood for more than 1 hour per working day and 8% did not walk at all during their shift.

When considering the time during which drivers sat (other than while driving the vehicle but including periods when sitting in the vehicle but not driving), 47% of taxi drivers reported sitting from 1 to 3 hours per day and 42% reported sitting for more than 3 hours in total per working shift.

Driving information

The questionnaire revealed that there were three main types of taxi driven by taxi drivers in the City of Southampton. Eight percent of the responding drivers reported driving a

Table 4.2. Physical characteristics of work of taxi drivers (cross-sectional baseline study). Data are given as frequency (*n*) and percentage (%)

Physical risk factors	Taxi drivers (n=209)
Lifting at work	
no	32 (15)
yes	177 (85)
Standing or walking at work (≥1h/day)	
no	115 (55)
yes	94 (45)
Trunk bent at work	
no	156 (75)
yes	53 (25)
Trunk twisted at work	
no	162 (77)
yes	47 (23)
Sitting > 3h at work	
no	121 (58)
yes	88 (42)
Previous job with:	
Professional driving	75 (36)
Physical demands	142 (68)
Sitting	84 (40)

purpose-built vehicle (i.e. TX1, TX2, Fairway, Metrocab, etc.). A purpose-adapted vehicle (e.g. Peugeot E7, Fiat Eurocab, etc.) was driven by 3% of responding drivers. A saloon car (e.g. Ford Mondeo, Vauxhall Vectra, BMW, Volvo, etc.) was driven by 88% of responding drivers. On average, taxi drivers reported 39.7 hours of driving per week with a minimum of 5 hours and a maximum of 80 hours per week.

Previous job

From the questionnaire it was possible to identify the amount of driving, lifting and sitting performed in previous jobs. Thirty-six percent of taxi drivers reported driving a vehicle in a previous job for at least one year. Sixty-eight percent of taxi drivers reported previous heavy physical loads at work (such as frequent heavy lifting) and 40% of taxi drivers reported sitting in previous jobs.

The main physical characteristics of the present and previous jobs of the population of taxi drivers are listed in Table 4.2.

Complete data on the physical activities in the present and previous jobs of taxi drivers are listed in Appendix E (Table E2).

4.1.1.4. Psychosocial risk factors

From the Karasek model (Karasek, 1979) (model predicting the mental strain and containing questions about decision how to work, what to do at work, choosing of timetable, support from colleagues or manager and satisfaction with the job of taxi driving)

Table 4.3. Psychosocial risk factors of taxi drivers (cross-sectional baseline study). Data are given and as frequency (*n*) and percentage (%) for psychosocial factors at work and as median and inter-quartile range of total score for psychosocial status (mental health, energy and vitality, psychosomatic distress status)

Psychosocial risk factors	Taxi drivers (n=209)
No choice and decision at work:	
- how to work	23 (11)
- what to do at work	31 (15)
- timetables and breaks	3 (1)
Support from colleagues	
yes	88 (43)
not applicable	69 (33)
Satisfaction at job	191 (91)
Mental health status	24 (21-27)
Energy and vitality status	15 (12-18)
Psychosomatic distress status	4 (2-6)

is clear that main parts of taxi drivers is self-employed and often decide the characteristics of the working shift.

From the SF-36 questionnaire (section ‘Other symptoms and feelings’), five of these questions were designed to assess the mental health of the respondent and four questions were used to asses the energy and vitality.

Questions detecting the psychosomatic distress level of the drivers consisted of ten questions about how different problems have distressed or bothered the respondent.

Psychosocial factors assessing mental health, energy and vitality and level of psychosomatic distress were used as categorical variables in further analysis.

Main psychosocial characteristics of the population of taxi drivers are listed in Table 4.3. Detailed information about classification and generalization of psychosocial risk factors are presented in the Chapter 3, paragraph 3.3.1.

Complete psychosocial data about taxi drivers derived from the questionnaire are listed in Appendix E (Table E3 and Table E4).

4.1.2. Whole-body vibration measurements and calculation of vibration exposure

Acceleration in the vehicle was measured and all data were analysed in accordance with recommendations in International Standards 2631 (1997). The precise procedure is described in Section 3.5.

The frequency-weighted acceleration in the *z*-axis (the dominant component of the vibration) was in the range from 0.39 to 0.47 ms^{-2} r.m.s. in the taxis in accord with ISO 2631 (1997).

The frequency-weighted vibration magnitudes measured in three different types of taxi (a saloon car, a purpose built taxi, and a purpose-adapted taxi, Figure 4.1.) over the 20-

I. II. III.

Figure 4.1. Tested taxi vehicles (I. Skoda Octavia, II. TX1, III.Vauxhall Zafira)

Table 4.4. Frequency-weighted root-mean-square (r.m.s.) acceleration magnitude (a_w) of vibration measured in the *x*-, *y*-, and *z*-directions, and the vector sum on the seat of the taxi vehicles

Type of driven vehicle	Model of driven vehicle	Frequency-weighted acceleration magnitude (ms^{-2} r.m.s.)			
		a_{wx}	a_{wy}	a_{wz}	a_{ws}
Taxi					
Saloon car	Skoda Octavia	0.12	0.14	0.47	0.52
Purpose build vehicle	TX1	0.14	0.16	0.44	0.50
Purpose adapted vehicle	Vauxhall Zafira	0.17	0.13	0.39	0.47

minute measurement period are presented in Table 4.4 and Appendix E, Table E5. Table 4.4 shows the *x*-, *y*-, and *z*-axis frequency-weighted vibration magnitudes on the seat and the vector sum of the frequency-weighted r.m.s. accelerations on the seat in accord with ISO 2631 (1997).

Calculation of whole-body vibration exposure

From knowledge of the type of driven vehicle, the dominant frequency-weighted r.m.s. acceleration measured in the vehicle and information about duration of driving reported in the questionnaire was estimated dose values for each taxi driver participating in the study. Taxi drivers reported median value of 7.9 hours of driving per day with range from 1 hour to 18 hours of driving per day. The drivers investigated in this study had average daily $A(8)$ value 0.43 ms^{-2} r.m.s. and average daily estimated vibration dose value ($eVDV_{dom}$) 8.34 $ms^{-1.75}$. The average duration of driving expressed in years was 12.27 with range

Table 4.5. Measures of daily and cumulative exposure to whole-body vibration in taxi drivers at the cross-sectional baseline study. Data are given as median and inter-quartile range

Measures of daily vibration exposure	Taxi drivers (n=209)
Daily driving time (h)	8 (5-10)
$A_{dom}(8)$ (ms^{-2} r.m.s.)	0.43 (0.33-0.56)
$eVDV_{dom}$ ($ms^{-1.75}$)	8.34 (7.7-9.1)
Duration of exposure (yr)	10 (5-18)
$\sum[t_i]$ ($h \times 10^3$)	14.4 (7.1-26.2)
$eVDV_{Total\text{-}dom}$ ($ms^{-1.75}$)	54.9 (45.8-64.6)

from one to 62 years. By combination of driving exposure expressed in years and hours per week was calculated total duration of driving ($\sum[t_i]$) expressed in hours. From self-reported driving times, it was estimated that the taxi drivers investigated in this study had average estimated life-time vibration dose value ($eVDV_{Total\text{-dom}}$) 54.92 $ms^{-1.75}$.

Main information about measures of daily and cumulative exposure to whole-body vibration are listed in the Table 4.5.

<u>Estimation of real duration of exposure to whole-body vibration in taxi drivers</u>

Information about the duration of driving provided by each tested taxi driver in the short questionnaire were compared with information obtained from the accelerometers. The duration of measurement and estimation of driving exposure for each driver is listed in Appendix E, Table E6. From twelve measurements and the recorded details it was found that drivers overestimate their exposure to driving on average by 31 % with a range from 17% to 47%.

Complete vibration exposure information are listed in Appendix E (Table E5). Whole-body vibration exposure information are divided into equal subgroups (approximate thirds: T1-T3) of taxi drivers as they will be use in statistical analysis.

4.1.3. Prevalence of health outcomes

4.1.3.1. Low back pain

Of the 209 taxi drivers who responded to the questionnaire, 94 had experienced low back pain during the past 12 months that lasted more than one day (12-months prevalence: 45% (38.3-51.7%)), 61 had experienced low back pain during the past 4 weeks (4-weeks prevalence: 29% (23-35.4%)) and 39 had experienced low back pain during the past 7 days (7-days prevalence: 19% (13.4-23.4%)) (See Figure 4.2).

All participants experiencing low back pain during the past 12 months have also replied to additional questions about low back pain symptoms. Of the 209 taxi drivers, 28% reported acute low back pain (pain present for less than 30 days) and 17% of taxi drivers experienced low back pain for more than 30 days. Despite the long presence of low back pain, only 12% of affected drivers visited a doctor and only 8% reported longer time than one week taken off from work due to low back pain.

Forty-seven percent of taxi drivers who had experienced low back pain during the past 12 months reported sudden onset of low back pain. A commonly reported activity when pain suddenly arrived was lifting, carrying or bending, driving or participation in sport. Twenty-nine percent of drivers had an accident to their back that required medical advice. The most common type of accidents reported were vehicle accidents, followed by heavy lifting and spinal injuries (slipped disc, trapped nerves and whiplash).

Information about how low back pain was affecting participants' daily lives during the past

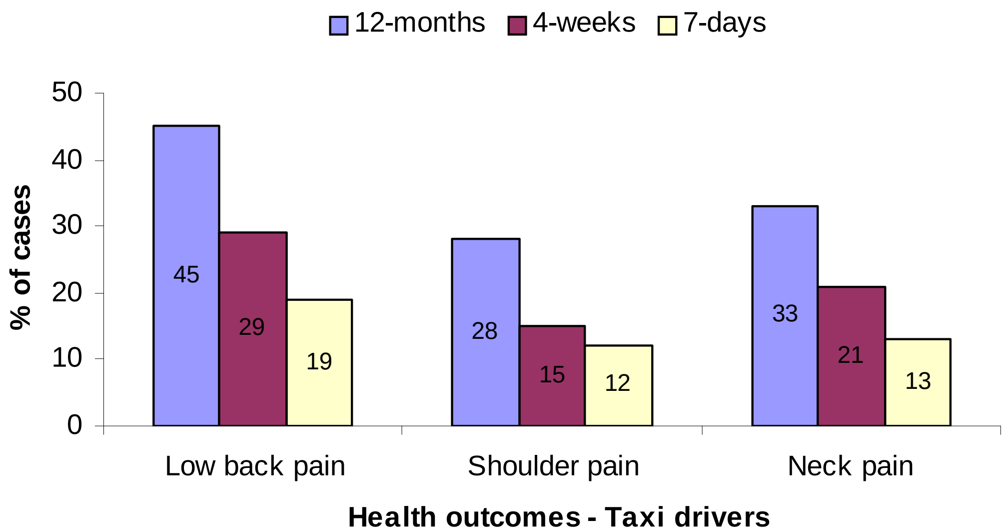


Figure 4.2. Prevalence of low back pain, shoulder pain and neck pain among taxi drivers (cross-sectional baseline study)

four weeks was used for estimation of disability due to low back pain. Participants who replied positively on more than half questions of the Rolland and Morris questionnaire were identified as disabled due to low back pain. In the cross-sectional study from the total of 209 of taxi drivers, 5% complained disability due to low back pain.

All information about presence and duration of low back pain, a visit to a doctor and days off work due to low back pain, the onset of low back pain, possible accidents hurting low back and the disability due to low back pain are listed in Table 4.6.

4.1.3.2. Prevalence of shoulder pain and neck pain

Taxi drivers also reported other health outcomes, such as shoulders pain and neck pain. Of the 209 subjects who responded to the questionnaire, 59 reported shoulder pain during

Table 4.6. Prevalence of health symptoms in the total sample of taxi drivers (cross-sectional baseline study)

Outcome	Taxi drivers (n=209) (%)
LBP in the previous 12 months	45
LBP in the previous 4 weeks	29
LBP in the previous 7 days	19
Episodes of acute LBP in the previous 12 months	28
Episodes of sciatica in the previous 12 months	14
Duration of LBP > 30 days/yr in the previous 12 months	17
High pain intensity in the lower back in the previous 7 days (Von Korf pain scale score > 5)	7
Disability due to the last episode of LBP (Roland & Morris disability scale score ≥ 12)	5
Visit to a doctor for LBP in the previous 12 months	12
Sick leave > 7 days due to LBP in the previous 12 months	8
Onset of LPB	
Gradual	23
Sudden outside work	11
Sudden at work	10
Accident requiring medical advice	13
Type of accident	
Vehicle accident	5
Heavy lifting	2
Spinal injury	3

the past 12 months (12-months prevalence: 28%), 31 reported shoulder pain during the past 4 weeks (4-weeks prevalence: 15%) and 24 reported shoulder pain during the past 7 days (7-days prevalence: 12%) (See Figure 4.2.).

Of the 209 respondents, 69 reported neck pain during the past 12 months (12-months prevalence: 33%), 43 reported neck pain during the past 4 weeks (4-weeks prevalence: 21%) and 28 experienced neck pain during the past 7 days (7-days prevalence: 13%) (See Figure 4.2.).

4.1.4. Low back pain - Univariate analysis (Simple logistic regression)

Possible risk factors for low back pain which may be derived from the questionnaires were divided into four subgroups: individual risk factors, physical risk factors, psychosocial risk factors and driving information. Each risk factor was entered into simple logistic regression to evaluate the possible relationship to low back pain during the past 12 months.

4.1.4.1. Individual factors

Age

By using univariate analysis it was found that prevalence of low back pain experienced at least one day during the past 12 months had tendency to increase with increasing age of drivers. However, there was not found any significant association.

Height

An increased prevalence of low back pain during the past 12 months was found with increasing stature. Statistically significant associations with low back pain were found in the middle height group (odds ratio, OR = 3.09).

Weight

The prevalence of low back pain during the past 12 months had the tendency to increase with increasing weight. The significant association was found between heavy group of drivers and prevalence of low back pain during the past 12 months (OR = 2.60).

BMI

The combination of anthropometrics information did not reveal any trend or significant association with prevalence of low back pain during the past 12 months.

Smoking

The prevalence of low back pain had tendency to increase with smoking or ex-smoking, but a significant association was not found.

Sport

The occurrence of low back pain during the past 12 months had tendency to increase with the fact that drivers were participating any form of exercise. However, a significant association was not found.

Other individual factors such as gender and ethnic origin were not used in the univariate analysis because the numbers of participants in each subgroup were not sufficient for using of statistical tests.

The associations between the individual risk factors and low back pain experienced for at least one day during the past 12 months in taxi drivers are presented as odds ratios (OR) with 95% confidence interval (CI) in Tables 4.7.

Table 4.7. Results of univariate analysis (simple logistic regression) for the association between low back pain during the past 12 months and various individual risk factors in taxi drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Individual risk factors	Taxi drivers (n=209) OR (95% CI)
Age (yr)	
≤ 36	1.00 (-)
37-46	1.02 (0.39-2.65)
> 46	1.41 (0.59-3.37)
Gender	n.a.
female	
male	
BMI (kg/m^2)	
≤ 24.34	1.00 (-)
24.35-27.28	0.76 (0.31-1.89)
> 27.29	1.04 (0.44-2.43)
Height (cm)	
≤ 170.18	1.00 (-)
170.19-177.8	3.09 (1.48-6.44)
> 177.8	1.85 (0.79-4.34)
Weight (kg)	
≤ 73	1.00 (-)
74-86	1.96 (0.85-4.54)
> 87	2.60 (1.14-5.93)
Smoking status	
no smoking	1.00 (-)
smoker/ex-smoker	1.73 (0.98-3.07)
Regular practising of sport	
no	1.00 (-)
yes	1.20 (0.69-2.07)

4.1.4.2. <u>Physical factors</u>

Lifting

Physical factors such as lifting, lifting while twisting, lifting while bending, lifting while bending and twisting in job were treated as dichotomous variables in univariate analysis.

Lifting at work was significantly associated with prevalence of low back pain during the past 12 months (OR 2.84). Other awkward postures such as performing lifting while bending or twisting, and lifting while bending while twisting the trunk were positively related to prevalence of low back pain during the past 12 months. The association between these tasks and presence of low back pain was significant (lifting while bending: OR = 2.35, lifting while twisting: OR = 1.82, and lifting while bending and twisting: OR = 1.97).

Bending and twisting

Performance such as bending and twisting at job were treated as dichotomous variables.

Prevalence of low back pain showed tendency to increase with twisting or bending of the trunk but the associations were not significant.

Standing or walking

Occurrence of low back pain during the past 12 months showed the tendency to increase with standing or walking for more than one hour per day. However, there was not found any significant association.

Sitting

Presence of low back pain during the past 12 months had also tendency to increase when focusing on sitting for more than three hours per day (other than when driving but including periods when sit in the car). However, this association was not significantly associated with prevalence of low back pain in the taxi drivers.

Previous job(s)

In the univariate analyses were followed information about previous job(s). Prevalence of low back pain during the past 12 months had tendency to increase with driving, sitting and physical demands in previous job. Previous physical demands (i.e. frequent heavy lifting) were significantly associated for low back pain during the past 12 months (OR = 2.10).

The associations between the physical risk factors and low back pain experienced for at least one day during the past 12 months in taxi drivers are presented as odds ratios with 95% confidence interval in Table 4.8.

Table 4.8. Results of univariate analysis (simple logistic regression) for the association between low back pain during the past 12 months and various work-related physical risk factors in taxi drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Physical risk factors	Taxi drivers (n=209) OR (95% CI)
Duration of work: ≥ 40hrs/week	
no	1.00 (-)
yes	1.85 (0.96-3.54)
Lifting at work	
no	1.00 (-)
yes	2.84 (1.21-6.65)
Lifting while bending at work	
no	1.00 (-)
yes	2.35 (1.28-4.29)
Lifting while twisting at work	
no	1.00 (-)
yes	1.82 (1.05-3.16)
Lifting while bending and twisting at work	
no	1.00 (-)
yes	1.97 (1.13-3.43)
Standing or walking: ≥1hr/day	
no	1.00 (-)
yes	1.24 (0.72-2.14)
Trunk bent at work	
no	1.00 (-)
yes	1.13 (0.60-2.10)
Trunk twisted at work	
no	1.00 (-)
yes	1.71 (0.89-3.29)
Sitting > 3h at work	
no	1.00 (-)
yes	1.42 (0.82-2.47)
Previous job with:	
Professional driving	1.43 (0.81-2.53)
Physical demands	2.10 (1.15-3.86)
Sitting	1.20 (0.69-2.08)

4.1.4.3. Psychosocial factors

Decision to perform various working tasks

No choice in decision how to perform work and what to do at work were associated with increased risk for low back pain experienced during the past 12 months. However, they were not found significantly related with increased prevalence of low back pain in taxi drivers.

Support and satisfaction at work

Low support and satisfaction at work did not show significant associations with increased risk of presence of low back pain in taxi drivers during the past 12 months.

Distress, Mental health and Energy/Vitality

The occurrence of all low back pain during the past 12 months tended to increase with more failing status of mental health, failing status of energy and vitality and increasing level of psychosomatic distress. Significant associations were found between low back pain experienced during the past 12 months and failing level of energy and vitality and increasing level of psychosomatic distress. The risk of low back pain in highly distressed group and group of drivers reporting poor energy and vitality status was more than seven times greater than in the group with no distress or healthy energy and vitality status (high psychosomatic distress: OR = 7.77, poor status of energy and vitality: OR = 7.55).

The associations between psychosocial risk factors and low back pain experienced for at least one day during the past 12 months in taxi drivers are presented as odds ratios with 95% confidence interval in Table 4.9.

4.1.4.4. Driving characteristics

Duration of driving and vibration dose values

Driving characteristics such as daily and cumulative exposure to driving were also investigated as possible risk factors for low back pain. Univariate tests showed increasing prevalence of low back pain in taxi drivers reporting increased daily and cumulative exposure to driving. A significantly increased prevalence of low back pain was found in the driving groups reporting driving a taxi for more than 9 hours per day (OR = 2.1), in driving groups reporting highest daily driving exposure expressed as $A(8)_{\mathrm{dom}}$ and $\mathrm{e}VDV_{\mathrm{dom}}$ (A(8): OR = 2.68, $\mathrm{e}VDV_{dom}$: OR = 2.30). Significantly increased prevalence of low back pain was found also in groups reporting highest cumulative exposure to driving in the form of total duration expressed in hours (OR = 1.89) and $\mathrm{e}VDV_{Total\text{-}\mathrm{dom}}$ (OR = 2.05).

The individual associations between the driving risk factors and low back pain experienced for at least one day during the past 12 months in taxi drivers are presented as odds ratios with 95% confidence interval in Table 4.10.

Table 4.9. Results of univariate analysis (simple logistic regression) for the association between low back pain during the past 12 months and various psychosocial risk factors in taxi drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Psychosocial risk factors	Taxi drivers (n=209)
	OR (95% CI)
Choice and decision at work:	
- how to work	
yes	1.00 (-)
no	1.36 (0.57-3.24)
- what to do at work	
yes	1.00 (-)
no	1.14 (0.53-2.46)
- timetables and breaks	
yes	1.00 (-)
no	0.06 (0.05-6.69)
Support from colleagues	
yes	1.00 (-)
low support	1.17 (0.58-2.36)
not applicable	1.26 (0.67-2.38)
Satisfaction at job	
yes	1.00 (-)
no	0.98 (0.37-2.58)
Mental health status	
healthy	1.00 (-)
medium	1.04 (0.05-2.16)
poor	1.98 (0.98-3.99)
Energy and vitality status	
healthy	1.00 (-)
medium	3.48 (1.29-9.41)
poor	7.55 (2.88-19.81)
Psychosomatic distress status	
healthy	1.00 (-)
medium	4.45 (2.05-9.68)
poor	7.77 (3.69-16.35)

4.1.5. Low back pain - Multivariate analysis (Multivariate logistic regression)

Upon completion of the simple logistic regression, variables were selected for multivariate analysis. Variables whose significance had a *p*-value less than 0.05 were considered as candidate for the multivariate analysis together with other variables of known biological importance.

Table 4.10. Results of univariate analysis (simple logistic regression) for the association between low back pain during the past 12 months and alternative measures of daily and cumulative exposure to whole-body vibration in taxi drivers (cross-sectional baseline study). Each measure of whole-body vibration exposure was included as a third based design variable (T_n). In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Measures of daily exposure to driving	Taxi drivers (n=209)		
	T1	T2	T3
Daily driving time (h)			
OR	1.00	0.91	2.30
(95% CI)	(-)	(0.56-2.14)	(1.17-4.52)
$A_{dom}(8)$ (ms^{-2} r.m.s.)			
OR	1.00	1.42	2.68
(95% CI)	(-)	(0.72-2.82)	(1.34-5.40)
VDV_{dom} ($ms^{-1.75}$)			
OR	1.00	1.09	2.10
(95% CI)	(-)	(0.46-1.81)	(1.06-4.16)
Exposure duration (yr)			
OR	1.00	0.91	1.32
(95% CI)	(-)	(0.47-1.76)	(0.68-2.59)
$\sum[t_i]$ (h $\times 10^3$)			
OR	1.00	1.29	1.89
(95% CI)	(-)	(0.65-2.56)	(0.94-3.77)
$VDV_{Total\text{-}dom}$ ($ms^{-1.75}$)			
OR	1.00	1.57	2.05
(95% CI)	(-)	(0.79-3.14)	(1.02-4.11)

4.1.5.1. Correlation between independent variables

At this point, statistical analysis was checked the multicollinearity of significant independent variables. The correlation was checked by using of a cross-tabulation between possibly related variables. In the case of high inter-correlation of two or more independent variables only one of the variables was chosen for the multivariate analysis.

The singularity of independent variable (the possibility that the independent variable is a combination of other tested independent variables) was also tested before entering of selected variables into the multivariate analysis. The correlation was tested by using of cross-tabulations. In the presence of singularity, only one of the variables was chosen for the multivariate analysis.

Table 4.11. Significant variables selected by univariate analysis, variables excluded from the further multivariate logistic regression, and variables of known biological importance in the cross-sectional baseline of taxi drivers

Variables selected by univariate analysis	Variables excluded from multivariate analysis	Variables of known biological importance	Variables suitable for multivariate analysis
Height Weight Lifting Lifting while bending Lifting while twisting Lifting while bending and twisting Previous physical demands Energy and vitality status Distress status	Lifting while bending Lifting while twisting Lifting while bending and twisting Energy and vitality status	Age	Age Height Weight Lifting Previous physical demands Distress status Driving information daily driving time (h) $A(8)_{dom}$ $eVDV_{dom}$ exposure duration (yrs) $\sum[t_i]$ (h) $eVDV_{Total\text{-}dom}$

By using of cross-tabulations was found associations between lifting and lifting while bending, lifting and lifting while twisting, lifting and lifting while twisting and bending. Other associations were found between distress status and energy and vitality status. For the further statistical analysis were considered to be more suitable variables lifting and level of psychosomatic distress.

Table 4.11 shows significant variables selected by univariate analysis in taxi drivers. Variables which were excluded from the further multivariate logistic regression and variables of known biological importance are marked.

4.1.5.2. Standard multiple logistic regression

Results from the standard multiple logistic regression, when all significant variables for low back pain outcomes and age as variable of known biological importance were entered into the multivariate logistic model together to examine the contribution of all possible variables at the same time, are presented in Table 4.12. The individual associations between the variables and low back pain experienced for at least one day during the past 12 months in taxi drivers are presented as odds ratios with 95% confidence interval.

Table 4.12. Results of multivariate analysis (standard and stepwise multiple logistic regression) for the association between low back pain during the past 12 months and various individual, physical and psychosocial risk factors in taxi drivers in the cross-sectional baseline study. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Risk factors	Taxi drivers (n=209)	
	Standard multiple logistic regression	Stepwise multiple logistic regression
	OR (95% CI)	OR (95% CI)
Age (yr)		n.a.
≤ 36	1.00 (-)	
37-46	0.73 (0.25-2.13)	
> 46	1.15 (0.43-3.03)	
Height (cm)		
≤ 170.18	1.00 (-)	1.00 (-)
170.19-177.8	2.67 (1.11-6.40)	3.23 (1.43-7.29)
> 177.8	1.33 (0.48-3.71)	1.86 (0.73-4.74)
Weight (kg)		n.a.
≤ 73	1.00 (-)	
74-86	1.73 (0.64-4.70)	
> 87	2.38 (0.87-6.52)	
Lifting at work		n.a.
no	1.00 (-)	
yes	1.63 (0.61-4.35)	
Previous job with:		
Physical demands	2.01 (1.03-4.29)	2.23 (1.12-4.45)
Psychosomatic distress status		
healthy	1.00 (-)	1.00 (-)
medium	4.53 (1.97-10.41)	4.36 (1.94-9.79)
poor	7.46 (3.38-16.49)	7.24 (3.35-15.63)

Results of standard multiple logistic regression in taxi drivers revealed that middle height (OR = 2.67), previous physical demands (OR = 2.01) and higher psychosomatic distress level (medium distress status: OR = 4.53, poor distress status: OR = 7.46) were significantly associated with increased prevalence of low back pain experienced for at least one day during the past 12 months when controlling for effect of all variables together (except driving information).

<u>Driving information</u>

Each aspect of driving information was entered into separate regression model together with all confounders selected by univariate analysis (except any information about driving) to investigate the possible relationship with low back pain experienced for at least one day during the past 12 months.

Table 4.13. shows the relationship between low back pain during the past 12 months and the driving information adjusted for several covariates. The individual associations between the driving information and low back pain experienced for at least one day during the past 12 months in taxi drivers are presented as odds ratios with 95% confidence interval.

In population of taxi drivers, multivariate tests showed an increasing prevalence of low back pain in groups reporting increased daily and cumulative exposure to driving. A significantly increased prevalence of low back pain was found in the driving group reporting driving a taxi for more than 9 hours per day (OR = 2.56), reporting a highest daily driving exposure expressed as A(8) (OR = 3.50) and eVDV_{dom} (OR = 2.81), and highest cumulative driving exposure expressed as total duration of driving in hours (OR = 2.57) and e$VDV_{Total\text{-}\mathrm{dom}}$ (OR = 3.13).

Table 4.13. Results of multivariate analysis (standard logistic regression) for the association between low back pain in the past 12 months on alternative measures of daily and cumulative exposure to whole-body vibration in taxi drivers in the cross-sectional baseline study. Each measure of whole-body vibration exposure was included as a third based design variable (T_n). In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Measures of daily exposure to driving	Taxi drivers (n=209)		
	T1	T2	T3
Daily driving time (h)			
OR (95% CI)	1.00 (-)	0.94 (0.42-2.10)	2.56 (1.13-5.79)
$A_{\mathrm{dom}}(8)$ (ms^{-2} r.m.s.)			
OR (95% CI)	1.00 (-)	1.77 (0.78-4.01)	3.50 (1.50-8.20)
VDV_{dom} ($\mathrm{ms}^{-1.75}$)			
OR (95% CI)	1.00 (-)	1.29 (0.57-2.93)	2.81 (1.13-5.79)
Exposure duration (yr)			
OR (95% CI)	1.00 (-)	1.46 (0.64-3.35)	1.75 (0.71-4.35)
$\sum[t_i]$ (h $\times 10^3$)			
OR (95% CI)	1.00 (-)	1.38 (0.59-3.24)	2.57 (1.00-6.62)
$VDV_{Total\text{-}\mathrm{dom}}$ ($\mathrm{ms}^{-1.75}$)			
OR (95% CI)	1.00 (-)	1.89 (0.81-4.42)	3.13 (1.21-8.14)

Odds ratios adjusted for following risk factors: age, height, weight, lifting at work, physical demands in previous job, psychosomatic distress status

4.1.5.3. Stepwise multiple logistic regression

Stepwise multiple logistic regression was used to identify the subset of independent variables (except driving information) having the strongest relationship to low back pain experienced for at least one day during the past 12 months (dependent variable). In this step of the statistical analysis only variables that had been found to be significantly related with low back pain during the past 12 months in the simple logistic regression were used. The final results of the stepwise multiple logistic regression are presented in Table 4.12.
In taxi drivers, the strongest predictors for increased prevalence of low back pain during the past 12 months were middle height of drivers (OR = 3.23), heavy physical load in previous work (OR = 2.23), and medium and high level of psychosomatic distress (OR = 4.36, OR = 7.24).

4.1.6. Neck pain - Univariate analysis (Simple logistic regression)

Neck pain in all populations was the second most common musculoskeletal problem. Collected information from taxi drivers allowed to perform statistical analysis uncovering the relationship between neck pain and possible risk factors.
Present or previous smoking as the only one individual risk factor have been associated with increased prevalence of neck pain in taxi drivers (OR = 2.49).

From the physical factors, an increased prevalence of neck pain during the past 12 months was found in taxi drivers reporting twisting at work (OR = 1.92), physical demands (i.e. frequent heavy lifting) and driving in previous job (OR = 2.13 and OR = 3.10).

There were no clear associations between neck pain during the past 12 months and psychosocial factors at work in taxi drivers. Psychosomatic distress (medium distress status: OR = 3.53, poor distress status: OR = 5.68), poor mental health (OR = 3.87) and worst energy and vitality status (medium vitality status: OR = 3.4, poor vitality status: OR = 6.42) seemed to be a significant predictor of neck pain in taxi drivers.

In the populations of taxi drivers, univariate tests did not found any significant association between increased prevalence of neck pain experienced for at least one day during the past 12 months and any metrics of daily or cumulative exposure to driving.

The associations between the risk factors and neck pain experienced for at least one day during the past 12 months in taxi drivers are presented as odds ratios with 95% confidence interval in Appendix E (Table E7 and Table E8).

Table 4.14. Results of multivariate analysis (simple logistic regression) for the association between neck pain during the past 12 months and various individual risk factors in taxi drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Factors	Taxi drivers (n=209)
	OR (95% CI)
Age (yr)	
≤ 36	1.00 (-)
37-46	2.89 (0.80-10.39)
> 46	2.17 (0.64-7.36)
Smoking status	
no smoking	1.00 (-)
smoker/ex-smoker	2.03 (0.98-4.24)
Trunk twisted at work	
no	1.00 (-)
yes	1.92 (0.91-4.07)
Psychosomatic distress status	
healthy	1.00 (-)
medium	3.24 (1.34-7.86)
poor	5.04 (2.21-11.49)

4.1.7. Neck pain - Multivariate analysis (Multivariate logistic regression)

Results from the standard multiple logistic regression, when all significant potential variables for neck pain outcomes and age were entered into the multivariate logistic model together to examine the contribution of all possible variables at the same time, are presented in Appendix E (Table E9 and Table E10).

In taxi drivers, the standard multiple logistic regression revealed that previous or present smoking (OR = 2.03), twisting at work (OR = 1.92), previous physical demands (OR = 2.00), and increased psychosomatic distress levels (medium distress status: OR = 3.24, poor distress status: OR = 5.04) were significantly associated with increased prevalence of neck pain when controlling for other variable presented in Table 4.14.

4.2. Cross-sectional baseline of police employees

4.2.1. Description of the population

The target population was 2105 police workers employed by the Grampian Police Force. The information about the number and contact information of the police employees were provided by the Service Centre of Aberdeen Police Station.

4.2.1.1. Response rate

From the total of 2105 posted questionnaires was returned 852 responses, giving an overall response rate of 41%. From the total of 852 responses, two cases were excluded because they did not wish to participate in the study.

In total, 850 questionnaires were used in the cross-sectional baseline study of police employees from the Aberdeen Police Force.

From the total of 850 police employees, who have participated in the study, 365 have been classified as police drivers and 485 were classified as non-drivers. Population of the police drivers and the non-drivers were classified and investigated as two different populations.

4.3. Cross-sectional baseline of police drivers

4.3.1. Description of the population

4.3.1.1. Individual information

In total, 365 questionnaires from police drivers were used in the cross-sectional baseline study of police employees from the Aberdeen Police Force.

From the total of 365 police employees classified as police drivers, 280 respondents (77%) were males and 84 of the respondents (23%) were females. The median age of police drivers was 37 years old with age range from 23 to 62 years. The majority of police drivers reported white (European) ethnic origin (98% of respondents). The median height of police drivers was 178 centimetres with range from 152 centimetres to 201 centimetres and the median weight of drivers was 82 kilograms with range from 52 kilograms to 120 kilograms. Thirty percent of police drivers reported smoking or past smoking for at least once a day for a month or longer where 10% of drivers reported current smoking. Seventy eight percent of police drivers reported regular practising of sport where the main part of them exercise one or two times per week.

Table 4.15. Individual characteristics of police drivers (cross-sectional baseline study). Data are given as median and interquartile range for age and anthropometric characteristics and as frequency (n) and percentage (%) for smoking, and physical activity

Individual risk factors	Police drivers (n=365)
Age (yr)	37 (32-43)
Height (cm)	177.8 (172.7-182.9)
Weight (kg)	81.9 (72.5-89.6)
Body mass index (kg/m^2)	25.6 (23.4-27.5)
Smoking:	
non-smokers	256 (70)
ex-smokers/smokers	108 (30)
Physical activity	
no	81 (22)
yes	284 (78)

Main individual characteristics of the population of police drivers are listed in Table 4.15. Individual characteristics are presented as median value and inter-quartile ranges as the main part of characteristics was not normally distributed (Kolmogonov-Smirnov test: age p = 0.00; BMI p = 0.39; height p = 0.00; weight p = 0.59).

Complete data about individual information of police drivers are listed in Appendix E (Table E1). Age and anthropometric information (height, weight, BMI) are divided into equal subgroups of police drivers as they will be used in statistical analysis.

4.3.1.2. Physical activities at present and previous job

From the total of 365, 49% of police drivers reported working for police force for more than 10 years and 83% of drivers reported working for more than 40 hours per one working week.

Police drivers were asked how many times per an average working day they lift loads greater than 15 kilograms, lifting while back is in bent position, lifting while back is in twisted position and lifting wile back is in a bent and twisted. Fifty-nine percent of police drivers reported lifting at job, while 3% of them reported lifting a load for more than 10 times per day. When considering lifting while doing other movement (twisting, bending or twisting while bending), lifting while bending reported more than 33% of drivers, lifting while twisting reported 25% of drivers and lifting while bending and twisting reported 22% of police drivers, however only small part of them reported to do such a task for more than 10 times per day.

Police drivers were also asked about frequency of performance such as bending (other than while lifting) and twisting (other than while lifting) during the average working day. From the 365 police drivers, 67% reported not performing of bending at work and 78% not performing of twisting at job.

From the questionnaire information was possible to derive that 84% of police drivers spent walking or standing for more than 1 hour per working day (58% stand or walk for 1-3 hours and 26% for more than 3 hours per working day).

When considering time which drivers spent sitting (other than in the vehicle), 58% of police drivers reported sitting from 1 to 3 hours per day and 34% reported sitting for more than 3 hours in total per working shift.

Driving information

The questionnaire revealed that there were two main types of police vehicles driven by police drivers in the Grampian Police Force. From the total of 365 police employees, 78% of the responding police drivers reported driving a general purpose vehicle (also called squad car) (e.g., Vauxhall Astra, Ford Focus, etc.). A traffic vehicle (also called high-speed vehicle) (e.g., Vauxhall Omega, Volvo, Range Rover/Discovery, etc.) was driven by 13% of responding drivers. Five percent of police drivers reported driving both types of vehicles.

Information about driving details of police drivers (such as type of driven vehicle, off-road driving and unloading of vehicle) are listed in Appendix E, Table E2.

Previous job

From the questionnaire was possible to identify driving, lifting and sitting performed in previous job(s). Forty-two of police drivers reported driving of vehicle in previous job for at least one year. Forty-nine of police drivers reported previous heavy physical load at work (such as frequent heavy lifting) and 33% of police drivers reported sitting in previous job(s).

Main physical characteristics of present and previous job of the population of police drivers are listed in Table 4.16.

Complete data about physical activities at present and previous job of police drivers are listed in Appendix E, Table E2.

Table 4.16. Physical characteristics of work of police drivers (cross-sectional baseline study). Data are given as frequency (n) and percentage (%)

Physical risk factors	Police drivers (n=365)
Lifting at work	
no	146 (41)
yes	218 (59)
Standing or walking at work:	
≥ 1h/day no	59 (16)
yes	304 (84)
Trunk bent at work	
no	245 (67)
yes	119 (33)
Trunk twisted at work	
no	285 (78)
yes	80 (22)
Sitting: > 3h at work	
no	240 (66)
yes	125 (34)
Previous job with:	
Professional driving	152 (42)
Physical demands	177 (49)
Sitting	122 (33)

4.3.1.3. Psychosocial risk factors

Main psychosocial characteristics of the population of police drivers are listed in Table 4.17. Detailed information about classification and generalization of psychosocial risk factors are presented in the Chapter 3, paragraph 3.3.1.

Complete psychosocial data about police drivers derived from the questionnaire are listed in Appendix E (Table E3 and Table E4).

4.3.2. Whole-body vibration measurements and calculation of vibration exposure

Acceleration in seven police vehicles was measured and all data analysed in accordance with recommendation in International Standards 2631 (1997). Precise procedure is described in Chapter 3, Section 3.5.

The frequency-weighted acceleration in the *z*-axis (the dominant component of the vibration) was in the range from 0.36 to 0.58 ms^{-2} r.m.s. in the police vehicles in accord with ISO 2631 (1997).

Table 4.17. Psychosocial risk factors of police drivers (cross-sectional baseline study). Data are given and as frequency (n) and percentage (%) for psychosocial factors at work and as median and inter-quartile range of total score for psychosocial statutes (mental health, energy and vitality, psychosomatic distress status)

Psychosocial risk factors	Police drivers (n=365)
No choice and decision at work:	
- how to work	69 (19)
- what to do at work	113 (31)
- timetables and breaks	131 (36)
Support from colleagues	
yes	320 (88)
Satisfaction at job	319 (87)
Mental health status	24 (21-27)
Energy and vitality status	16 (13-19)
Psychosomatic distress status	1 (0-2)

The frequency-weighted vibration magnitude measured in seven police vehicles (three types of general purpose vehicles, three types of traffic vehicles and one type of vehicle which is used for off-road driving, Figure 4.3.) over the 20-minute measurement period are presented in Table 4.18. Table 4.18. shows the *x*-, *y*-, and *z*-axis frequency-weighted vibration magnitudes on the seat and the vector sum of the frequency-weighted r.m.s. accelerations in each axis of the measurement on the seat in accord with ISO 2631 (1997).

Calculation of whole-body vibration exposure

From the knowledge of the type of driven vehicle, the dominant frequency-weighted r.m.s. acceleration measured in the vehicle and information about duration of driving reported in the questionnaire was estimated dose values for each police driver participating in the study.

As a median value, police drivers reported 2.65 hours of driving per day with range from one hour to eight hours of driving per day. The drivers investigated in this study had median daily $A(8)_{dom}$ value 0.27 ms^{-2} r.m.s. and median daily estimated vibration dose value ($eVDV_{dom}$) 6.3 $ms^{-1.75}$. The median duration of driving expressed in years was 7.19 with range from one to 33 years. By combination of driving exposure expressed in years and hours per week was calculated total duration of driving ($\sum[t_i]$) expressed in hours. From their self-reported driving times, it was estimated that the police drivers investigated

Table 4.18. Frequency-weighted root-mean-square (r.m.s.) acceleration magnitude (a_w) of vibration measured in the *x*-, *y*-, and *z*-directions, and the vector sum on the seat of the police vehicles. The vibration total value of frequency-weighted r.m.s. accelerations (a_w) is calculated according to International Standard ISO 2631-1 (1997)

Type of driven vehicle	Model of driven vehicle	Frequency-weighted acceleration magnitude (ms^{-2} r.m.s.)			
		a_{wx}	a_{wy}	a_{wz}	a_{ws}
Police vehicle					
General purpose vehicles					
	Land Rover-Discovery	0.16	0.22	0.36	0.48
	Vauxhall Astra	0.22	0.18	0.58	0.67
	Ford Focus	0.15	0.19	0.38	0.48
Traffic control vehicle					
	Vauxhall Omega	0.19	0.23	0.43	0.56
	BMW 750	0.14	0.24	0.45	0.56
	Ford Mondeo	0.20	0.22	0.46	0.58
Off-road vehicle					
	Land Rover-Ranger	0.19	0.22	0.43	0.55

in this study had average estimated life-time vibration dose value ($eVDV_{Total\text{-dom}}$) 39.72 $ms^{-1.75}$.

Information about measures of daily and cumulative exposure to whole-body vibration are listed in Table 4.19. Whole-body vibration exposure information are divided into equal subgroups (approximate thirds: T1-T3) of police drivers as they will be use in statistical analysis (Appendix E, Table E5.).

Table 4.19. Measures of daily and cumulative exposure to whole-body vibration in police drivers at the cross-sectional baseline study. Data are given as median and inter-quartile range

Measures of daily vibration exposure	Police drivers (n=365)
Daily driving time (h)	2.7 (1.6-4)
$A_{dom}(8)$ (ms^{-2} r.m.s.)	0.27 (0.2-0.31)
$eVDV_{dom}$ ($ms^{-1.75}$)	6.3 (5.5-6.7)
Duration of exposure (yr)	7.2 (6.3-8)
$\sum[t_i]$ (h $\times 10^3$)	4.7 (1.8-9.7)
$eVDV_{Total\text{-dom}}$ ($ms^{-1.75}$)	39.7 (31.4-47.7)

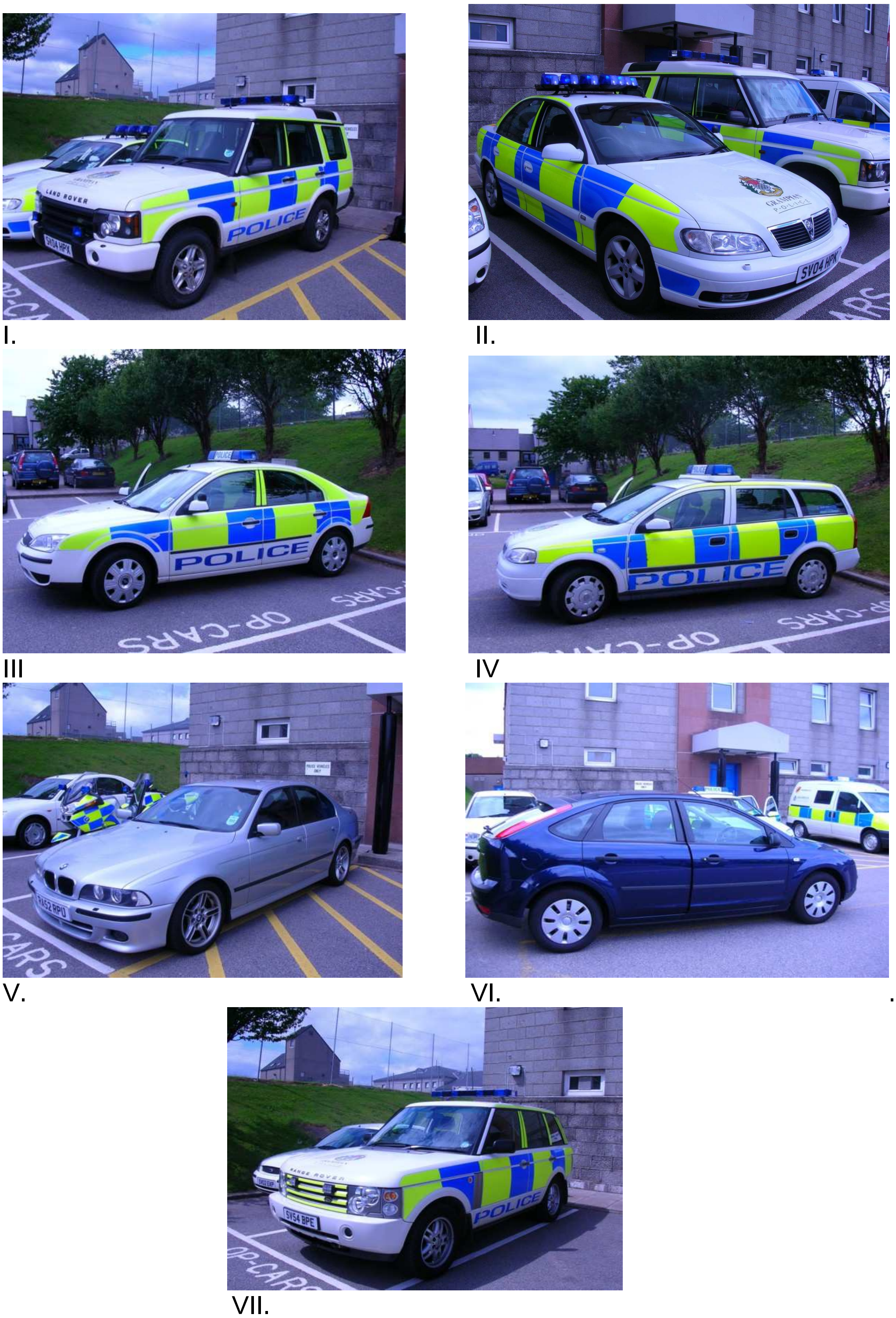


Figure 4.3. Tested police vehicles:
I. Land Rover- Discovery,
II. Vauxhall Astra,
III. Ford Focus,
IV. Vauxhall Omega,
V. BMW 750,
VI. Ford Mondeo,
VII. Land Rover- Ranger

4.3.3. Prevalence of health outcomes

4.3.3.1. Low back pain

Of the 365 police drivers who responded to the questionnaire, 195 had experienced low back pain during the past 12 months which lasted more than one day (12-months prevalence: 53% (48-58.6%), 129 had experienced low back pain during the past 4 weeks (4-weeks prevalence: 35% (30.4-40.3%)) and 70 had experienced low back pain during the past 7 days (7-days prevalence: 19% (15.1-23.3%)) (See Figure 4.4.).

All participants experiencing low back pain during the past 12 months have replied also additional questions about low back pain symptoms. Of the 365 drivers 33% reported acute low back pain (pain present for less than 30 days) and 20% of police drivers experienced low back pain for more than 30 days. Despite the long presence of low back pain, only 8% of affected drivers visited a doctor and 3% reported longer time taken off from work due to low back pain.

Twenty-six percent of the police drivers who had experienced low back pain during the past 12 months reported sudden onset of low back pain. As common performance when pain suddenly arrived were lifting, bending, and participation in sport. Thirteen percent of employees had an accident to their back that required medical advice. As the most common type of accident were heavy lifting, car accidents, falls, and sport events.

Information about how low back pain was affecting participants' daily life during the past four weeks was used for estimation of disability due to the low back pain. Participants who

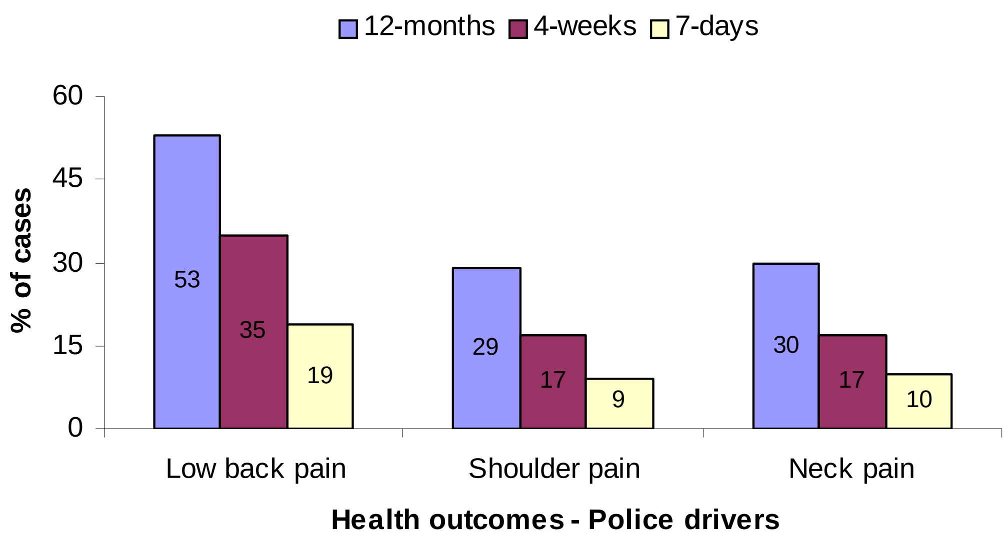


Figure 4.4. Prevalence of low back pain, shoulder pain and neck pain among police drivers (cross-sectional baseline study)

replied positively on more than half questions of the Rolland and Morris questionnaire were identified as disabled due to the low back pain. In the cross-sectional study from the total of 365 of police drivers, 4% complained disability due to low back pain.

All information about presence and duration of low back pain, the visit of doctor and days off work due to low back pain, the onset of low back pain, possible accidents hurting low back and disability due to low back pain are listed in Table 4.20.

4.3.3.2. Prevalence of shoulder pain and neck pain

Police drivers also reported other health outcomes, such as the shoulders pain and the neck pain. Of the 365 subjects who responded to the questionnaire, 106 reported

Table 4.20. Prevalence of health symptoms in the total sample of police drivers (cross-sectional baseline study)

Outcome	Police drivers (n=365) (%)
LBP in the previous 12 months	53
LBP in the previous 4 weeks	35
LBP in the previous 7 days	19
Episodes of acute LBP in the previous 12 months	33
Episodes of sciatica in the previous 12 months	13
Duration of LBP > 30 d/yr in the previous 12 months	20
High pain intensity in the lower back in the previous 7 days (Von Korf pain scale score > 5)	4
Disability due to the last episode of LBP (Roland & Morris disability scale score ≥ 12)	4
Visit to a doctor for LBP in the previous 12 months	12
Sick leave > 7 days due to LBP in the previous 12 months	3
Onset of LPB	
Gradual	27
Sudden outside work	17
Sudden at work	9
Accident requiring medical advice	13
Type of accident	
Vehicle accident	2
Heavy lifting	3
Fall	2
Spinal injury	1
Sport	1

shoulder pain during the past 12 months (12-months prevalence: 29%), 63 reported shoulder pain during the past 4 weeks (4-weeks prevalence: 17%) and 31 reported shoulder pain during the past 7 days (7-days prevalence: 9%) (See Figure 4.4.).

Of the 365 respondents, 111 reported neck pain during the past 12 months (12-months prevalence: 30%), 61 reported neck pain during the past 4 weeks (4-weeks prevalence: 17%) and 35 experienced neck pain during the past 7 days (7-days prevalence: 10%) (See Figure 4.4.).

4.3.4. Low back pain - Univariate analysis (Simple logistic regression)

Possible risk factors for low back pain which may be derived from the questionnaires were divided into four subgroups: individual risk factors, physical risk factors, psychosocial risk factors and driving information. Each risk factor was entered into simple logistic regression to evaluate the possible relationship to low back pain outcome.

4.3.4.1. <u>Individual factors</u>

Age

By using of univariate analysis was found that the prevalence of low back pain experienced at least one day during the past 12 months significantly increased in the middle age group of police drivers (OR = 2.00).

Gender

Being a male or female did not show significant association with increased prevalence of low back pain in population of police drivers.

Height

An increased prevalence of low back pain during the past 12 months was found with increasing stature. However, there was not found statistically significant association with low back pain.

Weight

The prevalence of low back pain during the past 12 months had the tendency to increase with increasing weight. The significant association was found between heavy group of drivers and prevalence of low back pain during the past 12 months (OR = 2.54).

BMI

The combination of anthropometrics information revealed significant association with increased prevalence of low back pain during the past 12 months in group reporting BMI more than 27.29 (OR = 2.42).

Smoking

The prevalence of low back pain did not show tendency to increase in police drivers reporting previous or current smoking.

Sport

The occurrence of low back pain during the past 12 months had tendency to increase with the fact that police drivers were participating some form of exercise. However, a significant association was not found.

The associations between the individual risk factors and low back pain experienced for at least one day during the past 12 months in police drivers are presented as odds ratios with 95% confidence interval in Table 4.21.

Table 4.21. Results of univariate analysis (simple logistic regression) for the association between low back pain during the past 12 months and various individual risk factors in police drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Individual risk factors	Police drivers (n=365)
	OR (95% CI)
Age (yr)	
≤ 36	1.00 (-)
37-46	2.00 (1.26-3.18)
>46	1.64 (0.91-2.97)
Gender	
female	1.00 (-)
male	0.84 (0.52-1.37)
BMI (kg/m^2)	
≤ 24.34	1.00 (-)
24.35-27.28	1.10 (0.67-1.80)
> 27.29	2.42 (1.39-4.20)
Height (cm)	
≤170.18	1.00 (-)
170.19-177.8	1.14 (0.63-2.09)
>177.8	1.30 (0.74-2.28)
Weight (kg)	
≤ 73	1.00 (-)
74-86	1.06 (0.62-1.80)
> 87	2.54 (1.47-4.38)
Smoking status	
no smoking	1.00 (-)
smoker/ex-smoker	1.08 (0.69-1.70)
Regular practising of sport	
no	1.00 (-)
yes	1.44 (0.83-2.53)

4.3.4.2. Physical factors

Lifting

Physical factors such as lifting, lifting while twisting, lifting while bending, lifting while bending and twisting in job were treated as dichotomous variables in univariate analysis.

Lifting at work was significantly associated with prevalence of low back pain during the past 12 months (OR 1.84). Other awkward postures such as performing lifting while bending or twisting, and lifting while bending while twisting the trunk were positively related to prevalence of low back pain during the past 12 months. The association between these tasks and presence of low back pain was significant (lifting while bending: OR = 2.06, lifting while twisting: OR = 2.03, and lifting while bending and twisting: OR = 2.39).

Bending and twisting

Performance such as bending and twisting at job were treated as dichotomous variables.

Prevalence of low back pain showed tendency to increase with twisting or bending of the trunk. The significantly increased prevalence of low back pain was in group of drivers reporting bending at work (OR = 2.08).

Standing or walking

There was not found associations pointing on increased prevalence of low back pain during the past 12 months in drivers reporting standing or walking for more than one hour per day.

Sitting

Sitting other than driving at work did not show significant association with increased prevalence of low back pain in police drivers.

Previous job(s)

In the univariate analyses were followed information about previous job(s). Prevalence of low back pain during the past 12 months had tendency to increase with driving, sitting and physical demands in previous job. However, these tasks were not significantly associated with increased prevalence of low back pain during the past 12 months.

The associations between the physical risk factors and low back pain experienced for at least one day during the past 12 months in police drivers are presented as odds ratios with 95% confidence interval in Table 4.22.

4.3.4.3. Psychosocial factors

Decision to perform various working tasks

No choice in decision how to perform work and what to do at work were not significantly associated with increased risk for prevalent low back pain experienced during the past 12 months.

Table 4.22. Results of univariate analysis (simple logistic regression) for the association between low back pain during the past 12 months and various work-related physical risk factors in police drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Physical risk factors		Police drivers (n=365) OR (95% CI)
Duration of work: ≥ 40hrs/week		
	no	1.00 (-)
	yes	1.05 (0.60-1.84)
Lifting at work		
	no	1.00 (-)
	yes	1.84 (1.21-2.81)
Lifting while bending at work		
	no	1.00 (-)
	yes	2.06 (1.31-3.22)
Lifting while twisting at work		
	no	1.00 (-)
	yes	2.03 (1.23-3.35)
Lifting while bending and twisting at work		
	no	1.00 (-)
	yes	2.39 (1.40-4.08)
Standing or walking: ≥1 h/day		
	no	1.00 (-)
	yes	0.88 (0.50-1.53)
Trunk bent at work		
	no	1.00 (-)
	yes	2.08 (1.32-3.28)
Trunk twisted at work		
	no	1.00 (-)
	yes	1.51 (0.91-2.50)
Sitting > 3h at work		
	no	1.00 (-)
	yes	1.06 (0.69-1.64)
Previous job with:		
	Professional driving	1.30 (0.86-1.98)
	Physical demands	1.36 (0.90-2.06)
	Sitting	1.21 (0.78-1.87)

Support and satisfaction at work

Low support and no satisfaction at work did show significant associations with increased risk of presence of low back pain in police drivers during the past 12 months (low support: OR = 2.17, no satisfaction OR = 2.19).

Distress, Mental health and Energy/Vitality

The occurrence of all low back pain during the past 12 months tended to increase with more failing status of energy and vitality and increasing level of psychosomatic distress. Significant associations were found between low back pain experienced during the past 12 months and increasing level of psychosomatic distress (medium psychosomatic distress: OR = 1.64, low status of psychosomatic distress: OR = 2.47).

The associations between the psychosocial risk factors and low back pain experienced for at least one day during the past 12 months in police drivers are presented as odds ratios with 95% confidence interval in Table 4.23.

4.3.4.4. Driving characteristics

Duration of driving and vibration dose values

Driving characteristics such as daily and cumulative exposure to driving were also investigated as possible risk factors for low back pain. Univariate tests showed increasing prevalence of low back pain in police drivers reporting increased cumulative exposure to driving. However, the associations of increased prevalence of low back pain with increased exposure to cumulative driving exposure were not significantly associated.

The individual associations between the driving risk factors and low back pain experienced for at least one day during the past 12 months in police drivers are presented as odds ratios with 95% confidence interval in Table 4.24.

4.3.5. Low back pain - Multivariate analysis (Multivariate logistic regression)

Upon completion of the simple logistic regression, variables were selected for multivariate analysis. Variables whose significance had a *p*-value less than 0.05 were considered as candidate for the multivariate analysis together with other variables of known biological importance.

Table 4.23. Results of univariate analysis (simple logistic regression) for the association between low back pain during the past 12 months and various psychosocial risk factors in police drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Psychosocial risk factors	Police drivers (n=365) OR (95% CI)
Choice and decision at work:	
- how to work	
yes	1.00 (-)
no	1.09 (0.64-1.84)
- what to do at work	
yes	1.00 (-)
no	0.85 (0.55-1.33)
- timetables and breaks	
yes	1.00 (-)
no	0.96 (0.63-1.48)
Support from colleagues	
yes	1.00 (-)
low support	2.17 (1.09-4.31)
Satisfaction at job	
yes	1.00 (-)
no	2.19 (1.13-4.26)
Mental health status	
healthy	1.00 (-)
medium	0.70 (0.41-1.18)
poor	1.26 (0.73-2.17)
Energy and vitality status	
healthy	1.00 (-)
medium	1.16 (0.68-1.98)
poor	1.36 (0.80-3.20)
Psychosomatic distress status	
healthy	1.00 (-)
medium	1.64 (1.01-2.66)
poor	2.47 (1.43-4.25)

4.3.5.1. Correlation between independent variables

At this point of statistical analysis was checked the multicollinearity and the singularity of significant independent variables.

By using of cross-tabulations was found associations between weight and BMI, lifting and lifting while bending, lifting and lifting while twisting, lifting and lifting while twisting and bending, low psychosomatic distress status and lack of satisfaction at work. For the further statistical analysis were considered to be more suitable variables weight, lifting and level of psychosomatic distress.

Table 4.24. Results of univariate analysis (simple logistic regression) for the association between low back pain during the past 12 months and alternative measures of daily and cumulative exposure to whole-body vibration in police drivers (cross-sectional baseline study). Each measure of whole-body vibration exposure was included as a third based design variable (T_n). In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Measures of daily exposure to driving	Police drivers (n=365)		
	T1	T2	T3
Daily driving time (h)			
OR	1.00	1.27	1.06
(95% CI)	(-)	(0.74-2.18)	(0.66-1.70)
$A_{dom}(8)$ (ms^{-2} r.m.s.)			
OR	1.00	1.40	1.07
(95% CI)	(-)	(0.82-2.40)	(0.66-1.74)
VDV_{dom} ($ms^{-1.75}$)			
OR	1.00	1.36	1.07
(95% CI)	(-)	(0.80-2.33)	(0.66-1.74)
Exposure duration (yr)			
OR	1.00	1.20	1.92
(95% CI)	(-)	(0.72-1.98)	(0.15-3.20)
$\sum[t_i]$ (h $\times 10^3$)			
OR	1.00	1.24	1.37
(95% CI)	(-)	(0.75-2.05)	(0.83-2.27)
$VDV_{Total\text{-}dom}$ ($ms^{-1.75}$)			
OR	1.00	1.40	1.51
(95% CI)	(-)	(0.83-2.35)	(0.90-2.55)

Table 4.25. shows significant variables selected by univariate analysis in police drivers. Variables which were excluded from the further multivariate logistic regression and variables of known biological importance are marked.

4.3.5.2. Standard multiple logistic regression

Results from the standard multiple logistic regression, when all significant variables for low back pain outcomes were entered into the multivariate logistic model together to examine the contribution of all possible variables at the same time, are presented in Table 4.26. The individual associations between the variables and low back pain experienced for at least one day during the past 12 months are presented as odds ratios with 95% confidence interval.

Results of standard multiple logistic regression in police drivers revealed that middle age (OR = 2.23), bending at work (OR = 2.19) and poor status of psychosomatic distress (OR

Table 4.25. Significant variables selected by univariate analysis, variables excluded from the further multivariate logistic regression and variables of known biological importance in the cross-sectional baseline of police drivers

Variables selected by univariate analysis	Variables excluded from multivariate analysis	Variables of known biological importance	Variables suitable for multivariate analysis
Age	Lifting while bending		Age
Height	Lifting while twisting		Weight
BMI	Lifting while bending and twisting		Lifting
Lifting	Satisfaction at work		Bending
Lifting while bending	BMI		Support at work
Lifting while twisting			Distress status
Lifting while bending and twisting			Driving information
Bending			daily driving time (h)
Support at work			$A(8)_{dom}$
Satisfaction at work			$eVDV_{dom}$
Distress status			exposure duration (yrs)
			$\sum[t_i]$ (h)
			$eVDV_{Total-dom}$

= 2.37)) were significantly associated with increased prevalence of low back pain experienced for at least one day during the past 12 months when controlling for effect of all variables together (except driving information).

Driving information

Each aspect of driving information was entered into separate regression model together with all confounders selected by univariate analysis (except any information about driving) to investigate the possible relationship with low back pain experienced for at least one day during the past 12 months.

Table 4.27. shows the relationship between low back pain during the past 12 months and the driving information adjusted for several covariates. The individual associations between the driving information and low back pain experienced for at least one day during the past 12 months are presented as odds ratios with 95% confidence interval.

In population of police drivers, multivariate tests did not revealed significantly increased prevalence of low back pain in any driving groups reporting increased daily and cumulative exposure to driving.

Table 4.26. Results of multivariate analysis (standard and stepwise multiple logistic regression) for the association between low back pain during the past 12 months and various individual, physical and psychosocial risk factors in police drivers in the cross-sectional baseline study. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Risk factors	Police drivers (n=365)	
	Standard multiple logistic regression	Stepwise multiple logistic regression
	OR (95% CI)	OR (95% CI)
Age (yr)		
≤ 36	1.00 (-)	1.00 (-)
37-46	2.23 (1.34-3.69)	2.31 (1.41-3.79)
> 46	1.88 (0.98-3.62)	2.07 (1.10-3.90)
Height (cm)		n.a.
≤ 170.18	1.00 (-)	
170.19-177.8	0.98 (0.50-1.91)	
> 177.8	1.12 (0.60-2.07)	
Lifting at work		
no	1.00 (-)	1.00 (-)
yes	1.57 (0.99-2.49)	1.66 (1.05-2.62)
Trunk bent at work		
no	1.00 (-)	1.00 (-)
yes	2.19 (1.33-3.62)	2.16 (1.32-3.35)
Support from colleagues		n.a.
yes	1.00 (-)	
low support	1.97 (0.95-4.10)	
Psychosomatic distress status		
healthy	1.00 (-)	1.00 (-)
medium	1.62 (0.97-2.72)	1.68 (1.01-2.81)
poor	2.37 (1.33-4.22)	2.39 (1.35-4.24)

4.3.5.3. Stepwise multiple logistic regression

Stepwise multiple logistic regression was used to identify the subset of independent variables (except driving information) having the strongest relationship to low back pain experienced for at least one day during the past 12 months (dependent variable). In this step of the statistical analysis only variables that had been found to be significantly related with low back pain during the past 12 months in the simple logistic regression were used. The final results of the stepwise multiple logistic regression are presented in Table 4.25.

In police drivers, the strongest predictors for increased prevalence of low back pain during the past 12 months were increased age of drivers (middle age group: OR = 2.32, high age group: OR = 2.07), heavy lifting at work (OR = 1.66), bending at work (OR = 2.16) and medium and high status of psychosomatic distress (OR = 1.68, OR = 2.39).

Table 4.27. Results of multivariate analysis (standard logistic regression) for the association between low back pain in the past 12 months on alternative measures of daily and cumulative exposure to whole-body vibration in police drivers in the cross-sectional baseline study. Each measure of whole-body vibration exposure was included as a third based design variable (T_n). In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Measures of daily exposure to driving	Police drivers (n=365)		
	T1	T2	T3
Daily driving time (h)			
OR	1.00	1.22	0.95
(95% CI)	(-)	(0.68-2.20)	(0.56-1.59)
$A_{dom}(8)$ (ms^{-2} r.m.s.)			
OR	1.00	1.28	0.93
(95% CI)	(-)	(0.71-2.30)	(0.54-1.58)
VDV_{dom} ($ms^{-1.75}$)			
OR	1.00	1.25	0.94
(95% CI)	(-)	(0.70-2.25)	(0.55-1.60)
Exposure duration (yr)			
OR	1.00	1.35	1.56
(95% CI)	(-)	(0.78-2.34)	(0.82-2.96)
$\sum[t_i]$ (h $\times 10^3$)			
OR	1.00	1.16	0.96
(95% CI)	(-)	(0.67-2.00)	(0.54-1.71)
$VDV_{Total\text{-}dom}$ ($ms^{-1.75}$)			
OR	1.00	1.29	1.02
(95% CI)	(-)	(0.74-2.26)	(0.57-1.84)

Odds ratios adjusted for following risk factors: age, weight, lifting at work, bending at work, support at work, psychosomatic distress status

4.3.6. Neck pain - Univariate analysis (Simple logistic regression)

In police drivers, significant association was found between increased prevalence of neck pain and following individual factors: middle weight group (OR = 0.53) and present or previous smoking (OR = 1.64).

From the physical factors, significant associations were found between increased prevalence of neck pain during the past 12 months and standing or walking for more than one hour per one working day (OR = 0.54), sitting for more than three hours per one working day (OR = 1.7) and prolonged sitting in previous job (OR = 1.67).

From the psychosocial factors in police drivers, there have been found significant association with lack of satisfaction at work (OR = 2.35), increasing psychosomatic

Table 4.28. Results of multivariate analysis (simple logistic regression) for the association between neck pain during the past 12 months and various individual risk factors in police drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Factors	Police drivers (n=365) OR (95% CI)
Age (yr)	
≤36	1.00 (-)
37-46	0.96 (0.31-3.00)
>46	1.03 (0.32-3.37)
Weight (kg)	
≤73	1.00 (-)
74-86	0.61 (0.17-2.22)
>87	1.19 (0.34-4.23)
Smoking status	
no smoking	1.00 (-)
smoker/ex-smoker	0.70 (0.27-1.84)
Standing or walking: ≥ 1hr/day	
no	1.00 (-)
yes	0.49 (0.11-2.24)
Sitting > 3h at work	
no	1.00 (-)
yes	1.64 (0.60-4.53)
Previous job with:	
Physical demands	
Sitting	2.55 (0.96-6.74)
Psychosomatic distress status	
healthy	1.00 (-)
medium	1.04 (0.35-3.07)
poor	3.58 (1.14-11.23)

distress (medium distress status: OR = 2.14, poor distress status: OR = 2.21) and poor energy and vitality status (OR = 2.51).

As well as in taxi drivers, in the populations of police drivers, univariate tests did not find any significant association between increased prevalence of neck pain experienced for at least one day during the past 12-months and any metrics of daily or cumulative exposure to driving.

The associations between the risk factors and neck pain experienced for at least one day during the past 12 months in police drivers are presented as odds ratios with 95% confidence interval in Appendix E (Table E7 and Table E8).

4.3.7. Neck pain - Multivariate analysis (Multivariate logistic regression)

Results from the standard multiple logistic regression, when all significant potential variables for neck pain outcomes and age were entered into the multivariate logistic model together to examine the contribution of all possible variables at the same time, are presented in Appendix E (Table E9 and E10).

In police drivers, the standard multiple logistic regression revealed that increased level of psychosomatic distress (poor distress status: OR = 3.58) were significantly associated with increased prevalence of neck pain when controlling for other variables presented in Table 4.28.

4.4. Cross-sectional baseline of police non-drivers

4.4.1. Description of the population

4.4.1.1. Individual information

In total, 485 questionnaires from police-non drivers were used in the cross-sectional baseline study of police employees from the Aberdeen Police Force.

From the total of 485 police employees classified as non-drivers, two hundred (41%) were males and 283 of the respondents (58%) were females. The median age was 42 years old with age range from 19 to 77 years. The median height of police non-drivers was 170 centimetres with range from 147 centimetres to 201 centimetres and the median weight was 76 kilograms with range from 45 kilograms to 149 kilograms. Thirty-four percent of non-drivers reported smoking or past smoking at least once a day for a month or longer where 12% reported current smoking. Seventy percent of police drivers reported regular practising of sport where the main part of them exercise one or two times per week.

Main individual characteristics of the population of police non-drivers are listed in Table 4.29. Individual characteristics are presented as median value and inter-quartile ranges as the main part of characteristics was not normally distributed (Kolmogonov-Smirnov test: age p = 0.05; BMI p = 0.00; height p = 0.00; weight p = 0.00).

Table 4.29. Individual characteristics of police non-drivers (cross-sectional baseline study). Data are given as median and interquartile range for age and anthropometric characteristics and as frequency (n) and percentage (%) for smoking, and physical activity

Individual risk factors	Non-drivers (n=485)
Age (yr)	42 (33-49)
Height (cm)	170.2 (162.6-177.8)
Weight (kg)	75.6 (64.8-88.2)
Body mass index (kg/m^2)	25.5 (23.1-28.5)
Smoking:	
non-smokers	317 (65)
ex-smokers/smokers	166 (34)
Physical activity	
no	152 (30)
yes	333 (70)

Complete data about individual information of non-drivers are listed in Appendix E (Table E1). Age and anthropometric information (height, weight, BMI) are divided into equal subgroups of police non-drivers as they will be use in statistical analysis.

4.4.1.2. Physical activities at present and previous job

From the total of 485, 32% of police non-drivers reported working for police force for more than 10 years and 37% reported working for more than 40 hours per working week. Police employees were asked how many times per an average working day they lift loads greater than 15 kilograms, lifting while back is in bent position, lifting while back is in twisted position and lifting wile back is in a bent and twisted. Twenty-eight percent of police non-drivers reported lifting at job, while 1% of them reported lifting a load for more than 10 times per day. When considering lifting while doing other movement (twisting, bending or twisting while bending), lifting while bending reported more than 10% of police non-drivers, lifting while twisting reported 7% of police non-drivers and lifting while bending and twisting reported more than 5% of police non-drivers, however only small part of them reported to do such a task for more than 10 times per day.

Police employees were also asked about frequency of performance such as bending (other than while lifting) and twisting (other than while lifting) during the average working day. From the 485 non-drivers, 82% reported not performing of bending at work and 90% not performing of twisting at job.

From the questionnaire information it was possible to derive that 49% of police non-drivers spent walking or standing for more than 1 hour per working day (32% stand or walk for 1-3 hours and 17% for more than 3 hours per working day).

When considering time which police non-drivers spent sitting (other than in the vehicle), 17% of non-drivers reported sitting from 1 to 3 hours per day and 76% reported sitting for more than 3 hours in total per working shift.

Previous job

From questionnaire was possible to identify driving, lifting and sitting performed in previous job(s). Thirty-one of non-drivers reported driving of vehicle in previous job for at least one year. Thirty percent of non-drivers reported previous heavy physical load at work (such as frequent heavy lifting) and 48% reported sitting in previous job(s).

Main physical characteristics of present and previous job of the population of police non-drivers are listed in Table 4.30.

Complete data about physical activities at present and previous job of non-drivers are listed in Appendix E,Table E2.

Table 4.30. Physical characteristics of work of police non-drivers (cross-sectional baseline study). Data are given as frequency (n) and percentage (%)

Physical risk factors	Non-drivers (n=485)
Lifting at work	
no	350 (72)
yes	135 (28)
Standing or walking at work:	
≥ 1h/day no	248 (51)
yes	235 (49)
Trunk bent at work	
no	396 (82)
yes	87 (18)
Trunk twisted at work	
no	437 (90)
yes	48 (10)
Sitting > 3h at work	
no	116 (24)
yes	369 (76)
Previous job with:	
Professional driving	148 (31)
Physical demands	146 (30)
Sitting	234 (48)

4.4.1.3. Psychosocial risk factors

Main psychosocial characteristics of the population of police non-drivers are listed in Table 4.31. Detailed information about classification and generalization of psychosocial risk factors are presented in the Chapter 3, paragraph 3.3.1.

Complete psychosocial data about non-drivers derived from the questionnaire are listed in Appendix E (Table E3 and Table E4).

4.4.2. Prevalence of health outcomes

4.4.2.1. Low back pain

Of the 485 non-drivers who responded to the questionnaire, 221 had experienced low back pain during the past 12 months and lasted more than one day (12-months prevalence: 46% (41-50.1%)), 100 had experienced low back pain during the past 4 weeks (4-weeks prevalence: 21% (16.5-24.3%)) and 54 had experienced low back pain during the past 7 days (7-days prevalence: 11% (8.3-14%)) See (Figure 4.5.).

Table 4.31. Psychosocial factors of police non-drivers (cross-sectional baseline study). Data are given and as frequency (n) and percentage (%) for psychosocial factors at work and as median and inter-quartile range of total score for psychosocial status (mental health, energy and vitality, psychosomatic distress status)

Psychosocial risk factors	Non-drivers (n=485)
No choice and decision at work:	
- how to work	120 (25)
- what to do at work	173 (36)
- timetables and breaks	119 (25)
Support from colleagues	
yes	421 (87)
Satisfaction at job	427 (88)
Mental health status	24 (21-26)
Energy and vitality status	16 (13-18)
Psychosomatic distress status	1 (1-3)

All participants experiencing low back pain during the past 12 months have replied also additional questions about low back pain symptoms. Of the 485 non-drivers, 31% reported acute low back pain (pain present for less than 30 days) and 14% experienced low back pain for more than 30 days. Eleven percent of non-drivers visited a doctor and 2% reported longer time taken off from work due to low back pain.

Forty-six percent of the non-drivers who had experienced low back pain during the past 12 months reported a sudden onset of low back pain. As common performance when pain suddenly arrived were lifting, bending, and participation in sport. Eleven percent of non-drivers had an accident to their back that required a medical advice. As the most common type of accident were heavy lifting, car accidents, falls, and sport events.

Information about how low back pain was affecting participants' daily life during the past 4 weeks was used for estimation of disability due to low back pain. Participants who replied positively on more than half questions of the Rolland and Morris questionnaire were identified as disabled due to low back pain. In the cross-sectional study from the total of 485 of police non-drivers, 2% complained of disability due to low back pain.

All information about presence and duration of low back pain, a visit of doctor and days off work due to low back pain, an onset of low back pain, possible accidents hurting low back and a disability due to low back pain are listed in Table 4.32.

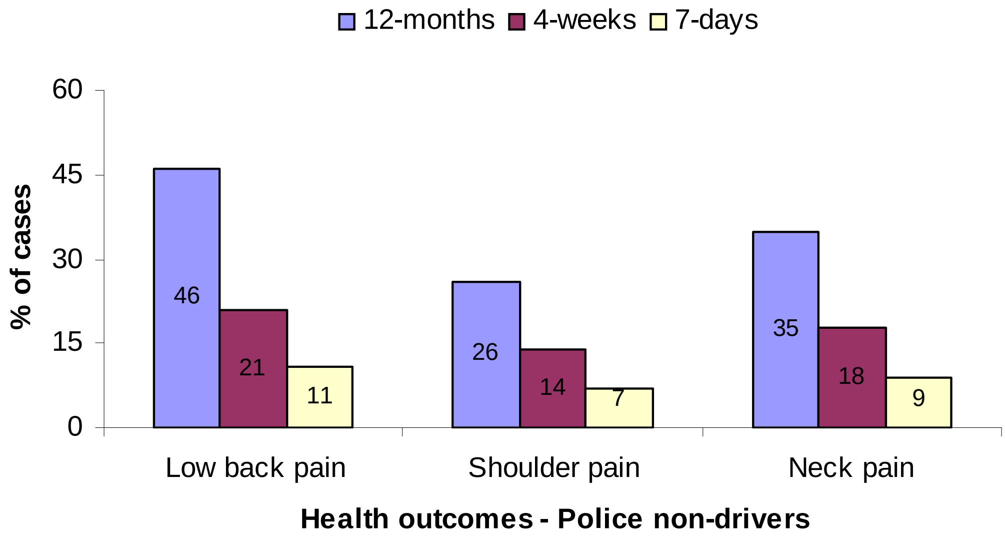


Figure 4.5. Prevalence of low back pain, shoulder pain and neck pain among police non-drivers (cross-sectional baseline study)

4.4.2.2. Prevalence of shoulder pain and neck pain

Police non-drivers also reported other health outcomes, such as shoulders pain and neck pain. Of the 485 subjects who responded to the questionnaire, 124 reported shoulder pain during the past 12 months (12 months prevalence: 26%), 63 reported shoulder pain during the past 4 weeks (4 weeks prevalence: 14%) and 32 reported shoulder pain during the past 7 days (7 days prevalence: 7%) (See Figure 4.5.).

Of the 485 respondents 170 reported neck pain during the past 12 months (12 months prevalence: 35%), 86 reported neck pain during the past 4 weeks (4 weeks prevalence: 18%) and 45 experienced neck pain during the past 7 days (7 days prevalence: 9%) (See Figure 4.5).

4.4.3. Low back pain - Univariate analysis (Simple logistic regression)

Each risk factor (i.e. individual, physical or psychosocial) was entered into simple logistic regression to evaluate the possible relationship to low back pain experienced for at least one day during the past 12 months.

4.4.3.1. Individual factors

Age

By using of univariate analysis was found that prevalence of low back pain experienced at least one day during the past 12 months had tendency to increase with increasing age of

Table 4.32. Prevalence of health symptoms in the total sample of non-drivers (cross-sectional baseline study)

Outcome	Non-drivers (n=485) (%)
LBP in the previous 12 months	46
LBP in the previous 4 weeks	21
LBP in the previous 7 days	11
Episodes of acute LBP in the previous 12 months	31
Episodes of sciatica in the previous 12 months	14
Duration of LBP > 30 d/yr in the previous 12 months	14
High pain intensity in the lower back in the previous 7 days (Von Korf pain scale score > 5)	4
Disability due to the last episode of LBP (Roland & Morris disability scale score ≥ 12)	2
Visit to a doctor for LBP in the previous 12 months	12
Sick leave > 7 days due to LBP in the previous 12 months	2
Onset of LPB	
Gradual	24
Sudden outside work	15
Sudden at work	6
Accident requiring medical advice	11
Type of accident	
Vehicle accident	2
Heavy lifting	1
Fall	1
Spinal injury	1
Sport	1

non-drivers. There was found a significant association between increased prevalence of low back pain and higher age (OR = 1.86).

Gender

Being a male showed significant associations with increased prevalence of low back pain in population of non-drivers (OR = 1.86).

Height

Significantly increased prevalence of low back pain during the past 12 months was found with increasing stature (middle stature group: OR = 1.61, high stature OR = 2.43).

Weight

The prevalence of low back pain during the past 12 months had a significant tendency to increase with increasing weight (middle weight group OR = 1.68, heavy group: OR = 1.98).

BMI

The combination of anthropometrics information revealed increased prevalence of low back pain with increasing BMI. However, there was not found any significant association with prevalence of low back pain during the past 12 months.

Smoking

There was not found any association between prevalence of low back pain during the past 12 months and smoking or ex-smoking in non-drivers.

Sport

There was not found any association between prevalence of low back pain and participation in any kind of sport in non-drivers.

The individual associations between the individual risk factors and low back pain experienced for at least one day during the past 12 months in police non-drivers are presented as odds ratios with 95% confidence interval in Table 4.33.

4.4.3.2. <u>Physical factors</u>

Duration of work

Working for police force for more than 40 hours per one working week showed a significant association with increased prevalence of low back pain in police non-drivers (OR = 1.62).

Lifting

Lifting at work together with other awkward postures held while lifting (i.e. lifting while bending or twisting, lifting while bending while twisting the trunk) were not found to be significantly related to prevalence of low back pain during the past 12 months.

Bending and twisting

Prevalence of low back pain showed tendency to increase significantly with bending at work (OR = 1.70). For performance of bending at work, a significant association with increased prevalence of low back pain in non-drivers was not found.

Standing or walking

There was not found any significant association between increased prevalence of low back pain and standing or walking for more than one hour per day at work.

Sitting

As well as for walking or standing, there was not found any significant association between increased prevalence of low back pain and sitting (while not driving) for more than three hours per day at work in police non-drivers.

Previous job(s)

In the univariate analyses were followed information about previous job(s). Characteristics of previous job (i.e. previous professional driving, previous physical demands and previous sitting) did not show any associations with prevalence of low back pain during the past 12 months.

Table 4.33. Results of univariate analysis (simple logistic regression) for the association between low back pain during the past 12 months and various individual risk factors in police non-drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Individual risk factors		Non-drivers (n=485) OR (95% CI)
Age (yr)		
	≤ 36	1.00 (-)
	37-46	1.53 (0.98-2.40)
	> 46	1.86 (1.19-2.89)
Gender		
	female	1.00 (-)
	male	1.86 (1.29-2.68)
BMI (kg/m^2)		
	≤ 24.34	1.00 (-)
	24.35-27.28	1.22 (0.78-1.92)
	> 27.29	1.49 (0.96-2.31)
Height (cm)		
	≤ 170.18	1.00 (-)
	170.19-177.8	1.61 (1.02-2.52)
	> 177.8	2.43 (1.54-3.82)
Weight (kg)		
	≤ 73	1.00 (-)
	74-86	1.68 (1.08-2.62)
	> 87	1.98 (1.26-3.10)
Smoking status		
	no smoking	1.00 (-)
	smoker/ex-smoker	1.16 (0.80-1.69)
Regular practising of sport		
	no	1.00 (-)
	yes	0.99 (0.66-1.48)

The individual associations between the physical risk factors and low back pain experienced for at least one day during the past 12 months in police non-drivers are presented as odds ratios with 95% confidence interval in Table 4.34.

Table 4.34. Results of univariate analysis (simple logistic regression) for the association between low back pain during the past 12 months and various work-related physical risk factors in police non-drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Physical risk factors		Non-drivers (n=485)
		OR (95% CI)
Duration of work: ≥ 40hrs/week		
	no	1.00 (-)
	yes	1.62 (1.12-2.35)
Lifting at work		
	no	1.00 (-)
	yes	0.90 (0.60-1.34)
Lifting while bending at work		
	no	1.00 (-)
	yes	1.23 (0.69-2.19)
Lifting while twisting at work		
	no	1.00 (-)
	yes	1.78 (0.86-3.70)
Lifting while bending and twisting at work		
	no	1.00 (-)
	yes	1.64 (0.74-3.66)
Standing or walking: ≥1h/day		
	no	1.00 (-)
	yes	0.85 (0.59-1.21)
Trunk bent at work		
	no	1.00 (-)
	yes	1.70 (1.06-2.71)
Trunk twisted at work		
	no	1.00 (-)
	yes	1.11 (0.61-2.02)
Sitting > 3h at work		
	no	1.00 (-)
	yes	0.88 (0.55-1.39)
Previous job with:		
	Professional driving	1.02 (0.69-1.51)
	Physical demands	0.95 (0.65-1.41)
	Sitting	0.92 (0.64-1.31)

4.4.3.3. Psychosocial factors

Decision to perform various working tasks

No choice in decision how to perform work and what to do at work were not associated with increased risk for low back pain experienced during the past 12 months.

Support and satisfaction at work

Low support and satisfaction at work were associated with increased prevalence of low back pain. However, they did not show any significant associations with increased risk of presence of low back pain in non-drivers during the past 12 months.

Table 4.35. Results of univariate analysis (simple logistic regression) for the association between low back pain during the past 12 months and various psychosocial risk factors in police non-drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Psychosocial risk factors	Non-drivers (n=485)
	OR (95% CI)
Choice and decision at work:	
- how to work	
yes	1.00 (-)
no	1.15 (0.76-1.74)
- what to do at work	
yes	1.00 (-)
no	0.94 (0.65-1.37)
- timetables and breaks	
yes	1.00 (-)
no	0.92 (0.60-1.39)
Support from colleagues	
yes	1.00 (-)
low support	1.41 (0.79-2.55)
Satisfaction at job	
yes	1.00 (-)
no	1.50 (0.86-2.62)
Mental health status	
healthy	1.00 (-)
medium	0.77 (0.48-1.23)
poor	1.00 (0.62-1.63)
Energy and vitality status	
healthy	1.00 (-)
medium	0.92 (0.57-1.48)
poor	1.33 (0.84-2.10)
Psychosomatic distress status	
healthy	1.00 (-)
medium	1.39 (0.90-2.13)
poor	1.86 (1.19-2.91)

Distress, Mental health and Energy/Vitality

The occurrence of low back pain during the past 12 months tended to increase with increasing level of psychosomatic distress. Significant associations were found between low back pain experienced during the past 12 months and high level of psychosomatic distress (OR = 1.86).

The individual associations between the psychosocial risk factors and low back pain experienced for at least one day during the past 12 months in police non-drivers are presented as odds ratios with 95% confidence interval in Table 4.35.

4.4.4. Low back pain - Multivariate analysis (Multivariate logistic regression)

Upon completion of the simple logistic regression, variables were selected for multivariate analysis. Variables whose significance had a *p*-value less than 0.05 were considered as candidate for the multivariate analysis together with other variables of known biological importance.

4.4.4.1. Correlation between independent variables

The multicollinearity and the singularity of significant independent variables were checked for all variables selected for multivariate analysis.

By using of cross-tabulations was not found any associations between variables selected for further statistical analysis.

Table 4.36 shows significant variables selected by univariate analysis in police non-drivers.

Table 4.36. Significant variables selected by univariate analysis, variables excluded from the further multivariate logistic regression and variables of known biological importance in the cross-sectional baseline of non-drivers

Variables selected by univariate analysis	Variables excluded from multivariate analysis	Variables of known biological importance	Variables suitable for multivariate analysis
Age Gender Height Weight ≥40 hrs/week of work Bending Distress status	n.a.	n.a.	Age Gender Height Weight ≥40 hrs/week of work Bending Distress status

4.4.4.2. Standard multiple logistic regression

Results from the standard multiple logistic regression, when all significant variables for low back pain outcomes were entered into the multivariate logistic model together to examine the contribution of all possible variables at the same time, are presented in Table 4.37. The individual associations between the variables and low back pain experienced for at least one day during the past 12 months are presented as odds ratios with 95% confidence interval.

Table 4.37. Results of multivariate analysis (standard and stepwise multiple logistic regression) for the association between low back pain during the past 12 months and various individual, physical and psychosocial risk factors in non-drivers in the cross-sectional baseline study. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Risk factors	Police non-drivers (n=485)	
	Standard multiple logistic regression	Stepwise multiple logistic regression
	OR (95% CI)	OR (95% CI)
Age (yr)		
≤ 36	1.00 (-)	n.a.
37-46	1.45 (0.88-2.39)	
> 46	2.05 (1.24-3.39)	
Gender		
male	1.00 (-)	n.a.
female	0.74 (0.38-1.44)	
Height (cm)		
≤ 170.18	1.00 (-)	1.00 (-)
170.19-177.8	1.60 (0.88-2.93)	1.64 (1.03-2.61)
> 177.8	2.78 (1.31-5.92)	2.71 (1.68-4.36)
Weight (kg)		
≤ 73	1.00 (-)	n.a.
74-86	1.22 (0.70-2.11)	
> 87	0.90 (0.49-1.64)	
Duration of work: ≥ 40 hrs/week		
no	1.00 (-)	n.a.
yes	1.57 (0.99-2.51)	
Trunk bent at work		
no	1.00 (-)	1.00 (-)
yes	1.98 (1.18-3.29)	1.60 (1.13-3.04)
Psychosomatic distress status		
healthy	1.00 (-)	1.00 (-)
medium	1.61 (1.01-2.56)	1.45 (0.92-2.28)
poor	2.01 (1.23-3.28)	1.85 (1.16-2.96)

In the multivariate logistic regression model of the non-driving population, significant associations were found between low back pain and an older age of participants (OR = 2.05), being tall (OR = 2.78), working for more than 40 hours per week (OR = 1.57), performing bending at work (OR = 1.98), and a higher level of psychosomatic distress (medium distress status OR = 1.61; poor distress status OR = 2.01).

4.4.4.3. Stepwise multiple logistic regression

Stepwise multiple logistic regression was used to identify the subset of independent variables having the strongest relationship to low back pain experienced for at least one day during the past 12 months (dependent variable). In this step of the statistical analysis only variables that had been found to be significantly related with low back pain during the past 12 months in the simple logistic regression were used. The final results of the stepwise multiple logistic regression are presented in Table 4.37.

In the non-driving population, increasing height (middle stature OR = 1.64; high stature OR = 2.71), bending (OR = 1.60) and high psychosomatic distress (OR = 1.85) were predictors of low back pain.

4.4.5. Neck pain - Univariate analysis (Simple logistic regression)

In police non-drivers there was not found significant association between increased prevalence of neck pain and any of the individual risk factors.

From the physical factors, significant associations were found between decreased prevalence of neck pain during the past 12 months and working as the police employee for more than 40 hours per one working week (OR = 0.65) and between increased prevalence of neck pain during the past 12 months and physical demands in previous job (OR = 1.54).

From the psychosocial factors in police non-drivers, there have been found significant association with low support at work (OR = 1.81), increasing level of psychosomatic distress (medium distress status: OR = 2.84, poor distress status: OR = 6.07), poor energy and vitality status (OR = 2.9) and poor mental health status (OR = 2.22).

The associations between the risk factors and neck pain experienced for at least one day during the past 12 months in police non-drivers are presented as odds ratios with 95% confidence interval in Appendix E (Table E7 and Table E8).

4.4.6. Neck pain - Multivariate analysis (Multivariate logistic regression)

Results from the standard multiple logistic regression, when all significant potential variables for neck pain outcomes and age were entered into the multivariate logistic model together to examine the contribution of all possible variables at the same time, are presented in Appendix E (Table E9 and Table E10).

In police non-drivers, the standard multiple logistic regression revealed that working for more than 40 hours per week (OR = 0.63), physical demands previous job (OR = 1.46) and increased psychosomatic distress levels (medium distress status: OR = 2.57, poor distress status: OR = 5.39) were significantly associated with increased prevalence of neck pain when controlling for other variables listed in Table 4.38.

Table 4.38. Results of multivariate analysis (simple logistic regression) for the association between neck pain during the past 12 months and various individual risk factors in the police non-drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Factors	Non-drivers (n=485)
	OR (95% CI)
Age (yr)	
≤ 36	1.00 (-)
37-46	1.57 (0.93-2.66)
> 46	1.29 (0.78-2.15)
Duration of work: ≥ 40hrs/week	
no	1.00 (-)
yes	0.63 (0.40-0.99)
Previous job with:	
Physical demands	1.46 (0.94-2.27)
Support from colleagues	
yes	1.00 (-)
low support	1.65 (0.85-3.18)
Psychosomatic distress status	
healthy	1.00 (-)
medium	2.57 (1.54-4.31)
poor	5.39 (3.21-9.05)

4.5. Differences of the study populations

4.5.1. Individual characteristics

Descriptive statistical analysis of individual information (i.e. age, anthropometrics, smoking habits and leisure activity exposure) showed that there are significant differences between population of taxi drivers, police drivers and non-drivers and also between non-drivers divided into males and females. (See Table 4.39. and Table 4.40.) Individual characteristics are reported in median values and interquartile ranges as the Kolmogonov-Smirnov test of normality revealed not normal distribution of main part of individual characteristics in all investigate populations.

4.5.2. Physical activities at work

Present job

Preliminary data analysis showed that there were statistically significant differences between amount of lifting, bending, twisting, walking for more than one hour per day and sitting (other while driving) in all three populations and also between non-drivers divided into males and females. When compared physical activities of driving populations amount of bending and sitting (other while driving) did not differ between police drivers and taxi

Table 4.39. Differences in individual characteristics of taxi drivers, police drivers and non-drivers (cross-sectional baseline study). Data are given as median and interquartile range for age and anthropometric characteristics and as frequency (n) and percentage (%) for smoking, and physical activity

Individual risk factors	Study populations		
	Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
Age (yr)	51 (41-58)	37 (32-43)[b]	42 (33-49)[a]
Height (cm)	175.3 (170.2-177.8)	177.8 (172.7-182.9)[b]	170.2 (162.6-177.8)[a]
Weight (kg)	84.6 (76.4-97.1)	81.9 (72.5-89.6)[b]	75.6 (64.8-88.2)[a]
Body mass index (kg/m^2)	27 (25-30.8)	25.6 (23.4-27.5)[b]	25.5 (23.1-28.4)[a]
Smoking:			
non-smokers	80 (38)	256 (70)	317 (65)
ex-smokers/smokers	127 (61)	108 (30)[d]	166 (34)[c]
Physical activity			
no	123 (59)	81 (22)	152 (30)
yes	86 (41)	284 (78)[d]	333 (70)[c]

Kruskal-Wallis Test: [a]p<0.05 (all populations), [b]p<0.05 (taxi drivers, police drivers)
Chi-Square Test: [c]p<0.05 (all populations), [d]p<0.05 (taxi drivers, police drivers)

Table 4.40. Individual characteristics of police non-drivers divided into males and females (cross-sectional baseline study). Data are given as median and interquartile range for age and anthropometric characteristics and as frequency (n) and percentage (%) for smoking, and physical activity

Individual risk factors	Males (n=200)	Females (n=282)
Age (yr)	44 (38-50)	40 (31-48)[a]
Height (cm)	180 (175-182)	165 (160-167)[a]
Weight (kg)	85.5 (80-94)	66.2 (60.3-75.6)[a]
Body mass index (kg/m^2)	26.44 (24.5-26.44)	24.58 (22.12-24.49)
Smoking:		
non-smokers	127 (63)	189 (67)
ex-smokers/smokers	73 (37)	93 (33)
Physical activity		
no	51 (25)	79 (28)
yes	149 (75)	204 (72)

Kruskal-Wallis Test: [a]$p<0.05$
Chi-Square Test: [b]$p<0.05$

drivers (See Table 4.41 and table 4.42.).

Previous job

Characteristics of previous job (i.e. previous driving, previous sitting and previous exposure to physical demands) showed statistical differences between all investigated populations and also between non-drivers divided into males and females. There were found significant differences in previous exposure to sitting when compared only populations of drivers (See Table 4.41. and Table 4.42.).

Driving information

There have been found significant differences in driving exposure expressed in different metrics (except duration of driving expressed in years) between taxi drivers and police drivers. Daily exposure to driving expressed in hours, *e*VDV and A(8) and cumulative exposure to driving expressed in *e*VDV and total number of driven hours were significantly higher in taxi drivers than in police drivers (See Table 4.43.).

Table 4.41. Differences in physical characteristics of work of taxi drivers, police drivers and non-drivers (cross-sectional baseline study). Data are given as frequency (n) and percentage (%)

Physical risk factors	Study populations		
	Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
Lifting at work			
no	32 (15)	146 (41)	350 (72)
yes	177 (85)	218 (59)[b]	135 (28)[a]
Standing or walking (≥ 1h/day)			
no	115 (55)	59 (16)	248 (51)
yes	94 (45)	304 (84)[b]	235 (49)[a]
Trunk bent at work			
no	156 (75)	245 (67)	396 (82)
yes	53 (25)	119 (33)	87 (18)[c]
Trunk twisted at work			
no	162 (77)	285 (78)	437 (90)
yes	47 (23)	80 (22)	48 (10)[a]
Sitting > 3h at work			
no	121 (58)	240 (66)	116 (24)
yes	88 (42)	125 (34)	369 (76)[c]
Previous job with:			
Professional driving	75 (36)	152 (42)	148 (31)[a]
Physical demands	142 (68)	177 (49)[b]	146 (30)[a]
Sitting	84 (40)	122 (33)	234 (48)[a]

Chi-Square Test: [a]p<0.05 (all populations), [b]p<0.05 (taxi drivers, police drivers)

4.5.3. Psychosocial variables

There have been found significant differences in psychosocial factors at work (i.e. choice and decision, support from colleagues and satisfaction at job). On overall, complete decision how to work, what to do at work and how to choose a timetable was reported by taxi drivers as they are often self-employed and they work alone.

All populations also significantly differed in the level of experienced psychosomatic distress. Highest scores of psychosomatic distress were found in taxi drivers followed by non-drivers and police drivers (See Table 4.44 and Table 4.45.).

4.5.4. Health outcomes

There have not been found significant differences between health outcomes (i.e. different characteristics of low back pain, neck pain and shoulder pain) in population of taxi drivers and police drivers.

Table 4.42. Physical characteristics of work of police non-drivers divided into males and females (cross-sectional baseline study). Data are given as frequency (n) and percentage (%)

Physical risk factors	Males (n=200)	Females (n=282)
Lifting at work yes	71 (36)	63 (22)[a]
Standing or walking at work: ≥ 1h/day yes	119 (60)	115 (41)[a]
Trunk bent at work yes	30 (15)	57 (20)
Sitting > 3h at work yes	159(80)	237 (84)
Previous job with:		
Professional driving	107 (54)	41 (15)[a]
Physical demands	87 (44)	58 (21)[a]
Sitting	80 (40)	154 (54)[a]

Chi-Square Test: [a]$p<0.05$ (all populations)

There have been found significant differences between low back pain experienced for at least one day during the past 4 weeks and 7 days and duration of low pack pain episode when compared all three populations (i.e. taxi drivers, police drivers and non-drivers). Police-non drivers reported less episode of low back pain and shorter duration of days off work due to low back pain (See Table 4.46.).

Table 4.43. Measures of daily and cumulative exposure to whole-body vibration in taxi drivers and police drivers at the cross-sectional baseline study. Data are given as median and inter-quartile range

Measures of daily vibration exposure	Driver groups	
	Taxi drivers (n=209)	Police drivers (n=365)
Daily driving time (h)	8 (6-10)	2.7 (1.6-4)[a]
$A_{dom}(8)$ (ms^{-2} r.m.s.)	0.43 (0.33-0.56)	0.27 (0.2-0.31)[a]
$eVDV_{dom}$ ($ms^{-1.75}$)	8.34 (7.7-9.1)	6.3 (5.5-6.7)[a]
Duration of exposure (yr)	10 (5-18)	7.2 (6.3-8)
$\sum[t_i]$ (h $\times 10^3$)	14.4 (7.1-26.2)	4.7 (1.9-9.7)[a]
$eVDV_{Total\text{-}dom}$ ($ms^{-1.75}$)	54.9 (46-64.6)	39.7 (31.5-47.7)[a]

Kruskal-Wallis Test: [a]$p<0.05$ (taxi drivers, police drivers)

Table 4.44. Differences in psychosomatic factors of taxi drivers, police drivers and non-drivers (cross-sectional baseline study). Data are given as frequency (n) and percentage (%) for psychosocial factors at work and as median and inter-quartile range of total score for psychosocial status

Psychosocial risk factors	Study populations		
	Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
No choice and decision at work:			
- how to work	23 (11)	69 (19)[d]	120 (25)[c]
- what to do at work	31 (15)	113 (31)[d]	173 (36)[c]
- timetables and breaks	3 (1)	131 (36)[d]	119 (25)[c]
Support from colleagues			
yes	88 (43)	320 (88)[d]	421 (87)[c]
not applicable	69 (33)		
Satisfaction at job	191 (91)	319 (87)	427 (88)
Mental health status	24 (21-27)	24 (21-27)	24 (21-26)
Energy and vitality status	15 (12-18)	16 (13-19)[b]	16 (13-18)
Psychosomatic distress status	4 (2-6)	1 (0-2)[b]	1 (1-3)[a]

Kruskal-Wallis Test: [a]p<0.05 (all populations), [b]p<0.05 (taxi drivers, police drivers)
Chi-Square Test: [c]p<0.05 (all populations), [d]p<0.05 (taxi drivers, police drivers)

There have been found significant differences between prevalence of health symptoms in the total sample of non-drivers divided into males and females (See Table 4.47.).

Table 4.45. Psychosocial factors of police non-drivers divided into males and females (cross-sectional baseline study). Data are given and as frequency (n) and percentage (%) for psychosocial factors at work and as median and inter-quartile range of total score for psychosocial status (mental health, energy and vitality, psychosomatic distress status)

Psychosocial risk factors	Females (n=200)	Males (n=282)
No choice and decision at work:		
- how to work	40 (20)	81 (29)
- what to do at work	58 (29)	115 (41)
- timetables and breaks	45 (22)	75 (27)
Support from colleagues		
yes	170 (85)	249 (88)
Satisfaction at job	179 (90)	246 (87)
Mental health status	25 (22-26)	24 (21-26)
Energy and vitality status	16 (14-19)	15 (13-18)
Psychosomatic distress status	1 (1-3)	1 (1-3)

Table 4.46. Prevalence (cross-sectional baseline study) of health symptoms in the total sample of taxi drivers, police drivers and non-drivers

Outcome	Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
	(%)	(%)	(%)
LBP in the previous 12 months	45	53	46
LBP in the previous 4 weeks	29	35	21[a]
LBP in the previous 7 days	19	19	11[a]
Episodes of acute LBP in the previous 12 months	28	33	31
Episodes of sciatica in the previous 12 months	14	13	14
Duration of LBP > 30 d/yr in the previous 12 months	17	20	14[a]
High pain intensity in the lower back in the previous 7 days (Von Korf pain scale score > 5)	7	4	4
Disability due to the last episode of LBP (Roland & Morris disability scale score ≥ 12)	5	4	2
Visit to a doctor for LBP in the previous 12 months	12	12	12
Sick leave > 7 days due to LBP in the previous 12 months	8	3[b]	2[a]
Onset of LPB			
Gradual	23	27	24
Sudden outside work	11	17	15
Sudden at work	10	9	6
Accident requiring medical advice	13	13	11
Type of accident			
Vehicle accident	5	2	2
Heavy lifting	2	3	1
Fall	0	2	1
Spinal injury	3	1	1
Sport	0	1	1

Chi-Square Test: [a]$p<0.05$ (all populations), [b]$p<0.05$ (taxi drivers, police drivers)

Prevalence ratios of different health outcomes in all populations are listed in Table 4.48.

Table 4.47. Prevalence of health symptoms in the total sample of non-drivers divided into males and females (cross-sectional baseline study)

Outcome	Males (n=200)	Females (n=282)
	(%)	(%)
LBP in the previous 12 months	43	49
LBP in the previous 4 weeks	20	23
LBP in the previous 7 days	10	13
NP in the previous 12 months	36	34
SP in the previous 12 months	24	27

Table 4.48. Prevalence ratios (PR) of health outcomes and 95% confidence intervals (95% CI) in population of taxi drivers, police drivers and non-drivers. As a reference categories were used prevalence of health outcomes in non-drivers

Health outcome	Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
	PR 95% CI	PR 95% CI	PR 95% CI
LBP in the previous 12 months	0.98 0.71-1.35	1.15 0.92-1.82	1.00
LBP in the previous 4 weeks	1.38 0.93-2.01	1.67 1.10-2.27	1.00
LBP in the previous 7 days	1.73 1.17-2.86	1.73 1.18-2.85	1.00
Episodes of acute LBP in the previous 12 months	0.90 0.69-1.30	1.07 0.74-1.45	1.00
Episodes of sciatica in the previous 12 months	1.00 0.64-1.64	0.95 0.63-1.41	1.00
Duration of LBP > 30 d/yr in the previous 12 months	1.21 0.82-2.00	1.43 0.14-1.37	1.00
High pain intensity in the lower back in the previous 7 days (Von Korf pain scale score > 5)	1.75 0.81-2.15	1.00 0.53-2.09	1.00
Disability due to the last episode of LBP (Roland & Morris disability scale score ≥ 12)	2.50 1.19-6.14	2.00 0.9-4.92	1.00
Visit to a doctor for LBP in the previous 12 months	1.00 0.63-1.73	1.00 0.69-1.61	1.00
NP in the previous 12 months	0.94 0.65-1.29	0.86 0.61-1.09	1.00
NP in the previous 4 weeks	1.17 0.80-1.81	0.94 0.65-1.34	1.00
NP in the previous 7 days	1.44 0.92-2.51	1.11 0.65-1.66	1.00
SP in the previous 12 months	1.08 0.80-1.65	1.12 0.88-1.62	1.00
SP in the previous 4 weeks	1.07 0.67-1.67	1.21 0.87-1.82	1.00
SP in the previous 7 days	1.71 0.91-3.21	1.29 0.78-2.19	1.00

4.6. Discussion of the cross-sectional baseline studies of taxi drivers, police drivers and police non-drivers

4.6.1. Presence of bias and limitation of the study

Epidemiological studies with cross-sectional study design are susceptible to bias which may affect the interpretation of results from the study. The assessment of exposure to risk factors after the onset of a health outcome brings the bias in possible wrong decision of the association between the health outcome and the risk factor. Exposure to some of the risks could arise as a consequence of the health problem rather causing the problem. Although the results of a cross-sectional study do not show the direction of a relationship between disease and risk factors but they can point on the importance of the relationship which needs to be investigated in the cohort study.

4.6.1.1. Selection bias

One of the main types of bias, called selection bias, may occur if the group of followed subjects is not a representative sample of the studied population about which the conclusion is drawn.

In this study, the presence of selection bias may arise by pooling population of taxi drivers and police drivers into one group of drivers. All of the populations significantly differ from each other in many individual, physical and psychosocial characteristics. By pooling of populations, the effect of some variables on presented health outcome may be suppressed. Therefore, in this study the presence of this type of bias was eliminated by investigating of three different populations separately (taxi drivers, police drivers and police non-drivers).

Response rate

The existence of selection bias is possible when the response rate of the study is too low. In this study, the presence of this type of selection bias was minimised by performance of reminder round where participants who did not reply to the initial questionnaire were contacted. The performance of the reminder raised the response rate by more than ten percent in taxi drivers. Unfortunately, it was not possible to perform the direct reminder round in the population of police drivers as the Police Force was worried of loosing of workers confidentiality. However, the reminder in a form of formal letter was published on the internal website. From the date of delivered responses was possible to estimate that the reminder raised the response rate by more than eight percent.

Non-response bias

Selection bias may also arise if people disabled by low back pain are more motivated to participate in the study than people who are healthy. Main approach how to avoid the low motivation of healthy respondents to participate in the study was including of questions about different health outcomes (i.e. neck pain, shoulder pain) which were not the major direction of the search at the beginning of the study. The inclusion of questions about other health problems supposed to have a masking effect so the responder will be not directly influenced. To check if the presence of this type of bias was eliminated, the subgroup of earlier respondents in taxi drivers and police employees was compared to the subgroup of later respondents. Because there was not found any significant differences in health outcomes and general characteristics in both subgroups the presence of this type of selection bias was excluded.

4.6.1.2. Information bias

Errors in obtaining information from participants, underestimation or overestimation of the health outcome of exposure to variables causing or aggravating the health outcomes may be other cause of bias presented in the epidemiological study.

Measurement bias

The presence of measurement bias may arise by using of inappropriate techniques to cumulate the data from participants. In this study the presence of this type of bias was eliminated by using of self-administered questionnaire which has been validated in previous epidemiological studies. The questions were formulated in the way to be clear, short, not confuse the participant and not give the possibility of multiple answers. In all investigated populations was used the same questionnaire (there was only small modification in type of driven vehicle at the job) and coding of all information was performed on the same level (except driving information where have been found significant differences in taxi drivers and police drivers).

Some of the participants may be influenced by the general knowledge about the nature of low back pain and its possible risk factors. From previous studies was suggested that the most likely overestimated activities are lifting activities and other physical activities such as bending or twisting. In this study, the presence of the working activity was treated as YES or NO and therefore there is no reason to suspect overestimation in working activities such as lifting, twisting, bending, etc. However, there is possible the presence of inaccurate assessment of whole-body vibration exposure to which drivers are exposed. Taxi drivers and police drivers have reported their driving exposure in hours per one working week and any possible overestimation of the duration cause the overestimation in calculation of whole-body vibration doses. Generally, the presence of inaccurate assessment of vibration exposure may be caused by the uncertainty in the evaluation of the vibration magnitude (measurement in the field condition) and in the evaluation of duration to driving (reported by each driver by self-administered questionnaire). In the study of Pinto and Stacchini (2006) was revealed that the main uncertainty of evaluation was the presence of differences of machines characteristics and different working cycles. The overall relative uncertainty *p* in their whole-body vibration field assessment was in the range from 14 to 32%.

Recall bias

One of the other possible reasons for presence of recall bias is recall time. It is complicated to detect and eliminated recall bias. In the cross-sectional type of the study, subjects report their exposure history to different variables after the development of the health problem. Therefore individuals who have experienced low back pain may tend to remember better the exposure to possible risk factors for low back pain than participants who were not affected by this health problem.

Healthy worker effect

There may be also a possibility that the health problem developed in some participants in the previous jobs where they have been exposed to possible increased exposure of lifting, walking, driving, etc. This type of effect is known as secondary healthy worker effect. The inclusion of questions about previous profession and exposure to sitting, heavy physical load and driving provided control of this effect of bias in the study.

4.6.1.3. Confounding bias

Possible bias called confounding bias may arise if the effect of the risk factor on the health outcome is influenced by presence of other variable which is associated together with the heath outcome and the risk factor. In this study, the presence of the confounding of the bias was eliminated by the choice of the right statistical approach and by eliminating the effect of confounders from the final statistical approach.

4.6.1.4. Other limitations

One of the limitations of this research may be a low number of subjects (especially taxi drivers) participating in this study. Initially almost nine hundred of taxi drivers and more than two thousand of police employees were contacted. Although, there was performed a reminder round of the questionnaire the response rate of all populations was relatively low in comparison to previously published studies. The response rate in epidemiological studies depends on the methods how was the information collected. By using of direct interview or phone interview naturally results higher response rate of participants than when using of self-administered questionnaire. The response rate form epidemiological studies on low back pain vary from 42% to 91% (Burdorf, 1989; Boshuizen *et al.*, 1990; Bovenzi *et al.*, 2002; Palmer *et al.*, 2003). In this study, the low response rate in police employees may be explained by the lack of direct reminder round which was not approved by the Aberdeen Police Force. The low response rate in taxi drivers may be explained by different causes. Taxi drivers, who often work for more than eight hours per day, were not willing to answer the questionnaire which will take long time to fill in compare to police employees who replied to the questionnaire at work as all the correspondence was carried by internal post. From the Legal and Democratic Services was confirmed that main part of the taxi drivers in the City of Southampton has a non-European origin. From the low response rate of non-European origin taxi drivers it could be also hypothesised that non-native English speakers may have had problem with understanding some of the questions and filling in the questionnaire. There should be also accepted the loss of response in the delivering process as some of the information may have been lost by the post.

4.6.2. Prevalence of low back pain and other health outcomes

4.6.2.1. <u>Prevalence of low back pain</u>

The 12-month prevalence of low back pain in the cross-sectional baseline study of taxi drivers and police drivers was comparable to that found in other studies of driving populations. In this study, the police drivers (53% (48-58.6%) in the cross-sectional baseline study) reported higher 12-month prevalence of low back pain than taxi drivers (45% (38.3-51.7%) in the cross-sectional baseline study). Generally, epidemiological studies with cross-sectional or case-control designs and literature reviews of epidemiological studies report 40 to 60% of professional drivers with low back pain (Wikström *et al.*, 1994, Bovenzi *et al.*, 1999). A study by Magnusson *et al.* (1996) found that 50% of bus drivers and truck drivers reported low back pain. A study of fork-lift truck and freight-container tractor drivers by Boshuizen *et al*. (1992) found the prevalence of low back pain to be 51%. Also in later study of Torén *et al*. (2002) was reported similar prevalence of low back pain problems in tractor drivers (61%).

When considering professional car drivers, Pietri *et al.* (1992) found that 40% of car drivers reported low back pain in the past year, and Porter *et al.* (2002) found the one-year prevalence of low back pain among car drivers to be 45%. In the cross-sectional study of taxi drivers in China, Chen *et al.* (2004) found that 51% of urban taxi drivers reported low back pain in the past year. Also results from longitudinal study of Japanese taxi drivers performed by Funakoshi *et al.* (2003) showed one year prevalence of low back pain to be around 46%. On the other hand, there have been epidemiological studies reporting higher or lower prevalence of low back pain. In studies of Bovenzi *et al.* (1992, 1999) was found the prevalence of low back pain experienced during the past 12 months to be 84% in bus drivers and 91% in tractor drivers. Low prevalence of low back pain was reported in the study of Boshuizen *et al*. (1990), where only 31% of tractor drivers reported presence of low back pain during the past 12 months. Differences in observed occurrence of low back pain outcomes my result in different type of studies, different techniques of low back pain assessment and mainly in different definition of low back pain problems presented in the studies. Generally, prevalence of low back pain in taxi drivers and police drivers was comparable to that found in studies of VIBRISKS partners using the similar version of questionnaire. The prevalence of low back pain experienced for at least one day during the past 12 months varied from 40% to 58% in studies of bus drivers, agriculture and construction drivers, and forestry vehicle drivers performed in Italy, Nederland and Sweden. The comparison of results with VIBRISKS partners revealed that also presence of low back pain during the past seven days, episodes of acute low back pain, disability caused by low back pain and sick leave from job caused by low back pain in taxi drivers and police drivers felt in the range of prevalence values reported in bus drivers and agriculture and construction drivers.

The non-driving population, represented by police employees who reported less than 5 hours of driving per working week, had a similar 12-month prevalence of low back pain (46% (41-50.1%) in the baseline cross-sectional study) to the population of taxi drivers. The prevalence of low back pain in the police non-driving population is consistent with the 12-month or life-time prevalence reported in other epidemiological studies of general populations (e.g. Frymoyer *et al.,* 1983; Damkot *et al.*, 1984; Riihimäki *et al.*, 1989; Masset *et al.*, 1994). However, epidemiological studies of the general population do not always distinguish between professional drivers and those who do not drive in their job. Prevalence of low back pain in control groups not exposed to professional driving from epidemiological studies concerning low back pain in drivers vary from 40% to 66% (Anderson, 1992; Kompier *et al.*, 1987, Porter *et al.*, 2002 and Bovenzi *et al.*, 1992).

4.6.2.2. Prevalence of neck pain and shoulder pain

The literature about presence of neck pain and shoulder pain in professional drivers and also in general population is not that broad as literature concerning low back pain problems. Generally, epidemiological studies report 21% to 53% of professional drivers with neck pain and 29% to 47% of professional drivers with shoulder pain (Kompier *et al.*, 1987; Anderson, 1992; Magnusson *et al.*, 1996, Mansfield *et al.*, 2001). In this study, the prevalence of neck pain and shoulder pain in taxi drivers and the police drivers were consistent with prevalence of neck pain and shoulder pain reported in the study of bus drivers and agriculture and construction drivers performed by VIBRISKS partners.

Very approximately, there were similar rates of prevalence of low back pain, neck pain and shoulder pain during the past 12 months in police drivers, taxi drivers, and non-drivers.

Comparable values of health outcomes suggest that the non-drivers were at a similar risk of developing low back pain, neck pain and shoulder pain as the drivers.

4.6.3. Whole-body vibration exposure

4.6.3.1. Vibration measurements

Dupuis and Zerlett (1987) published a summary of the vertical vibration loads occurring in different types of vehicles. The range of the frequency-weighted acceleration in the *z*-axis in different types of cars was from 0.2 to 0.75 ms^{-2} r.m.s.

In previous studies of taxi drivers performed by Chen *et al.* (2003), the mean frequency-weighted acceleration in the *z*-axis (the dominant vibration component) was 0.31 ms^{-2} r.m.s. with a range from 0.17 to 0.55 ms^{-2} r.m.s. Chen *et al.* performed the measurement on 247 taxi vehicles manufactured by Honda, Ford, Nissan and Toyota. Similar values of the mean frequency-weighted acceleration in the *z*-axis were confirmed in the study of Funakoshi *et al.* (2004). The measurement of twelve taxi vehicles (Nissan and Toyota models) revealed the mean *z*-axis weighted acceleration to be 0.31 ms^{-2} r.m.s. with a range from 0.26 to 0.34 ms^{-2} r.m.s when evaluated in accord with ISO 2631 (1997).

In this study, the *z*-axis vibration on the seat was also the dominant vibration component in all measurements in both the taxis and the police vehicles. In the saloon car, which was the type of taxi driven by most taxi drivers in the City of Southampton, the frequency-weighted acceleration in the z-axis was 0.47 ms^{-2} r.m.s. In the police vehicles, the highest frequency-weighted acceleration in the z-axis was measured in one of the general purpose vehicles (0.58 ms^{-2} r.m.s.). The frequency-weighted acceleration on the seat in taxi or police vehicles was greater in the present measurements than in the studies of drivers reported by Chen *et al.* and by Funakoshi *et al.* The greater values may reflect differences in the driving characteristics such as driving speeds, road surfaces, and the design of the vehicles. From the study of Chen *et al.* is clear that taxi drivers in China are restricted to driving speed limit of 30 kilometres per hour in metropolitan areas and 40 kilometres per hour in suburban areas and therefore higher speed of driving was likely to occur in the performed measurements. The present vibration measurements are broadly consistent with those reported from previous studies of exposure to whole-body vibration in vehicles in Great Britain (Paddan *et al.*, 1999; Paddan and Griffin, 2002). Paddan *et al.* in their extensive study of evaluation of common sources of vibration in Great Britain found the mean frequency-weighted acceleration (vertical vibration on the seat) of seven different cars to be 0.39 ms^{-2} r.m.s., with a range from 0.31 to 0.48 ms^{-2} r.m.s. In later study of Paddan and Griffin was found the mean frequency-weighted acceleration (vertical vibration on the seat) of 25 different cars to be 0.43 ms^{-2} r.m.s., with a range from 0.26 to 0.75 ms^{-2} r.m.s. when evaluated in accord with ISO 2631 (1997).

4.6.3.2. <u>Overestimation of driving exposure</u>

Barriera-Viruet *et al.* (2006) performed a systematic review of thirteen studies investigating a possible overestimation of different working tasks (force, duration and frequency of working tasks) identified as risk factors for musculoskeletal disorders in the literature. From the review was concluded that comparison of self-reported working tasks in the form of duration (i.e. duration of driving, standing, lifting, etc.) and observed working tasks have been low-to-moderate (50% agreement). Main part of reviewed studies investigating the presence of musculoskeletal problems reported overestimation of working tasks by the affected cases. The presence of substantial differences in the total time for performing some specific physical work demands when using direct observation and self-administered questionnaire was confirmed in the study performed by one of the VIBRISKS partner (Tiemessen *et al.,* 2007).

In this study, the physical risk factors at work were assessed as dichotomous (performing of the working tasks: YES/NO). By using of dichotomous answers may be excluded the presence of underestimation or overestimation of physical tasks at work. The only information recorded in the duration was exposure to driving. In the case of taxi drivers, if the drivers did not properly distinguish between the periods when they were ‘on duty’ but waiting for passengers and the periods when the vehicle was running, there will have been errors, probably overestimation of vibration exposure duration. From a small study with 8-hour measurements of whole-body vibration it was found that a group of taxi drivers in the City of Southampton overestimated their driving exposure by 31% on average (with a range from 17% to 47%). This overestimation is based on twelve measurements in different types of vehicles.

4.6.4. Risk factors for low back pain

Cross-sectional study design may be one of the most frequently used epidemiological study design in medical literature. However, the risk factors found to be associated with health problem in this type of study cannot be interpreted as causal factors. Cross-sectional study design is used to formulate the hypothesis but not to test them.

4.6.4.1. Driving factors as a possible risks for low back pain

Some epidemiological studies of professional drivers have examined the risk of low back pain due to increased duration of driving (i.e. hours per day, hour per week or number of years). In this cross-sectional study significant association was found between increased prevalence of low back pain and driving a taxi for more than nine hours per working day. Similar finding were reported by Chen *et al.* (2005). In their study they have found significant associations between low back pain in taxi drivers and driving for more than 8 hours per day. Also other studies of professional drivers have reported significantly increased prevalence of low back problems with increasing duration of driving. In studies of Pietri *et al.* (1992) and Porter *et al.* (2002) was found that professional car drivers who drive for more than 20 hours per working week are at significant risk of developing low back pain when compared to drivers with shorter driving exposure.

From critical literature reviews of epidemiological studies it has been found that there have been only a few epidemiological studies which have investigated the risk of low back pain from exposure to whole-body vibration exposure in a form of dose-response relationship in professional drivers (Wikström *et al.*, 1994; Bovenzi and Hulshof, 1999; Lings and Leboeuf-Yde, 2000, Gallais and Griffin, 2006). Studies of Bovenzi *et al.* (1992, 1994, and 1996) reported significantly increased prevalence of low back pain of low back complaints with increasing total vibration dose in bus drivers and truck drivers. The increased prevalence of low back pain with increased total vibration dose was also reported in study of truck drivers performed by Boshuizen *et al.* (1990). Similar finding were confirmed by Magnusson *et al.* (1996) in the study of musculoskeletal disorders in bus drivers and truck drivers. Magnusson *et al.* have found the association between increased risk low back pain and long term exposure to vibration but did not find significant associations with daily vibration exposure.

On the other hand, in the study of Palmer *et al.* (2003) was found only weak associations between prevalence of low back pain and increasing total occupational vibration dose value in the extensive study of general population.

In this study of professional car drivers, various alternative indicators of the extent of exposure to driving from taxi driving and police driving were investigated. The cross-sectional study multivariate data analysis showed that increased daily and cumulative life-time exposure to driving expressed in different metrics were possible predictors of low back pain experienced during the past 12 months in population of taxi drivers.

The cross-sectional study of police drivers did not reveal any statistically significant associations suggesting increased prevalence of low back pain with increased driving. Results of VIBRISKS partners investigating prevalence of low back pain in bus drivers and agriculture and construction drivers suggested that the measures of daily vibration exposure are poorly associated with most of the low back pain outcomes. They have also reported that the dose measures of vibration exposure expressed in hours is better predictor for low back pain than vibration doses combining weighted acceleration magnitude and total duration of exposure.

Expressed in terms of vibration dose values, the exposure action value for whole-body vibration is 9.1 $ms^{-1.75}$ and the exposure limit value is 21 $ms^{-1.75}$ in the EU Physical Agents (Vibration) Directive, with both measures assessed in the dominant axis. From their self-reported driving times, it is estimated that the drivers investigated in this study had average daily vibration dose values close to the EU daily exposure action value: 8.34 $ms^{-1.75}$ in taxi drivers and 6.09 $ms^{-1.75}$ in police drivers. Eighteen percent of taxi drivers but no police drivers had vibration exposures greater than the 9.1 $ms^{-1.75}$ exposure action value. No taxi drivers or police driver had an exposure greater than the 21 $ms^{-1.75}$ exposure limit value. Chen *et al.* (2003) reported the average daily vibration dose value to be on average 15.06 $ms^{-1.75}$ with range from 7.4 to 31.25 $ms^{-1.75}$ in the population of urban taxi drivers in China. Chen also found that the majority of tested vehicles did not exceed the exposure action value of 0.5 ms^{-2} r.m.s. as suggested in ISO 2631 (1997). The higher dose values in taxi drivers in China when compared with dose values of taxi drivers and police drivers in this study maybe explained by increased duration of driving per day.

If it is assumed that the drivers overestimated their exposures by 31%, the average daily exposures reduce to 7.61 $ms^{-1.75}$ for taxi drivers and 5.65 $ms^{-1.75}$ for police drivers with one of taxi drivers and none of police drivers exceeding the exposure action value and none of taxi drivers and police drivers exceeding the exposure limit value. This is not inconsistent with the implications of the EU Physical Agents (Vibration) Directive for the assessment of the risks associated with car driving.

Expressed in terms of root-mean-square acceleration, the exposure action value for whole-body vibration is a daily *A*(8) of 0.5 ms^{-2} r.m.s. and the exposure limit value is 1.15 ms^{-2} r.m.s. in the EU Physical Agents (Vibration) Directive, with both measures assessed in the dominant axis. The drivers investigated in this study had average daily *A*(8) values below the EU daily exposure action value: 0.44 ms^{-2} r.m.s. in taxi drivers and 0.26 ms^{-2} in police drivers. Thirty-nine percent of taxi drivers and no police driver had vibration exposures greater than the 0.5 ms^{-2} r.m.s. exposure action value. No taxi drivers or police driver had an *A*(8) exposure greater than the 1.15 ms^{-2} r.m.s. exposure limit value. If it is assumed that the drivers overestimated their exposure by 31%, the average daily exposure action values reduce to 0.38 ms^{-2} r.m.s. for taxi drivers and 0.22 ms^{-2} r.m.s. for police drivers with 3% of taxi drivers and none of police drivers exceeding the exposure action value and none of taxi drivers or police drivers exceeding the exposure limit value. The absence of clear evidence of low back pain suggests the exposure values may be conservative for car driving (of the type investigated) when exposures are calculated from exposure durations reported by drivers. Because the conservativeness of exposure values, the EU Physical Agents (Vibration) Directive places no obligation on the employer to undertake periodic administrative, technical and medical measures in order to protect the workers against the risks rising from vibration exposure experienced during the working time.

The association between low back pain and driving is a complex and it is difficult to separate and investigate the effect of only one factor. In addition to duration of driving and whole body vibration exposure, low back pain in drivers might be also influenced with other risk factors associated with driving (e.g. the more constrained posture of drivers than passengers, forces at the feet when operating foot pedals, load from the arms, head posture, back movement, twisting to look rearward while reversing, forces during entry and exit from a car, etc.).

From the literature is generally agreed that back pain is multifactor in its origin. In each population of drivers, and in each individual driver, there are different risk factors (individual, physical and psychosocial) which may also influence the prevalence of low back pain.

4.6.4.2. <u>Non-driving factors as a possible risks for low back pain</u>

Psychosocial distress

In the cross-sectional study, increased psychosomatic distress was a strong predictor of the prevalence of lo back pain experienced for at least one day during the past 12 months in all investigated driving populations (i.e. taxi drivers and the police drivers). Increased psychosomatic distress was also a strong predictor of the presence of low back pain in police non-drivers. Similar findings of the importance of psychosocial factors, such as anxiety, depression, and stressful events among individuals with back pain have been identified in other studies (e.g. Bergenudd and Nilsson, 1988; Gallais and Griffin, 2006). It is not clear the extent to which psychosocial problems are the cause of low back pain or caused by back pain. The evidence from literature is pointing more on the role of stress in the development of various musculoskeletal troubles than on the opposite relationship Bongers *et al.* (1993). On the other hand there is also evidence that the presence of pain may increase the higher sensibility of reporting presence of various symptoms (Frymoyer *et al*. in 1980; Waddell, 2004). Although both relationships are probably true.

Anthropometrics

In taxi drivers and non-drivers, being tall was significantly associated with low back pain. The findings of previous epidemiological studies investigating the relationship between low back pain and anthropometric information (i.e. height, weight, BMI) are not unified. Anthropometric individual factors such as height and weight seem to have an important role in increasing the prevalence of low back pain in some published epidemiological studies. Heliövaara (1987) studied body height, obesity and the risk of herniated lumbar intervertebral disc and found that the body mass index was an independent risk factor in a male population and that height and heavy body mass may be important contributors for disc herniation in general population. Gyntelberg (1974) suggested that taller individuals are at greater risk for low back pain when compared with shorter people. Also study of taxi drivers performed by Chen *et al.* (2004) reported positive associations between low back pain and increased body mass index of taxi drivers. However, main parts of epidemiological studies in population of professional car drivers or general population have not found that increased body height or body weight increases the risk of back pain (Gallais and Griffin, 2006).

Age

Previous epidemiological studies have found that the prevalence of back problems increases with increasing age (Gallais and Griffin, 2006). Bovenzi and Betta (1994), Bovenzi (1996) in their studies of agricultural tractor drivers and bus drivers found an association between back problems and increasing age. The lifetime prevalence of low back pain, sciatic pain, and acute low back pain increased with increasing age for tractor drivers and also for group of control subjects. In the baseline cross-sectional study of police drivers it was found that the risk of back pain was higher in the middle age group than in the older and younger age groups. The effect of decreased prevalence of low back pain in older age groups might be explained by the 'healthy worker effect' in which those with back pain tend to leave the job, resulting in less back pain with increasing age. Although the association between the prevalence of low back pain and older age of police drivers was not significant the risk of low back pain in this group was almost twice as high as in young drivers. In the non-driving population, the risk of back pain was greater in the oldest age group than in the middle and youngest age groups.

Physical risk factors

An influence of physical demands at work on prevalence of low back pain has been found in some epidemiological studies of professional drivers and general population (Gallais and Griffin, 2006). Some of the studies report an association between physical load at work and some of them not. Significant associations between increased prevalence of lifting was found in car drivers (Kelsey *et al.*, 1984), commercial travellers (Pietri *et al.*, 1992), truck drivers (Magnusson *et al.,* 1996), bus drivers (Jensen *et al.*, 1996) and general population (Riihimäki *et al.*, 1989). On the other hand there have been also many studies where the association with increased prevalence of back pain was not found (Kelsey, 1975; Kelsey and Hrady, 1975; Barnekow-Bergkvist *et al.*, 1998; Chen *et al.*, 2004, 2005). A significant increase in prevalence of low back pain was also found in the taxi drivers reporting heavy physical load (i.e. heavy repetitive lifting, etc.) in previous job. In police drivers and non-drivers was found association between increased prevalence of low back pain and bending at work.

VIBRISKS partners have investigated various individual, physical and psychosocial risk factors influencing the prevalence of low back pain in professional drivers. Generally it was concluded that age and physical index (combination of physical risk factors such as lifting, bending, twisting, etc. at work) were associated with increased risk of low back pain in driving populations.

4.6.5. Risk factors for neck pain

As previously stated, there is limited evidence of associations between increased prevalence of neck pain and possible risk factors. In this study, the presence of increased psychosocial distress status and physical demands at present or previous work were the most associated factors for neck pain in all three investigated populations. Previous

epidemiological studies are confirming the negative influence of increased stress and psychosocial risk factors at work on development of neck pain in drivers (Krause *et al.*, 1997; Barnekow-Berkvist *et al.*, 1998). Also presence of physical factors such as lifting, carrying and longer duration of work is documented to be important risk factor for neck pain in professional drivers (Jensen *et al.*, 1996; Krause *et al.*, 1997).
In this study the association between neck pain and possible risk factors have been investigated mainly to confirm if there are similarities in possible predictors for low back pain and neck pain in the investigated populations. The results revealed the importance of increased psychosocial distress status in development of both musculoskeletal disorders. Despite the importance of psychosocial risk factors on prevalence of low back pain or neck pain, from this study type cannot be concluded whether increased psychosocial distress is the cause or is caused by the presence of health problems.

4.7. Conclusion of the cross-sectional baseline studies of taxi drivers, police drivers and non-drivers

The 12-month prevalence of low back pain in the non-driving population was similar to the 12-month prevalence of low back pain reported by the driving populations in this study, suggesting that the driving and non-driving populations were at a similar risk of developing low back pain.

In the taxi drivers, increased exposure to daily and cumulative driving was a possible risk factor for increased of prevalence of low back pain. In the police drivers, increased exposure to driving was not an important risk factor for increased prevalence of low back pain.

In taxi drivers, police drivers, and in the non-driving population, the presence of low back pain experienced for at least one day during the past 12 months was significantly associated with individual risk factors (e.g. age, height), physical factors (e.g. previous physical load, bending) and, psychosocial risk factors (i.e. increased psychosomatic distress status).

From a cross-sectional study, where the health outcome and possible risk factors were measured at the same time, it cannot be concluded whether found relationships are the cause or effect of this health outcome. Longitudinal studies, with measurements of repeated monitoring of risk factors and health outcome over the time, are needed to determine the plausible role of risk factors in the development of low back pain in the selected population. Therefore all risk factors significantly associated with increased risk of prevalent low back pain from initial cross-sectional baseline study were investigated as possible risk factors for the development of low back pain in the longitudinal study of selected populations.

CHAPTER FIVE

LONGITUDINAL STUDY

5.1. Longitudinal study of taxi drivers

5.1.1. Description of the population

In the second year of the study, questionnaires were posted to the taxi drivers who had replied in the cross-sectional baseline of the study. The target population was 209 taxi drivers located in the City of Southampton. As well as in the baseline study, all information about the contact details of taxi drivers were provided by the Legal and Democratic Services of the Southampton City Council.

Six hundred and fifty-five taxi drivers who have not replied at the first year of the study were also contacted in purpose to create a comparison group.

5.1.1.1. Response rate

To enhance the response rate of taxi drivers, three reminders were performed and a financial bonus was proposed. A small cash reward was offered to five randomly selected drivers who answered both questionnaires (baseline and follow-up).

From the total of 209 posted questionnaires, 155 responses were returned, giving an overall response rate of 74%. From the total of 155 responses, eleven cases were excluded because they did not wish to participate in the study or they were no longer taxi drivers.

In total, 144 questionnaires from taxi drivers were used in the baseline and the follow-up of the longitudinal study.

From the total of 654 taxi drivers who have not replied at the cross-sectional baseline, 33 responses were returned and used for the comparisons of information with the cohort of taxi drivers participated in the whole longitudinal study.

5.1.1.2. Comparison of cross-sectional baseline and longitudinal baseline of taxi drivers

Statistical analysis were performed to see differences of individual, physical and psychosocial information of the cross-sectional baseline of taxi drivers (n=209) and the longitudinal baseline of taxi drivers (n=144).

Individual characteristics

Descriptive statistical analysis of individual information (i.e. age, anthropometrics, smoking habits and leisure activity exposure) showed that there are no significant differences between the cross-sectional baseline and the longitudinal baseline of taxi drivers (See Table 5.1.).

Physical activities at work

Data analysis showed that there are no statistically significant differences between amount of lifting, bending, twisting, walking for more than one hour per day and sitting (other while driving) between the cross-sectional baseline and the longitudinal baseline of taxi drivers (See Table 5.2.).

Table 5.1. Differences in individual characteristics of the cross-sectional baseline and longitudinal baseline of taxi drivers. Data are given as median and inter-quartile range for age and anthropometric characteristics and as frequency (n) and percentage (%) for smoking, and physical activity

Individual risk factors	Taxi drivers	
	Cross-sectional baseline (n=209)	Longitudinal baseline (n=144)
Age (yr)	51 (41-58)	52 (43-59)
Height (cm)	175.3 (170.2-177.8)	175.3 (170.2-177.8)
Weight (kg)	84.6 (76.4-97.1)	86.1 (77.3.- 97.2)
Smoking (n):		
non-smokers	80 (38)	51 (35)
ex-smokers/smokers	127 (61)	91 (63)
Physical activity		
no	123 (59)	78 (54)
yes	86 (41)	66 (46)

Table 5.2. Differences in physical characteristics of work of the cross-sectional baseline and longitudinal baseline of taxi drivers. Data are given as frequency (n) and percentage (%)

Physical risk factors	Taxi drivers	
	Cross-sectional baseline (n=209)	Longitudinal baseline (n=144)
Lifting at work		
no	32 (15)	21 (15)
yes	177 (85)	123 (85)
Standing or walking (≥1h/day)		
no	115 (55)	80 (56)
yes	94 (45)	64 (44)
Trunk bent at work		
no	156 (75)	109 (76)
yes	53 (25)	35 (24)
Trunk twisted at work		
no	162 (77)	108 (75)
yes	47 (23)	36 (25)
Sitting >3h at work		
no	121 (58)	83 (58)
yes	88 (42)	61 (42)
Previous job with:		
Professional driving	75 (36)	52 (36)
Physical demands	142 (68)	97 (67)
Sitting	84 (40)	53 (37)

Characteristics of the previous job (i.e. previous driving, previous sitting and previous exposure to physical demands) as well did not show statistical differences between the cross-sectional baseline and the longitudinal baseline of taxi drivers (See Table 5.2.).

There have not been found significant differences in driving exposure expressed in different metrics in the cross-sectional baseline and the longitudinal baseline of taxi drivers (See Table 5.3.).

Psychosocial variables

There have not been found significant differences in psychosocial factors at work (i.e. choice and decision, support from colleagues and satisfaction at job). There have been found significant differences in the level of experienced psychosomatic distress between both populations. On overall, highest scores of psychosomatic distress were found in taxi drivers in the cross-sectional baseline (See Table 5.4.).

Table 5.3. Measures of daily and cumulative exposure to whole-body vibration in the cross-sectional baseline and longitudinal baseline of taxi drivers. Data are given as median and inter-quartile range

Measures of daily vibration exposure	Taxi drivers	
	Cross-sectional baseline (n=209)	Longitudinal baseline (n=144)
Daily driving time (h)	8 (5 -10)	8 (6-10)
$A_{dom}(8)$ (ms^{-2} r.m.s.)	0.43 (0.33-0.56)	0.44 (0.32-0.55)
$eVDV_{dom}$ ($ms^{-1.75}$)	8.3 (7.7-9.1)	8.6 (7.7-9.1)
Duration of exposure (yr)	12.0 (5.0-18.0)	9.5 (5.3-18.8)
$\sum[t_i]$ (h $\times 10^3$)	14.4 (7.1-26.2)	14.4 (8.0-25.2)
$eVDV_{Total\text{-}dom}$ ($ms^{-1.75}$)	54.9 (45.8-64.6)	56.0 (45.4-63.8)

Health outcomes

There have not been found significant differences between health outcomes (i.e. different characteristics of low back pain, neck pain and shoulder pain) in the cross-sectional baseline and the longitudinal baseline of taxi drivers (See Table 5.5.).

Table 5.4. Differences in psychosocial factors of the cross-sectional baseline and longitudinal baseline of taxi drivers. Data are given and as frequency (n) and percentage (%) for psychosocial factors at work and as median and inter-quartile range of total score for psychosocial statutes

Psychosocial risk factors	Taxi drivers	
	Cross-sectional baseline (n=209)	Longitudinal baseline (n=144)
No choice and decision at work:		
- how to work	23 (11)	14 (10)
- what to do at work	31 (15)	19 (14)
- timetables and breaks	3 (1)	2 (1)
Support from colleagues		
yes	88 (43)	57 (40)
not applicable	69 (33)	47 (33)
Satisfaction at job	191 (91)	133 (92)
Mental health status	24 (21-27)	25 (21-27)
Energy and vitality status	15 (12-18)	15 (12-19)
Psychosomatic distress status	4 (2-6)	1 (0-4)[a]

Mann-Whitney U Test: [a]$p<0.05$

Table 5.5. Prevalence of health symptoms in the cross-sectional baseline and longitudinal baseline of taxi drivers

Outcome	Taxi drivers (%)	
	Cross-sectional baseline	Longitudinal baseline
LBP in the previous 12 months	45	44
LBP in the previous 4 weeks	29	28
LBP in the previous 7 days	19	19
NP in the previous 12 months	33	33
NP in the previous 4 weeks	21	20
NP in the previous 7 days	13	14
SP in the previous 12 months	28	32
SP in the previous 4 weeks	15	17
SP in the previous 7 days	12	13

Complete data about individual, physical, psychosocial information and health outcomes of the longitudinal baseline of taxi drivers are listed in Appendix E (Tables E11, E12, E13, E14).

5.1.1.3. <u>Comparison of longitudinal baseline and longitudinal follow-up of taxi drivers</u>

Statistical analyses were performed to see possible changes of individual, physical and psychosocial information in the follow-up of taxi drivers.

Individual characteristics

Descriptive statistical analysis of individual information (weight, smoking habits and leisure activity exposure) showed that there are no significant changes between the longitudinal baseline and the follow-up of taxi drivers (See Table 5.6.).

Physical activities at work

Data analysis showed that there were statistically significant differences between amount of bending in the baseline and follow up of the taxi drivers. Other physical activities such as lifting, twisting, walking and sitting (other while driving) did not show significant changes between the longitudinal baseline and the follow-up of taxi drivers (See Table 5.6.).

Table 5.6. Differences in individual, physical and psychosocial characteristics of the baseline and follow-up of the longitudinal study of taxi drivers. Data are given as median and interquartile range or as frequency (n) and percentage (%)

Individual risk factors	Taxi drivers	
	Baseline (n=144)	Follow-up (n=144)
Weight (kg)	84.6 (76.4-97.3)	86 (77.5-97)
Smoking (n):		
non-smokers	51 (35)	40 (28)
ex-smokers/smokers	91 (63)	98 (68)
Physical activity		
no	78 (54)	71 (49)
yes	66 (46)	65 (45)
Lifting at work		
no	21 (15)	14 (10)
yes	123 (85)	130 (90)
Standing or walking (≥1h/day)		
no	80 (56)	84 (56)
yes	64 (44)	58 (40)
Trunk bent at work		
no	109 (76)	91 (63)[b]
yes	35 (24)	52 (36)
Trunk twisted at work		
no	108 (75)	96 (67)
yes	36 (25)	47 (33)
Sitting >3h at work		
no	83 (58)	72 (50)
yes	61 (42)	71 (49)
Psychosomatic distress status	1 (0-4)	1 (1-4)
Daily driving time (h)	8 (6-10)	8 (7-10)
$A_{dom}(8)$ (ms^{-2} r.m.s.)	0.44 (0.32-0.55)	0.44 (0.38-0.56)
$eVDV_{dom}$ ($ms^{-1.75}$)	8.6 (7.7-9.1)	8.6 (8.0-9.1)

Chi-Square Test: [b]$p<0.5$

When considering driving information, there have not been found significant changes in daily driving exposure expressed in different metrics in the follow-up of taxi drivers (See Table 5.6.).

Psychosocial variables

There have not been found significant changes in the level of experienced psychosomatic distress between the longitudinal baseline and follow-up of taxi drivers (See Table 5.6.).

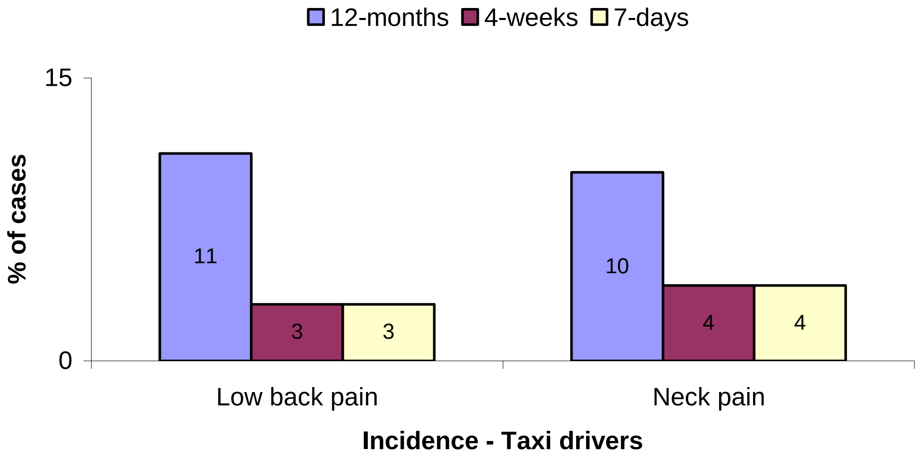


Figure 5.1. Incidence of low back pain and neck pain among taxi drivers

5.1.2. Occurrence of health outcomes

5.1.2.1. Low back pain

In the follow-up study, nine taxi drivers reported a new episode of low back pain during the past 12 months (12-months incidence: 11%), two taxi drivers reported a new episode of low back pain during the past 4 weeks (4-weeks incidence: 3%) and two reported a new episode of low back pain during the past 7 days (7-days incidence: 3%).

Forty-three taxi reported a persistent episode of low back during the past 12 months (12-months persistence: 67%), and 26 of taxi drivers during the past 4 weeks and during the past 7 days (4-weeks, 7-days persistence: 41%).

The incidence and the persistence of low back pain among taxi drivers are illustrated graphically in Figure 5.1 and Figure 5.2.

5.1.2.2. Neck pain

In the follow-up study, 10 taxi drivers reported a new episode of neck pain during the past 12 months (12-months incidence: 10%), 4 taxi drivers reported a new episode of neck pain during the past 4 weeks and during the past 7 days (4-weeks incidence, 7-days incidence: 4%).

A persistent episode of neck pain during the past 12 months was reported in 29 taxi drivers (12-months persistence: 60%). Twenty-three taxi drivers reported persistent episode of neck pain during the past 4 weeks (4-weeks persistence: 48%) and 22 taxi drivers reported persistent neck pain during the past 7 days (7-days persistence: 46%).

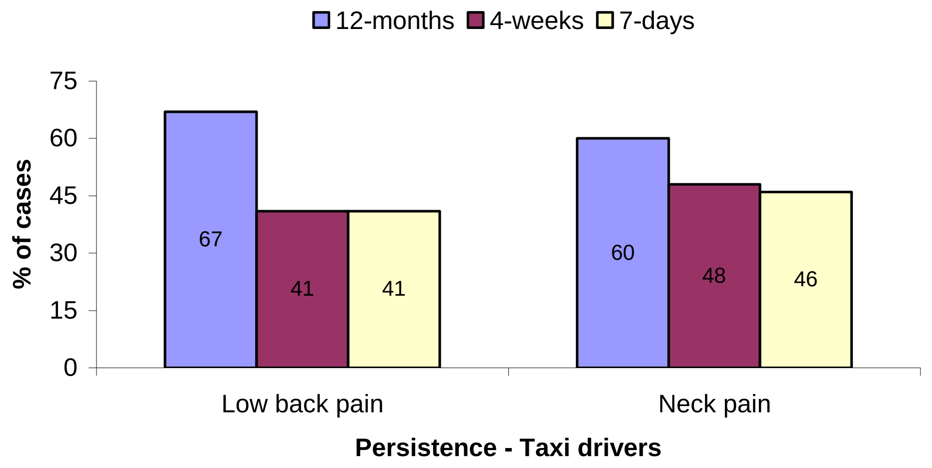


Figure 5.2. Persistence of low back pain and neck pain among taxi drivers

The incidence and the persistence of neck pain among taxi drivers are illustrated graphically in Figure 5.1 and Figure 5.2.

5.1.3. Risk factors for low back pain

The selection of candidate risk factors for the final multivariate analysis in the longitudinal study was based on results from the cross-sectional baseline study of the taxi drivers.

All risk factors that were selected by stepwise multiple logistic regression in the cross-sectional baseline study of the taxi drivers were considered to be possible predictors for low back pain and were automatically entered into the final statistical model of the whole longitudinal study. Possible predictors for low back pain are summarised in Table 5.7.

The multivariate analysis followed separately the participants who reported episodes of low back pain lasting for at least one day during the past 12 months in the cross-sectional baseline of the study (the ‘persistence group’) and participants who did not report an episode of low back pain during the past 12 months in the cross-sectional baseline of the study (the ‘incidence group’).
Persistence group than consisted from participants reporting low back pain episode during the cross-sectional study and also experiencing low back pain in the follow-up of the study; and participants reporting low back pain episode during the cross-sectional study and no low back pain in the follow-up of the study. Similarly, incidence group consisted from participants reporting no low back pain episode during the cross-sectional study and presence of low back pain in the follow-up of the study; and participants reporting no low

Table 5.7. Significant variables selected for multivariate analysis in the longitudinal study of taxi drivers

Variables suitable for multivariate analysis of taxi drivers
Age
Height
Previous physical demands
Distress status
Driving information
daily driving time (h)
$A(8)_{dom}$
$eVDV_{dom}$
exposure duration (yrs)
$\sum[t_i]$ (h)
$eVDV_{Total\text{-}dom}$

back pain episode during the cross-sectional study and no low back pain in the follow-up of the study.

5.1.3.1. Incidence of low back pain

Multivariate analysis was not undertaken on the incidence group of taxi drivers because the number of new cases was too low (n=9). Descriptive analysis were therefore performed to see the differences between potential risk factors for low back pain in taxi drivers reporting new episode of low back pain and the drivers not reporting new episode of low back pain during the past 12 months. Generally drivers reporting new episode of low back pain were older, reporting more physical load at previous work, longer total duration of driving in hours and years and higher symptoms of psychosomatic distress. However, there have not been found any significant differences in different characteristics between drivers reporting new episode of low back pain and drivers without pain. (See Table 5.8.)

5.1.3.2. Persistence of low back pain

In taxi drivers, the standard multiple logistic regression revealed that there was increasing persistence of low back pain during the past 12 months with increasing body height (significant in both height groups: OR = 5.55, OR = 16.56) and high psychosomatic

Table 5.8. Incidence group. Differences in individual, physical and psychosocial characteristics in the taxi drivers reporting new episode of low back pain and in taxi drivers without low back pain. Data are given as median and interquartile range or as frequency (n) and percentage (%)

Individual risk factors	Taxi drivers	
	New episode of LBP (n=9)	No LBP (n=71)
Age (yr)	53 (44.5-60.5)	51 (40-59)
Height (cm)	172.7 (168.3-184.2)	172.7 (167.6-177.8)
Psychosomatic distress status	2 (1-7)	1 (0-3)
Daily driving time (h)	8 (7-9)	8 (6-10)
$A_{dom}(8)$ (ms^{-2} r.m.s.)	0.44 (0.44-0.50)	0.44 (0.33-0.56)
$eVDV_{dom}$ ($ms^{-1.75}$)	8.6 (7.8-8.8)	8.6 (7.9-9.1)
Duration of exposure (yr)	14.0 (7.5-16.5)	10.0 (6.0-20.0)
$\sum[t_i]$ ($h \times 10^3$)	19.2 (16.8-27.2)	17.4 (8.1-30.0)
$eVDV_{Total\text{-}dom}$ ($ms^{-1.75}$)	58.6 (55.3-64.6)	58.5 (47.3-66.5)

distress status (OR = 6.20). Increased risk of low back pain was found in the middle age group of taxi drivers, but the association was not statistically significant (OR = 3.42).

Results of the standard multiple logistic regression, when all significant potential variables for low back pain outcomes (without information on driving exposure) and age as variable of known biological importance were entered into the multivariate logistic model together to examine the contribution of all possible variables at the same time, are presented in Table 5.9.

Multiple logistic regression allowed the influence of driving information on the persistence of low back pain to be seen by forcing the relevant variables into the statistical model. Each aspect of driving information (i.e. measures of daily and cumulative driving exposure) was entered into separate regression models with other confounders selected in the cross-sectional baseline study (except any information about driving).

In the persistence group of taxi drivers there was no significant association between increased persistence of low back pain and any variable reflecting driving. The final standard multiple logistic regressions including driving information are presented in Table 5.10.

Table 5.9. Persistence group of taxi drivers in the follow-up of the longitudina study. Standard multivariate logistic regression for the associatio between low back pain during the past 12-months and variou individual and work-related risk factors in taxi drivers. In the tabl are presented adjusted odds ratios (OR) and 95% confidenc intervals (95% CI)

Factors	Taxi drivers (n=80)
	OR (95% CI)
Age (yr)	
≤ 36	1.00 (-)
37-46	3.42 (0.30-38.57)
> 46	1.67 (0.20-14.00)
Height (cm)	
≤ 170.18	1.00 (-)
170.19-177.8	5.55 (1.12-27.43)
> 177.8	16.56 (1.80-152.40)
Previous job with:	
Physical demands	0.88 (0.21-3.72)
Psychosomatic distress status	
healthy	1.00 (-)
medium	1.72 (0.27-10.90)
poor	6.20 (1.30-29.60)

5.1.4. Risk factors for neck pain

Multiple logistic regression was also performed for the neck pain in taxi drivers. As the number of taxi drivers experiencing new episodes of neck pain during the past 12 months was very low, the statistical analysis were focused on the persistence group.

The standard multiple logistic regression did not reveal significant associations with any of the individual, physical or psychosocial risk factors in the persistent group of taxi drivers. Multiple logistic models allowing the influence of driving information on the persistent neck pain revealed significant associations with persistent neck pain and increased duration of daily driving in taxi drivers.

Results from the standard multiple logistic regression, when all significant potential variables for neck pain outcomes and age were entered into the multivariate logistic model together to examine the contribution of all possible variables at the same time, are presented in Appendix E (Table E15 and E16).

Table 5.10. Multivariate logistic regression of low back pain in the 12 months on alternative measures of daily and total cumulative vibration exposure to whole-body vibration in taxi drivers in the persistence group of the one-year follow-up period. Each measure of whole-body vibration exposure was included as a third based design variable. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Measures of WBV exposure	Taxi drivers (n=80)		
	T1	T2	T3
Daily driving time (h)			
OR	1.00	0.23	0.25
(95% CI)	(-)	(0.02-2.15)	(0.03-1.97)
$A_{dom}(8)$ (ms^{-2} r.m.s.)			
OR	1.00	0.73	0.49
(95% CI)	(-)	(0.09-5.70)	(0.07-3.37)
$eVDV_{dom}$ ($ms^{-1.75}$)			
OR	1.00	0.62	0.45
(95% CI)	(-)	(0.08-4.89)	(0.07-2.98)
Exposure duration (yr)			
OR	1.00	1.91	0.72
(95% CI)	(-)	(0.28-13.01)	(0.10-5.23)
$\sum[t_i]$ ($h \times 10^3$)			
OR	1.00	9.71	1.20
(95% CI)	(-)	(0.77-121.97)	(0.14-10.18)
$eVDV_{Total\text{-}dom}$ ($ms^{-1.75}$)			
OR	1.00	1.93	1.46
(95% CI)	(-)	(0.23-16.06)	(0.15-13.85)

Odds ratios adjusted for following risk factors: age, height, previous physical load, psychosomatic distress status

5.2. Longitudinal study of police employees

5.2.1. Description of the population

In the second year of the longitudinal study, questionnaires were posted to the police employees (police drivers and police non-drivers) employed by the Grampian Police Force who had participated in the cross-sectional baseline of the study. The information about the number of participants and contact information of police employees were provided by the Service Centre of Aberdeen Police Station.

5.2.2. Response rate

To enhance the response rate of police employees, one reminder round in the form of a letter printed in the internal magazine was performed and a small financial amount was donated to the Diced Cap Charitable Trust for each completed questionnaire.

From the total of 850 posted questionnaires 521 responses were returned, giving an overall response rate of 61%. From the total of 521 returned questionnaires, two responses from participants were excluded because they were no longer in the police force.

In total, 519 questionnaires of police employees participated in the baseline and the follow-up of the longitudinal study.

5.3. Longitudinal study of police drivers

5.3.1. Description of the population

5.3.1.1. Response rate

From the total of 365 posted questionnaires, 219 responses were returned giving an overall response rate of 60%. There was no questionnaire excluded from the study.

In total, 219 questionnaires from police drivers were used in the baseline and follow-up of the longitudinal study.

5.3.1.2. Comparison of cross-sectional baseline and longitudinal baseline of police drivers

Statistical analysis were performed to see differences of individual, physical and psychosocial information of the cross-sectional baseline of police drivers (n=365) and the longitudinal baseline of police drivers (n=219).

Table 5.11. Differences in individual characteristics of the cross-sectional baseline and longitudinal baseline of police drivers. Data are given as median and interquartile range for age and anthropometric characteristics and as frequency (n) and percentage (%) for smoking, and physical activity

Individual risk factors	Police drivers	
	Cross-sectional baseline (n=365)	Longitudinal baseline (n=219)
Age (yr)	37 (32-43)	38 (33-44)
Height (cm)	177.8 (172.7-182.9)	180 .3 (172.7-182.9)
Weight (kg)	81.9 (72.5-89.6)	83.7 (72.9-90.9)
Smoking (n):		
non-smokers	256 (70)	155 (71)
ex-smokers/smokers	108 (30)	63 (29)
Physical activity		
no	81 (22)	31 (14)
yes	284 (78)	188 (86)

Individual characteristics

Descriptive statistical analysis of individual information (i.e. age, anthropometrics, smoking habits and leisure activity exposure) showed that there are no significant differences between the cross-sectional baseline and the longitudinal baseline of police drivers (See Table 5.11.).

Physical activities at work

Data analysis showed that there are no statistically significant differences between amount of lifting, bending, twisting, walking for more than one hour per day and sitting (other while driving) between the cross-sectional baseline and the longitudinal baseline of police drivers (See Table 5.12.).

Characteristics of previous job (i.e. previous driving, previous sitting and previous exposure to physical demands) as well did not show statistical differences between the cross-sectional baseline and the longitudinal baseline of police drivers (See Table 5.12.).

There have not been found significant differences in driving exposure expressed in different metrics (except duration of driving expressed in years) in the cross-sectional baseline and the longitudinal baseline of police drivers (See Table 5.13.).

Table 5.12. Differences in physical characteristics of work of the cross-sectional baseline and longitudinal baseline of police drivers. Data are given as frequency (n) and percentage (%)

Physical risk factors	Police drivers	
	Cross-sectional baseline (n=365)	Longitudinal baseline (n=219)
Lifting at work		
no	146 (41)	94 (43)
yes	218 (59)	124 (57)
Standing or walking (≥1h/day)		
no	59 (16)	38 (17)
yes	304 (84)	180 (82)
Trunk bent at work		
no	245 (67)	147 (67)
yes	119 (33)	71 (32)
Trunk twisted at work		
no	285 (78)	174 (80)
yes	80 (22)	45 (20)
Sitting >3h at work		
no	240 (66)	139 (64)
yes	125 (34)	80 (37)
Previous job with:		
Professional driving	152 (42)	100 (46)
Physical demands	177 (49)	107 (49)
Sitting	122 (33)	74 (34)

Psychosocial variables

There have not been found significant differences in psychosocial factors at work (i.e. choice and decision, support from colleagues and satisfaction at job), energy and vitality status, mental health status and psychosomatic distress between both populations (See Table 5.14.).

Health outcomes

There have not been found significant differences between health outcomes (i.e. different characteristics of low back pain, neck pain and shoulder pain) in the cross-sectional baseline and the longitudinal baseline of police drivers (See Table 5.15.).

Complete data about individual, physical, psychosocial information and health outcomes of the longitudinal baseline of police drivers are listed in Appendix E (Tables E11, E12, E13, E14).

Table 5.13. Measures of daily and cumulative exposure to whole-body vibration in the cross-sectional baseline and longitudinal baseline of police drivers. Data are given as median and inter-quartile range

Measures of daily vibration exposure	Police drivers	
	Cross-sectional baseline (n=365)	Longitudinal baseline (n=219)
Daily driving time (h)	2.7 (1.6-4.0)	2.5 (1.8-4.0)
$A_{dom}(8)$ (ms^{-2} r.m.s.)	0.27 (0.20-0.31)	0.25 (0.21-0.31)
$eVDV_{dom}$ ($ms^{-1.75}$)	6.3 (5.5-6.7)	6.1 (5.5-6.7)
Duration of exposure (yr)	9.9 (4.3-16.8)	10.3 (4.3-17.0)
$\sum[t_i]$ ($h \times 10^3$)	5.3 (3.2-8.0)	5 (3.6-8.0)
$eVDV_{Total\text{-}dom}$ ($ms^{-1.75}$)	39.7 (31.4-47.67)	39.9 (31.9-47.65)

5.3.1.3. Comparison of longitudinal baseline and longitudinal follow-up of police drivers

Statistical analyses were performed to see possible changes of individual, physical and psychosocial information in the baseline and the follow-up of the longitudinal study of police drivers.

Individual characteristics

Descriptive statistical analysis of individual information (weight, smoking habits and leisure

Table 5.14. Differences in psychosocial factors of the cross-sectional baseline and longitudinal baseline of police drivers. Data are given and as frequency (n) and percentage (%) for psychosocial factors at work and as median and inter-quartile range of total score for psychosocial statutes

Psychosocial risk factors	Police drivers	
	Cross-sectional baseline (n=365)	Longitudinal baseline (n=219)
No choice and decision at work:		
- how to work	69 (19)	35 (16)
- what to do at work	113 (31)	62 (29)
- timetables and breaks	131 (36)	72 (33)
Support from colleagues		
yes	320 (88)	196 (90)
Satisfaction at job	319 (87)	192 (88)
Mental health status	24 (21-27)	25 (22-27)
Energy and vitality status	16 (13-19)	16 (14-19)
Psychosomatic distress status	1 (0-2)	1 (0-2)

Table 5.15. Prevalence of health symptoms in the cross-sectional baseline and longitudinal baseline of police drivers

Outcome	Police drivers (%)	
	Cross-sectional baseline	Longitudinal baseline
LBP in the previous 12 months	53	56
LBP in the previous 4 weeks	35	37
LBP in the previous 7 days	19	18
NP in the previous 12 months	30	32
NP in the previous 4 weeks	17	19
NP in the previous 7 days	10	8
SP in the previous 12 months	29	32
SP in the previous 4 weeks	17	19
SP in the previous 7 days	9	9

activity exposure) showed that there are no significant changes between the longitudinal baseline and the follow-up of police drivers (See Table 5.16.).

Physical activities at work

Data analysis showed that there were no statistically significant changes between physical activities such as lifting, bending, twisting, walking and sitting (other while driving) in the longitudinal baseline and the follow-up of police drivers (See Table 5.16.).

When considering driving information, there have not been found significant changes in daily driving exposure expressed in different metrics in the follow-up of police drivers (See Table 5.16.).

Psychosocial variables

There have not been found significant changes in the level of experienced psychosomatic distress between the longitudinal baseline and the follow-up of police drivers (See Table 5.16.).

5.3.2. Occurrence of health outcomes

5.3.2.1. Low back pain

In the follow-up study, 25 police drivers reported a new episode of low back pain during the past 12 months (12-months incidence: 26%), 11 police drivers reported a new episode

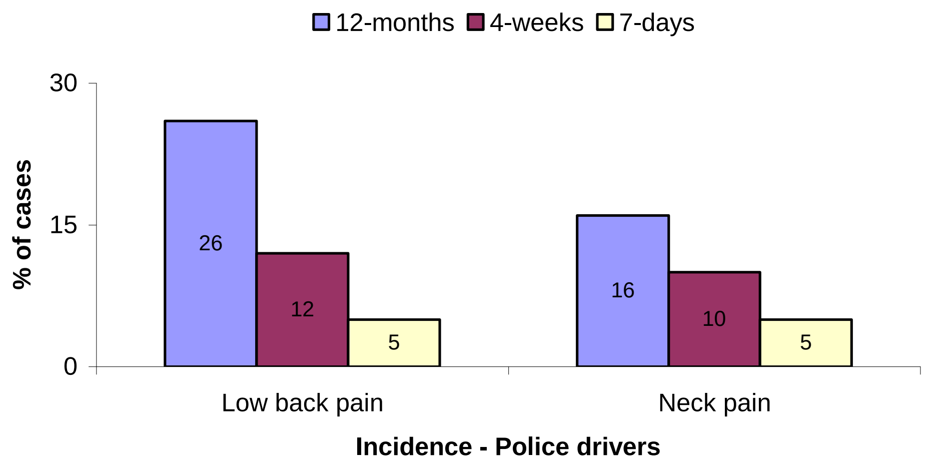


Figure 5.3. Incidence of low back pain and neck pain among police drivers

of low back pain during the past 4 weeks (4-weeks incidence: 12%) and 5 police drivers reported a new episode of low back pain during the past 7 days (7-days incidence: 5%).

Ninety-five police drivers reported a persistent episode of low back during the past 12 months (12-months persistence: 77%), 66 of police drivers reported persistent episode during the past 4 weeks (4-weeks persistence: 54%) and 31 police drivers reported persistent low back pain during the past 7 days (7-days persistence: 31%).

The incidence and the persistence of low back pain among police drivers are illustrated graphically in Figure 5.3. and Figure 5.4.

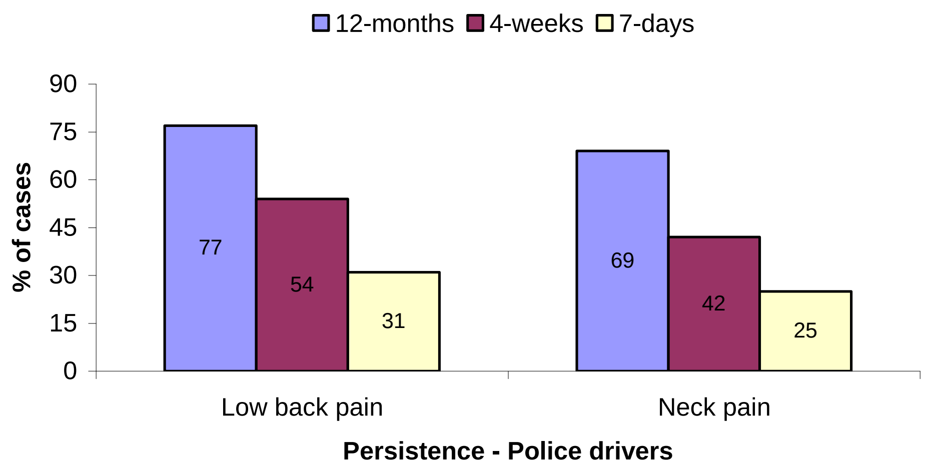


Figure 5.4. Persistence of low back pain and neck pain among police drivers

Table 5.16. Differences in individual, physical and psychosocial characteristics of the baseline and follow-up of the longitudinal study of police drivers. Data are given as median and interquartile range or as frequency (n) and percentage (%)

Individual risk factors	Police drivers	
	Baseline (n=219)	Follow-up (n=219)
Weight (kg)	83.7 (72.9-90.9)	83.5 (72.5-91.8)
Smoking (n):		
non-smokers	155 (71)	145 (66)
ex-smokers/smokers	63 (29)	70 (32)
Physical activity		
no	31 (14)	32 (15)
yes	188 (86)	185 (85)
Lifting at work		
no	94 (43)	108 (49)
yes	124 (57)	109 (50)
Standing or walking (≥ 1h/day)		
no	38 (17)	44 (20)
yes	180 (82)	174 (80)
Trunk bent at work		
no	147 (67)	158 (72)
yes	71 (32)	60 (27)
Trunk twisted at work		
no	174 (80)	174 (80)
yes	45 (20)	44 (20)
Sitting > 3h at work		
no	139 (64)	122 (56)[b]
yes	80 (37)	95 (43)
Psychosomatic distress status	1 (0-2)	1 (0-3)
Daily driving time (h)	2.5 (1.8-4.0)	3.0 (2.0-4.0)
$A_{dom}(8)$ (ms^{-2} r.m.s.)	0.25 (0.21-0.31)	0.27 (0.22-0.32)
$eVDV_{dom}$ ($ms^{-1.75}$)	6.1 (5.5-6.7)	6.3 (5.7-6.9)

5.3.2.2. Neck pain

In the follow-up study, 24 police drivers reported a new episode of neck pain during the past 12 months (12-months incidence: 16%), 15 police drivers reported new episode of neck pain during the past 4 weeks (4-weeks incidence: 10%) and 7 police drivers reported new episode of low back pain during the past 7 days (7-days incidence: 5%).

A persistent episode of neck pain during the past 12 months was reported in 49 police drivers (12-months persistence: 69%). Thirty police drivers reported persistent episode of neck pain during the past 4 weeks (4-weeks persistence: 42%) and 18 police drivers reported persistent neck pain during the past 7 days (7-days persistence: 25%).

The incidence and the persistence of neck pain among police drivers are illustrated graphically in Figure 5.3. and Figure 5.4.

5.3.3. Risk factors for low back pain

The selection of suitable candidate risk factors for the final multivariate analysis in the longitudinal study was based on results from the cross-sectional baseline study of police drivers.

The multivariate analysis followed separately police drivers who reported episodes of low back pain lasting for at least one day during the past 12 months in the cross-sectional baseline of the study ('the persistence group') and police drivers who did not report an episode of low back pain during the past 12 months in the cross-sectional baseline of the study ('the incidence group').

Persistence group than consisted from police drivers reporting low back pain episode during the cross-sectional study and also experiencing low back pain in the follow-up of the study; and police drivers reporting low back pain episode during the cross-sectional study and no low back pain in the follow-up of the study. Similarly, incidence group consisted from police drivers reporting no low back pain episode during the cross-sectional study and presence of low back pain in the follow-up of the study; and police

Table 5.17. Significant variables selected for multivariate analysis in the longitudinal study of police drivers

Variables suitable for multivariate analysis
Age
Lifting
Bending
Distress status
<u>Driving information</u>
daily driving time (h)
$A(8)_{dom}$
$eVDV_{dom}$
exposure duration (yrs)
$\sum[t_i]$ (h)
$eVDV_{Total\text{-}dom}$

drivers reporting no low back pain episode during the cross-sectional study and no low back pain in the follow-up of the study.

All risk factors that were selected by stepwise multiple logistic regression in the cross-sectional baseline study were considered to be possible predictors for low back pain in policed drivers and were automatically entered into the final statistical model of the longitudinal study. Possible predictors for low back pain are listed in Table 5.17.

5.3.3.1. Incidence of low back pain

In police drivers, the standard multiple logistic regression revealed that there was a significant increase in the incidence of low back pain in the driving group with poor psychosomatic distress status (OR = 5.44) and middle age (OR = 3.21).

Results of the standard multiple logistic regression, when all significant potential variables for low back pain in police drivers (without information on driving exposure) and age as variables of known biological importance were entered into the multivariate logistic model together to examine the contribution of all possible variables at the same time, are presented in Table 5.18.

Multiple logistic regression allowed the influence of driving information on the incidence of

Table 5.18. Incidence group of participants in the follow-up of the longitudina study. Standard multivariate logistic regression for the associatio between low back pain during past 12 months and various individua and work-related risk factors in police drivers. In the table ar presented adjusted odds ratios (OR) and 95% confidence interval (95% CI)

Factors		Police drivers (n=96) OR (95% CI)
Age (yr)		
	≤ 36	1.00 (-)
	37-46	3.21 (1.11-9.25)
	> 46	0.29 (0.03-2.65)
Lifting		
	no	1.00(-)
	yes	0.43 (0.14-1.38)
Bending		
	no	1.00 (-)
	yes	0.35 (0.06-2.07)
Psychosomatic distress status		
	healthy	1.00 (-)
	medium	1.53 (0.48-4.87)
	poor	5.44 (1.27-23.39)

Table 5.19. Multivariate logistic regression of low back pain in the 12 months on alternative measures of daily and total cumulative vibration exposure to whole-body vibration in police drivers in the incidence group of the one-year follow-up period. Each measure of whole-body vibration exposure was included as a third based design variable. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Measures of WBV exposure	Police drivers (n=96)		
	T1	T2	T3
Daily driving time (h)			
OR	1.00	8.24	7.69
(95% CI)	(-)	(1.27-53.43)	(1.58-37.40)
$A_{dom}(8)$ (ms^{-2} r.m.s.)			
OR	1.00	10.85	9.84
(95% CI)	(-)	(1.64-71.63)	(1.84-52.58)
$eVDV_{dom}$ ($ms^{-1.75}$)			
OR	1.00	10.85	9.84
(95% CI)	(-)	(1.64-71.63)	(1.84-52.58)
Exposure duration (yr)			
OR	1.00	1.27	0.79
(95% CI)	(-)	(0.38-4.23)	(0.19-3.32)
$\sum[t_i]$ (h $\times 10^3$)			
OR	1.00	2.07	3.05
(95% CI)	(-)	(0.29-14.82)	(0.72-12.93)
$eVDV_{Total\text{-}dom}$ ($ms^{-1.75}$)			
OR	1.00	2.57	2.58
(95% CI)	(-)	(0.51-12.87)	(0.53-12.56)

Odds ratios adjusted for following risk factors: age, lifting, bending, psychosomatic distress status

low back pain to be seen by forcing the relevant variables into the statistical model. Each aspect of driving information (i.e. measures of daily and cumulative driving) was entered into separate regression model with other confounders selected in the cross-sectional study (except any information about driving).

The incidence of low back pain increased significantly with increasing daily driving exposure expressed as duration of driving in hours (T1: OR = 8.24, T2: OR = 7.69), $A_{dom}(8)$ (T1: OR = 10.85, T2: OR = 9.84) and $eVDV_{dom}$(T1: OR = 10.85, T2: OR = 9.84) . There were non-significant trends for increased incidence of low back pain in police drivers during the past 12 months with increased cumulative exposure to driving. The final standard multiple logistic regressions including driving information are presented in Table 5.19.

5.3.3.2. Persistence of low back pain

Results of the standard multiple logistic regression, when all significant potential variables for low back pain in police drivers (without information on driving exposure) and age as variables of known biological importance were entered into the multivariate logistic model together to examine the contribution of all possible variables at the same time, are presented in Table 5.20.

In police drivers, the standard multiple logistic regression only revealed a significantly increased persistence of low back pain in the driving group with poor psychosomatic distress status (OR = 4.76).

In the persistence group of police drivers, the persistence of low back pain experienced during the past 12 months increased with increasing total duration of driving expressed in years. A statistically significant increase in the persistence of low back pain was found in those who had driven a police vehicle for more than 15.4 years (OR = 5.95). The final standard multiple logistic regressions including driving information are presented in Table 5.21.

Table 5.20. Persistence group of participants in the follow-up of the longitudina study. Standard multivariate logistic regression for the associatio between low back pain during past 12-months and various individua and work-related risk factors in police drivers. In the table ar presented adjusted odds ratios (OR) and 95% confidence interval (95% CI)

Factors		Police drivers (n=123) OR (95% CI)
Age (yr)		
	≤ 36	1.00 (-)
	37-46	1.68 (0.61-4.61)
	> 46	0.81 (0.26-2.56)
Lifting		
	no	1.00 (-)
	yes	1.13 (0.45-2.85)
Bending		
	no	1.00 (-)
	yes	1.60 (0.61-4.16)
Psychosomatic distress status		
	healthy	1.00 (-)
	medium	1.65 (0.59-4.61)
	poor	4.76 (1.48-15.26)

5.3.4. Risk factors for neck pain

Multiple logistic regression was also performed for the neck pain in police drivers.

The standard multiple logistic regression did not reveal significant associations with any of the individual, physical or psychosocial risk factors in the persistent group and also in the incidence group of police drivers.

Multiple logistic models allowing the influence of driving information on the persistent neck pain did not reveal any significant associations with persistent or incident neck pain and increased duration of daily or cumulative driving in police drivers.

Results from the standard multiple logistic regression, when all significant potential variables for neck pain outcomes and age were entered into the multivariate logistic model together to examine the contribution of all possible variables at the same time, are presented in Appendix E (Table E15 and E16).

Table 5.21. Multivariate logistic regression of low back pain in the 12-months on alternative measures of daily and total cumulative vibration exposure to whole-body vibration in police drivers in the persistence group of the one-year follow-up period. Each measure of whole-body vibration exposure was included as a third based design variable. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Measures of WBV exposure	Police drivers (n=123)		
	T1	T2	T3
Daily driving time (h)			
OR	1.00	0.60	0.52
(95% CI)	(-)	(0.15-2.35)	(0.15-1.79)
$A_{dom}(8)$ (ms^{-2} r.m.s.)			
OR	1.00	0.69	0.51
(95% CI)	(-)	(0.17-2.92)	(0.14-1.90)
$eVDV_{dom}$ (ms$^{-1.75}$)			
OR	1.00	0.56	0.42
(95% CI)	(-)	(0.13-2.49)	(0.11-1.64)
Exposure duration (yr)			
OR	1.00	2.98	5.95
(95% CI)	(-)	(0.87-10.21)	(1.69-21.03)
$\sum[t_i]$ (h $\times 10^3$)			
OR	1.00	3.85	2.44
(95% CI)	(-)	(0.38-38.61)	(0.80-7.43)
$eVDV_{Total\text{-}dom}$ (ms$^{-1.75}$)			
OR	1.00	3.06	2.12
(95% CI)	(-)	(0.71-13.04)	(0.61-7.44)

Odds ratios adjusted for following risk factors: age, lifting, bending, psychosomatic distress status

5.4. Longitudinal study of police non-drivers

5.4.1. Description of the population

5.4.1.1. Response rate

In the follow-up of the longitudinal study, questionnaires were posted to the 485 police non-drivers who had participated in the cross-sectional baseline of the study. From the total of 302 returned questionnaires, two responses were excluded because they were no longer in the police force.

In total, 300 questionnaires from police non-drivers were used in the baseline and the follow-up of the longitudinal study.

5.4.1.2. Comparison of cross-sectional baseline and longitudinal baseline of police non-drivers

Statistical analysis were performed to see differences of individual, physical and psychosocial information of the cross-sectional baseline of police non-drivers (n=485) and the longitudinal baseline of police non-drivers (n=300).

Individual characteristics

Descriptive statistical analysis of individual information (i.e. age, anthropometrics, smoking habits and leisure activity exposure) showed that there are no significant differences between the cross-sectional baseline and the longitudinal baseline of police non-drivers (See Table 5.22.).

Physical activities at work

Data analysis showed that there are no statistically significant differences between amount of lifting, bending, twisting, walking for more than one hour per day and sitting (other while driving) between the cross-sectional baseline and the longitudinal baseline of police non-drivers (See Table 5.23.).

Characteristics of previous job (i.e. previous driving, previous sitting and previous exposure to physical demands) as well did not show statistical differences between the cross-sectional baseline and the longitudinal baseline of police non-drivers (See Table 5.24.).

Psychosocial variables

There have not been found significant differences in psychosocial factors at work (i.e. choice and decision, support from colleagues and satisfaction at job), energy and vitality

Table 5.22. Differences in individual characteristics of the cross-sectional baseline and longitudinal baseline of police non-drivers. Data are given as median and interquartile range for age and anthropometric characteristics and as frequency (n) and percentage (%) for smoking, and physical activity

Individual risk factors	Police non-drivers	
	Cross-sectional baseline (n=485)	Longitudinal baseline (n=300)
Age (yr)	42 (33-49)	41 (33-49)
Height (cm)	170.2 (162.6-177.8)	170.2 (162.6-177.8)
Weight (kg)	75.6 (64.8-88.2)	76.7 (65.8-88.2)
Smoking (n):		
non-smokers	317 (65)	205 (68)
ex-smokers/smokers	166 (34)	94 (31)
Physical activity		
no	152 (30)	83 (27)
yes	333 (70)	217 (72)

status, mental health status and psychosomatic distress between both populations (See Table 5.24.).

Health outcomes

There have not been found significant differences between health outcomes (i.e. different characteristics of low back pain, neck pain and shoulder pain) in the cross-sectional baseline and the longitudinal baseline of police non-drivers (See Table 5.25.).

Complete data about individual, physical, psychosocial information and health outcomes of the longitudinal baseline of police non-drivers are listed in Appendix E (Tables E17, E18, E19 and E20).

5.4.1.3. <u>Comparison of longitudinal baseline and longitudinal follow-up of police non-drivers</u>

Statistical analyses were performed to see possible changes of individual, physical and psychosocial information in the follow-up of the longitudinal study of police non-drivers.

Table 5.23. Differences in physical characteristics of work of the cross-sectional baseline and longitudinal baseline of police non-drivers. Data are given as frequency (n) and percentage (%)

Physical risk factors	Police non-drivers	
	Cross-sectional baseline (n=485)	Longitudinal baseline (n=300)
Lifting at work		
no	350 (72)	220 (73)
yes	135 (28)	80 (27)
Standing or walking (≥ 1h/day)		
no	248 (51)	158 (53)
yes	235 (49)	140 (47)
Trunk bent at work		
no	396 (82)	246 (82)
yes	87 (18)	52 (17)
Trunk twisted at work		
no	437 (90)	273 (91)
yes	48 (10)	27 (9)
Sitting > 3h at work		
no	116 (24)	69 (23)
yes	369 (76)	231 (77)
Previous job with:		
Professional driving	148 (31)	95 (33)
Physical demands	146 (30)	87 (29)
Sitting	234 (48)	148 (49)

Individual characteristics

Descriptive statistical analysis of individual information (weight, smoking habits and leisure activity exposure) showed that there are no significant changes between the longitudinal baseline and the follow-up of police non-drivers (See Table 5.26.).

Physical activities at work

Data analysis showed that there were no statistically significant changes between physical activities such as lifting, bending, twisting, walking and sitting (other while driving) in the longitudinal baseline and the follow-up of police non-drivers (See Table 5.26.).

Psychosocial variables

There have not been found significant changes in the level of experienced psychosomatic distress between the longitudinal baseline and the follow-up of police non-drivers (See Table 5.26.).

Table 5.24. Differences in psychosocial factors of the cross-sectional baseline and longitudinal baseline of police non-drivers. Data are given and as frequency (n) and percentage (%) for psychosocial factors at work and as median and intrequartile range of total score for psychosocial statutes.

Psychosocial risk factors	Police non-drivers	
	Cross-sectional baseline (n=485)	Longitudinal baseline (n=300)
No choice and decision at work:		
- how to work	120 (25)	72 (24)
- what to do at work	173 (36)	103 (34)
- timetables and breaks	119 (25)	72 (24)
Support from colleagues yes	421 (87)	266 (89)
Satisfaction at job	427 (88)	269 (90)
Mental health status	24 (21-26)	24 (21-26)
Energy and vitality status	16 (13-18)	16 (14-18)
Psychosomatic distress status	1 (1-3)	1 (0-3)

5.4.2. Occurrence of health outcomes

5.4.2.1. Low back pain

In the follow-up of the study, from the total of 300 police non-drivers, 43 reported a new

Table 5.25. Prevalence of health symptoms in the cross-sectional baseline and longitudinal baseline of police non-drivers

Outcome	Police non-drivers (%)	
	Cross-sectional baseline	Longitudinal baseline
LBP in the previous 12 months	46	47
LBP in the previous 4 weeks	21	21
LBP in the previous 7 days	11	12
NP in the previous 12 months	35	36
NP in the previous 4 weeks	18	19
NP in the previous 7 days	9	10
SP in the previous 12 months	26	26
SP in the previous 4 weeks	14	16
SP in the previous 7 days	7	8

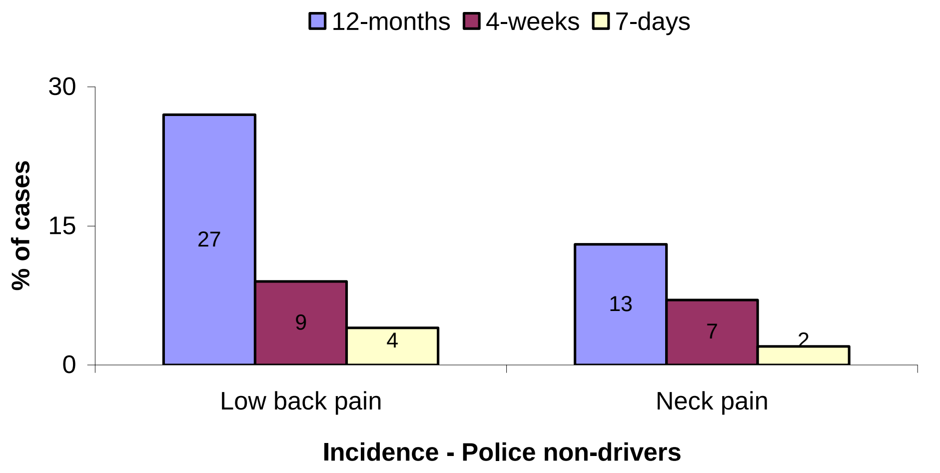


Figure 5.5. Incidence of low back pain and neck pain among police non-drivers

episode of low back pain during the past 12 months (12 months incidence: 27%), 14 reported a new episode of low back pain during the past 4 weeks (4 weeks incidence: 9%), and 7 reported a new episode of low back pain during the past 7 days (7 days incidence: 4%).

A persistent episode of low back pain during the past 12 months was reported in 88 police non-drivers (12 months persistence: 63%), 51 of police non-drivers reported a persistent episode of low back pain during the past 4 weeks (4 weeks persistence: 36%), and 27 of police non-drivers reported a persistent episode during the past 7 days (7 days persistence: 19%).

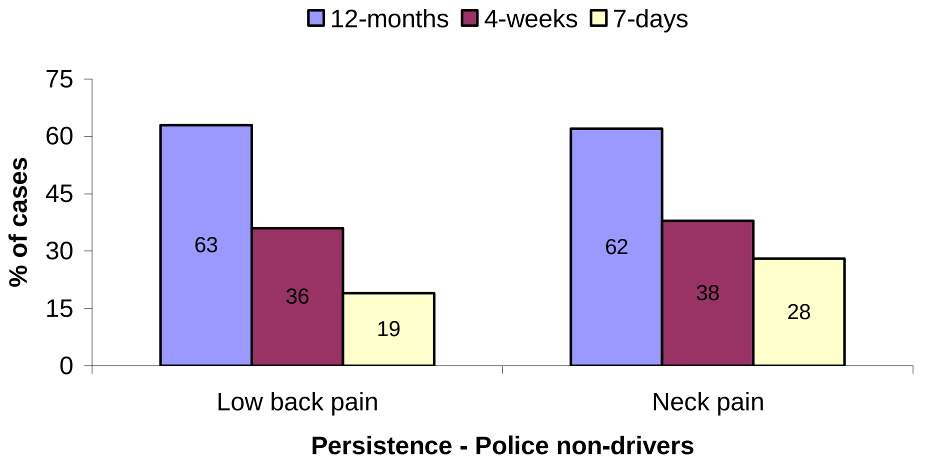


Figure 5.6. Persistence of low back pain and neck pain among police non-drivers

Table 5.26. Differences in individual, physical and psychosocial characteristics of the baseline and follow-up of the longitudinal study of police non-drivers. Data are given as median and interquartile range or as frequency (n) and percentage (%)

Individual risk factors	Police non-drivers	
	Baseline (n=300)	Follow-up (n=300)
Weight (kg)	75.6 (64.8-88.2)	76.73 (65.81-88.2)
Smoking (n):		
non-smokers	205 (68)	202 (67)
ex-smokers/smokers	94 (31)	95 (32)
Physical activity		
no	83 (27)	77 (26)
yes	217 (72)	223 (74)
Lifting at work		
no	220 (73)	221 (74)
yes	80 (27)	79 (26)
Standing or walking (≥ 1h/day)		
no	158 (53)	153 (51)
yes	140 (47)	146 (49)
Trunk bent at work		
no	246 (82)	246 (82)
yes	52 (17)	52 (17)
Trunk twisted at work		
no	273 (91)	270 (90)
yes	27 (9)	30 (10)
Sitting > 3h at work		
no	69(23)	61 (20)
yes	231 (77)	237 (79)
Psychosomatic distress status	1 (0-3)	1 (0-3)

The incidence and persistence of low back pain among police non-drivers are illustrated graphically in Figure 5.5. and Figure 5.6.

5.4.2.2. Neck pain

In the follow-up study, 25 police non-drivers reported a new episode of neck pain during the past 12 months (12 months incidence: 13%), 13 police non-drivers reported a new episode of neck pain during the past 4 weeks (4 weeks incidence: 7%) and 4 police non-drivers reported new episode of neck pain during the past 7 days (7 days incidence: 2%).

A persistent episode of neck pain during the past 12 months was reported in 68 police non-drivers (12 months persistence: 62%). Forty-one police non-drivers reported persistent episode of neck pain during the past 4 weeks (4 weeks persistence: 38%) and

28 police non-drivers reported persistent neck pain during the past 7 days (7 days persistence: 28%).

The incidence and the persistence of neck pain among police non-drivers are illustrated graphically in Figure 5.5. and Figure 5.6.

5.4.3. Risk factors for low back pain

The selection of suitable candidate risk factors for the final multivariate analysis in the longitudinal study was based on results from the cross-sectional baseline study of police non-drivers.

The multivariate analysis followed separately police non-drivers who reported episodes of low back pain lasting for at least one day during the past 12 months in the cross-sectional baseline of the study (the 'persistence group') and police non-drivers who did not report an episode of low back pain during the past 12 months in the cross-sectional baseline of the study (the 'incidence group').

Persistence group than consisted from police non-drivers reporting low back pain episode during the cross-sectional study and also experiencing low back pain in the follow-up of the study; and police non-drivers reporting low back pain episode during the cross-sectional study and no low back pain in the follow-up of the study. Similarly, incidence group consisted from police non-drivers reporting no low back pain episode during the cross-sectional study and presence of low back pain in the follow-up of the study; and police non-drivers reporting no low back pain episode during the cross-sectional study and no low back pain in the follow-up of the study.

All risk factors that were selected by stepwise multiple logistic regression in the baseline cross-sectional study were considered to be possible predictors for low back pain in policed non-drivers and were automatically entered into the final statistical model of the longitudinal study. Possible predictors for low back pain are listed in Table 5.27.

Table 5.27. Significant variables selected for multivariate analysis in the longitudinal study of police non-drivers

Variables suitable for multivariate analysis
Age
Height
Bending
Distress status

Table 5.28. Incidence group of participants in the follow-up of the longitudinal study. Standard multivariate logistic regression for the association between low back pain during past 12-months and various individual and work-related risk factors in police non-drivers. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Factors		Police non-drivers (n=160)
		OR (95% CI)
Age (yr)		
	≤ 36	1.00 (-)
	37-46	1.20 (0.49-2.97)
	> 46	0.82 (0.32-2.14)
Height (cm)		
	≤ 170.18	1.00 (-)
	170.19-177.8	0.53 (0.20-1.42)
	> 177.8	1.97 (0.73-5.37)
Bending		
	no	1.00 (-)
	yes	0.75 (0.26-2.20)
Psychosomatic distress status		
	healthy	1.00 (-)
	medium	0.72 (0.27-1.91)
	poor	3.11 (1.29-7.51)

5.4.3.1. Incidence of low back pain

In non-drivers, the standard multiple logistic regression only revealed a significant increase in the incidence of low back pain in the group with poor psychosomatic distress status (OR = 3.11).

Results of the standard multiple logistic regression, when all significant potential variables for low back pain in non-police drivers and age as variables of known biological importance were entered into the multivariate logistic model together to examine the contribution of all possible variables at the same time, are presented in Table 5.28.

5.4.3.2. Persistence of low back pain

In the multiple logistic regression model of the non-driving population, a significantly increased persistence of low back pain was found with performing bending at work (OR = 3.58), and with middle age group of participants (OR = 3.23). Analysis also revealed a trend for increased persistence of low back pain with increasing height.

Results of the standard multiple logistic regression, when all significant potential variables for low back pain in police non-drivers and age as variables of known biological importance were entered into the multivariate logistic model together to examine the contribution of all possible variables at the same time, are presented in Table 5.29.

5.4.4. Risk factors for neck pain

Multiple logistic regression was also performed for the neck pain in police non-drivers.

The standard multiple logistic regression did not reveal significant associations with any of the individual, physical or psychosocial risk factors in the incidence group of police non-drivers. The only significant association was found between persistent neck pain and increased level of psychosomatic distress (OR = 4.78).

Results from the standard multiple logistic regression, when all significant potential variables for neck pain outcomes and age were entered into the multivariate logistic model together to examine the contribution of all possible variables at the same time, are presented in Appendix E (Table E21 and Table E22).

Table 5.29. Persistence group of participants in the follow-up of the longitudinal study. Standard multivariate logistic regression for the association between low back pain during past 12-months and various individual and work-related risk factors in police non- drivers. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Factors		Police non-drivers (n=140)
		OR (95% CI)
Age (yr)		
	≤ 36	1.00 (-)
	37-46	3.23 (1.16-8.98)
	> 46	1.48 (0.59-3.76)
Height (cm)		
	≤ 170.18	1.00 (-)
	170.19-177.8	1.67 (0.67-4.18)
	> 177.8	2.02 (0.80-5.11)
Bending		
	no	1.00 (-)
	yes	3.58 (1.17-10.95)
Psychosomatic distress status		
	healthy	1.00 (-)
	medium	1.83 (0.75-4.45)
	poor	1.81 (0.68-4.82)

5.5. Discussion of the longitudinal studies of taxi drivers, police drivers and police non-drivers

5.5.1. Presence of bias and limitations of the longitudinal study

5.5.1.1. Selection bias

The loss of follow-up participants

The main limitations of all longitudinal epidemiological studies are high cost and time dependency which may result in a loss of participants. It is crucial to keep the loss of follow-up participants to minimum in order to eliminate these biases.

The limitation of this longitudinal study of taxi drivers and police employees was low number of subjects participating already in the first year of the study. To avoid the low response rate in the follow-up of the study, reminding rounds were performed and financial bonus offered to the participants. In the case of taxi drivers, three reminder rounds increased the response rate of the follow-up to 69%. In the case of police employees, one reminder round increased the response rate of the follow-up to 61%. The response rates reported in epidemiological studies differ depending on the type of data collection. Studies performing an oral or a phone interview are reporting higher response rate in the follow-up of the study (i.e. Gyntelberg, 1974; Biering-Sørensen, 1984). Generally follow-up studies using self-administered questionnaire report the response rate between 56% and 81% (Pietri *et al.*, 1992; Hoogerdoorn *et al.*, 2002; Niemistö *et al.*, 2004; Hulshof *et al.*, 2007; Lundström *et al.*, 2007).

Non-response bias

The non-response bias may influence the estimation of incident and persistent low back pain in all studied populations. It is generally easier to verify the presence of non-response bias in a longitudinal study than in a cross-sectional study. The performance of reminder rounds in follow-up of the longitudinal study also minimised the non-response bias which may bring the domination of people with musculoskeletal problems as they are more motivated to participate in the study.

Representativeness of population

No presence of significant differences between characteristics of study populations in the cross-sectional baselines and longitudinal baselines are confirming that the population of taxi drivers, police drivers and non-drivers were representative samples selected for the longitudinal study. In the case of taxi drivers, the representativeness was also confirmed

by comparison of the cohort of longitudinal study with again-contacted non-respondents from the first year of the study.
It is not possible to conclude that the population of taxi drivers or police drivers is a representative sample of a driving population. There have been previously investigated different types of driving populations and each of this study population is different in many ways. Already population of taxi drivers and police drivers in this longitudinal study showed to be significantly different in almost all investigated risk factors for low back pain.

5.5.1.2. Information bias

Questionnaire study design always brings the potential of presence of the information bias. Participants experiencing low back pain problems may wrongly assume the association between their health problems and some of the factors they think may be responsible for their problem. Such association may result in underestimation or overestimation of the real cause or effect of low back pain.

Presence of reporting bias resulting in underestimation or overestimation of exposure to various risk factors and recall bias were minimised by the design of the questionnaire which was validated and used in previous epidemiological studies.

More information about the presence and elimination of possible information bias were discussed in Chapter 4, Paragraph 4.6.1.

The main advantage of the longitudinal studies is that the design of the study allows the decision of relationship between the health outcomes and investigated risk factor. The measurement of exposure to possible risk factors before the onset of the health problem could asses if the presence of risk factor could arise as a consequence of the health problem or if the presence of the risk factor is causing the health problem.

5.5.2. Incidence and persistence of low back pain and other health outcomes

At this time, there is limited number of longitudinal studies investigating the presence of low back pain in professional drivers. Also the number of studies investigating incident or persistent back pain in general population is low.
The 12-month incidence of low back pain in this longitudinal study of taxi drivers and police drivers fall within the percentage range found in other studies of driving or non-driving populations. In this study, the police drivers reported a higher 12-month incidence of low back pain than taxi drivers (police drivers: 26%, taxi drivers: 11%). Generally, epidemiological studies report 6 to 38% of cases with incident low back pain (Gyntelberg,

1974; Biering-Sørensen, 1984; Pietri *et al.*, 1992; Smedley *et al.*, 1999; Tubach *et al.*, 2004). When considering professional car drivers, Pietri *et al.* (1992) found that 15% of car drivers reported incident low back pain in the past year and Funakoshi *et al*. (2003) reported 26% of taxi drivers experiencing new episode of low back pain. As reported in the Chapter 4, paragraph 4.5.2., the similarities and differences in occurrence of health outcomes in different studies have to be considered with respect to different design of performed studies, different techniques of low back pain assessment and mainly in different definition of low back pain problems.

The 12-month persistence of low back pain in this longitudinal study of taxi drivers and police drivers was higher that found in other studies of non-driving populations. In this study, the reported 12-month persistence of low-back pain was higher in police drivers (77%) than in taxi drivers (67%). Generally, epidemiological studies report 34 to 63% of cases with persistent low back pain (Biering-Sørensen, 1984; Thomas *et al.*, 1999; Tubach *et al.*, 2004).

Incidence of low back pain

The incidence of low back pain in police drivers was similar to that found in studies by VIBRISKS partners using a similar version of the self-administered questionnaire. The incidence of low back pain experienced for at least one day during the past 12 months varied from 26% to 30% in studies of bus drivers, agriculture and construction drivers, and forestry vehicle drivers performed in Italy, Netherlands and Sweden.

The non-driving population, represented by police employees who reported less than 5 hours of driving per working week, were more than twice the 12-month incidence of low back pain (27%) when compared with taxi drivers. The persistent low back pain in the police non-driving population (63%) is consistent with the 12-month persistence of taxi drivers.

In this study, taxi drivers reported lower incidence of low back pain (more than factor two) than police drivers, police non-drivers and also other professional drivers investigated by other partners of VIBRISKS.

One explanation of the difference between populations may come already from the initial part of the study (the cross-sectional baseline) and is known as selection bias (response bias). Response bias is present when generally healthy individuals do not tend to reply in the epidemiological studies concerning health problems. However, this explanation may be rejected as reminder round to enhance the response rate was performed. Also, the prevalence of low back pain in the cross-sectional study of taxi drivers comparable with studies of police drivers and non-drivers and also other previously reported epidemiological studies is suggesting that there is no presence of non-response bias from taxi drivers.

Second explanation of decreased incidence low back pain in taxi drivers may be the loss of replies during the follow-up. The lack of replies from taxi drivers may result in low number of taxi drivers reporting new cases of low back pain. Also this explanation could be refused as the descriptive statistics showed that the response rate of taxi drivers with no low back pain in the first year of the study was higher that response rate of police drivers and non-drivers.

Third possible explanation may be the presence of healthy worker effect when taxi drivers with low back pain tend to leave their work. Although the Legal Office Licence Centre of the City of Southampton did not report any decrease of taxi drivers in the City of Southampton during the longitudinal study, it is not possible to reject the possibility of taxi drivers to leave their work because of the presence of health problems.

Presence of different characteristics of taxi drivers and police employees may also explain decreased incidence of low back pain in taxi drivers. From descriptive statistics was derived that taxi drivers significantly differed in age, smoking, performance of lifting at work and duration of driving (expressed in different metrics) from police drivers and non-drivers who did not show any differences in these characteristics. However, the differences showed on relationship of increased age, smoking, lifting and exposure to driving and decreased incidence of low back pain in taxi drivers. Therefore, the decreased incidence of low back pain in taxi drivers may be explained by differences in characteristics of the populations which were not investigated by the self-administered questionnaire. One of them is the sitting posture adopted while working. From the nature of the taxi driving job is assumed that most of the drivers are self-employed and they choose the taxi vehicle alone. Also, the vehicle is often operated by one owner and therefore the vehicle features such as type of seat, seat suspension, seat inclination, distance from the steering wheel and foot pedals, etc. is adjusted to the highest comfort of the driver. Important fact is that taxi drivers are not restricted to use the seat belts while driving in the city resulting in more comfort while driving. Comfort while performing taxi driving may be the cause why taxi drivers are reporting lower incident pain than police employees.

Some previous epidemiological studies also suggested the difference in educational and social level to be the possible risk factor for increased presence of low back pain. However, the weak evidence concerning the relationship between the increased presences of low back pain is mainly suggested in the lower educational class (Gyntelberg, 1974; Pope, 1989; Bernekow-Bergkvist *et al.*, 1998; Waddel, 1998).

Generally, to work in a police force request higher education that to perform taxi driving. However, the level of education in taxi drivers cannot be followed as it was not part of the self-administered questionnaire.

Persistence of low back pain

Persistent pain, when participants experiencing low back pain during the baseline and also during the follow-up of the longitudinal study, was highest in the police drivers. The presence of increased persistent pain may be influenced by loss of interest to participate in the study from drivers who had low back pain in the cross-sectional baseline of the study and after recovered during the follow-up of the study. In other words, the explanation of increased persistence in police drivers is result of response bias where people without the health problem do not tend to participate in the study. Descriptive statistics however revealed that the decrease of replies from participants experiencing low back pain in the cross-sectional baseline and longitudinal baseline was not statistically different than in police non-drivers and taxi drivers.

Results did not confirm any significant difference in individual, physical and psychosocial characteristics in persistent cases of investigated populations (cross-sectional baseline and follow-up populations). Therefore increased persistence of low back pain in police drivers cannot be explained by differences in characteristics of investigated populations obtained from the self-administered questionnaire.

Increased persistence of low back pain in police drivers may be explained by differences in characteristics of the populations which were not investigated by the self-administered questionnaire. As decreased incidence of low back pain in taxi drivers, increased persistence of low back pain in police drivers may be explained by sitting posture adopted while working. Police drivers often drive different marks of vehicles, which are operated by more drivers. Therefore the type of seating and other vehicle features are not adapted to suit the different drivers. A strained seating posture raised by presence of a waist belt (a police radio, a gun, a handcuffs and a truncheon), inadequate adjustment of the seat resulting in the abnormal force on the steering wheel and foot pedals, etc. may be the cause of persistent pain in police drivers.

The important role of comfort while driving (improved postures and freedom of movement while driving) and reduced physical workload of the spine on occurrence of low back pain in taxi drivers and police drivers may be confirmed by results of study performed by Porter *et al.* (2002). In their study, drivers with adjustable lumbar support, steering wheel adjustment, automatic gear box, cruise control, etc. reported less absence of low back pain episodes than drivers who reported not enough headroom, poor pedal position, poor steering wheel position or no backrest angle adjustment. Also in the study of Pietri *et al.* (1992) the lack of comfort of the seat in the commercial travellers was significantly associated with increased prevalence and incidence of low back pain.

The nature of the profession may also play crucial role in the rating of health problems. Most taxi drivers are self-employed, with a long duration of driving and few days off work to maximise their income. Taxi drivers may therefore underestimate the presence of low back pain because it did not make them cut down some working days. On the other hand, police drivers are employed by the state and their income is generally not influenced by days off work due to health problems.

Police drivers also reported higher incidence and persistence of neck pain (incidence: 16%, persistence: 69%) experienced for at least one day during the past 12 months than taxi drivers and police non-drivers. However, the number of police drivers developing new episode of neck pain was lower than in the study of agriculture and construction drivers in the Netherlands (VIBRISKS). The literature about presence of incident neck pain in professional drivers and also in general population is not that broad as literature concerning low back pain problems. There have not been found suitable longitudinal studies allowing the comparison of incidence or persistence of neck pain in police and taxi drivers.

5.5.3. Driving factors as risks for low back pain

There was significantly increased incidence of low back pain in police drivers who had increased daily exposure to driving. The data from the longitudinal design of the study allowed following the group of individuals with no presence of low back pain and increased daily driving exposure at the initial examination to see if they develop low back pain under the increased exposure to driving. In all police drivers who were exposed to increased exposure of daily driving at both questionnaire examinations developed new episode of low back pain at the follow-up of the longitudinal study. It was not possible to confirm statistically the associations between increased daily exposure to driving and development of new cases of low back pain in the incidence group of taxi drivers because the number of new cases of low back pain during the past 12 months was too low. However, from the descriptive statistics was confirmed that more than 67% of taxi drivers who were exposed to increased exposure of daily driving in both questionnaire examinations developed new episode of low back pain during the follow-up of the study. These associations are confirming the important role of daily exposure to driving on development of low back pain in population of professional drivers. Results supporting the hypothesis that increased duration of driving is a causal risk factor for low back pain was published in the study of Pietri *et al.* (1992). In their study was found that with increased duration of driving (driving for more than 20 hours per one working week) increase the risk of new episodes of low back pain in commercial travellers.

The longitudinal study of taxi drivers did not reveal any statistically significant associations suggesting increased persistence of low back pain with increased daily or cumulative driving. The lack of associations of daily or cumulative exposure to driving with persistent low back pain maybe explained by the secondary worker healthy effect. The healthy worker effect appear when drivers who are exposed to higher dose of daily and cumulative exposure to driving and suffering by low back pain during the cross-sectional baseline study leave their job during the follow-up so they do not longer participate in the longitudinal study. From the responses of the drivers who did not participate in the follow-up part and reported low back pain in the cross-sectional baseline study, almost half of them reported daily and cumulative driving in the highest exposure group. Therefore it may be hypothesised that presence of healthy worker effect reduced the association between persistent low back pain and driving.

5.5.4. Non-driving risk factors for low back pain

Psychosomatic distress

In the longitudinal study, increased psychosomatic distress was a strong predictor of the persistence of low back pain experienced for at least one day during the past 12 months in all investigated driving populations (i.e. the taxi drivers and the police drivers). Increased psychosomatic distress was also a strong predictor of the incident back pain in police non-drivers. The descriptive statistics in taxi drivers showed on increased psychosomatic distress level in drivers reporting new episodes of low back pain than on drivers without pain. Similar findings of the importance of psychosocial factors, such as anxiety, depression, and stressful events among individuals with back pain have been identified in other studies (e.g., Bergenudd and Nilsson, 1988; Gallais and Griffin, 2006).

As previously stated in the discussion of the Chapter 4, cross-sectional design of the study was not able to conclude if increased level of psychosomatic distress is the cause of low back pain or caused by back pain. The change of health problem under persistent level of distress must be recorded to decide if cause of low back pain in drivers is high level of psychosomatic distress. The longitudinal design of the study allowed following the group of individuals with no presence of low back pain and at the same time with increased psychosomatic distress at the initial examination and allowed to see if they develop low back pain under the increased psychosomatic distress. In populations of drivers, all taxi drivers and 55% of police drivers with increased level of psychosomatic distress in the baseline and also the follow-up of the longitudinal study developed new episode of low back pain. Also in police non-drivers was incident pain reported in 80% of individual with persistently increased level of psychosomatic distress in baseline and follow-up of the longitudinal study.

After closer examination of low back pain in all populations it is clear that the low back pain persists in individuals with constantly increased level of psychosomatic distress (taxi drivers: 83%, police drivers: 92%, police non-drivers: 89%).

These associations confirm the important role of increased psychosomatic distress in the development of new cases of low back pain in all studied populations.

Age

From personal literature review of car driving populations was found that the prevalence of back problems increases with increasing age. The review also showed that after reaching the age about 50 years old the prevalence of low back pain in car drivers slightly decrease (see Gallais and Griffin, 2006). Similar results were confirmed in all longitudinal studies of professional drivers from VIBRISKS partners.

In the follow-up part of this longitudinal study was found that the risk of incident low back pain was significantly higher in the middle age group of police drivers than in the older and younger age groups. The increased risk of incident low back pain in middle age group might be explained by the ‘healthy worker effect’ in which those with back pain tend to leave the job, resulting in decrease of back pain in older age group. In the case of police drivers and police non-drivers, the presence of healthy worker effect already in the cross-sectional baseline of the study may result in increased risk of incident low back pain in middle age individuals and decreased risk in older individuals. Similar findings were confirmed in persistent low back pain in all investigated populations. In the non-driving population, the risk of persistent back pain was significantly greater in the middle age group than in the oldest and youngest age groups. Although the association between the persistence of low back pain and age of taxi drivers and police drivers was not significant the risk of persistent low back pain in middle age group was higher than in older and younger drivers.

Bending

A significant increase in persistent low back pain was found in the police non-drivers reporting bending at work. Similar findings of the importance of bending among individuals with prevalent low back pain have been identified in other studies (e.g. Riihimäki *et al.*, 1989, Gallais and Griffin, 2006). From longitudinal studies, there have been presented results confirming important role of bending on persistent or incident episode of low back pain in general population (Hoogendoorn *et al.*, 2002; Tubach *et al.*, 2004). However, there have been also studies which did not confirm the causative association between low back pain and bending or other physical load at work such as lifting, twisting or carrying (Pietri *et al*., 1992; Thomas *et al.*, 1999). As bending was found to be significantly associated only with persistent low back pain it is more appropriate to call bending as aggravating risk factor for low back pain in non-driving population.

Anthropometrics

In the taxi drivers, being tall was significantly associated with persistent low back pain. Anthropometric individual factors such as height and weight seem to have an important role in increasing the prevalence of low back pain in some published epidemiological studies as discussed in the Chapter 4, paragraph 4.5. However, some studies have not found that increased body height increases the risk of back pain (see Gallais and Griffin, 2006). Similarly as for bending, because the significant associations with low back pain was found in the persistent group of taxi drivers, increased height seems to aggravate the presence of low back pain once it appear.

5.6. Conclusion on the longitudinal studies of taxi drivers, police drivers and non-drivers

The 12-month incidence of low back pain was lower in the taxi drivers than in the police drivers and the police non-drivers. Generally, the 12-month incidence of low back pain among police employees was similar to that reported in other populations (e.g., general populations, driving populations).

The 12-month persistence of low back pain was similar in the non-driving populations to that in the two driving populations. The 12-month persistence of low back pain among all three investigated populations was higher than that reported for other populations (e.g., general populations, driving populations).

In the police drivers, increased daily exposure to driving was a statistically significant risk factor for increased incidence of low back pain. In the taxi drivers, increased exposure daily or life-time driving was not an important risk factor for the persistence of low back pain.

In taxi drivers, police drivers, and in the non-driving population, the presence of low back pain experienced for at least one day during the past 12 months was significantly associated with individual risk factors (e.g. age, height), physical factors (e.g. bending) and, mainly, psychosocial risk factors (i.e. increased psychosomatic distress).

CHAPTER SIX

GENERAL DISCUSSION

6.1. Thesis contribution

There have been many epidemiological studies of low back pain in professional drivers. However, most have employed cross-sectional study designs that are less demanding on time and financial expense than longitudinal study design but cannot reveal the complex causation of low back pain.

In the initial literature research it was found that there were only a limited number of longitudinal studies investigating low back pain in professional drivers (i.e. Brendstrup *et al.,* 1987; Pietri *et al.* 1992*;* Funakoshi *et al.,* 2003), and the number of studies in professional car drivers was limited to only two (Pietri *et al.* in a population of commercial travellers and Funakoshi *et al.* in taxi drivers).

This study of low back pain in taxi drivers and police employees therefore represents a large addition to knowledge of the prevalence, incidence and persistence of low back pain in professional car drivers. The main priorities of this research were a strong longitudinal study design, choice of the under-investigated car-driving profession, and the consideration of various potential risk factors for the presence of low back pain.

6.2. Presence of low back pain

6.2.1. Prevalence of low back pain in car drivers and non-drivers

Focusing on the low back pain experienced for at least one day during the past 12 months, the prevalence of low back pain in the cross-sectional baseline study of taxi drivers and police drivers was similar to that found in other studies of professional driver populations within the scope of the research of VIBRISKS and the studies reviewed in the Chapter 2.

In this study it was found that 53% (48-58.6%) of the police drivers and 45% (38.3-51.7%) of the taxi drivers reported low-back pain during the past 12 months. Generally, previous epidemiological studies with cross-sectional or case-control designs report 40 to 60% of professional drivers with low back pain (e.g. Wikström *et al.*, 1994; Bovenzi *et al.*, 1999; Magnusson *et al.*, 1996; Boshuizen *et al*., 1992; Torén *et al*., 2002; Appendix A).

Looking more closely, epidemiological studies of professional car drivers report the prevalence range of low back pain from 40% to 51% (Pietri, 1992; Porter *et al.*, 2002; Funakoshi *et al.*, 2003; Chen *et al.*, 2004). In this cross-sectional study of taxi drivers and police drivers, the prevalence of low back pain fell in the range of reported low back pain in previously published studies of professional car drivers.

In this study, the non-driving population had a similar 12-month prevalence of low back pain (46% (41-50.1%) in the baseline cross-sectional study) to the population of taxi drivers and police drivers. The prevalence range of low back pain from previous studies of general populations (Frymoyer *et al.,* 1983; Damkot *et al.*, 1984; Riihimäki *et al.*, 1989; Masset *et al.*, 1994) is consistent with the prevalence of low back pain in the non-driving population of police employees.

Very approximately, there were similar rates of prevalence of low back pain during the past 12 months in police drivers, taxi drivers, and non-drivers. Comparable values of health outcomes between studied populations, populations studied in the scope of the VIBRISKS project, and studies reviewed in Chapter 2 also suggest that the non-driving populations were at a similar risk of developing low back pain as the professional drivers.

6.2.2. Incidence and persistence of low back pain in car drivers and non-drivers

Over 12 months, the incidence of low back in taxi drivers who had been free of low back pain in the cross-sectional baseline was 11%, the incidence in police drivers was 26% and the incidence in police non-drivers was 27%.

The 12-month incidence of low back pain in this longitudinal study of taxi drivers and police employees falls within the range found in other studies of driving and non-driving populations, which report 6 to 38% of cases with incident low back pain (Gyntelberg, 1974; Biering-Sørensen, 1984; Pietri *et al.*, 1992; Smedley *et al.*, 1999; Tubach *et al.*, 2004). The limited number of longitudinal studies of the incidence of low back pain presents a wide incidence range. Although the incidence values fall into this range, the comparison of results should be interpreted by taking into account the differences of each epidemiological study.

Previous epidemiological studies report 34 to 63% of cases with persistent low back pain (Biering-Sørensen, 1984; Thomas *et al.*, 1999; Tubach *et al.*, 2004). In the present study, the 12-month persistence of low back pain of taxi drivers (67%), police drivers (77%) and police non-drivers (63%) was higher than those found in other studies.

As previously stated, differences in the observed occurrence of low back pain may result from the different designs of epidemiological studies, differences between the investigated population groups, different techniques for risk factors assessment and, mainly, different definitions of low back pain problems in each study.

What can be the reason for the different occurrence of low back pain in the different studied populations?

In the present study, taxi drivers reported a lower incidence of low back pain (by more than a factor of two) than police drivers and police non-drivers. The possible explanations of these results were considered to be the presence of study bias and the presence of different characteristics in the studied populations.

Presence of bias

The first possible reason for a lower incidence of low back pain among taxi drivers may be the presence of bias (possible sources of bias considered in the study are presented in Figure 6.1).

The presence of selection bias (low-response, non-response bias or loss of follow-up) and information bias (such as measurement bias and recall bias) was minimised by the choice

TYPE OF BIAS

Selection bias
- low response rate
- non-response effect
- loss of follow-up
- representativnost of study group

Information bias
- measurement bias
- recall bias
- healthy worker effect

Confounding bias
- effect of confounders

Figure 6.1. Possible type of bias presented in the study

of study design, repeated monitoring of populations, and the selection of measurement apparatus. As discussed in the first paragraph of the discussion of the cross-sectional baseline study (4.6.1.) and the longitudinal study (5.5.1), it is believed that such biases were excluded and were not the reason for differences in incidence in the different study groups.

An explanation of the lower incidence of low back pain among taxi drivers than police drivers may be the presence of a 'healthy worker effect'. During the follow-up study, some questionnaires were returned with a note that the addressed taxi driver no longer worked in the profession. A lower incidence of low back pain in taxi drivers may then result from drivers leaving their jobs due to a new episode of low back pain. The presence of a healthy worker effect in taxi drivers was not verified by information provided by the Legal Office Licence Centre of the City of Southampton. From the official register of taxi drivers in the City of Southampton it was not confirmed that there was a decrease in taxi drivers leaving their job. However, based on the returned notes from taxi drivers, it is not possible to reject the hypothesis that some taxi drivers leave their work because of the presence low back pain.

Because of the confidentiality rules required by the Aberdeen Police Force, it was not possible to determine whether the healthy worker effect was present in the population of police employees. The confidentiality procedure, protecting the privacy of police employees did not allow the gathering of information about employees leaving their profession or even the reasons for leaving the employment of the police.

Presence of different characteristics in the studied populations

Another possible reason for different incidence rates among taxi drivers and police drivers is the presence of different characteristics in both populations. Descriptive statistics pointed to significant differences in all characteristics (i.e. individual, physical and psychosocial characteristics) between taxi drivers and police drivers. The direction of the differences in age, smoking, lifting, and duration of driving would suggest increased incidence of low back pain in taxi drivers compared to the studied populations of police drivers and non-drivers. In previous epidemiological studies such characteristics were often associated with increased risk of low back pain (e.g. increased age : Bovenzi and Betta, 1994; Bovenzi, 1996; smoking: Frymoyer *et al.*, 1980, 1983; Kelsey *et al.*, 1984 ; Pietri *et al.*, 1992 ; Liira *et al.*, 1996; Levangie, 1999; performance of lifting: Magora, 1974; Frymoyer *et al.*, 1983; Damkot *et al.*, 1984 ; Kelsey *et al.*, 1984; Svensson *et al.*, 1989 ; Walsh *et al.*, 1989 ; Liira *et al.*, 1996 ; Magnusson *et al.*, 1996; increased duration of driving: Kelsey and Hardy, 1975; Pietri *et al.*, 1992; Chen *et al.*, 2004; Tubach *et al.*, 2004). For this reason the differences in the incidence of low back pain between taxi drivers and police employees should be explained by presence of other differences between the populations.

In several epidemiological studies, differences in educational and social level have been suggested as risk factors for low back pain (Gyntelberg, 1974; Pope, 1989; Bernekow-Bergkvist *et al.*, 1998; Waddel, 1998). Although, there have been associations between the level of education in previous studies, this hypothesis could not be verified in this study as the level of education among taxi drivers and police employees was not known.

The nature of the profession, such as the type of employment (self-employed or employed, part-time or full-time employment) may also play role in the reporting of health problems. Most of the investigated taxi drivers were self-employed (more than 95%) and were able to plan independently their work shifts. The irregular income of taxi drivers may reflect longer durations of driving and fewer days off-work in order to satisfy their needs. Taxi drivers may therefore underestimate the presence of low back pain because it did not cause a reduction in their working days. On the other hand, the police drivers were employed by the state and their income was generally not influenced by days off work due to health problems. Therefore police employees may remember better their health problems connected with temporary suspension of work.

Previous epidemiological studies suggest adjustable features of the vehicle have a role in the prevalence and incidence of low back pain in professional drivers (e.g. Pietri *et al.*, 1992; Porter *et al.*, 2002). In our study, greater comfort while performing taxi driving may be the cause of why taxi drivers reported lower incident pain and also lower prevalent pain than police drivers. More precisely, the presence of vehicle features such as the type of seat, the presence of seat suspension, different seat inclination, adjustability of the seat and steering wheel, etc. may influence the presence of low back pain. Because taxi drivers are mainly self-employed, they have a choice of vehicle and the presence of different features and their adjustment in the vehicle are adapted to the comfort of the driver. In the police force, one police vehicle is usually shared by a group of drivers and one driver operates different vehicles. The type of seating and other vehicle features are less adapted to suit the individual police driver. A strained seating posture caused by wearing a waist belt (a police radio, a gun, handcuffs and a truncheon), or inadequate adjustment of the seat resulting in excessive force on the steering wheel and foot pedals, etc. may contribute to persistent pain in police drivers.

6.3. Risk factors for low back pain

Some epidemiological studies have focused on only one group of risk factors (individual, physical or psychosocial) or a few possible risk factors causing or aggravating low back pain. As an example, studies performed in professional drivers focus mainly on the association between exposure to whole-body vibration and the presence of low back pain (e.g. Kelsey and Hardy, 1975; Dupuis and Zerlett, 1987; Burdorf, 1989; Boshuizen *et al*., 1990, 1992, etc.). Such studies often ignore, or forget, the important role of other physical, psychosocial and individual risk factors in the development of low back pain in professional drivers.

The initial intention of this study was to find out if car driving, expressed in different metrics, is a cause of low back pain. The extensive literature review performed at the beginning of the study pointed to the importance of other risk factors such as individual, physical and psychosocial factors. That is why the broad range of possible risk factors for low back pain was investigated in the study.

As the dependent variable of the statistical analysis in the cross-sectional study and the longitudinal study was used presence of low back for at least one day during the past 12 months. The choice of this dependent variable was derived from previously published studies of professional drivers where low back pain during the past 12 months is the main studied health outcome (Pietri *et al,.* 1992; Wikström *et al.*, 1994; Magnusson *et al.* 1996; Bovenzi *et al.*, 1999; Porter *et al.*, 2000; Torén *et al,*. 2002; Funakoshi *et al.*, 2003; Chen *et al.,* 2004; etc.). Choice of different dependent variable such as low back pain during the past 4 weeks or during the past 7 days, intensity of low back pain, disability caused by low back pain or duration of absence from work due to low back pain will probably uncover different risk factors associated with such health outcomes. However, it is presumed that the choice of different dependent variable will also point on importance of risk factors associated with low back pain during the past 12 months, such as increased psychosomatic distress and increasing duration of driving.

6.3.1. Cross-sectional baseline study

Risk factors significantly associated with low back pain in the cross-sectional baseline of the study were identified as possible risk factors for low back pain. As previously stated, the cross-sectional design of the baseline study, which summarised the possible risk factors and health problems at one point in time, was not suitable for identifying whether such risk factors cause low back pain or are a secondary effect.

<u>Psychosocial risk factors</u>

From the psychosocial factors, the strongest association was found between increased level of psychosomatic distress and the prevalence of low back pain in all investigated populations. The presence of such a relationship has been found in several previous epidemiological studies (e.g. Gyntelberg, 1974; Bergenudd and Nilsson, 1988; Biering-Sørensen *et al.*, 1989; Svensson and Andersson, 1989; Heliövaara *et al.,* 1991; Pietri *et al.*, 1992; Bongers *et al.*, 1993; Barnekow-Bergkvist *et al.,* 1998). However from the study design, it was not possible to conclude if increased psychosomatic level was the cause of low back pain or an effect of low back pain.

Individual risk factors

From all individual factors investigated in the study, an association was found with increased height in taxi drivers and police non-drivers. There have been many previously published studies investigating the relationship between anthropometric information and presence of low back pain (Gyntelberg, 1974; Heliövaara, 1987; Levangie, 1999; Miyamoto, 2000; Porter and Gyi, 2002; Chen *et al.*, 2004). Generally it is accepted that anthropometric characteristics have minimal risk for development of back problems (Waddell, 2004).

Increasing age and its association to prevalent low back pain have been discussed in many studies. Generally, it is accepted that the prevalence of low back pain increases from teens to late 50s but then may fall slightly above the age of 60 years (e.g. Biering-Sørensen, 1982; Boshuizen *et al.*, 1992; Bovenzi and Betta, 1994; Bovenzi, 1996). This is consistent with findings in the population of police non-drivers. In the population of police drivers, a significantly increased prevalence of low back pain was found in the middle age group. The increased presence of low back pain in the middle age group could be explained by the presence of the healthy worker effect. The increased prevalence of low back pain in police drivers from 37 to 46 years old may reflect the absence of police drivers who decided to leave their job because of the presence of low back pain. As the profession of police driver require good status of health and physical fitness, the increased prevalence of low back pain may also reflect the absence of employees who did not enter police driving because of the presence of low back pain.

Physical risk factors

The most important determinant of the risk of reported low back pain in taxi drivers was the presence of repetitive heavy lifting in a previous job, and in police drivers and police non-drivers bending in the present job. From previous studies it is clear that lifting, twisting and bending are the risk factors most associated with prevalent low back pain (Magora

1974; Frymoyer *et al.*, 1983; Damkot *et al.,* 1984; Kelsey *et al.*, 1984; Riihimäki *et al.*, 1989; Svensson *et al.,* 1989; Walsh *et al.,* 1989; Pietri *et al.*, 1992; Magnusson *et al.,* 1996; Jensen *et al.*, 1996; Liira *et al.,* 1996; Xu *et al*., 1997; Ozguler *et al.*, 2000). This finding raises the question of whether heavy manual work is the cause of low back pain or just an aggravator of the problems. Such a question may be explained by the longitudinal follow-up results.

<u>Driving risk factors</u>

In this study, various alternative indicators of the extent of exposure to driving (i.e. daily and cumulative exposure to driving) from taxi driving and police driving were investigated.

The results showed that increased daily and cumulative life-time exposure to driving expressed in different metrics were possible predictors of low back pain experienced during the past 12 months in the population of taxi drivers. This finding is in accord with published studies of professional drivers of heavy machines (i.e. tractor drivers, track drivers, bus drivers, fork-lift drivers, etc.) (e.g. Boshuizen *et al.*, 1990; Bovenzi *et al.*, 1992, 1994, and 1996; Magnusson *et al.,* 1996) and also professional car drivers (e.g. Pietri *et al.*, 1992; Porter *et al.*, 2002; Chen *et al.*, 2005).

The lack of any discovered association between increased exposure to driving and low back pain in police drivers may be explained by the quantity of driving. From descriptive statistics the exposure to driving in taxi drivers was much greater than in police drivers. Taxi drivers were generally driving for their whole shift while police drivers drove only as a part of their job.

In this study, the estimated average daily vibration dose value of taxi drivers and police drivers was close to the EU daily exposure action value of 9.1 $ms^{-1.75}$ (taxi drivers: 8.34 $ms^{-1.75}$, police drivers: 6.09 $ms^{-1.75}$). Although they often had had long exposures to driving, only 18% of taxi drivers and no police drivers exceeded the EU exposure action value and no drivers exceeded the EU exposure limit value of 21 $ms^{-1.75}$. Although the EU Physical Agents (Vibration) Directive places no obligation on the employer to undertake periodic medical examinations when the exposure is less than the exposure action value, there is a general obligation on all employers to minimise the exposure of all workers to whole-body vibration.

Expressed in root-mean-square acceleration, only thirty-nine percent of taxi drivers and no police driver had a daily A(8) exposure greater than 0.5 ms^{-2} r.m.s. (exposure action value) and no drivers exceeded the exposure limit value of 1.15 ms^{-2} r.m.s. defined in the EU Physical Agents (Vibration) Directive to be the value above which administrative, technical and medical measures have to be implemented by the employer in order to protect the workers against the risks rising from vibration exposure. A study of taxi drivers performed by Chen *et al.* (2003), found the majority of taxi drivers to do not exceed the exposure action value of 0.5 ms^{-2} r.m.s.

6.3.2. Longitudinal study

The aim of the follow-up study, where the development of low back pain in populations was followed over time, was to ascertain true associations between low back pain and risk factors ascertained in the cross-sectional baseline.

<u>Psychosocial risk factors</u>

Increased psychosomatic distress was a predictor of the incidence of low back pain in police drivers (the incidence of low back pain was elevated by a factor of 5.44 in the group with a poor psychosomatic distress level) and in police non-drivers (elevated by a factor of 3.11 in the group with a poor psychosomatic distress level). The descriptive statistics also showed increased psychosomatic distress in taxi drivers reporting new episodes of low back pain when compared to drivers without pain. In the incidence group, it was necessary to follow subjects reporting increased psychosomatic distress in order to investigate the causality of increased psychosomatic distress on the development of low back pain. In the incidence group, all taxi drivers, the majority of police non-drivers, and more than half of the police drivers with permanently increased level of psychosomatic distress (i.e., a high level of psychosomatic distress in both the initial cross sectional questionnaire and the follow-up questionnaire) developed a new episode of low back pain during the follow-up of the study.

It is not clear the extent to which psychosocial problems are the cause of low back pain or caused by back pain. Although several associations between psychosocial risk factors and low back pain may be suggested:

> - High psychosomatic distress at work or personal life may cause changes in neurohormonal pathways of the spine and cause undesirable metabolic activity in bask tissue.
>
> Psychosomatic distress may have also more indirect effects on the biomechanics of the low back and cause the pain. Presence of distress risk factors influence the mechanical spinal load by changes in muscles (i.e. changes in posture, movements and forces) and revealing low back pain.
>
> - Psychosomatic distress might influence the reporting of low back pain. Generally individuals with higher distress status are more sensible to different health

symptoms than healthy individuals. The presence of pain may increase the higher sensibility of reporting presence of various symptoms patients who are more anxious or depressed have greater difficulty to cope with pain and that is why they seek more medical attention.

- Increased psychosomatic distress may also arrive as a consequence of low back pain. Low back pain may seriously affect the private and working life. Experience of life difficulties may than naturally influence presence of increased psychosomatic distress status among some individuals.

Although this study of taxi drivers and police employees confirms an important role for psychosomatic distress in the development of low back pain, it cannot offer an explanation for the mechanisms involved in the development of low back pain associated with increased psychosomatic distress.

Increased psychosomatic distress was also a strong predictor of the persistence of low back pain experienced for at least one day during the past 12 months in all investigated driving populations (i.e. the taxi drivers and the police drivers).

Individual risk factors

In the longitudinal study it was found that the risk of incident low back pain was significantly higher in the middle age group of police drivers than in the older and younger age groups. This result might be explained by the healthy worker effect. Drivers with low back pain may tend to leave their job, resulting in a decrease of back pain in the remaining older age drivers. The healthy worker effect detected in the cross-sectional baseline may result in increased risk of incident low back pain in middle aged individuals (in police drivers and also police non-drivers) and decreased risk in older individuals. Similar findings were apparent for persistent low back pain in all investigated populations

Taller stature remained a significant risk factor for persistent low back pain in taxi drivers and police non-drivers. As no significant associations were found between the incidence of low back pain and stature in any investigated population it could be concluded that increased stature plays a role in aggravating existing low back pain.

Physical risk factors

In the cross-sectional study a few risk factors were found to be associated with low back pain (i.e., previous heavy lifting in taxi drivers and bending in police employees). In the longitudinal study, the only significant association between low back pain and heavy manual work was found in police non-drivers. In police non-drivers, persistent low back pain was significantly related to bending. As no significant associations were found between the incidence of low back pain and increased bending in the investigated population of police drivers and non-drivers it is appropriate to class bending as an aggravating risk factor for low back pain in the non-driving population.

Driving risk factors

There was a significantly increased incidence of low back pain in police drivers who had increased daily exposure to driving. From this result arises a question: how is it possible that increased daily exposure is associated with new cases of low back pain when the initial cross-sectional study did not find an association between prevalent low back pain and daily driving in police drivers?

The lack of associations of daily exposure to driving with prevalent low back pain in police car drivers may be explained by a healthy worker effect. Such an effect may cause the absence of drivers experiencing health problem due to increased exposure to driving. As the level of health is one of the important requirements for the police profession, a healthy worker effect is possible.

Finding that increased daily driving is associated with the development of new cases of low back pain in police drivers stimulates another question: how is it possible for increased duration of daily driving in police drivers to increase the incidence of low back pain if there is no difference in the incidence of low back pain between drivers and non-drivers? Or, conversely, how is it possible that there is no difference in the incidence of low back pain between drivers and non-drivers if daily driving is associated with the development of low back pain? Several explanations are plausible.

The similar incidence of low back pain in police drivers and non-drivers may have arisen from the influence of a factor that affected both populations and is associated with increased daily driving in the driving population. For example, increased daily driving is associated with an increased duration of sitting and also an increased duration in a constrained and poor posture. If these factors were responsible for low back pain in the drivers there could have been a similar effect of prolonged sitting or constrained posture in non-drivers.

An alternative explanation for the apparent contradiction may be that the increased incidence of low back pain in non-drivers may have been caused by increased psychosomatic stress – the only factor found to be significantly associated with increased the incidence of low back pain in non-drivers. However, the initial descriptive statistics and descriptive statistics of the follow-up indicated that there were no significant differences between the driving and non-driving police employees in any measure of psychosomatic distress. So increased distress level cannot explain the contradictory finding of similar incidence of low back pain in police-non drivers and drivers.

It is possible that there is factor that was not investigated in the study questionnaire increased the probability of low back pain in the non-drivers. Previous epidemiological studies have considered also the relationship between low back pain and individual characteristics, such as alcohol consumption, educational level, money income, etc. (e.g. Gyntelberg, 1974; Pope, 1989; Bernekow-Bergkvist *et al.*, 1998; Waddel, 1998). The presence of the influence of some such factor causing low back pain even though it was not monitored in this study may explain why the incidence of low back pain in non-drivers was similar to that reported in drivers where the increase was caused by increased daily driving.

An alternative explanation for the increased incidence of low back pain in non-drivers may be presence of an investigated factor whose effects were not uncovered due to an inappropriate study design. The population of non-drivers was composed of males and females. A factor elevating the incidence of low back in a sub-population of males but having the opposite, or no effect, in a sub-population of females could have been masked by grouping together these two sub-populations. Although the individual and physical characteristics of males and females significantly differed, there was not found any risk factors to be associated with low back pain for at least one day during the past 12 months in one group and not in the other one.
The population of non-drivers was defined as police employees who were not driving for more than 5 hours per week during their working shift, and so was consisted of employees who were either sitting or walking for most of their working shift. A factor elevating the incidence of low back in a sub-population of sitters but having the opposite, or no effect, in a sub-population of walkers could have been masked by grouping together these two sub-populations.

Yet another explanation may be that the significant association between increased exposure to daily driving and new cases of low back pain in police drivers (driving for 2-3 hours per day: $p<0.03$; driving for more than 3 hours per day: $p<0.01$) was due to chance. As previously stated, it was decided that all variables of known biologic importance, for which the statistical tests showed a *p*-value less than 0.05 were considered to be potentially important factors for the health outcome. This significant level was proposed by

Hosmer and Lemeshow (1989) and is commonly used in published epidemiological studies.

It was not possible to confirm an association between increased daily exposure to driving and the development of new cases of low back pain in the incidence group of taxi drivers because the number of new cases of low back pain during the past 12 months was too low. However, from the descriptive statistics it was confirmed that more than 67% of taxi drivers who were exposed to driving longer than 6 hours per day in both questionnaire examinations developed new episode of low back pain during the follow-up of the study.

The lack of associations between persistent low back pain and daily or cumulative exposure to driving in both car driving populations may be explained by "a secondary healthy worker effect". The secondary healthy worker effect may appear when drivers, exposed to a greater dose of daily or cumulative exposure to driving with low back pain during the cross-sectional baseline study leave their job during the follow-up period so that they no do not participate in the longitudinal study. Less than half of the taxi drivers, and less than third of the police drivers, not participating in the follow-up questionnaire but reporting low back pain in the cross-sectional baseline study reported daily and cumulative driving in the highest exposure group. To accept the presence of the secondary healthy worker effect it was expected that there will be found an elevated percentage of drivers from the highest exposure group not participating in the follow-up but reporting low back pain in the cross-sectional baseline study.

<u>Which aspect of driving is to blame?</u>

Many published studies have reported that the development of low back pain is associated with the duration of driving and exposure to whole-body vibration. However, such health problems may be caused by factors that are closely associated with driving, such as vehicle design, seating and vehicle features which may influence driving posture. As an example, sitting in a constrained posture without sufficient back support increases the pressure on inter-vertebral discs and also increases the activity of spinal muscles (Anderssson *et al.,* 1974).

The effect of the posture adopted while driving was not investigated in this study of professional drivers. However, the profession of taxi drivers is obviously connected with a constrained sitting posture and lack of physical activity while driving, and also while seated and waiting for passengers. In police drivers, there might be insufficient spinal support in addition to their waist belt (with radio, gun, handcuffs and truncheon) playing a role in the development of low back pain.

6.4. Applications of the research

In every population of car drivers, and in each individual car driver, there are different risk factors for low back pain, so some may be at high risk and others at no measurable risk.
It is difficult to uncover all possible risk factors for low back pain in professional car drivers and even more difficult is to eliminate them.
The findings of this study lead to the conclusion that the prevention of increased distress and the reduction of daily driving will be reflected in a lower incidence of low back pain in professional car drivers. Such a conclusion leads to recommendations which are, however, not easy to apply. For example, in the profession of taxi drivers it is difficult to reduce the duration of daily driving as driving is the principal duty and is reflecting the living income.

Recommendations for future work

As typical in scientific research, the findings raise new questions and hypotheses which need to be answered. There is no doubt that further epidemiology research to uncover the causation of low back pain is needed.

More research is needed to uncover the real mechanisms between psychosocial risk factors and low back pain.
This study confirms a role of psychosomatic distress in the development of new episodes of low back pain in professional car drivers. The clarification of the mechanism between present distress and low back pain may subsequently contribute in the management of the working environment.

More research is needed to uncover the real relationship between factors included in professional car driving and low back pain
Future studies should recognise that car driving involves a combination of many ergonomic factors such as exposure to whole-body vibration, prolonged sitting, constrained posture, etc. Better understanding of the relationships may contribute to reductions in exposure to such factors (i.e., reducing the durations of driving shifts, vehicles equipped with adjustable features for maximum comfort while driving, etc.).

More research is needed to uncover whether professional car drivers are at a higher risk of low back pain than professions with no driving
In this study there was no significant difference between the prevalence of low back pain in two populations of car drivers and a population of non-drivers. No difference between

the prevalence of low back pain in drivers and non-drivers should imply that there is no influence of the duration of driving on the presence of low back pain. However, as there was a significant association between new cases of low back pain and increased duration of driving, there remains a question: is the increase in low back pain with increased driving caused by the driving or by other factors related to increased driving, such as prolonged sitting or constrained posture – factors which are present also in the daily work of non-drivers.

More research is needed to uncover the relationship between different characteristics of low back pain and risk factors for the development of low back pain in car drivers.

Future studies should consider other different definitions of low back pain: low back pain experienced for at least one day during the past ‘4 week or pain experienced for at least one day during the past 7 days, intensity of low back pain, disability due to low back pain, duration off work due to low back pain, etc..

CHAPTER SEVEN

GENERAL CONCLUSION

7.1. Introduction

The presence of low back pain (i.e. the prevalence, incidence and persistence of low back pain) and possible risk factors for the development of low back pain (i.e. individual, physical and psychosocial risk factors) were investigated in this longitudinal study comprising a cross-sectional baseline and a follow-up in professional taxi drivers from the City of Southampton, and police drivers and non-driving police employees from the Aberdeen Police Force.

This final chapter presents the main conclusions of the research based on the findings from each study population at each step of the entire study.

7.2. Findings from the cross-sectional baseline study

- **Prevalence of low back pain**

In the cross-sectional baseline study, 45% of taxi drivers, 53% of police drivers and 46% of police non-drivers reported experiencing low back pain for at least one day during the past 12 months, (Chi-square test, $p = 0.09$). [Chapter 4]

- **Risk factors associated with presence of low back pain**

The following risk factors were significantly associated ($p<0.05$) with the prevalence of low back pain during the past 12-months and considered as potential risk factors in the follow-up study [Chapter 4]:

- In the population of taxi drivers there were significant associations between low back pain and stature, increased duration of daily and cumulative driving, previous physical load, and psychosomatic distress;

- In the population of police drivers there were significant associations between low back pain and age, lifting, bending, and psychosomatic distress;

- In the population of police non-drivers there were significant associations between low back pain and stature, bending and psychosomatic distress.

- **Overestimation of driving exposure**

An experimental study suggested that the daily duration of exposure to vibration reported by professional taxi drivers was overestimated. The level of overestimation, based on 12 twelve measurements, averaged 31%. [Chapter 4]

7.3. Findings from the follow-up of the longitudinal study

- **Incidence of low back pain**

In the follow-up of the longitudinal study, 11% of taxi drivers, 26% of police drivers and 27% of police non-drivers reported new cases of low back pain lasting at least one day during the past 12 months, (Chi-square test, $p = 0.02$). . [Chapter 5]

- **Persistence of low back pain**

In the follow-up of the longitudinal study, 67% of taxi drivers, 77% of police drivers and 63% of police non-drivers reported persistent low back pain for at least one day during the past 12 months, (Chi-square test, $p = 0.04$). . [Chapter 5]

- **Risk factors for incident low back pain**

The following risk factors were significantly associated ($p<0.05$) with the incidence of low back pain during the past 12-months [Chapter 5]:

- In the population of police drivers there were significant associations between the incidence of low back pain and age (greatest in middle age), daily duration of driving, and psychosomatic distress.

- In the population of police non-drivers there were significant associations between the incidence of low back pain and psychosomatic distress.

- **Risk factors for persistent low back pain**

The following risk factors were significantly associated (p<0.05) with the persistence of low back pain during the past 12-months [Chapter 5]:

- In the population of taxi drivers there were significant associations between the persistence of low back pain and stature, and psychosomatic distress.

- In the population of police drivers there were significant associations between the persistence of low back pain and psychosomatic distress.

- In the population of police non-drivers there were significant associations between the persistence of low back pain and age (greatest in middle age), and bending.

7.4. Conclusions across the whole study

- **Presence of low back pain in different populations**

From the observed prevalence of low back pain it is concluded that there was no significant difference in the prevalence of low back pain in taxi drivers, police drivers and police non-drivers. Consequently, for the populations of car drivers investigated, it is concluded that there was no difference in the prevalence of low back pain between driving and non-driving populations.

- **Risk factors for development of low back pain**

Driving

The longitudinal study of police drivers pointed to significant associations between the incidence of low back pain and the daily duration of driving. Increased exposure to driving was forced in as a potential risk factor in the follow-up study even though it was not significantly associated with the prevalence of low back pain in the cross-sectional baseline of the police drivers. The apparently significant influence of duration of driving on low back pain points to the importance of uncovering the real associations between the development of low back pain and factors associated with daily driving (e.g., ergonomic factors - prolonged sitting, constrained posture, etc.).

Associations between increased duration of driving and the development of low back pain could not be confirmed in the taxi drivers because the number of taxi drivers with incident low back pain was too few for statistical tests to have sufficient statistical power.

Psychosomatic distress level

In car drivers, the follow-up study found an association between increased psychosomatic distress and increases in both the incidence and the persistence of low back pain. This finding is consistent with the increased prevalence of low back pain in the car drivers with increased psychosomatic distress in the cross-sectional baseline of the study. In the population of non-drivers there was also an association between increased psychosomatic distress and the incidence of new cases of low back pain.

Significant associations found between increased level of psychosomatic distress and new cases of low back pain seem to confirm the causal effect of this factor on the development of low back pain in drivers and non-drivers.

REFERENCES

Adams MA, Bogduk N, Burton K, Dolan P (2002) The biomechanics of back pain. Churchill Livingstone, New York, ISBN: 0-443-062072

Andersson BJG, Örtengren R (1974) Lumbar disc pressure and myoelectric back muscle activity during sitting. Scandinavian Journal of Rehabilitation Medicine, 6: 115-121

Andersson BJG, Chaffin DB, Pope MH (1984) Occupational biomechanics of the lumbar spine. Lumbar spine biomechanics. Special studies, New York, ISBN: 0-03-063288-9

Anderson R (1992) The back pain of bus drivers. Prevalence in an urban area of California. Spine, 17: 1481-1488

Backman AL (1983) Health survey of professional drivers. Scandinavian Journal of Work, Environment and Health, 9: 30-35

Barriera-Viruet H, Sobeih TM, Daraiseh D, Salem S (2006) Questionnaires vs observational and direct measurements: a systematic review. Theoretical Issues in Ergonomics Science, 7: 261-284

Barker DJP, Rose G (1990) Epidemiology in medical practice. Churchill Livingstone, Medical Division of Longman Group UK Limited, ISBN: 0-443-03783-3

Barnekow-Bergkvist M, Hedberg GE, Janlert U and Jansson E (1998) Determinants of self-reported neck-shoulder and low back symptoms in a general population. Spine, 23: 235-243

Battié MC, Videman T, Gibbons LE, Manninen H, Gill K, Pope M, Kaprio J (2002) Occupational driving and lumbar disc degeneration: a case-control study. The Lancet, 360: 1369-1374

Beaglehole R, Bonita R, Kjellström T (1993) Basic Epidemiology, Geneva: World Health Organization, ISBN: 9241544465

Bergenudd H, Nilsson B (1988) Back pain in middle age; occupational workload and psychologic factors: an epidemiological survey. Spine, 13: 58-60

Biering-Sørensen F (1982) Low back trouble in a general population of 30-, 40-, 50-, and 60-year-old men and women. Study design, representativeness and basic results. Danish Medical Bulletin, 289-299

Biering-Sørensen F (1983) A prospective study of low back pain in a general population. I. Occurrence, recurrence and aetiology. Scandinavian Journal of Rehabilitation Medicine, 15: 71-79

Biering-Sørensen F (1983) A prospective study of low back pain in a general population. II. Location, character, aggravating and relieving factors. Scandinavian Journal of Rehabilitation Medicine, 15: 81-88

Biering-Sørensen F (1984) A one-year prospective study of low back trouble in a general population. The prognostic value of low back history and physical measurements. Danish Medical Bulletin, 31: 362-375

Biering-Sørensen F, Hilden J (1984) Reproducibility of the history of low back trouble. Spine, 9: 280-286

Biering-Sørensen F, Thomsen C (1986) Medical, social and occupational history as risk indicators for low back trouble in a general population. Spine, 11: 720-725

Biering-Sørensen F, Thomsen C, Hilden J (1989) Risk indicators for low back trouble. Scandinavian Journal of Rehabilitation Medicine, 21: 151-157

Bongers PM, Boshuizen HC, Hulshof CTJ (1990) Self reported back pain in drivers of wheelloaders. Accademisch proefschrift, Universiteit van Amsterdam, 205-220

Bongers PM, Hulshof CTJ, Dijkstra L, Boshuizen HC (1990) Back pain and exposure to whole body vibration in helicopter pilots. Ergonomics, 33: 1007-1026

Bongers PM, Winter CR, Kompier MAJ, Hildebrndt VH (1993) Psychosocial factors at work and musculoskeletal disease. Scandinavian Journal of Environmental Health, 19: 297-312

Boshuizen HC, Bongers PM, Hulshof CT (1990) Self-reported pain in tractor drivers exposed to whole-body vibration. International Archives of Occupational and Environmental Health, 62: 109-115

Boshuizen HC, Bongers PM, Hulshof CT (1992) Self-reported back pain in fork-lift truck and freight-container tractor drivers exposed to whole-body vibration. Spine, 17: 59-65

Bovenzi M (1992) Low back pain in bus drivers exposed to whole-body vibration. Paper presented at the United Kingdom Meeting on Human Response to Vibration held at I.S.V.R., University of Southampton, UK, 117-1059

Bovenzi M, Zadini A (1992) Self-reported low back symptoms in urban bus drivers exposed to whole-body vibration. Spine, 17: 1048-1059

Bovenzi M, Betta A (1994) Low-back disorders in agricultural tractor drivers exposed to whole-body vibration and postural stress. Applied Ergonomics, 25: 231-241

Bovenzi M (1996) Low back pain disorders and exposure to whole-body vibration in the workplace. Seminars in Perinatology, 20: 38-53

Bovenzi M, Hulshof CTJ (1999) An updated review of epidemiologic studies on the relationship between exposure to whole-body vibration and low back pain. International Archive of Occupational and Environmental Health, 72: 351-365

Bovenzi M, Rui F, Negro C, D'Agostin FD, Angotzi G, Bianchi S, Bramanti L, Festa G, Gatti S, Pinto I, Rondina L, Stacchini N (2006) An epidemiological study of low back pain in professional drivers. Journal of Sound and Vibration, 298: 514-539

Bradford-Hill A (1971) Principles of medical statistics. The Lancet, London, ISBN: 090051101X

Braggins S (1994) The back functions, malfunctions and care. ISBN 0-7234-1904-3

Brendstrup T, Biering-Sørensen F, (1987) Effect of fork-lift truck driving on low-back trouble. Scandinavian journal of work, environment and health, 13: 445-452

Brouwer S, Kuijer W, Dijkstra PU, Göeken LNH, Groothoff JW, Geertzen JHB (2004) Reliability and stability of the Rolland Morris Disability Questionnaire, Disability and rehabilitation, Taylor & Francis group, 26: 162-165

Burdorf A, Naaktgeboren B (1993) Occupational risk factors for low back pain among sedentary workers. Journal of Occupational Medicine, 35: 1213-1220

Burdorf A, Hulshof CTJ (2005) Effects of exposure to whole-body vibration on low back pain and its consequences for sickness absence and associated work disability. Journal of sound and vibration, 298: 480-491

Chaffin DB, Park KS (1973) A longitudinal study of low-back pain as associated with occupational weight lifting factors. American Industrial Hygiene Association Journal, 34: 513-524

Chambers R (2001) Back pain matters in primary care: clinical management of back pain in a healthy and safe environment. Abingdon : Radcliffe Medical, ISBN: 1-85775-418-2

Chen JC, Chang WR, Shih TS, Chen CJ, Chang WP, Dennerlein JT, Ryan LM, Christiani DC (2003) Predictors of whole-body vibration levels among urban taxi drivers. Ergonomics, 46: 1075-1090.

Chen JC, Chan WP, Katz JN, Chang WP, Christiani DC (2004) Occupational and personal factors associated with acquired lumbar spondylolisthesis of urban taxi drivers. Occupational and Environmental Medicine, 61: 992-998

Chen JC, Chan WP, Chang WP, Christiani DC (2005) Occupational factors associated with low back pain in urban taxi drivers. Occupational Medicine, 55: 535-540

Coggon D, Rose G, Barker DJP (1993) Epidemiology for the uninitiated. BMJ Publishing Group, London, ISBN: 0-7279-0770-0

Damkot DK, Pope MH, Lord J, Frymoyer JW (1984) The relationship between work history, work environment and low-back pain in men. Spine, 9: 395-399

Deyo RA, Tsui-Wu YJ (1987) Descriptive epidemiology of low back pain and its related medical care in the United States. Spine, 12: 264-268

Directive 2002/44/EC of the European parliament and of the council of 25 June 2002 on the minimum health and safety requirements regarding requirements regarding the exposure of workers to the risks arising from physical agents (vibration). Official Journal of the European Communities, L 177/13

Dupuis H, Zerlett G (1987) Whole-body vibration and disorders of the spine. International Archives of Occupational and Environmental Health, 59: 323-336

Froom P, Barzilay J, Caine Y, Margaliot S, Forecast D, Gross M (1986) Low back pain in pilots. Aviation, Space and Environmental Medicine, 57: 94-95

Frymoyer JW, Pope MH, Costanza MC, Rosen JC, Goggin JE, Wilder DG (1980) Epidemiologic studies of low-back pain. Spine, 5: 419-423

Frymoyer JW, Pope MH, Clements JH, Wilder DG, MacPherson B, Ashikaga T (1983) Risk factors in low-back pain. An epidemiological survey. Journal of Bone and Joint Surgery (Am), 65: 213-8

Funakoshi M, Tamura A, Taoda K, Tsujimura H, Nishiyama K (2003) Risk factors for low back pain among taxi drivers in Japan San Ei Shi, 45: 235-247

Funakoshi M, Taoda K, Tsujimura H, Nishiyama K (2004) Measurement of whole-body vibration in taxi drivers. Journal of Occupational Health, 46: 119-124

Gallais L, Griffin MJ (2006) Low back pain in car drivers: A review of studies published 1975 to 2005. Journal of Sound and Vibration, 298: 499-513

Giles LGF, Singer KP (2003) Clinical anatomy and management of low back pain, Volume1. Oxford, Butterworth – Heinemann, ISBN 0-750623950

Gordis L (1996) Epidemiology, Philadelphia : W.B. Saunders, ISBN: 0-7216-5137-2

Griffin MJ (1982) The effects of vibration on health. Report prepared for the Health and Safety Directorate of the Commission of the European Communities. Institute of Sound and Vibration Research. Memorandum No.632, Institute of Sound and Vibration, University of Southampton

Griffin MJ (1990) Handbook of human vibration. Published: Academic Press, London, ISBN: 0-12-303040-4

Gyntelberg F (1974) One year incidence of low back pain among male residents of Copenhagen aged 40-59. Danish Medical Bulletin, 21: 30-26

Hartvigsen J, Leboeuf-Yde C, Lings S, Corder EH (2000) Is sitting-while-at-work associated with low back pain? A systematic, critical review. Scandinavian Journal of Public Health, Vol. 28, 230-239

Heliövaara M (1987). Occupation and risk of herniated lumbar intervertebral disc or sciatica leading to hospitalisation. Journal of Chronic Diseases, 40: 259-264

Heliövaara M, Mäkelä M, Knekt P, Impivaara O, Aromaa A (1991) Determinants of sciatica and low-back pain. Spine, 16: 608-614

Hildebrandt VH (1987) A review of epidemiological research on risk factors of low back pain. Muskuloskeletal disorders at work: Editor: Buckle P, Proceedings of conference, University of Surrey, Guildford. Taylor and Francis, ISBN: 0-85066-381-4, 9-16

Holmström EB, Lindell J, Moritz U (1992) Low back pain and neck/shoulder pain in construction workers: occupational workload and psychosocial risk factors. Part 1: Relationship to low back pain. Spine, 17: 663-671

Hoogendoorn WE, Bongers PM,Vet HCW, Ariëns GAM, Mechelen W, Bouter LM (2002) High physical work load and low job satisfaction increase the risk of sickness absence due to low back pain: results of a prospective cohort study. Occupational and Environmental Medicine, 59: 323-328

Hosmer DW, Lemeshow S (1989) Applied logistic regression, John Wiley & Sons, Inc. ISBN 0-471-61553-6

Hulshof CTJ, Van der Laan GJ, Braam ITJ, Verbeek J (2000) Criteria for recognition of whole-body vibration injury as occupational disease: A review. 2nd International Conference on Whole-body Vibration Injuries, Siena, Italy. 57-58

International Organisation for Standardisation (1997) Guide for the evaluation of human exposure to whole-body vibration – part1: general requirements, Geneva, ISO 2631-1

Jayson MIV (1992) The lumbar spine and back pain. Churchill Livngstone, ISBN 0 443-04189-X

Jensen MV, Tuchsen F and Ørhede E (1996) Prolapsed Cervical intervertebral disc in male professional drivers in Denmark, 1981-1990. Spine, 21: 2352-2355

Johanning E (1991) Back disorders and health problems among subway train operators exposed to whole-body vibration. Scandinavian Journal of Work, Environment and Health, 17: 414-419

Karasek RA (1979) Job demands, job decision latitude, and mental strain: Implications for job redesign, Administrative Science Quarterly, 24: 285-308

Kelsey JK (1975) An epidemiological study of the relationship between occupations and acute herniated lumbar intervertebral discs. International Journal of Epidemiology, 4: 197-205

Kelsey JK, Hardy RJ (1975) Driving of motor vehicles as a risk factor for acute herniated lumbar intervertebral disc. American Journal of Epidemiology, 102: 63-73

Kelsey JK, Golden AL (1978) Occupational and workplace factors associated with low back pain. Occupational Medicine, State of the Art Reviews, 3: 7-16

Kelsey JK, Githens PB, O'Conner T, Weil U, Calogero JA, Holford TR, White AA, Walter SD, Ostfeld AM, Southwick WO (1984) Acute prolapsed Lumbar intervertebral disc. An epidemiologic study with special reference to driving automobiles and cigarette smoking. Spine, 9: 608-613

Kleinbaum DG, Kupper LL, Morgenstern H (1982) Epidemiologic Research, principles and quantitative methods, New York: Wiley, ISBN: 0-47128985

Kompier M, Vries M, Noord F, Mulders H, Meijman T, Broersen J (1987) Physical work environment and musculoskeletal disorders in the busdriver's profession. Musculoskeletal disorders at work. In P. Buckle (editor), Taylor and Francis, London: 17-22

Krause N, Ragland DR, Greiner BA, Syme SL, Fisher JM (1997) Psychosocial job factors associated with back and neck pain in public transit operators. Scandinavian Journal of Work, Environment and Health, 23: 179-186

Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sorensen F, Andersson G, Jorgensen K (1987) Standardised Nordic Questionnaire for the analysis of musculoskeletal symptoms. Applied Ergonomics, 18: 233-237

Levangie PK (1999) Association of low back pain with self-reported risk factors among patients seeking physical therapy services. Journal of Physical Therapy, 79: 757-766

Liira JP, Shannon HS, Chambers LW, Haines TA (1996) Long-term back problems and physical work exposures in the 1990 Ontario health survey. American Journal of Public Health, 86: 382-387

Lings S, Leboeuf-Yde C (2000) Whole-body vibration and low back pain: a systematic, critical review of the epidemiological literature 1992-1999. International Archive of Occupational and Environmental Health, 73: 290-297

Magnusson ML, Pope MH, Wilder DG, Areskoug B (1996) Are occupational drivers at an increased risk of developing musculoskeletal disorders? Spine, 6: 710-717

Magnusson ML, Pope MH (1998) A review of the biomechanics and epidemiology of working postures. Journal of Sound and Vibration 215, 4: 965-976

Magora A (1970) Investigation of the relation between low back pain and occupation. Industrial Medicine, I, 39: 28-34

Magora A (1970) Investigation of the relation between low back pain and occupation. Industrial Medicine, II, 39: 31-37

Magora A (1972) Investigation of the relation between low back pain and occupation. III. Physical requirements: Sitting, standing and weight lifting. Industrial Medicine, 41: 5-9

Magora A (1973) Investigation of the relation between low back pain and occupation. IV. Physical requirements: Bending, rotation, reaching and sudden maximal effort. Scandinavian Journal of Rehabilitation Medicine, 5: 191-196

Magora A (1974) Investigation of the relation between low back pain and occupation. VI. Medical history and symptoms. Scandinavian journal of rehabilitation medicine, 6: 81-88

Maniadakis N, Gray A (2000) The economic burden of back pain in the UK. Pain, 84: 95-103

Mansfield NJ, Marshall JM (2001) Symptoms of musculoskeletal disorders in stage rally drivers and co-driver. British Journal of Sports Medicine, 35: 314-320

Masset D, Malchaire J (1994) Low back pain. Epidemiologic aspects and work-related factors in the steel industry. Spine, 19: 143-146

Miyamoto M, Shirai Y, Nakayama Y, Gembun Y, Kaneda K (2000) An epidemiologic study of occupational low back pain in truck drivers. Journal of Nippon Medical School, 67: 186-190

Nagi SZ, Riley LE, Newby LG (1973) A social epidemiology of back pain in a general population. Journal of Chronic Diseases, 26: 769-779

Nieuwenhuijsen MJ (2005) Design of exposure questionnaires for epidemiological studies. Occupational Environmental Medicine, 62: 272-280

Niemistö L, Sarna S, Lahtinen-Suopanki T, Lindgren KA, Hurri H (2004) Predictive factors for 1-year outcome of chronic low back pain following manipulation, stabilizing exercises, and physician consultation or physician consultation alone. Journal of Rehabilitation Medicine, 36: 104-109

Okunribido OO, Magnusson M, Pope MH (2006) Low back pain in drivers: The relative role of whole-body vibration, posture and manual material handling. Journal of Sound and Vibration 298: 540-555

Ozguler A, Leclerc A, Landre M–F, Pietri-Taleb F, Niedhammer I (2000) Individual and occupational determinants of low back pain according to various definitions of low back pain. Journal of Epidemiological and Community Health, 54: 215-220

Paddan GS, Haward BM, Griffin MJ (1999) Whole-body vibration: evaluation of some common sources of exposure in Great Britain. Health and safety executive, Contract research report, 235. HSE Books: ISBN: 0-7176-2471-1

Paddan GS, Griffin MJ (2002) Evaluation of whole-body vibration in vehicles. Journal of Sound and Vibration, 253: 195-213

Palmer KT, Coggon D, Bendall H, Pannett B, Griffin MJ, Haward BM (1999) Whole-body vibration: Occupational exposures and their health effects in Great Britain. Health and safety executive, Contract research report, 235. HSE Books: ISBN: 0-7176-2477-3

Palmer KT, Griffin MJ, Bendall H, Pannett B, Coggon D (2000) Prevalence and pattern of occupational exposure to whole body vibration in Great Britain: findings from a national survey. Occupational and Environmental Medicine, 57: 229-236

Palmer KT, Griffin MJ, Syddall HE, Pannett B, Cooper C, Coggon D (2003) The relative importance of whole body vibration and occupational lifting as risk factors for low-back pain. Occupational Environmental Medicine, 60: 715-721

Pietri F, Leclerc A, Boitel L, Chastang J, Morcet J, Blondet M (1992) Low back pain in commercial travelers. Scandinavian Journal of Work, Environment and Health, 18: 52-58

Pinto I, Stacchini N (2006) Uncertainty in the evaluation of occupational exposure to whole-body vibration. Journal of Sound and Vibration, 298: 556-562

Pope MH (1989) Risk indicators in low back pain. Annals of medicine, 21:387-392

Porter JM, Gyi DE (2002) The prevalence of musculoskeletal troubles among car drivers. Occupational Medicine, 52: 4-12

Reisbord LS, Greenland S (1985) Factors associated with self-reported back-pain prevalence: A population-based study. Journal of Chronic Diseases, 38: 691-702

Reulen RC, Zeegers MP, Jenkinson C, Lancashire ER, Winter DL, Jenney ME, Hawkins MM (2006) The use of the SF-36 questionnaire in adult survivors of childhood cancer: evaluation of data quality, score reliability, and scaling assumptions, Health and Quality of Life Outcomes, 4: 77

Rey P (1979) Ergonomic criteria necessary to epidemiological studies in industrial medicine and public health, Ergonomics, 22: 661-667

Riihimäki H, Tola S, Videman T, Hänninen K (1989) Low-back pain and occupation: A cross-sectional questionnaire study of men in machine operating, dynamic physical work, and sedentary work. Spine, 14: 204-209

Riihimäki H (1991) Low-back pain, its origin and risk indicators. Scandinavian Journal of Work, Environment and Health, 17: 81-90

Rothman KJ, Greenland S (1998) Modern Epidemiology, Philadelphia: Lippincott-Raven, ISBN: 0-316757802

Sandover J, Gardner L, Stroud P, Robertson N (1994) Some epidemiological issues regarding vibration and tractor driving. Proceedings of the United Kingdom informal group meeting on human response to vibration. Institute of Naval Medicine, Gosport, UK: 1-21

Seidel H, Heide R (1986) Long-term effects of whole-body vibration: a critical survey of the literature. International Archive of Occupational and Environmental Health, 58: 1-26

Skovron ML, Szpalski M, Nordin M, Melot C, Cukier D (1994) Sociocultural factors for low back pain. A population-based study in Belgian adults. Spine, 19: 129-137

Smedley J, Inskip H, Coper C, Coggo D (1999) Natural history of low back pain: A longitudinal study in nurses. Spine, 8: 210-217

Svensson HO (1982) Low back pain in forty to forty-seven year old men. II. Socio-economic factors and previous sickness absence. Scandinavian Journal of Rehabilitation Medicine, 14: 55-60

Svensson HO, Andersson GBJ (1983) Low-back pain in 40- to 47- year-old men: Work history and work environments factors. Spine, 8: 272-276

Svensson HO, Vedin A, Wilhelmsson C, Andersson GBJ (1983) Low-back pain in relation to others diseases and cardiovascular risk factors. Spine 8: 277-285

Svensson HO, Andersson GBJ (1989) The relationship of low-back pain, work history, work environment, and stress: A retrospective cross-sectional study of 38- to 64-years-old women. Spine, 14: 517-522

Tiemessen IJH, Hulshof CTJ, Frings-Dresen MHW (2007) Direct observational assessment of physical work demands while measuring the whole body vibration magnitude. Journal of Sound and Vibration, 310: 1080-1092

Thomas E, Silman AJ, Croft PR, Papageorgiou AC, Jayson MIV, Macfarlane GJ (1999) Predicting who develops chronic low back pain in primary care: a prospective study. British Medical Journal, 328: 1662-1667

Toren A, ÖBerg K, Lembke B, Enlund K, Rask-Andersen A (2002) Tractor-driving hours to self-reported low-back and hip symptoms. Applied Ergonomics 33: 139-146

Tubach F, Beauté J and Leclerc A (2004) Natural history and prognostic indicators of sciatica. Journal of Clinical Epidemiology, 57: 174-179

Videman T, Nurminen T, Tola S, Kuorinka I, Vanharanta H, Troup JDG (1984) Low-back pain in nurses and some loading factors of work. Spine, 9: 400-403

Videman T, Nurminen T, Troup JDG (1990) Lumbar spinal pathology in cadaveric material in relation to history of back pain, occupation and physical loading. Spine, 15: 728-740

Videman T, Simonen R, Usenius J-P, Österman K, Battié MC (2000) The long-term effects of rally driving on spinal pathology. Clinical Biochemics, 15: 83-86

Waddell G (1999) The back pain revolution. Churchill Livingstoene, ISBN 0-443-060398

Waddell G (2004) The back pain revolution. Churchill Livingstone, ISBN: 0-4430-7227-2

Walsh K, Varnes N, Osmond C, Styles R, Coggon D (1989) Occupational causes of low-back pain. Scandinavian Journal of Work, Environment and Health, 15: 54-59

Walsh K, Cruddas M, Coggon D (1992) Low back pain in eight areas of Britain. Journal of Epidemiology and Community Health, 46: 227-230

Webb P, Bain C, Pirrozo S (2005) Essential Epidemiology, an introduction for students and health professionals, Cambridge : Cambridge University Press, ISBN: 0-521546613

Wikström B-O, Kjellberg A, Landström U (1994) Health effect of long-term occupational exposure to whole-body vibration: A review. International Journal of Industrial Ergonomics, 14: 273-292

Wilder DG, Pope MH (1996) Epidemiological and aetiological aspects of low back pain in vibration environments – un update. Clinical Biomechanics, 11: 61-73

Xu Y, Bach E, Orhede E (1997) Work environment and low back pain: the influence of occupational activities. Occupational and Environmental Medicine, 54: 741-745

http://www.humanvibration.com/EU/VINET/VINET_index.htm

http://www.vibrisks.soton.ac.uk

http://www.nlm.nih.gov

http://www.backkrack.co.uk

http://www.cviceni.net

http://www.energycenter.com

http://www.ilchiro.org

http://www.spine.com.au

http://www.wvneuro.com

http://www.mayoclinic.com

http://www.med.umich.edu

http://www.backsupport.com

http://www.servers.medlib.hscbklyn.edu

APPENDIX A

Epidemiological studies concerning low back pain

Table A1: Summary of reviewed epidemiological studies concerning low back pain

Author	Year	Study population	Low back pain (%)				
			Prevalence			Incidence	Persistence
			Lifetime	12-months	point		
Magora A.	1970, 1972,1973, 1974	8 different ocupations	•	•	13	•	•
Nagi S.Z., *et al.*	1973	general population	18	•	•	•	•
Gyntelberg F.	1974	men (age: 40-59)	54	•	•	26	•
Frymoyer J.W., *et al.*	1980	general population (< 55 years)	10	•	•	•	•
Svensson H.O., *et al.*	1982, 1983	men (age: 40-47)	61	•	31	•	•
Biering-Sørensen F.	1982, 1983, 1984, 1986, 1989	general population	62	45	14	6	34
Backman A.	1983	professional drivers	•	40 (4-weeks LBP)	•	•	•
Frymoyer J.W., *et al.*	1983	general population	70	•	•	•	•
Damkot D.K., *et al.*	1984	general population (men)	44	•	•	•	•
Videman T., et al.	1984	hospital nurses	79-85	•	•	•	•
Reisbord L.S., *et al.*	1985	general population	•	•	18	•	•
Froom M.D., *et al.*	1986	pilots	24	•	18	•	•
Brendstrup T. , Biering-Sørensen F.	1987	fork-lift truck drivers	79	•	•	51	•
		not exposed workers	64	•	•	47	•
Kompier M., *et al.*	1987	bus drivers	57	•	•	•	•
		not exposed workers	40	•	•	•	•
Deyo R.A., Tsui-Wu Y.J.	1987	general population	14	10	7	•	•
Dupuis H., *et al.*	1987	earth moving machinery	•	•	69	•	•
Kompier M., *et al.*	1987	bus drivers	•	57	•	•	•
		white & blue collar workers	•	40	•	•	•
Bergenudd H., *et al.*	1988	general population	•	•	29	•	•
Burdorf A.	1989	bus drivers	61 (BP)	•	•	•	•
		earth moving maqchinery	52 (BP)	•	•	•	•
Riihimäki H., *et al.*	1989	machine operators	90	82	•	•	•
		office workers	75	61	•	•	•
Svensson H.O., *et al.*	1989	women (age: 38-64)	66	•	•	•	•

Table A1 (cont.): Summary of reviewed epidemiological studies concerning low back pain

Author	Year	Study population	Low back pain (%)				
			Prevalence			Incidence	Persistence
			Lifetime	12-months	point		
		helicopter pilots	55	•	•	•	•
Bongers P.M., *et al.*	1990	not exposed co-workers	11	•	•	•	•
		wheel loader operators	47	•	•	•	•
Bongers P.M., *et al.*	1990	not exposed co-workers	39	•	•	•	•
		tractor drivers	•	31	•	•	•
Boshuizen H.C., *et al.*	1990	not exposed co-workers	•	19	•	•	•
Heliövaara M., *et al.*	1991	general population	•	•	12	•	•
		subway train opeartors	56	•	•	•	•
Johaning E.	1991	not exposed co-workers	23	•	•	•	•
		bus drivers	•	•	66	•	•
Anderson R.	1992	not exposed group	•	•	45	•	•
		fork-lift truck drivers, freight-container tractor drivers	41	•	•	•	•
Boshuizen H.C., et *al.*	1992	not exposed co-workers	31	•	•	•	•
		fork-lift drivers	57	•	•	•	•
Boshuizen H.C., et *al.*	1992	not exposed co-workers	16	•	•	•	•
		bus drivers	84	83	62	•	•
Bovenzi M.	1992, 1996	not exposed co-workers	66	66	46	•	•
		bus drivers	84	83	•	•	•
Bovenzi M., Zadini A.	1992	not exposed workers	66	66	•	•	•
Holmström E.B., *et al.*	1992	construction workers	•	54	•	•	•
Pietri F., et *al.*	1992	commercial travelers	•	30	•	15	•
Walsh K., *et al.*	1992	general population	58	36	•	•	•
		crane operators	•	40	•	•	•
		carrier drivers	•	31	•	•	•
Burdorf A., et *al.*	1993	not exposed workers	•	20	•	•	•

Table A1 (cont.): Summary of reviewed epidemiological studies concerning low back pain

Author	Year	Study population	Low back pain (%)				
			Prevalence			Incidence	Persistence
			Lifetime	12-months	point		
Bovenzi M., Betta A.	1994	tractor drivers	81	72	•	•	•
		office workers	42	37	•	•	•
Masset D., Malchaire J.	1994	steel industry workers	32	32	18	•	•
Sandover J., et *al.*	1994	tractor drivers	64	46	•	•	•
		not exposed workers	48	16	•	•	•
Skovron M.L.	1994	general population	59	•	•	•	•
Magnusson M.L., et *al.*	1996	bus drivers	65	•	•	•	•
		truck drivers	55	•	•	•	•
		sedentary workers	42	•	•	•	•
Krause N., *et al.*	1997	transit operators	•	•	19	•	•
Xu Y., et *al.*	1997	general population	•	40	•	•	•
Barnekow-Bergkvist, et *al.*	1998	general population	•	44	•	•	•
Thomas E., et *al.*	1999	general population	•	•	•	•	42
Smedley J.C.	1999	hospital nurses	•	60	•	38	•
Miyamoto M., *et al.*	2000	truck drivers	•	50 (4-weeks LBP)	•	•	•
Ozguler A., *et al.*	2000	4 different occupations	•	43 (6-months LBP)	•	•	•
Videman T., et *al.*	2000	rally drivers	67	89	•	•	•
		general population	64	79	•	•	•
Mansfield N.J., *et al.*	2001	rally drivers & co-drivers	•	•	70	•	•
Palmer K.T., et *al.*	2002	general population	•	47	•	•	•
Porter J.M., Gyi D.E.	2002	car drivers	61	55	30	•	•
		non-drivers	55	46	25	•	•
Torén A., et *al.*	2002	tractor drivers	•	61	•	•	•
Funakoshi M., *et al.*	2003	taxi drivers	•	46	•	26	•
Tubach F., et *al.*	2004	eletricity and gas company workers	•	36 (sciatica)	•	20	59

Table A1 (cont.): Summary of reviewed epidemiological studies concerning low back pain

Author	Year	Study population	Low back pain (%)				
			Prevalence			Incidence	Persistence
			Lifetime	12-months	point		
Okunribido O.O., *et al.*	2006	8 different populations	•	56	30	•	•
		pilots	•	81	42	•	•
		tractor drivers	•	43	17	•	•
		works drivers	•	44	•	•	•
		taxi drivers	•	63	•	•	•
		police drivers	•	•	19	•	•
		controls	•	•	37	•	•
Chen J., et *al.*	2004, 2005	taxi drivers	•	51	•	•	•
VIBRISKS	2007	bus drivers	•	40	17	30	•
		forestry vehicle drivers	•	58	32	•	•
		agriculture and construction drivers	•	58	33	26	•
		taxi drivers	•	45	19	11	67
		police drivers	•	53	19	26	77
		non-drivers	•	46	11	27	63

APPENDIX B

Epidemiological studies concerning low back pain in car drivers

Table B1: Summary of reviewed epidemiological studies concerning low back pain in car drivers

Author (year)	Study design	Subject group	Control group	Data source	Confounders controlled for	Driving exposure description	Health outcome	Author's conclusion
Kelsey J.L. (1975)	Case-control study (n=934)	Subjects with acute HLID[a]	Subjects without problems (matched and unmatched control group)	X-ray, interview, diagnostic tests	Sitting, age, driving, lifting, pushing, pulling, carrying	Duration: job involving sitting half of the working time in a motor vehicle	Driving a motor vehicle and herniated disc: RR=2.75	People in occupations requiring prolonged driving of motor vehicles appear to be at particularly higher risk of HLID. Another associated factor was prolonged sitting
Kelsey J.L., Hardy R.J. (1975)	**Case-control study (n=934)**	**Subjects with acute HLID (group of drivers)**	**Subjects without problems (matched and unmatched control group)**	**X-ray, interview, diagnostic tests**	**Driving**	**Duration: job involving sitting half of the working time in a motor vehicle**	**Occupational driving and herniated disc: RR=2.75 Other driving and herniated disc: RR=2.16**	**Driving of motor vehicles was associated with an increased risk of HLID. Those spending half or more of the working time driving are about 3 times more likely to develop HLID**
Buckle P.W., *et al.* (1980)	Cross-sectional study (pilot study)	General population (n=68)	none	Interview	Driving, bending, lifting, twisting	Mileage: ≤19,000 miles/year >19,000 miles/year average annual miles: 16,754	69% of studied population reported more than one episode of LBP	Driving high mileages (over 19,000 miles/year) was a significant factor affecting occurrence and location of pain
Frymoyer J.W., *et al*. (1980)	Cross-sectional study	General population n=3,920 (≤55 years)	none	Questionnaire	Age, sport, psychosocial factors, smoking, lifting, carrying, pulling, pushing, bending, twisting, driving	No information about duration or distance of driving	LBP during past 3 years: males – 11% females – 9.5%	No relation was found between driving and LBP. Smoking, anxiety, depression, pregnancy, lifting, carrying, pushing, pulling, bending, twisting, and vibration (nondriving) were all identified to have a relation to LBP
Frymoyer J.W., *et al*. (1983)	Cross-sectional study (n=1,221)	General population (no pain, moderate pain, severe pain) (18-55 years)	none	Questionnaire	Age, smoking, lifting, carrying, hand-transmitted vibration, driving, sport	No information about duration or distance of driving	Lifetime prevalence of LBP: 69.9%. 88.1% of patients with moderate pain and 89.5% of patients with severe LBP reported driving	Driving of automobiles was more frequent in those with LBP. Other risk factors associated with severe LBP were repetitive lifting, using vibratory hand-tools, smoking and tobacco consumption
Kelsey J.L., *et al.* (1984)	Case-control study (n=566)	Subjects with acute HLID	Subjects without problems (matched and unmatched control group)	X-ray, interview, diagnostic tests	Age, height, weight, smoking, lifting, driving, sport	Vehicle type: Ford Motor Company (FMC), American Motors (AM), General Motors (GM), Chrysler Corporation (CC), Japanese and Swedish cars	The risk for prolapsed lumbar disc was associated with each additional amount of 5h/week spent driving the following vehicles: OR=1.4 (FMC /AM),OR=1.2 (GM/CC), OR=0.7 (Swedish/Japanese cars)	Increased risk associated with each 5 hours per week spent driving in a motor vehicle over the past 5 years (except Swedish and Japanese cars). Another factor affecting HLID was smoking

Table B1 (cont.): Summary of reviewed epidemiological studies concerning low back pain in car drivers

Author (year)	Study design	Subject group	Control group	Data source	Confounders controlled for	Driving exposure description	Health outcome	Author's conclusion
Heliövaara H. (1987)	Longitudinal study (n=2,732)	Subjects with HLID or sciatica	General population	Questionnaire	Gender, occupational activity, work capacity, driving, chronic cough, stress	Occupation: motor vehicle drivers	Risk of HLID in vehicle drivers: RR=2.9 Risk of HD or sciatica in vehicle drivers RR=4.6	Motor vehicle drivers showed the highest relative risk of herniated lumbar disc. The risk of herniated lumbar disc was about three times and sciatica over four times higher than in other professional workers
Hedberg G.E. (1988)	**Case-control study (n=570)**	**Professional drivers**	**Professional drivers**	**Questionnaire**	**Age**	**Occupation: professional drivers (taxi drivers, driving instructors, lorry drivers, truck drivers, etc.**	**Prevalence of LBP complaints was higher that in other body regions for all drivers group Risk of LBP in: taxi drivers RR=0.91 instructor drivers RR=1.17 (when all drivers used as comparison group)**	**The period prevalence of musculoskeletal complaints was highest for LBP and tended to increase with age**
Walsh K., *et al.* (1989)	Cross-sectional study (n=545)	General population (20-70 years)	none	Questionnaire	Age, lifting, driving, sitting, walking, using vibrating machinery	Duration: Driving car >4h/day	Lifetime prevalence of LBP: males - 64.5%, females - 61.4%, Total - 63% Sciatica: males - 9.5%, females - 2.03%	Car driving increased the risk of LBP among men but not among women. Lifting and carrying weights over 25kg, and sitting >2h/day were associated with LBP
Pietri F., *et al.* (1992)	**Longitudinal study (n=1,719) (Baseline: cross-sectional)**	**Commercial travellers**	**none**	**Interview**	**Age, gender, smoking, BMI, carrying, standing, psychosocial problems**	**Information about the vehicle driven Distance: km/year Duration: h/week**	**Prevalence of LBP (%): males=25.1, females=34.9 Incidence of LBP: males=12.6, females=16.8 OR for incidence of LBP and driving: 10-14h/week: 4.0, 15-19h/week: 4.8 20-24h/week: 3.3, ≥25h/week: 3.7**	**Baseline study: the strongest relationship with LBP was observed for driving (≥20h/week), psychosomatic factors, smoking, standing, and carrying loads. Follow-up: the relationship with LBP was observed for driving and psychosocial factors**
Masset D., Malchaire J. (1994)	Cross-sectional study (n=618)	Blue collar workers (≤40 years)	none	Questionnaire	Age, driving, strained posture, lifting, psychosocial characteristics	Frequency of exposure	Lifetime prevalence of LBP: 66% 12-month prevalence of LBP: 50% 7-day prevalence of LBP: 25%	Daily duration of driving vehicles and heavy effort with shoulders were significantly associated with LBP
Liira J.P., *et al.* (1996)	Cross-sectional study (n=38,540)	Nine occupational groups (blue and white collar workers)	none	Questionnaire	Gender, age, smoking, education, sitting, driving, lifting, bending, BMI	Duration: driving for more than ½ working day	OR of LBP and driving: white-collar workers OR=1.15, blue-collar workers OR=1.28	Age, smoking, blue-collar occupation, bending, lifting, working with vibrating machines, awkward position were all related to increased risk of LBP

Table B1 (cont.): Summary of reviewed epidemiological studies concerning low back pain in car drivers

Author (year)	Study design	Subject group	Control group	Data source	Confounders controlled for	Driving exposure description	Health outcome	Author's conclusion
Xu Y., *et al.* (1997)	Cross-sectional study (n=5,185)	Random sample of population (11 occupational groups)	none	Telephone interview	Gender, education, heavy lifting, concentration, walking, standing up, twisting or bending, driving	Duration: exposure to WBV <37h/week exposure to WBV ≥37h/week	LBP prevalence: males – 63% females – 57%	Increased risk of LBP for vibration affecting the whole body, physical hard work, frequently twisting or bending, standing up, concentration demands
Barnekow-Berkvist M. *et al.* (1998)	Longitudinal study (baseline: cross-sectional) (n=425)	Students	none	Questionnaire, diagnostic tests	BMI, smoking, sport, fixed posture, lifting, driving	No information about duration or distance of driving	One year prevalence of LBP: males: 50% females: 40.5%	Low back problems were associated with monotonous work among men and women, and exposure to vibration among men
Levangie P.K. (1999)	Longitudinal study (baseline: case-control study) (n=300)	Subjects with low back pain (n=150)	Subjects without low back pain (n=150)	Questionnaire	Smoking, driving, sitting, lifting, standing, sport, BMI	Duration: <1h/day, ≥1h/day	Association between LBP and spending ≥1h/day in car (compared with <1h/day): OR=2.49	LBP was positively associated with smoking, pregnancy, industrial vibration and time spent in a car
Ozguler A., *et al.* (2000)	Cross-sectional study (n=725)	Active workers (office, hospital, warehouse and airport sectors)	none	Questionnaire	Gender, age, BMI, psychological stress, pulling, pushing, carrying, driving for more than 2h/day, bending	Duration: never or seldom, often or every day driving	Six-month prevalence of LBP: 43.03% (male and female), 40.85% (male), 45.4% (female)	Driving more than 2h/day was a risk factor for chronic LBP
Videman T., *et al.* (2000)	**Case-control study (n=32)**	**Top rally drivers and co-drivers (n=18)**	**General population (n=14)**	**Interview, MRI**	**Driving, age**	**Rally driving: mean speed >100km/h up to 200km/h, extreme vibration, shock impact from frequent jumps 2-5m up to 20m**	**Twelve-month prevalence of LBP among rally drivers: 89% Twelve-months prevalence of LBP among control group: 79%**	**Results do not indicate driving and associated WBV exposure as significant causes of disc degeneration**
Mansfield N.J., Marshall J.M. (2001)	**Cross sectional study (n=90)**	**Rally drivers and co-drivers**	**none**	**Questionnaire**	**Driving**	**Years of rallying, extreme driving condition**	**Problems: lumbar spine 70%, cervical spine 54%, shoulders 47%, thoracic spine 36%**	**Higher prevalence of LBP in drivers and co-drivers than generally reported by workers exposed to WBV. The prevalence of back problems is related to the extreme environment of the rally car**

Table B1 (cont.): Summary of reviewed epidemiological studies concerning low back pain in car drivers

Author (year)	Study design	Subject group	Control group	Data source	Confounders controlled for	Driving exposure description	Health outcome	Author's conclusion
Battié M.L., *et al.* (2002)	**Longitudinal study (baseline: case-control) (n=90)**	**Monozygotic twins (identical twins)**		**Interview, MRI**	**Driving, smoking, lifting, twisting**	**Duration: h/week, type of vehicle, calculation of driving exposure for every job held**	**Frequency of LBP over past 12 months (1-7 scale): drivers: 4.7, twin siblings: 4.7**	**Driving was not associated with accelerated lumbar degeneration and structural abnormalities. Occupational drivers and their co-twins reported similar amounts of LBP**
Porter J.M., Gyi D.E. (2002)	**Cross-sectional study (n=600)**	**Randomly selected population**	**none**	**Interview**	**Age, gender, smoking, BMI, sport**	**Annual mileage (private), driving for work per week (hours, miles), journey to work per week (hours, miles)**	**Mean number of days ever absent from work with low back trouble: 22.4 (≥25,001miles/year), 3.3 (<5,000miles/year), 51.4 (driving >20h/week), 8.1 (<10h/week)**	**Car driving, in terms of annual mileage, distance driven to work, and time taken to drive this distance, are associated with reported sickness absence due to low back troubles**
Chen J-C. *et al*. (2004)	**Cross-sectional study (n=1,242)**	**Taxi drivers**	**none**	**X-ray, questionnaire**	**Lifting, twisting and bending, psychosocial factors, age, gender, BMI, sport, driving**	**Duration: ≤5 years of driving, 6-15 years of driving, >15 years of driving**	**One year prevalence of LBP=51% Total prevalence of ASL[d] = 3.2% Prevalence of ASL: ≤5 years of driving = 1.1%, 6-15 years of driving = 2.4%**	**Driving taxi >5 years, age, BMI, strenuous exercise were significantly associated with higher prevalence of spondylolisthesis**
Tubach F. *et al.* (2004)	Longitudinal study (n=3,240)	Subjects working in the national electricity and gas company	none	Questionnaire	BMI, hobby, carrying, driving, pulling, pushing, depression, job satisfaction	Duration: driving more than 2h/day (combination of driving at work and commuting to and from work)	Persistence or occurrence of sciatica when driving >2h/day: < once a week: OR = 2.37, > once a week: OR = 1.79, everyday: OR = 1.01	Factors that predict the persistence or recurrence of sciatica: a job involving carrying heavy loads or driving more than 2h/day, a high psychosomatic score
Chen J-C. *et al.* (2005)	**Cross-sectional study (n=1,355)**	**Taxi drivers**	**none**	**Questionnaire**	**Twisting and bending, lifting, driving, psychosocial factors**	**Duration: Years of driving, days/month driving, hrs/day driving**	**OR of LBP in different duration driving groups: ≤4hrs/day: OR=1 4-8hrs/day: OR=1.41 8-10hrs/day:OR=1.76 >10hrs/day:OR=2.12**	**After adjustment of potential factors was found that driving time >4hrs/day, frequent bending/twisting while driving, job stress, job dissatisfaction were significantly associated with higher LBP prevalence**

[a] HLID (herniated lumbar intervertebral disc); [b] BMI (body mass index); [c] MRI (magnetic resonance imaging), [d] ASL (spondylolisthesis)

APPENDIX C

Self administered questionnaire for subjects

SERIAL NO: G

MEDICAL RESEARCH COUNCIL

HUMAN FACTORS RESEARCH UNIT

Survey of Work Activities and Health

The answers given on this form are confidential.
Replies will ONLY be seen by the small research team.

SECTION A: ABOUT YOURSELF

1. Please fill in your date of birth — Day ☐☐ Month ☐☐ Year ☐☐☐

2. *and* your sex — Male ☐ Female ☐

3. Please record your height *and* your weight — Height ☐ ft ☐☐ in or ☐☐☐ cm

Weight ☐☐ st ☐☐ lbs or ☐☐☐ kg

4. Please indicate your ethnic origin by ticking the appropriate box — ☐ White (European) ☐ Other (please specify) ____________

5. Have you ever **smoked** regularly (i.e. at least once a day for a month or longer? *If* ***NO****, please go to question 6.* — No ☐ Yes ☐

5a. If ***YES,*** how old were you when you **first** smoked regularly? — ☐☐ years

5b. Do you **still** smoke regularly? — No ☐ Yes ☐

5c. If ***NO***, how old were you when you **last** smoked regularly? — ☐☐ years

6. Do you exercise regularly? *If* ***NO****, please go to question 8.* — No ☐ Yes ☐

6a. If ***YES***, how often each week do you exercise sufficient to raise a sweat?

Less than 1 time ☐ 1 or 2 times ☐ 3 times ☐ More than 3 times ☐

7. During your leisure time, do you have any sport or hobbies, which expose your body to vibration (e.g. motorcycle biking, rally driving, motor boat driving, etc.)?

No ☐ Yes ☐ *If No, please go to question 8.*

7a. If *Yes*, please specify which type of sport or hobby is it ______________________________

7b. How many hours per week do you practise a sports or hobby that exposes your body to vibration?

Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

8. How many hours per week do you spend sitting during an average day **outside work**?

Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

9. How many hours per week do you spend walking during an average day **outside work**?

Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

10. How many times do you lift loads greater than 15 kg (30 lbs) during an average day **outside work**?

Not at all ☐ 1 - 10 times ☐ More than 10 times ☐

11. About how many miles do you drive each year **outside work** (in your own time)?*(Include any journeys to and from work)*

Less than 5,000 ☐ 5,000- 15,000 ☐ More than 15,000 ☐

SECTION B: YOUR CURRENT JOB

12. When did you start your current job? Month ☐☐ Year ☐☐☐☐

13. How many hours per week do you work in this job? ☐☐ hours

Your views about your job

14. In your job, do you have a choice in deciding:

	Often	*Sometimes*	*Seldom*	*Never/almost never*
a) **How** you do your work?	☐	☐	☐	☐
b) **What** you do at work?	☐	☐	☐	☐
c) Your work timetable and breaks?	☐	☐	☐	☐

15. When you have difficulties in your work, how often do you get help and support from your colleagues or immediate line manager?

Often ☐ Sometimes ☐ Seldom ☐ Never ☐ Not applicable ☐

16. How satisfied have you been with your job as a whole, taking everything into consideration?

Very satisfied ☐ Satisfied ☐ Dissatisfied ☐ Very dissatisfied ☐

Activities in your job

*We are interested in the physical activities that you carry out in **an average working day** in the job. Please think about the pattern of activity in a typical work day and tick the most appropriate box(es).*

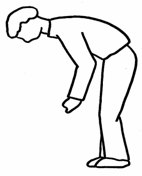
Lifting

17. How many **times** in an average working day do you lift loads greater than 15 kg (30 lbs) – e.g. an average child of three or a small suitcase with belongings?

Not at all ☐ 1 - 10 times ☐ More than 10 times ☐

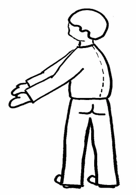
*If **Not at all**, please go to question 19.*

18. And how many **times** in an average working day do you lift such a load **whilst your back is in a bent position**, as shown?



Not at all ☐ 1 - 10 times ☐ More than 10 times ☐

18a. And how many **times** in an average working day do you lift such a load **whilst your back is in a twisted position**, as shown?



Not at all ☐ 1 - 10 times ☐ More than 10 times ☐

18b. And how many **times** in an average working day do you lift such a load **whilst your back is in a bent and twisted position**, as shown?

Not at all ☐ 1 - 10 times ☐ More than 10 times ☐

Digging

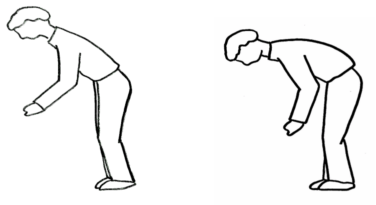
19. Does an average working day involve digging or shovelling? No ☐ Yes ☐

Posture

20. During an average day in the job, how many hours in total are spent standing or walking?

None ☐ Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

21. Does an average working day involve bending as shown below (other than while lifting)?



No ☐ Yes ☐

*If **NO**, please go to question 22.*

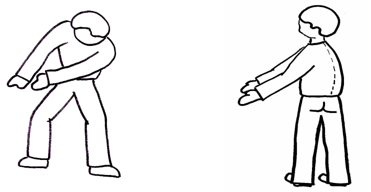
21a. If ***YES***, how many times in an average working day do you bend over in such a position?

Less than 5 times ☐ 5 - 20 times ☐ more than 20 times ☐

21b. And, if you add together all the time in an average working day that you spend in such a position, how many hours does that make?

Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

22. Does an average day in the job involve twisting as shown below (other than while lifting)?



No ☐ Yes ☐

*If **NO**, please go to question 23.*

22a. If ***YES,*** how many times in an average working day do you twist like this?

Less than 5 times ☐ 5 - 20 times ☐ more than 20 times ☐

22b. And, if you add together all the time in an average working day that you spend in such a twisted position, how many hours does that make?

Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

23. Does an average working day involve sitting for longer than three hours at a time?

No ☐ Yes, but I **can** get up and move around when I want to ☐ Yes, but I **cannot** get up and move around even if I want to ☐

24. During an average working day, how many hours in total are spent sitting - other than sitting in a vehicle?

Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

25. During an average working day, how many hours in total are spent sitting in a stationary vehicle?

Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

26. During an average working day, how many hours in total are spent sitting in a vehicle driven by someone else?

Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

27. During an average working day, how many hours in total are spent driving (include only the time you are driving the vehicle)?

Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

(If your job does not involve driving for more than 1 hour per day, please go straight to question 33)

Professional Driving

28. Which type of the vehicles do you normally drive in the job, and for how many hours per week on average?

Total driving time (per week): time vehicle is being driven

	Tick if driven in the job	*hrs*	*mins*
a) Traffic vehicle/ High-speed vehicle (e.g. Vauxhall Omega, Volvo, Range Rover/ Discovery)	☐	☐☐	☐☐
b) Squad car driver (e.g. Vauxhall Astra or Ford Focus)	☐	☐☐	☐☐
d) Other (please specify) ______________________	☐	☐☐	☐☐

29. Do you ever have to drive with your back bent forward or twisted in the job? Seldom/never ☐ Often ☐

30. Do you regularly have to load or unload the vehicle(s) you drive by moving heavy materials or equipment by hand?

No ☐ Yes ☐

31. During a typical working week, how much of the time do you spend driving off road in your job?

Not at all ☐ Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

32. Does the vehicle you normally drive have automatic gears? No ☐ Yes ☐

SECTION C: OTHER JOBS YOU MAY HAVE HELD

*Complete this section **only** if you have held other jobs in the past. **Otherwise go to Section D.***

33. We are interested in your previous work – including, the kind of job, when it was done, and whether or not it involved professional driving. Please fill in the table below to show **all of the jobs you've held for a year or more**.

Ignore the job you may have told us about in Section B. But include all the other jobs held for a year or more, beginning with the first job after leaving school or higher education.

Age started	Age stopped	Occupation	Which vehicle(s) did you drive professionally in the job? (✓) *(Do not include journeys to and from work)*								
			None	Car or van	Bus or lorry	Motor-cycle	Fork-lift truck	Tractor	Loader	Dump or excavator	Other large vehicle (describe)
☐☐ *age in years*	☐☐ *age in years*	________	☐	☐	☐	☐	☐	☐	☐	☐	☐________
☐☐ *age in years*	☐☐ *age in years*	________	☐	☐	☐	☐	☐	☐	☐	☐	☐________
☐☐ *age in years*	☐☐ *age in years*	________	☐	☐	☐	☐	☐	☐	☐	☐	☐________
☐☐ *age in years*	☐☐ *age in years*	________	☐	☐	☐	☐	☐	☐	☐	☐	☐________

Please check that the table includes all jobs held for a year or more (excluding any current one). If you need more space attach an extra sheet here.

34. Did your previous job(s) involve prolonged sitting (other then when driving)? No☐ <1 hr/day ☐ 1-3 hrs/day ☐ >3 hrs/day☐

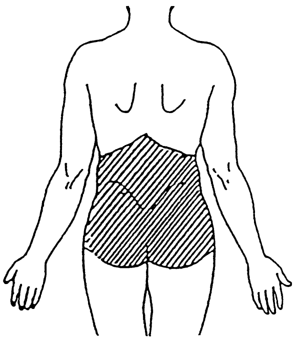
35. Did your previous job(s) involve heavy physical demands (e.g. frequent heavy lifting) ? No ☐ Yes ☐

SECTION D: YOUR HEALTH: ACHES AND PAINS

This section concerns ***aches and pains*** *you may have had in different parts of the body and at different times.*

The first few questions focus on pain in the LOW BACK in the past 12 MONTHS

36. During the **past 12 months** have you had **back pain** in the area shown in the diagram, which lasted more than a day? *(Don't include pain occurring only during pregnancy, menstrual periods or the course of a feverish illness such as 'flu.)*



No ☐ Yes ☐

If ***NO****, go straight to question 52.*

36a. How long in total during the **past 12 months** has this low back pain been present? *(Tick one.)*

1 - 2 days ☐ 3 - 6 days ☐ 7 - 30 days ☐
1 - 3 months ☐ More than 3 months ☐

37. How much time in total have you taken off work in the **past 12 months** because of low back pain?

None ☐ 1 - 6 days ☐ 7 - 14 days ☐
15 - 30 days ☐ 1 - 3 months ☐ More than 3 months ☐

38. Have you visited a doctor because of this low back pain during the **past 12 months**? No ☐ Yes ☐

39. Has the pain spread down your leg to below your knee during the **past 12 months**? No ☐ Yes ☐

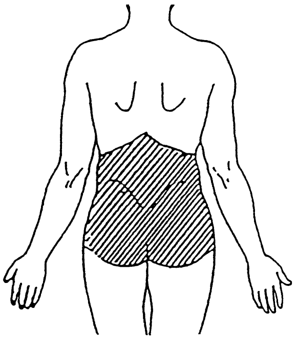
40. Has the pain made it difficult or impossible to put on your shoes, socks, stockings, or tights during the **past 12 months**? No ☐ Yes ☐

41. Do you get back pain while driving? No ☐ Yes ☐

42. Do you get back pain shortly after driving? No ☐ Yes ☐

Your back in the PAST 4 WEEKS

43. During the **past 4 weeks** have you had **low back pain** (as shown in the diagram) which lasted more than a day? *(Don't include pain occurring only during pregnancy, menstrual periods or the course of a feverish illness such as 'flu.)*



No ☐ Yes ☐

*If **NO**, go straight to question 49.*

44. These questions are about the way your back pain is affecting your daily life. We would like to know if you are, or have been in the past 4 weeks in any of the situations listed below (please tick all the items that apply).

Because of my back:	*No*	*Yes*
a) I stay at home most of the time because of my back.	☐	☐
b) I change position frequently to try and get my back comfortable.	☐	☐
c) I walk more slowly than usual because of my back.	☐	☐
d) Because of my back, I am not doing any of the jobs that I usually do around the house.	☐	☐
e) Because of my back, I use a handrail to get upstairs.	☐	☐
f) Because of my back, I lie down to rest more often.	☐	☐
g) Because of my back, I have to hold onto something to get out of an easy chair.	☐	☐
h) Because of my back, I try to get other people to do things for me.	☐	☐
i) I get dressed more slowly than usual because of my back.	☐	☐
j) I only stand up for short periods of time because of my back.	☐	☐
k) Because of my back, I try not to bend or kneel down.	☐	☐
l) I find it difficult to turn over in bed because of my back.	☐	☐
m) My back is painful almost all the time.	☐	☐
n) I find it difficult to get out of a chair because of my back.	☐	☐
o) My appetite is not very good because of my back pain.	☐	☐
p) I have trouble putting on my socks (or tights) because of the pain in my back.	☐	☐
q) I only walk short distances because of my back pain.	☐	☐
r) I sleep less well because of my back pain.	☐	☐
s) Because of my back pain, I get dressed with help from someone else.	☐	☐
t) I sit down for most of the day because of my back.	☐	☐
u) I avoid heavy jobs around the house because of my back.	☐	☐
v) Because of my back pain, I am more irritable and bad tempered with people than usual.	☐	☐
w) Because of my back pain, I go upstairs more slowly than usual.	☐	☐
x) I stay in bed most of the time because of my back.	☐	☐

And now your back in the PAST 7 DAYS

45. During the **past 7 days** have you had **low back pain**, which lasted more than a day? *If NO, go to question 49.* No ☐ Yes ☐

45a. If ***YES***, has the pain spread down your leg to below your knee during the **past 7 days**? No ☐ Yes ☐

46. Has the back pain made it difficult or impossible for you to put on shoes, socks or tights in the **past 7 days**? No ☐ Yes ☐

47. Have you had any time off work because of back pain in the **past 7 days**? No ☐ Yes ☐

48. How would you rate your low back pain on a 0 - 10 scale during a typical day in the **past 7 days** (where **0 = no pain** and **10 = worst pain you can imagine**)?

(Please circle one number.)

No pain — *Worst pain you can imagine*

0 1 2 3 4 5 6 7 8 9 10

Finally your back when symptoms FIRST BEGAN

49. When this low back pain **first** started, did it come on gradually or suddenly?

Gradually ☐ Suddenly outside work ☐ Suddenly at work ☐

50. *If* this came **suddenly**, when did you first experience it? Year ☐☐

50a. And if **suddenly**, what were you doing at the time? ______________________________

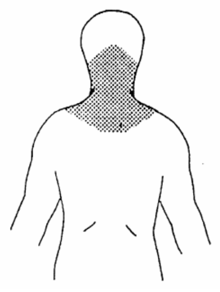
51. Have you ever had an accident to your back that required medical advice? *If NO, go to question 52.* No ☐ Yes ☐

51a. If ***YES***. What type of accident? ______________________________

51b. When did it happen? Year ☐☐

The next few questions focus on pain in your NECK

52. During the **past 12 months** have you had **neck pain** (in the area shown in the diagram) which lasted more than a day?



No ☐ Yes ☐

*If **NO**, go straight to question 59.*

52a. How long in total during the **past 12 months** has this neck pain been present? *(Tick one.)*

1 - 2 days ☐ 3 - 6 days ☐ 7 - 30 days ☐

1 - 3 months ☐ More than 3 months ☐

53. How much time in total have you taken off work in the **past 12 months** because of neck pain?

None ☐ 1 - 6 days ☐ 7 - 14 days ☐

15 - 30 days ☐ 1 - 3 months ☐ More than 3 months ☐

54. Have you had this neck pain during the **past 4 weeks**? No ☐ Yes ☐

55. Have you visited a doctor because of this neck pain during the **past 12 months**? No ☐ Yes ☐

56. Have you had neck pain, which lasted a day or more in the **past 7 days**? *If **NO**, go to question 57.* No ☐ Yes ☐

56a. If ***YES***, how would you rate your neck pain on a 0 - 10 scale during a typical day in the **past 7 days** (where **0 = no pain** and **10 = worst pain you can imagine**)? *(Please circle one number)*

No pain *Worst pain you can imagine*

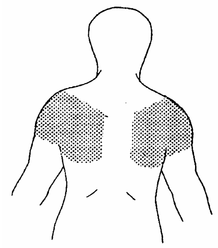
0 1 2 3 4 5 6 7 8 9 10

57. Do you get neck pain while driving? No ☐ Yes ☐

58. Do you have neck pain shortly after driving? No ☐ Yes ☐

Finally, in this section, some questions about pain in your SHOULDER(S)

59. During the **past 12 months** have you had **shoulder pain** (in the area shown in the diagram), which lasted more than a day?



No ☐ Yes ☐

*If **NO**, go straight to question 67.*

59a. How long in total during the **past 12 months** has this shoulder pain been present? *(Tick one.)*

1 - 2 days ☐ 3 - 6 days ☐ 7 - 30 days ☐
1 - 3 months ☐ more than 3 months ☐

60. How much time in total have you taken off work in the **past 12 months** because of shoulder pain?

None ☐ 1 - 6 days ☐ 7 - 14 days ☐
15 - 30 days ☐ 1 - 3 months ☐ More than 3 months ☐

61. Have you visited a doctor because of this shoulder pain during the **past 12 months**? No ☐ Yes ☐

62. Have you had this shoulder pain during the **past 4 weeks**? *If **NO**, go to question 65.* No ☐ Yes ☐

63. During the **past 4 weeks**, when your shoulder pain was **at its worst**, how much difficulty did you have with the following activities? *(Please tick all the activities that apply.)*

Activities		*No difficulty*	*Difficult*	*Impossible*
a)	Sleeping	☐	☐	☐
b)	Getting dressed	☐	☐	☐
c)	Carrying bags	☐	☐	☐
d)	Opening doors	☐	☐	☐
e)	Routine jobs around the house	☐	☐	☐

64. Have you had shoulder pain lasting a day or more in the **past 7 days**? *If **NO**, go to question 65.* No ☐ Yes ☐

64a. If ***YES***, how would you rate your shoulder pain on a 0 - 10 scale during a typical day in the **past 7 days** (where **0 = no pain** and **10 = worst pain you can imagine**)?

(Please circle one number.)

No pain *Worst pain you can imagine*

0 1 2 3 4 5 6 7 8 9 10

65. Do you get shoulder pain while driving? No ☐ Yes ☐

66. Do you get shoulder pain shortly after driving? No ☐ Yes ☐

SECTION E: OTHER SYMPTOMS AND FEELINGS

This section concerns ***other symptoms*** *and your* ***feelings*** *about health problems.*

67. Firstly, some questions about how you feel and how things have been with you **during the past 4 weeks**. *Please tick the* <u>*one box*</u> *for each question which most closely reflects how you feel.*

How much of the time **during the past 4 weeks** …….	*None of the time*	*A little of the time*	*Some of the time*	*Most of the time*	*All of the time*
a) …did you feel full of life?	☐	☐	☐	☐	☐
b) …have you been a very nervous person?	☐	☐	☐	☐	☐
c) …have you felt so down in the dumps that nothing could cheer you up?	☐	☐	☐	☐	☐
d) …have you felt calm and peaceful?	☐	☐	☐	☐	☐
e) …did you have a lot of energy?	☐	☐	☐	☐	☐
f) …have you felt downhearted and low?	☐	☐	☐	☐	☐
g) …did you feel worn out?	☐	☐	☐	☐	☐
h) …have you been a happy person?	☐	☐	☐	☐	☐
i) …did you feel tired?	☐	☐	☐	☐	☐

68. During the past **12 months**, how many days of sick leave have you taken (for all reasons combined)?

None ☐   1 - 2 days ☐   3 - 6 days ☐

7 - 30 days ☐   1 - 3 months ☐   More than 3 months ☐

69. Below is a list of problems people sometimes have. Please read each one carefully and circle the number that best describes how much that problem has distressed or bothered **you** during the **past 7 days including today**.

		Not at all	*A little bit*	*Moderately*	*Quite a bit*	*Extremely*
a)	Faintness or dizziness.	0	1	2	3	4
b)	Pains in the heart or chest.	0	1	2	3	4
c)	Your feelings being easily hurt.	0	1	2	3	4
d)	Feeling that people are unfriendly or dislike you.	0	1	2	3	4
e)	Feeling inferior to others.	0	1	2	3	4
f)	Nausea or upset stomach.	0	1	2	3	4
g)	Trouble getting your breath.	0	1	2	3	4
h)	Numbness or tingling in parts of your body.	0	1	2	3	4
i)	Feeling weak in parts of your body.	0	1	2	3	4
j)	Feeling very self-conscious with others.	0	1	2	3	4

70. Whether you have back pain or not, based on your own views and what the doctor or others may have told you about pain in the back, how strongly do you agree with the following statements?

Please circle one number for each statement which most closely reflects how you feel.
(1 means you completely disagree, 5 means you completely agree)

		Completely disagree				*Completely agree*
a)	Physical activity worsens back pain.	1	2	3	4	5
b)	Physical activities should be avoided if they might make the pain worse.	1	2	3	4	5
c)	An increase in pain is an indication to stop what one is doing.	1	2	3	4	5
d)	Rest is needed to get better.	1	2	3	4	5
e)	Normal work should be avoided until the pain is treated.	1	2	3	4	5
f)	It is important to see a doctor straight away at the first sign of trouble.	1	2	3	4	5
g)	Neglecting problems of this kind can cause permanent health problems.	1	2	3	4	5
h)	Back pain normally gets better by itself.	1	2	3	4	5

You have finished. Please take a moment to look through your answers. Return the questionnaire to us in the pre-paid envelope supplied. Once again thank you for your time and help.

SERIAL NO: S2

MEDICAL RESEARCH COUNCIL

HUMAN FACTORS RESEARCH UNIT

Southampton Survey of Work Activities and Health

The answers given on this form are confidential.
Replies will ONLY be seen by the small research team

Please fill in today's date ☐☐ *day* ☐☐ *month* ☐☐☐☐ *year*

SECTION A: ABOUT YOURSELF

1. Please fill in your date of birth ☐☐ *day* ☐☐ *month* ☐☐☐☐ *year*

2. Please record your weight ☐☐ st ☐☐ lbs or ☐☐☐ kg

3. Do you **smoke** regularly (i.e. at least once a day for a month or longer)? No ☐ Yes ☐

4. Do you exercise regularly? *If **NO**, please go to question 5.* No ☐ Yes ☐

4a. If ***YES***, how often each week do you exercise sufficient to raise a sweat?

Less than 1 time ☐ 1 or 2 times ☐ 3 times ☐ More than 3 times ☐

SECTION B: YOUR CURRENT JOB

5. Has there been any change in job activities since you completed the last questionnaire 12 months ago?

No ☐ Yes ☐ *If **NO**, please go to question 6.*

If *YES*, new job title ________________________

If *YES* what was the cause you have changed your job? ________________________

6. Do you work as a taxi driver Full-time ☐ Part-time ☐ ?

7. Which type of vehicle do you normally drive in the job and for how many hours per week on average?

Type of vehicle	*Tick if driven in the job*	*Total driving time (per week)** *hrs*	*mins*
a) Purpose build taxi (TX1, TX2, Fairway, Metrocab, etc.)	☐	☐☐	☐☐
b) Purpose adapted taxi (Peugeot E7, Fiat Eurocab, etc.)	☐	☐☐	☐☐
c) Saloon car (Mondeo, Vectra, BMW 5, Volvo, etc.)	☐	☐☐	☐☐
d) MPV (Renault Scenic, etc.)	☐	☐☐	☐☐
e) Other (please specify) ________________________	☐	☐☐	☐☐

** Total driving time (per week): time vehicle is being driven*

activities in your job

*We are interested in the physical activities that you carry out in **an average working day** in your job as a taxi driver. Please think about the pattern of activity in a typical work day and tick the most appropriate box(es).*

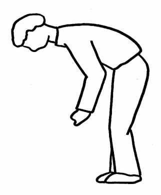
Lifting

8. How many **times** in an average working day do you lift loads greater than 15 kg (30 lbs) - e.g. an average child of three or a small suitcase with belongings?

Not at all ☐ 1 - 10 times ☐ More than 10 times ☐

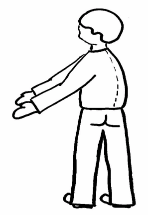
*If **Not at all**, please go to question 10.*

9. And how many **times** in an average working day do you lift such a load **whilst your back is in a bent position**, as shown?



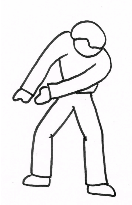
Not at all ☐ 1 - 10 times ☐ More than 10 times ☐

9a. And how many **times** in an average working day do you lift such a load **whilst your back is in a twisted position**, as shown?



Not at all ☐ 1 - 10 times ☐ More than 10 times ☐

9b. And how many **times** in an average working day do you lift such a load **whilst your back is in a bent and twisted position**, as shown?



Not at all ☐ 1 - 10 times ☐ More than 10 times ☐

Digging

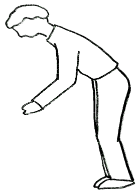
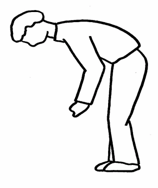
10. Does an average working day involve digging or shovelling? No ☐ Yes ☐

Posture

11. During an average day in the job, how many hours in total are spent standing or walking?

None ☐ Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

12. Does an average working day involve bending as shown below (<u>other as while lifting</u>)?

No ☐ Yes ☐

*If **NO**, please go to question 13.*

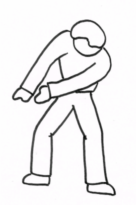
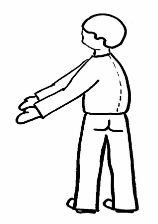
12a. If ***YES***, how many times in an average working day do you bend over in such a position?

Less than 5 times ☐ 5 - 20 times ☐ More than 20 times ☐

12b. And, if you add together all the time in an average working day that you spend in such a position, how many hours does that make?

Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

13. Does an average day in the job involve twisting as shown below (<u>other as while lifting</u>)?

No ☐ Yes ☐

*If **NO**, please go to question 14.*

13a. If ***YES,*** how many times in an average working day do you twist like this?

Less than 5 times ☐ 5 – 20 times ☐ More than 20 times ☐

13b. And, if you add together all the time in an average working day that you spend in such a twisted position, how many hours does that make?

Less than an hour ☐ 1 – 3 hours ☐ More than 3 hours ☐

14. During an average working day, how many hours in total are spent sitting <u>(other than when driving but including periods when you sit in your vehicle but are not driving</u>)?

Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

15. Does an average working day involve sitting for longer than three hours at a time?

No ☐ Yes, but I <u>**can**</u> get up and move around when I want to ☐ Yes, but I <u>**cannot**</u> get up and move around even if I want to ☐

16. During an average working day, how many hours in total are spent driving (<u>include only the time vehicle is being driven</u>)?

Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

17. Do you ever have to drive with your back bent forward or twisted in the job?

Seldom/never ☐ Often ☐

18. During a typical working week, how much of the time do you spend driving off road in your job?

Not at all ☐ Less than an hour ☐ 1 - 3 hours ☐ More than 3 hours ☐

Your views about your job

19. In your job, do you have a choice in deciding:

	Often	*Sometimes*	*Seldom*	*Never/almost never*
a) **How** you do your work?	☐	☐	☐	☐
b) **What** you do at work?	☐	☐	☐	☐
c) Your work timetable and breaks?	☐	☐	☐	☐

20. When you have difficulties in your work, how often do you get help and support from your colleagues or immediate line manager?

Often ☐ Sometimes ☐ Seldom ☐ Never ☐ Not applicable ☐

21. How satisfied have you been with your job as a whole, taking everything into consideration?

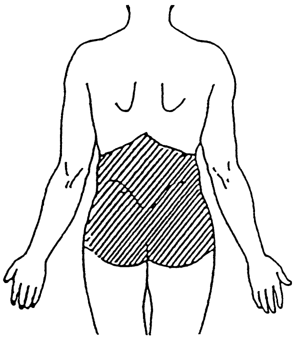
Very satisfied ☐ Satisfied ☐ Dissatisfied ☐ Very dissatisfied ☐

SECTION C: YOUR HEALTH: ACHES AND PAINS

We are interested in knowing whether you have had ***aches and pains*** *since we last contacted you, about 12 months ago.*

The first few questions focus on pain in the LOW BACK.

22. Since answering our questionnaire approximately 12 months ago, have you had **back pain** in the area shown in the diagram, which lasted more than a day? *(Don't include pain occurring only during pregnancy, menstrual periods or the course of a feverish illness such as 'flu).*



No ☐ Yes ☐

*If **NO**, go straight to question 33, page 9.*

22a. If ***YES***, how long in total **since we last questioned you**, has this low back pain been present? *(Tick one.)*

1 - 2 days ☐ 3 - 6 days ☐ 7 - 30 days ☐
1 - 3 months ☐ More than 3 months ☐

23. How much time in total have you taken off work **since we last questioned you**, because of low back pain?

None ☐ 1 - 6 days ☐ 7 - 14 days ☐
15 - 30 days ☐ 1 - 3 months ☐ More than 3 months ☐

24. Have you visited a doctor or other health care professional because of this low back pain **since we last questioned you**? No ☐ Yes ☐

25. Has the pain spread down your leg to below your knee **since we last questioned you**? No ☐ Yes ☐

26. Do you get back pain while driving? No ☐ Yes ☐

27. Do you get back pain shortly after driving? No ☐ Yes ☐

28. **Since we last questioned you**, have you had to cut down or avoid any of the following activities in your job because of low back pain?

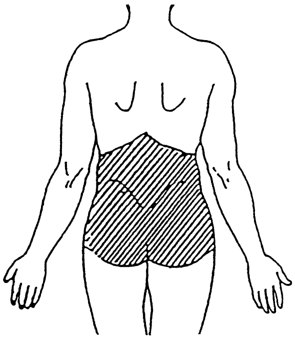
(Please tick one box for each line.)

	Not needed to cut down/avoid this activity	*Had to cut down/avoid because of back pain*	*This activity is not normally part of the job*
a) Lifting loads greater than 10 kg (20lbs).	☐	☐	☐
b) Lifting while your back is bent or twisted.	☐	☐	☐
c) Working with your hands above shoulder height.	☐	☐	☐
d) Working as a professional driver (ie driving in the job for an hour or more on most work days).	☐	☐	☐
e) Prolonged standing or walking in the job.	☐	☐	☐

Your back in the PAST 4 WEEKS

The next few questions focus on your back in the ***past 4 weeks****.*

29. During the **past 4 weeks** have you had **low back pain** (as shown in the diagram) which lasted more than a day? *(Don't include pain occurring only during pregnancy, menstrual periods or the course of a feverish illness such as 'flu).*



No ☐ Yes ☐

*If **NO**, go straight to question 31, page 9.*

29a. If ***YES***, these questions are about the way your back pain is affecting your daily life. We would like to know if you are, or have been in the **past 4 weeks**, in any of the situations listed below.

(Please tick all the items that apply.)

		No	*Yes*
a)	I stay at home most of the time because of my back.	☐	☐
b)	I change position frequently to try and get my back comfortable.	☐	☐
c)	I walk more slowly than usual because of my back.	☐	☐
d)	Because of my back I am not doing any of the jobs that I usually do around the house.	☐	☐
e)	Because of my back, I use a handrail to get upstairs.	☐	☐
f)	Because of my back, I lie down to rest more often.	☐	☐
g)	Because of my back, I have to hold onto something to get out of an easy chair.	☐	☐
h)	Because of my back, I try to get other people to do things for me.	☐	☐
i)	I get dressed more slowly than usual because of my back.	☐	☐
j)	I only stand up for short periods of time because of my back.	☐	☐
k)	Because of my back, I try not to bend or kneel down.	☐	☐
l)	I find it difficult to turn over in bed because of my back.	☐	☐
m)	My back is painful almost all the time.	☐	☐
n)	I find it difficult to get out of a chair because of my back.	☐	☐
o)	My appetite is not very good because of my back pain.	☐	☐
p)	I have trouble putting on my socks (or tights) because of the pain in my back.	☐	☐
q)	I only walk short distances because of my back pain.	☐	☐
r)	I sleep less well because of my back pain.	☐	☐
s)	Because of my back pain, I get dressed with help from someone else.	☐	☐
t)	I sit down for most of the day because of my back.	☐	☐
u)	I avoid heavy jobs around the house because of my back.	☐	☐
v)	Because of my back pain, I am more irritable and bad tempered with people than usual.	☐	☐
w)	Because of my back pain, I go upstairs more slowly than usual.	☐	☐
x)	I stay in bed most of the time because of my back.	☐	☐

And now your back in the PAST 7 DAYS

30. If you had **low back pain**, how would you rate it on a 0 - 10 scale during a typical day in the **past 7 days** (where **0 = no pain** and **10 = worst pain you can imagine**)?

(Please circle one number.)

No pain — *Worst pain you can imagine*

0 1 2 3 4 5 6 7 8 9 10

Pattern of back pain

31. Were you getting this low back pain at the time you last answered our questionnaire? No ☐ Yes ☐

*If **YES,** go to question 33, if **NO** please continue.*

32. a) **When** did the pain start? ☐☐ months *or* ☐☐ weeks ago

b) **How** did the pain start? Suddenly ☐ Gradually ☐

If suddenly,

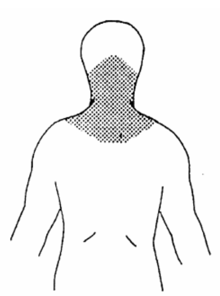
c) Where were you when the pain started? At work ☐ At home or elsewhere ☐

d) And what were you doing when the pain started? ______________________

____

The next few questions focus on pain in your NECK

33. Since answering our questionnaire approximately 12 months ago, have you had **neck pain** (in the area shown in the diagram), which lasted more than a day?



No ☐ Yes ☐

*If **NO**, go straight to question 39, page 10.*

33a. If ***YES,*** how long in total **since we last questioned you**, has this neck pain been present? *(Tick one.)*

1 - 2 days ☐ 3 - 6 days ☐ 7 - 30 days ☐

1 - 3 months ☐ More than 3 months ☐

34. How much time in total have you taken off work **since we last questioned you**, because of neck pain?

None ☐ 1 - 6 days ☐ 7 - 14 days ☐
15 - 30 days ☐ 1 - 3 months ☐ More than 3 months ☐

35. Have you visited a doctor or other health care professional because of this neck pain **since we last questioned you**? No ☐ Yes ☐

36. **Since we last questioned you**, have you had to cut down or avoid any of the following activities in your job because of pain in the neck?

(Please tick one box for each line.)

	Not needed to cut down/avoid this activity	*Had to cut down/avoid because of back pain*	*This activity is not normally part of the job*
a) Lifting loads greater than 10 kg (20lbs).	☐	☐	☐
b) Working with your hands above shoulder height.	☐	☐	☐
c) Working as a professional driver (ie driving in the job for an hour or more on most work days).	☐	☐	☐

37. Have you had this neck pain during the **past 4 weeks**? *If **NO**, go to question 39.* No ☐ Yes ☐

38. If you had neck pain, how would you rate it on a 0 - 10 scale during a typical day in the **past 7 days** (where **0 = no pain** and **10 = worst pain you can imagine**)?

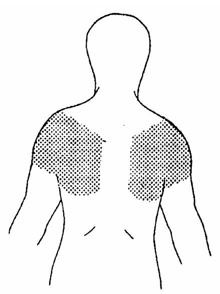
(Please circle one number.)

No pain *Worst pain you can imagine*

0 1 2 3 4 5 6 7 8 9 10

Finally, in this section, some questions about pain in your SHOULDER(S)

39. Since answering our questionnaire approximately 12 months ago, have you had **shoulder pain** (in the area shown in the diagram), which lasted more than a day?



No ☐ Yes ☐

*If **NO**, go straight to question 45, page 12.*

39a. If ***YES*** how long in total **since we last questioned you** has this shoulder pain been present? *(Tick one.)*

1 - 2 days ☐ 3 - 6 days ☐ 7 - 30 days ☐
1 - 3 months ☐ More than 3 months ☐

40. How much time in total have you taken off work **since we last questioned you**, because of shoulder pain?

None ☐ 1 - 6 days ☐ 7 - 14 days ☐
15 - 30 days ☐ 1 - 3 months ☐ More than 3 months ☐

41. Have you visited a doctor or other health care professional because of this shoulder pain **since we last questioned you**? No ☐ Yes ☐

42. **Since we last questioned you**, have you had to cut down or avoid any of the following activities in your job because of pain in your shoulder(s)?

(Please tick one box for each line.)

	Not needed to cut down/avoid this activity	*Had to cut down/avoid because of back pain*	*This activity is not normally part of the job*
a) Lifting loads greater than 10 kg (20lbs).	☐	☐	☐
b) Digging or shovelling.	☐	☐	☐
c) Working with your hands above shoulder height.	☐	☐	☐
d) Working as a professional driver (ie driving in the job for an hour or more on most work days).	☐	☐	☐

43. Have you had this shoulder pain during the **past 4 weeks**? No ☐ Yes ☐

*If **NO**, go to question 45.*

44. If you had **shoulder** pain, how would you rate it on a 0 - 10 scale during a typical day in the **past 7 days** (where **0 = no pain** and **10 = worst pain you can imagine**)?

(Please circle one number.)

No pain *Worst pain you can imagine*

0 1 2 3 4 5 6 7 8 9 10

SECTION E: OTHER SYMPTOMS AND FEELINGS

*This section concerns **other symptoms** and your **feelings** about health problems.*

45. Firstly, some questions about how you feel and how things have been with you **during the past 4 weeks**. *Please tick the one box for each question which most closely reflects how you feel.*

How much of the time **during the past 4 weeks** …….	*None of the time*	*A little of the time*	*Some of the time*	*Most of the time*	*All of the time*
a) …did you feel full of life?	☐	☐	☐	☐	☐
b) …have you been a very nervous person?	☐	☐	☐	☐	☐
c) …have you felt so down in the dumps that nothing could cheer you up?	☐	☐	☐	☐	☐
d) …have you felt calm and peaceful?	☐	☐	☐	☐	☐
e) …did you have a lot of energy?	☐	☐	☐	☐	☐
f) …have you felt downhearted and low?	☐	☐	☐	☐	☐
g) …did you feel worn out?	☐	☐	☐	☐	☐
h) …have you been a happy person?	☐	☐	☐	☐	☐
i) …did you feel tired?	☐	☐	☐	☐	☐

46. During the past **12 months**, how many days of sick leave have you taken (for all reasons combined)?

None ☐ 1 - 2 days ☐ 3 - 6 days ☐

7 - 30 days ☐ 1 - 3 months ☐ More than 3 months ☐

47. Below is a list of problems people sometimes have. Please read each one carefully and circle the number that best describes how much that problem has distressed or bothered **you** during the **past 7 days including today**.

		Not at all	*A little bit*	*Moderately*	*Quite a bit*	*Extremely*
a)	Faintness or dizziness.	0	1	2	3	4
b)	Pains in the heart or chest.	0	1	2	3	4
c)	Your feelings being easily hurt.	0	1	2	3	4
d)	Feeling that people are unfriendly or dislike you.	0	1	2	3	4
e)	Feeling inferior to others.	0	1	2	3	4
f)	Nausea or upset stomach.	0	1	2	3	4
g)	Trouble getting your breath.	0	1	2	3	4
h)	Numbness or tingling in parts of your body.	0	1	2	3	4
i)	Feeling weak in parts of your body.	0	1	2	3	4
j)	Feeling very self-conscious with others.	0	1	2	3	4

48. Whether you have back pain or not, based on your own views and what the doctor or others may have told you about pain in the back, how strongly do you agree with the following statements?

Please circle one number for each statement which most closely reflects how you feel.
1 means you completely disagree, 5 means you completely agree

		Completely disagree				*Completely agree*
a)	Physical activity worsens back pain	1	2	3	4	5
b)	Physical activities should be avoided if they might make the pain worse.	1	2	3	4	5
c)	An increase in pain is an indication to stop what one is doing.	1	2	3	4	5
d)	Rest is needed to get better.	1	2	3	4	5
e)	Normal work should be avoided until the pain is treated.	1	2	3	4	5
f)	It is important to see a doctor straight away at the first sign of trouble.	1	2	3	4	5
g)	Neglecting problems of this kind can cause permanent health problems.	1	2	3	4	5
h)	Back pain normally gets better by itself.	1	2	3	4	5

A part of our health survey is direct observation of the working environment and postures held while driving.

If you wish to participate in this study, a measuring system (which will not interfere with your driving and working tasks) will be installed in your car at the beginning of a working day and uninstalled at the end of the day.

As a 'thank you' for your cooperation you will be paid if you are selected to participate in this further study.

NO, I do not wish to participate in the study ☐

YES, I wish to participate in the study ☐

If *YES*, please give your phone number or contact (email address, etc.) to arrange the study. ____________________

If you have any questions concerning this study please contact Lenka Justinova, who is based at the University of Southampton (Email: lj1@isvr.soton.ac.uk, tel.: 02380 593235)

You have finished. Please take a moment to look through your answers. Return the questionnaire to us in the pre-paid envelope supplied.

APPENDIX D

Motivation letters for subjects

MRC Environmental Epidemiology Resource Centre,
University of Southampton
Southampton General Hospital
Tremona Road
Southampton, SO16 6YD

Dear Sir or Madam

We would be grateful for a few minutes of your time to assist with some important research by completing a questionnaire.

By completing the enclosed questionnaire you will contribute to a better understanding of health problems in taxi drivers all over the world.

It will take approximately 25 minutes to complete the questionnaire. The completed questionnaire should be placed in the pre-paid envelope and posted.

To thank you for your cooperation, all drivers who return completed questionnaires will be entered for a draw in which five drivers will win £20.00.

All information you provide will be strictly confidential to the small research team. It will not be used or made available in any form that could allow individuals to be identified. The research team at the University is not aware of your name. The Southampton City Council will not see your responses.

Southampton City Council, Southampton Hackney Association, Southampton TGWU, Southampton Taxi Consultative Council, and Private Hire Association have agreed to the research and the distribution of the questionnaire.

If you have any questions, please contact Lenka Justinova, at the University of Southampton (email: lj1@isvr.soton.ac.uk; tel.: 02380 593235).

Thank you for your time and cooperation.

Yours faithfully,

Keith T Palmer
Consultant Occupational Physician

Michael J Griffin
Professor of Human Factors

Lenka Justinova
Research student

MRC Environmental Epidemiology Resource Centre,
University of Southampton
Southampton General Hospital
Tremona Road
Southampton, SO16 6YD

Questionnaire: Follow-up

Dear Sir or Madam,

Twelve months ago you kindly complete a questionnaire for our research into the health of taxi drivers. Responses to that initial questionnaire were interesting and we now ask that you complete the second and final questionnaire.

By completing the enclosed follow-up questionnaire you will contribute to a better understanding of health problems in taxi drivers around the world.

It will take approximately 20 minutes to complete the questionnaire. The questionnaire should then be placed in the pre-paid envelope and posted.

To thank you for your cooperation, all drivers who return completed questionnaires will be entered for a draw in which five drivers will win £20.00.

All information you provide will be strictly confidential to the small research team. It will not be used, or made available, in any form that allows individuals to be identified. The research team at the University is not aware of your name. The Southampton City Council will not see your responses.

Southampton City Council, Southampton Hackney Association, Southampton TGWU, Southampton Taxi Consultative Council, and Private Hire Association have agreed to the research and the distribution of the questionnaire.

If you have any questions, please contact Lenka Justinova, at the University of Southampton (email: lj1@isvr.soton.ac.uk; tel.: 02380 593235).

Thank you for your time and cooperation.

Yours faithfully,

Keith T Palmer	Michael J Griffin	Lenka Justinova
Consultant Occupational Physician	**Professor of Human Factors**	**Research student**

LEGAL & DEMOCRATIC SERVICES
MARK HEATH, LLB Solicitor, Dip. LG
Solicitor to the Council
Southampton City Council
Southbrook Rise,
4-8 Millbrook Road East
Southampton SO15 1YG

Please address all correspondence to:
Licensing – Southampton City Council,
PO Box 1344, Southampton SO15 1WQ

SOUTHAMPTON CITY COUNCIL

Direct dial: 023 8083 2706
Please ask for: Mr Hall
E-mail: licensing@southampton.gov.uk
Our ref: LL40
Your ref:

To all Southampton Licensed Hackney Carriage and Private Hire Drivers

7 December, 2004

Dear Sir or Madam,

SOUTHAMPTON UNIVERSITY SURVEY OF WORK ACTIVITIES AND HEALTH

The Southampton Survey of Work Activities and Health is being conducted by the University of Southampton with Southampton City Council's support together with that of your trade representative associations.

You are encouraged to participate by reading the attached letter and completing the enclosed questionnaire.

Please note that the University has not received any of your personal details – all address labels have been produced in the Licensing office at Southbrook Rise.

Thank you for your co-operation.

Yours faithfully,

Phil Hall
for Solicitor to the Council

SUsurvey.doc

MRC Environmental Epidemiology Unit
(University of Southampton)
Southampton General Hospital
Tremona Road
Southampton
SO16 6YD

Dear Sir or Madam

Southampton Health Survey of Police Employees

We would be grateful for a few minutes of your time to assist with some important research by completing a questionnaire. We will make a donation to Diced Cap for every completed questionnaire we receive.

By completing the enclosed questionnaire you will also contribute to a better understanding of health problems in various occupations around the world.

The University of Southampton leads this international project with collaboration between the Human Factors Research Unit and the MRC Environmental Epidemiological Unit. The research involves collecting similar details from participants in six European countries in France, Germany, Netherlands, Italy, Sweden, and the UK.

The Operational Support Division, Grampian Police, support your participation.

All information you provide will be strictly confidential to the small research team. It will not be used or made available in any form that could allow individuals to be identified.

If you have any questions concerning the study please contact Lenka Justinova, who is based at the University of Southampton (02380 593235).

It will take approximately 30 minutes to complete the questionnaire. The completed questionnaire should then be placed in the pre-paid envelope and posted.

Thank you for your time and kind cooperation.

Yours faithfully,

Keith T Palmer **Consultant Occupational Physician**	Michael J Griffin **Professor of Human Factors**	Lenka Justinova **Research student**

University of Southampton | isvr | MRC Medical Research Council

Reminder: Survey of Work Activities and Health performed by the University of Southampton

Dear Sir or Madam,

A few weeks ago we asked for a few minutes of your time to assist with some important research by completing a questionnaire. **As we have promised, we will make a donation to Diced Cap for every completed questionnaire we receive**.

We have received many responses, and thank you for the good participation. However, we have not received completed questionnaires from some of you.

It will take you approximately 30 minutes to complete the questionnaire. The completed questionnaire should be placed in the pre-paid envelope, which was enclosed in the questionnaire package, and then posted.

The Operational Support Division, Grampian Police, support your participation.

All information you provide will be confidential to the research team. It will not be used or made available in any form that could allow individuals to be identified.

Your reply is important to us and we are very grateful for your help. Thank you for your time and cooperation.

Yours faithfully,

Michael J Griffin
Professor of Human Factors

Lenka Justinova
Research student

COLIN McKERRACHER LLB

Chief Constable

Police Headquarters
Queen Street
Aberdeen
AB10 1ZA

Our Ref: 6 June 2005
Your Ref:

Tel: 0845 600 5 700

Dear Colleague

Back Pain Survey

Professor Griffin, Southampton University, approached the Force to see if we would be willing to take part in research into health, in particular to back pain and it's relationship to the work environment. I feel that this is an important issue and have agreed to distribute the enclosed questionnaire, which has been prepared by the team at Southampton, to every employee.

The research is fully funded by the EU and I hope you will take the time to contribute to the work by completing the questionnaire. A follow up survey will be undertaken in twelve months time when all employees who return this questionnaire will be sent a shorter version to complete.

The team at Southampton will not have access to any database with the names of individuals. All questionnaires should be returned directly to Southampton in prepaid envelopes and the Force will have no access to information regarding individuals. This will ensure confidentiality of individual details. A summary of the results of the survey will be sent to the Force and this will be made available to all members of staff.

As an added incentive to complete the questionnaire Professor Griffin will make a donation to Diced Cap for every questionnaire returned.

Colin Menzies
Chief Superintendent
Corporate Development

APPENDIX E

Additional tables of results

Table E1. Individual information of taxi drivers, police drivers and non-drivers (cross-sectional baseline study). Data are given as frequency (n) and percentage (%)

Factors	Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
	n (%)	n (%)	n (%)
Age (yr)			
≤36	25 (12)	171 (47)	162 (33)
37-46	57 (27)	132 (36)	156 (32)
>46	126 (60)	61 (17)	161 (33)
Gender			
male	199 (95)	280 (77)	200 (41)
female	10 (5)	84 (23)	283 (58)
Height (cm)			
≤170.2	56 (27)	67 (18)	256 (53)
170.2-177.8	76 (36)	116 (32)	110 (23)
>177.8	40 (19)	181 (50)	113 (23)
missing	37 (18)	1	6 (1)
Weight (kg)			
≤73	371 (18)	97 (27)	213 (44)
74-86	75 (36)	129 (35)	128 (26)
>86	84 (40)	127 (35)	124 (26)
missing	13 (6)	12 (3)	20 (4)
BMI			
≤24.3	29 (14)	127 (35)	274 (36)
24.4-27.3	55 (26)	129 (35)	140 (29)
>27.3	81 (39)	96 (26)	150 (31)
missing	43 (21)	13 (4)	21 (4)
Smoking status			
ex-smoker/smoker	127 (61)	108 (30)	166 (34)
smoker	57 (27)	38 (10)	57 (12)
non-smoker	80 (38)	256 (70)	317 (65)
Physical activity			
never	123 (59)	81 (22)	152 (30)
1-2/week	40 (19)	136 (37)	143 (30)
3/week	28 (13)	77 (21)	80 (17)
>4/week	18 (9)	71 (20)	110 (23)

Table E2. Physical activities and driving information of taxi drivers, police drivers and non-drivers (cross-sectional baseline study). Data are given as frequency (n) and percentage (%)

Factors		Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
		n (%)	n (%)	n (%)
Duration of work ≥10 years		107 (51)	186 (49)	156 (32)
Duration of work ≥40hrs/week		154 (74)	303 (83)	181 (37)
Working activities (per day)				
Lifting	not at all	32 (15)	146 (41)	350 (72)
	1-10 times	156 (75)	206 (56)	129 (27)
	>10 times	21 (10)	12 (3)	6 (1)
Lifting & bending	not at all	70 (33)	243 (66)	428 (88)
	1-10 times	121 (58)	121 (33)	50 (10)
	>10 times	18 (9)	1 (0.5)	2 (0.5)
Lifting & twisting	not at all	107 (51)	266 (73)	444 (92)
	1-10 times	95 (46)	87 (24)	32 (7)
	>10 times	7 (3)	2 (1)	0 (0)
Lifting & twisting & bending				
	not at all	119 (56)	276 (76)	450 (93)
	1-10 times	85 (41)	75 (21)	26 (5)
	>10 times	5 (2)	4 (1)	0 (0.5)
Standing or walking	none	17 (8)	0 (0)	40 (8)
	<1 hour	98 (47)	59 (16)	208 (43)
	1-3 hours	84 (40)	211 (58)	153 (32)
	>3 hours	10 (5)	93 (26)	82 (17)
Trunk bent	not at all	156 (75)	245 (67)	396 (82)
	<5 times	20 (10)	50 (14)	36 (7)
	5-20 times	26 (12)	53 (15)	40 (8)
	>20 times	7 (3)	11 (3)	8 (2)
Trunk twisted	not at all	162 (77)	285 (78)	437 (90)
	<5 times	14 (7)	44 (12)	16 (3)
	5-20 times	26 (12)	24 (7)	22 (5)
	>20 times	7 (3)	6 (2)	7 (1)
Sitting other than driving	<1 hour	22 (11)	204 (56)	36 (7)
	1-3 hours	99 (47)	36 (11)	80 (17)
	>3 hours	88 (42)	125 (34)	369 (76)
Previous job with professional driving		75 (36)	152 (42)	148 (31)
Previous job with heavy physical load		142 (68)	177 (49)	146 (30)
Previous job with prolonged sitting		84 (40)	122 (33)	234 (48)
Type of driven vehicle				
	purpose build taxi	13 (8)	-	n.a.
	purpose adapted taxi	10 (3)	-	
	saloon car	187 (88)	-	
	traffic vehicle	-	47 (13)	
	squad car	-	286 (78)	
	traffic vehicle and squad car	-	17 (5)	
	other	2 (1)	13 (4)	
Unloading vehicle		100 (48)	81 (22)	n.a.
Driving off road (per day)				
	not at all	148 (71)	261 (72)	n.a.
	<1 hour	34 (16)	84 (23)	
	1-3 hours	13 (6)	14 (4)	
	>3 hours	10 (5)	5 (1)	

Table E3. Psychosocial status (at work) of taxi drivers, police drivers and non-drivers (cross-sectional baseline study). Data are given as frequency (n) and percentage (%)

Factors	Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
	n (%)	n (%)	n (%)
Job decision:			
(i) how to do your work:			
often	164 (79)	135 (37)	209 (43)
sometimes	18 (9)	161 (44)	154 (32)
seldom	8 (4)	48 (13)	68 (14)
never/almost never	15 (7)	21 (6)	52 (11)
(ii) what to do at work:			
often	139 (67)	88 (24)	137 (28)
sometimes	34 (16)	162 (44)	174 (36)
seldom	11 (5)	72 (20)	93 (19)
never/almost never	20 (10)	41 (11)	80 (17)
(iii) timetable & breaks:			
often	193 (92)	107 (29)	225 (46)
sometimes	11 (5)	124 (34)	139 (29)
seldom	1 (1)	70 (19)	59 (12)
never/almost never	2 (1)	61 (17)	60 (13)
Job support:			
often	28 (13)	172 (47)	261 (54)
sometimes	60 (29)	148 (40)	160 (33)
seldom	21 (10)	36 (10)	47 (8)
never	29 (14)	7 (2)	3(3)
not applicable	69 (33)	2 (1)	-
Job satisfaction:			
very satisfied	56 (27)	83 (23)	148(30)
satisfied	135 (64)	236 (65)	279 (58)
dissatisfied	14 (7)	42 (12)	50 (10)
very dissatisfied	4 (2)	4(1)	7 (1)

Table E4. Psychosocial status of taxi drivers, police drivers and non-drivers (cross-sectional baseline study). Data are given as frequency (n) and percentage (%)

Factors	Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
	n (%)	n (%)	n (%)
Mental health status: have you			
(i) been a nervous person			
none of the time	126 (60)	206 (56)	253 (52)
a little of the time	40 (19)	109 (30)	153 (32)
some of the time	32 (15)	41 (11)	63 (13)
most of the time	6 (3)	7 (2)	11 (2)
all of the time	0	1	3 (1)
(ii) felt down that nothing could cheer you up			
none of the time	101 (48)	201 (55)	273 (56)
a little of the time	57 (27)	110 (30)	127 (26)
some of the time	40 (19)	50 (14)	74 (15)
most of the time	4 (2)	4 (1)	8 (2)
all of the time	2 (1)	0	1
(iii) felt calm and peaceful			
none of the time	13 (6)	15 (4)	13 (3)
a little of the time	24 (12)	45 (12)	80 (17)
some of the time	78 (37)	170 (47)	207 (43)
most of the time	75 (36)	128 (35)	179 (37)
all of the time	16 (8)	7 (2)	4 (1)
(iv) downhearted and low			
none of the time	58 (28)	121 (33)	150 (31)
a little of the time	87 (42)	164 (45)	208 (43)
some of the time	45 (22)	69 (19)	104 (21)
most of the time	11 (5)	9 (3)	20 (4)
all of the time	4 (2)	1	2 (0.5)
(v) been a happy person			
none of the time	6 (3)	2 (0.5)	2 (0.5)
a little of the time	22 (11)	22 (6)	34 (7)
some of the time	51 (24)	106 (29)	144 (30)
most of the time	104 (50)	212 (58)	288 (59)
all of the time	4 (2)	23 (6)	16 (3)

Table E4. (cont.) Psychosocial status of taxi drivers, police drivers and non-drivers (cross-sectional baseline study). Data are given as frequency (n) and percentage (%)

Factors	Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
	n (%)	n (%)	n (%)
Energy and vitality status: did you			
(i) feel full of life			
none of the time	21 (10)	12 (3)	19 (4)
a little of the time	17 (18)	50 (14)	76 (6)
some of the time	83 (40)	143 (39)	178 (37)
most of the time	55 (26)	148 (41)	206 (43)
all of the time	9 (4)	11 (3)	5 (1)
(ii) have a lot of energy			
none of the time	19 (9)	18 (5)	20 (4)
a little of the time	41 (20)	43 (12)	88 (18)
some of the time	79 (38)	156 (43)	202 (42)
most of the time	56 (27)	140 (38)	171 (35)
all of the time	10 (5)	7 (2)	1
(iii) fell worn out			
none of the time	28 (13)	37 (10)	58 (12)
a little of the time	64 (31)	161 (44)	191 (39)
some of the time	79 (38)	121 (33)	173 (36)
most of the time	28 (13)	41 (11)	53 (11)
all of the time	6 (3)	4 (1)	8 (2)
(iv) feel tired			
none of the time	16 (8)	12 (3)	7 (1)
a little of the time	48 (23)	94 (26)	153 (32)
some of the time	94 (45)	180 (49)	222 (46)
most of the time	39 (19)	65 (18)	83 (17)
all of the time	9 (4)	13 (4)	19 (4)

Table E4. (cont.) Psychosocial status of taxi drivers, police drivers and non-drivers (cross-sectional baseline study). Data are given as frequency (n) and percentage (%)

Factors	Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
	n (%)	n (%)	n (%)
Psychosomatic distress status			
(i) faintness or dizziness			
not at all	184 (88)	321 (88)	401 (83)
a little bit	12 (6)	34 (9)	56 (12)
moderately	1 (0.5)	5 (1)	17 (4)
quite a bit	3 (1)	2 (0.5)	4 (1)
extremely	6 (3)	0	2 (0.5)
(ii) pains in the heart or chest			
not at all	164 (79)	331 (91)	434 (90)
a little bit	24 (12)	25 (7)	34 (7)
moderately	7 (3)	4 (1)	5 (1)
quite a bit	5 (2)	3 (1)	5 (1)
extremely	2 (1)	0	2 (0.5)
(iii) nausea or upset stomach			
not at all	148 (71)	259 (71)	319 (66)
a little bit	25 (12)	58 (16)	109 (23)
moderately	21 (10)	33 (9)	24 (5)
quite a bit	6 (3)	12 (3)	22 (5)
extremely	2 (1)	1	6 (1)
(iv) trouble getting the breath			
not at all	147 (70)	332 (91)	416 (86)
a little bit	31 (15)	22 (6)	46 (10)
moderately	13 (6)	5 (1)	13 (3)
quite a bit	9 (4)	2 (0.5)	4 (1)
extremely	1 (0.5)	1	1
(v) numbness or tingling			
not at all	143 (68)	297 (81)	365 (75)
a little bit	39 (19)	39 (11)	71 (15)
moderately	9 (4)	18 (5)	27 (6)
quite a bit	11 (5)	6 (2)	14 (3)
extremely	1 (0.5)	3 (1)	3 (0.5)
(vi) feeling weak in the body			
not at all	153 (73)	248 (68)	325 (67)
a little bit	20 (9.6)	70 (19)	103 (21)
moderately	16 (7.7)	31 (9)	33 (7)
quite a bit	7 (3.3)	10 (3)	16 (3)
extremely	4 (1.9)	4 (1)	4 (1)

Table E5. Measures of daily and cumulative exposure to whole-body vibration in taxi drivers and police drivers at the cross-sectional baseline study. Equal subgroups (approximate thirds: T1-T3) of drivers as they are used in further statistical analysis

Taxi drivers (n=209)	Police drivers (n=365)
Measures of daily vibration exposure	
Daily driving time ≤ 6 hours (T1) 6.1 - 9 hours (T2) > 9 hours (T3)	Daily driving time ≤ 2 hours (T1) 2.1 – 3.2 hours (T2) > 3.2 hours (T3)
$A_{dom}(8)$ ≤ 0.33 ms^{-2} r.m.s. (T1) 0.34 – 0.5 ms^{-2} r.m.s. (T2) > 0.5 ms^{-2} r.m.s. (T3)	$A_{dom}(8)$ ≤ 0.22 ms^{-2} r.m.s. (T1) 0.23 – 0.28 ms^{-2} r.m.s. (T2) > 0.29 ms^{-2} r.m.s. (T3)
$eVDV_{dom}$ ≤ 8 ($ms^{-1.75}$) (T1) 8.1 – 8.8 ($ms^{-1.75}$) (T2) > 8.8 ($ms^{-1.75}$) (T3)	$eVDV_{dom}$ ≤ 5.7 ($ms^{-1.75}$) (T1) 5.8 – 6.4 ($ms^{-1.75}$) (T2) > 6.4 ($ms^{-1.75}$) (T3)
Duration of exposure (yr) ≤ 3 years (T1) 3.1 – 13 years (T2) > 13 years (T3)	Duration of exposure (yr) ≤ 5.7 years (T1) 5.8 – 15.3 years (T2) > 15.3 years (T3)
Total driving time ($\sum[t_i]$): (h $\times 10^3$) hours ≤ 9 (T1) 9.1 – 21.6 (T2) > 21.6 (T3)	Total driving time ($\sum[t_i]$): (h $\times 10^3$) hours ≤ 3 (T1) 3.1 – 7.5 (T2) > 7.48 (T3)
$VDV_{Total\text{-}dom}$ ($ms^{-1.75}$) ≤ 48.6 ($ms^{-1.75}$) (T1) 48.7 – 61.4 ($ms^{-1.75}$) (T2) > 61.4 ($ms^{-1.75}$) (T3)	$VDV_{Total\text{-}dom}$ ($ms^{-1.75}$) ≤ 34.5 ($ms^{-1.75}$) (T1) 34.6 - 44 ($ms^{-1.75}$) (T2) > 44 ($ms^{-1.75}$) (T3)

Table E6. Comparison of measured and estimated duration of driving in taxi drivers

Driver	Duration of measurement	Driving duration reported by driver	Real duration of driving	Overestimation of drivng
Taxi driver 1	8hrs	6hrs	4hrs 24 min	36%
Taxi driver 2	8hrs	5hrs	4hrs 9min	17%
Taxi driver 3	8hrs	7hrs	4hrs 30min	44%
Taxi driver 4	8hrs	8hrs	5hrs 19min	34%
Taxi driver 5	8hrs	6hrs	4hrs 15min	29%
Taxi driver 6	8hrs	7hrs	3hrs 42min	47%
Taxi driver 7	8hrs	7hrs	4hrs 32min	35%
Taxi driver 8	8hrs	6hrs	4hrs 42min	22%
Taxi driver 9	8hrs	6hrs	4hrs 42min	22%
Taxi driver 10	8hrs	7hrs	4hrs 54min	30%
Taxi driver 11	8hrs	8hrs	6hrs 7min	24%
Taxi driver 12	8hrs	5hrs	3hrs 59min	28%
TOTAL				31%

Table E7. Results of univariate analysis (simple logistic regression) for the association between neck pain during the past 12 months and various individual risk factors in taxi drivers, police drivers and non-drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Factors	Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age (yr)			
≤36	1.00	1.00	1.00
37-46	3.06 (0.93-10.14)	1.36 (0.82-2.24)	1.33 (0.83-2.12)
>46	2.82 (0.91-8.72)	1.68 (0.91-3.13)	1.41 (0.89-2.23)
Gender			
female	n.a.	1.00	1.00
male		1.62 (0.97-2.70)	0.93 (0.64-1.35)
BMI (kg/m^2)			
≤24.3	1.00	1.00	1.00
24.4-27.3	0.85 (0.33-2.21)	0.71 (0.41-1.23)	0.93 (0.58-1.51)
>27.3	0.80 (0.33-1.97)	1.31 (0.75-2.29)	1.41 (0.89-2.22)
Height (cm)			
≤170.2	1.00	1.00	1.00
170.2-177.8	1.82 (0.84-3.97)	0.62 (0.33-1.17)	0.83 (0.51-1.33)
>177.8	1.78 (0.73-4.37)	0.57 (0.32-1.03)	1.09 (0.69-1.73)
Weight (kg)			
≤73	1.00	1.00	1.00
74-86	0.98 (0.42-2.28)	0.53 (0.30-0.95)	1.43 (0.90-2.26)
>87	0.93 (0.41-2.14)	0.90 (0.52-1.57)	1.31 (0.82-2.09)
Smoking status			
no smoking	1.00	1.00	1.00
smoker/ex-smoker	2.49 (1.31-4.73)	1.64 (1.02-2.65)	1.17 (0.79-1.73)
Regular practising of sport			
no	1.00	1.00	1.00
yes	1.43 (0.79-2.57)	1.89 (0.96-3.73)	1.44 (0.95-2.17)

Table E7. (cont.) Results of univariate analysis (simple logistic regression) for the association between neck pain during the past 12 months and various work-related physical risk factors in the drivers, police drivers and non-drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Factors	Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Duration of work: ≥40hrs/week			
no	1.00	1.00	1.00
yes	1.05 (0.54-2.04)	0.70 (0.39-1.25)	0.65 (0.44-0.97)
Lifting at work			
no	1.00	1.00	1.00
yes	1.58 (0.67-3.72)	1.08 (0.69-1.71)	0.82 (0.54-1.25)
Lifting while bending at work			
no	1.00	1.00	1.00
yes	1.67 (0.89-3.17)	1.04 (0.65-1.67)	1.40 (0.78-2.52)
Lifting while twisting at work			
no	1.00	1.00	1.00
yes	1.69 (0.94-3.02)	1.22 (0.73-2.04)	1.10 (0.52-2.30)
Lifting while bending and twisting at work			
no	1.00	1.00	1.00
yes	1.34 (0.75-2.39)	1.16 (0.68-1.98)	1.36 (0.61-3.02)
Standing or walking (≥1hr/day)			
no	1.00	1.00	1.00
yes	1.68 (0.94-3.01)	0.54 (0.31-0.96)	0.91 (0.62-1.32)
Trunk bent at work			
no	1.00	1.00	1.00
yes	1.83 (0.96-3.49)	1.52 (0.82-2.79)	1.48 (0.92-2.38)
Trunk twisted at work			
no	1.00	1.00	1.00
yes	1.92 (0.99-3.74)	1.39 (0.83-2.85)	1.50 (0.82-2.75)
Sitting >3h at work			
no	1.00	1.00	1.00
yes	1.00 (0.56-1.79)	1.70 (1.10-2.70)	1.49 (0.94-2.34)
Previous job with:			
Professional driving	3.10 (1.70-5.67)	1.27 (0.81-1.99)	1.09 (0.73-1.64)
Physical demands	2.13 (1.09-4.14)	1.56 (0.99-2.46)	1.54 (1.03-2.30)
Sitting	1.46 (0.82-2.63)	1.67 (1.05-2.66)	1.05 (0.72-1.52)

Table E7. (cont.) Results of univariate analysis (simple logistic regression) for the association between neck pain during the past 12 months and various psychosocial risk factors in drivers, police drivers and non-drivers in the cross-sectional baseline study. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Factors	Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Choice and decision at work:			
- how to work			
yes	1.00	1.00	1.00
no	0.87 (0.34-2.22)	1.17 (0.67-2.05)	1.05 (0.68-1.62)
- what to do at work			
yes	1.00	1.00	1.00
no	0.66 (0.28-1.55)	1.12 (0.69-1.81)	1.14 (0.77-1.67)
- timetables and breaks			
yes	1.00	1.00	1.00
no	1.00 (0.09-11.22)	0.98 (0.61-1.56)	1.22 (0.80-1.87)
Support from colleagues			
yes	1.00	1.00	1.00
low support	0.72 (0.34-1.52)	1.56 (0.81-3.01)	1.81 (1.00-3.27)
not applicable	0.92 (0.47-1.79)	-	-
Satisfaction at job			
yes	1.00	1.00	1.00
no	0.76 (0.26-2.24)	2.35 (1.25-4.40)	1.96 (1.12-3.42)
Mental health status			
healthy	1.00	1.00	1.00
medium	1.84 (0.78-4.34)	0.82 (0.45-2.99)	1.47 (0.86-2.50)
poor	3.87 (1.72-8.74)	1.65 (0.92-2.95)	2.22 (1.30-3.80)
Energy and vitality status			
healthy	1.00	1.00	1.00
medium	3.40 (1.07-10.79)	1.59 (0.85-2.99)	1.34 (0.78-2.29)
poor	6.42 (2.11-19.53)	2.51 (1.36-4.64)	2.90 (1.75-4.83)
Psychosomatic distress status			
healthy	1.00	1.00	1.00
medium	3.53 (1.52-8.21)	2.14 (1.25-3.64)	2.84 (1.73-4.65)
poor	5.68 (2.58-12.48)	2.21 (1.25-3.91)	6.07 (3.67-10.02)

Table E8. Results of univariate analysis (simple logistic regression) for the association between neck pain during the past 12 months and alternative measures of daily and cumulative exposure to whole-body vibration in taxi drivers and police drivers in the cross-sectional baseline study. Each measure of whole-body vibration exposure was included as a third based design variable (T_n), assuming the lowest quartile as the reference category. In the table are presented crude odds ratios (OR) and 95% confidence intervals (95% CI)

Measures of WBV exposure	Taxi drivers (n=209)			Police drivers (n=365)		
	T1	T2	T3	T1	T2	T3
Daily driving time (h)						
OR	1.00	0.88	1.55	1.00	0.74	1.04
(95% CI)	(-)	0.43-1.83	0.78-3.11	(-)	0.41-1.36	0.63-1.72
$A_{dom}(8)$ (ms^{-2} r.m.s.)						
OR	1.00	1.19	1.64	1.00	1.10	1.10
(95% CI)	(-)	0.58-2.46	0.80-3.36	(-)	0.61-1.96	0.65-1.87
VDV_{dom} ($ms^{-1.75}$)						
OR	1.00	0.86	1.46	1.00	1.08	1.10
(95% CI)	(-)	0.42-1.76	0.73-2.95	(-)	0.60-1.93	0.65-1.87
Exposure duration (yr)						
OR	1.00	0.78	0.76	1.00	1.10	1.62
(95% CI)	(-)	0.39-1.56	0.37-1.54	(-)	0.63-1.94	0.94-2.79
$\sum[t_i]$ (h $\times 10^3$)						
OR	1.00	0.84	0.66	1.00	1.04	1.27
(95% CI)	(-)	0.42-1.70	0.32-1.37	(-)	0.59-1.81	0.74-2.19
$VDV_{Total\text{-}dom}$ ($ms^{-1.75}$)						
OR	1.00	0.98	0.80	1.00	1.02	1.40
(95% CI)	(-)	0.48-1.98	0.38-1.65	(-)	0.57-1.83	0.80-2.46

Table E9. Results of multivariate analysis (standard logistic regression) for the association between neck pain during the past 12 months and various individual risk factors in taxi drivers, police drivers and non-drivers in the cross-sectional baseline study. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Factors	Taxi drivers (n=209)	Police drivers (n=365)	Non-drivers (n=485)
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age (yr)			
≤36	1.00	1.00	1.00
37-46	2.89 (0.80-10.39)	0.96 (0.31-3.00)	1.57 (0.93-2.66)
>46	2.17 (0.64-7.36)	1.03 (0.32-3.37)	1.29 (0.78-2.15)
Weight (kg)			
≤73		1.00	
74-86	n.a.	0.61 (0.17-2.22)	n.a.
>87		1.19 (0.34-4.23)	
Smoking status			
no smoking	1.00	1.00	n.a.
smoker/ex-smoker	2.03 (0.98-4.24)	0.70 (0.27-1.84)	
Duration of work: ≥40hrs/week			
no	n.a.	n.a.	1.00
yes			0.63 (0.40-0.99)
Standing or walking (≥1h/day)			
no	n.a.	1.00	n.a.
yes		0.49 (0.11-2.24)	
Trunk twisted at work			
no	1.00	n.a.	n.a.
yes	1.92 (0.91-4.07)		
Sitting >3h at work			
no	n.a.	1.00	n.a.
yes		1.64 (0.60-4.53)	
Previous job with:			
Physical demands	2.00 (0.97-4.12)	n.a.	1.46 (0.94-2.27)
Sitting	n.a.	2.55 (0.96-6.74)	n.a.
Support from colleagues			
yes	n.a.	n.a.	1.00
low support			1.65 (0.85-3.18)
Psychosomatic distress status			
healthy	1.00	1.00	1.00
medium	3.24 (1.34-7.86)	1.04 (0.35-3.07)	2.57 (1.54-4.31)
poor	5.04 (2.21-11.49)	3.58 (1.14-11.23)	5.39 (3.21-9.05)

Table E10. Results of multivariate analysis (standard logistic regression) for the association between neck pain during the past 12 months and alternative measures of daily and cumulative exposure to whole-body vibration in taxi drivers and police drivers in the cross-sectional baseline study. Each measure of whole-body vibration exposure was included as a third based design variable (T_n), assuming the lowest quartile as the reference category. In the table are presented adjustef odds ratios (OR) and 95% confidence intervals (95% CI)

Measures of WBV exposure	Taxi drivers (n=209)			Police drivers (n=365)		
	T1	T2	T3	T1	T2	T3
Daily driving time (h)						
OR	1.00	0.88	1.46	1.00	0.75	1.16
(95% CI)	(-)	0.39-2.00	0.65-3.26	(-)	0.17-3.40	0.40-3.36
$A_{dom}(8)$ (ms^{-2} r.m.s.)						
OR	1.00	1.20	1.77	1.00	0.88	0.99
(95% CI)	(-)	0.53-2.74	0.77-4.09	(-)	0.22-3.56	0.23-2.98
VDV_{dom} ($ms^{-1.75}$)						
OR	1.00	0.92	1.67	1.00	0.88	0.99
(95% CI)	(-)	0.40-2.10	0.73-3.80	(-)	0.22-3.56	0.23-2.98
Exposure duration (yr)						
OR	1.00	0.87	0.66	1.00	1.28	2.65
(95% CI)	(-)	0.38-1.97	0.27-1.57	(-)	0.34-4.79	0.62-11.35
$\sum[t_i]$ (h $\times 10^3$)						
OR	1.00	0.68	0.42	1.00	1.56	1.54
(95% CI)	(-)	0.25-1.35	0.17-1.04	(-)	0.42-5.78	0.40-5.88
$VDV_{Total\text{-}dom}$ ($ms^{-1.75}$)						
OR	1.00	0.83	0.60	1.00	1.67	1.50
(95% CI)	(-)	0.36-1.90	0.25-1.46	(-)	0.41-6.83	0.36-6.34

Odds ratio are adjusted for:
Taxi drivers: age, smoking, twisting, psychosomatic distress
Police drivers: age, previous physical load, psychosocial distress

Table E11. Individual information of taxi drivers, police drivers and non-drivers (baseline of the longitudinal study). Data are given as frequency (n) and percentage (%)

Factors	Taxi drivers (n=144)	Police drivers (n=219)	Non-drivers (n=300)
	n (%)	n (%)	n (%)
Age (yr)			
≤36	19 (13)	97 (44)	103 (34)
37-46	35 (24)	83 (38)	93 (31)
>46	89 (62)	39 (18)	98 (33)
Gender			
male	137 (95)	166 (76)	130 (43)
female	7 (5)	53 (24)	168 (56)
Height (cm)			
≤170.2	41 (29)	43 (20)	150 (50)
170.2-177.8	57 (40)	65 (30)	75 (25)
>177.8	24 (17)	110 (50)	70 (23)
missing	22 (15)		
Weight (kg)			
≤73	23 (16)	56 (26)	128 (43)
74-86	54 (38)	72 (33)	88 (29)
>86	62 (43)	83 (38)	75 (25)
missing	5 (4)	8 (4)	
Smoking status			
ex-smoker/smoker	91 (35)	63 (29)	94 (31)
non-smoker	51 (63)	155 (71)	205 (68)
Physical activity			
no	78 (54)	31 (14)	83 (27)
yes	66 (46)	188 (86)	217 (72)

Table E12. Physical activities and driving information of taxi drivers, police drivers and non-drivers (baseline of the longitudinal study). Data are given as frequency (n) and percentage (%)

Factors	Taxi drivers (n=144)	Police drivers (n=219)	Non-drivers (n=300)
	n (%)	n (%)	n (%)
Duration of work ≥10 years	73 (51)	118 (54)	101 (34)
Duration of work ≥40hours/week	108 (75)	182 (83)	114 (38)
Working activities (per day)			
Lifting			
not at all	21 (15)	94 (43)	220 (73)
1-10 times	109 (76)	117 (54)	78 (26)
>10 times	14 (9)	7 (3)	2 (1)
Lifting & bending			
not at all	45 (31)	141 (64)	266 (89)
1-10 times	85 (59)	77 (35)	31 (10)
>10 times	14 (9)	1 (1)	0 (0)
Lifting & twisting			
not at all	71 (49)	165 (75)	278 (93)
1-10 times	67 (47)	49 (21)	17 (6)
>10 times	6 (4)	3 (1)	0 (0)
Lifting & twisting & bending			
not at all	75 (52)	167 (76)	279 (93)
1-10 times	65 (45)	45 (21)	15 (5)
>10 times	4 (3)	3 (1)	0 (0)
Standing or walking			
none	11 (8)	38 (17)	23 (8)
<1 hour	69 (48)	127 (58)	135 (45)
1-3 hours	58 (40)	53 (24)	89 (30)
>3 hours	6 (4)	0 (0)	51 (17)
Trunk bent			
not at all	109 (76)	147 (67)	246 (82)
yes	35 (24)	71 (32)	52 (17)
Trunk twisted			
not at all	108 (75)	174 (80)	273 (91)
yes	36 (25)	45 (20)	27 (9)
Sitting other than driving			
<1 hour	17 (12)	19 (9)	20 (7)
1-3 hours	66 (46)	120 (55)	49 (16)
>3 hours	61 (42)	80 (37)	231 (77)
Previous job with professional driving	52 (36)	100 (46)	95 (32)
Previous job with heavy physical load	97 (67)	107 (49)	87 (29)
Previous job with prolonged sitting	53 (37)	74 (34)	148 (49)

Table E13. Psychosocial status (at work) of taxi drivers, police drivers and non-drivers (baseline of the longitudinal study). Data are given as frequency (n) and percentage (%)

Factors	Taxi drivers (n=144)	Police drivers (n=219)	Non-drivers (n=300)
	n (%)	n (%)	n (%)
Job decision:			
(i) how to do your work:			
often	114 (79)	83 (38)	139 (46)
sometimes	12 (8)	101 (46)	88 (29)
seldom	5 (4)	28 (13)	43 (14)
never/almost never	9 (6)	7 (3)	29 (10)
(ii) what to do at work:			
often	99 (69)	53 (24)	92 (31)
sometimes	21 (15)	103 (47)	104 (35)
seldom	5 (4)	43 (20)	60 (20)
never/almost never	14 (10)	19 (9)	43 (14)
(iii) timetable & breaks:			
often	134 (93)	71 (32)	144 (48)
sometimes	6 (4)	74 (34)	82 (27)
seldom	1 (0.5)	45 (21)	37 (12)
never/almost never	1 (0.5)	27 (12)	35 (12)
Job support:			
often	18 (13)	104 (48)	165 (55)
sometimes	39 (27)	92 (42)	101 (34)
seldom	16 (11)	18 (8)	27 (9)
never	22 (15)	4 (2)	7 (2)
not applicable	47 (33)	1 (0.5)	0 (0)
Job satisfaction:			
very satisfied	42 (29)	53 (24)	94 (31)
satisfied	91 (63)	139 (64)	175 (59)
dissatisfied	9 (6)	24 (11)	29 (9)
very dissatisfied	2 (1)	3 (1)	2 (1)

Table E14. Psychosocial status of taxi drivers, police drivers and non-drivers (baseline of the longitudinal study). Data are given as frequency (n) and percentage (%)

Factors	Taxi drivers (n=144)	Police drivers (n=219)	Non-drivers (n=300)
	n (%)	n (%)	n (%)
Mental health status: have you			
(i) been a nervous person			
none of the time	91 (63)	131 (60)	161 (54)
a little of the time	26 (18)	62 (28)	94 (31)
some of the time	20 (14)	21 (18)	39 (13)
most of the time	4 (3)	4 (2)	5 (2)
all of the time	0 (0)	1 (0.5)	1 (0)
(ii) felt down that nothing could cheer you up			
none of the time	72 (50)	130 (59)	181 (60)
a little of the time	37 (26)	63 (29)	76 (25)
some of the time	28 (19)	25 (11)	40 (13)
most of the time	2 (1)	1 (0.5)	3 (1)
all of the time	1 (1)	0 (0)	0 (0)
(iii) felt calm and peaceful			
none of the time	8 (6)	8 (4)	6 (2)
a little of the time	15 (10)	23 (10)	53 (18)
some of the time	56 (39)	102 (47)	131 (44)
most of the time	52 (36)	82 (37)	106 (35)
all of the time	11 (8)	4 (2)	0 (0)
(iv) downhearted and low			
none of the time	41 (29)	80 (36)	93 (31)
a little of the time	60 (42)	100 (46)	137 (46)
some of the time	32 (22)	35 (16)	60 (20)
most of the time	6 (4)	3 (1)	10 (3)
all of the time	2 (1)	1 (0.5)	0 (0)
(v) been a happy person			
none of the time	3 (2)	1 (0.5)	2 (1)
a little of the time	16 (11)	9 (4)	15 (5)
some of the time	33 (23)	60 (27)	86 (29)
most of the time	75 (52)	132 (60)	186 (62)
all of the time	15 (10)	17 (8)	11 (4)

Table E14. (cont.) Psychosocial status of taxi drivers, police drivers and non-drivers (baseline of the longitudinal study). Data are given as frequency (n) and percentage (%)

Factors	Taxi drivers (n=144)	Police drivers (n=219)	Non-drivers (n=300)
	n (%)	n (%)	n (%)
Energy and vitality status: did you			
(i) feel full of life			
none of the time	14 (10)	9 (4)	15 (5)
a little of the time	29 (20)	24 (11)	39 (13)
some of the time	53 (37)	87 (40)	112 (37)
most of the time	40 (28)	93 (43)	130 (43)
all of the time	5 (4)	5 (2)	4 (1)
(ii) have a lot of energy			
none of the time	14 (10)	13 (6)	13 (4)
a little of the time	28 (19)	19 (9)	53 (18)
some of the time	49 (34)	98 (45)	126 (42)
most of the time	43 (30)	85 (39)	108 (36)
all of the time	7 (5)	3 (1)	0 (0)
(iii) fell worn out			
none of the time	17 (12)	25 (11)	37 (12)
a little of the time	50 (35)	96 (44)	124 (41)
some of the time	52 (36)	75 (34)	105 (35)
most of the time	17 (12)	22 (10)	30 (10)
all of the time	5 (4)	1 (0.5)	4 (1)
(iv) feel tired			
none of the time	10 (7)	9 (4)	4 (1)
a little of the time	35 (24)	58 (27)	87 (29)
some of the time	66 (46)	107 (49)	149 (50)
most of the time	25 (17)	34 (16)	50 (17)
all of the time	6 (4)	10 (5)	10 (3)

Table E14. (cont.) Psychosocial status of taxi drivers, police drivers and non-drivers (baseline of the longitudinal study). Data are given as frequency (n) and percentage (%)

Factors	Taxi drivers (n=144)	Police drivers (n=219)	Non-drivers (n=300)
	n (%)	n (%)	n (%)
Psychosomatic distress status			
(i) faintness or dizziness			
not at all	123 (85)	194 (89)	248 (83)
a little bit	11 (8)	19 (9)	36 (12)
moderately	1 (1)	3 (1)	11 (4)
quite a bit	3 (2)	2 (1)	1 (0)
extremely	0 (0)	0 (0)	1 (0)
(ii) pains in the heart or chest			
not at all	111 (77)	206 (94)	268 (89)
a little bit	17 (12)	9 (4)	19 (6)
moderately	6 (4)	3 (1)	4 (1)
quite a bit	5 (4)	1 (0.5)	4 (1)
extremely	1 (1)	0 (0)	2 (1)
(iii) nausea or upset stomach			
not at all	104 (72)	156 (71)	202 (67)
a little bit	15 (10)	40 (18)	62 (21)
moderately	16 (11)	14 (6)	15 (5)
quite a bit	4 (3)	9 (4)	16 (5)
extremely	3 (2)	0 (0)	3 (1)
(iv) trouble getting the breath			
not at all	101 (70)	200 (91)	261 (87)
a little bit	23 (16)	12 (6)	27 (9)
moderately	9 (6)	3 (1)	7 (2)
quite a bit	6 (4)	1 (1)	1 (0)
extremely	1 (1)	0 (0)	1 (0)
(v) numbness or tingling			
not at all	97 (67)	179 (82)	227 (76)
a little bit	29 (20)	23 (11)	44 (15)
moderately	7 (5)	11 (5)	16 (5)
quite a bit	8 (6)	4 (2)	10 (3)
extremely	0 (0)	0 (0)	1 (0)
(vi) feeling weak in the body			
not at all	75 (52)	149 (68)	205 (68)
a little bit	40 (28)	42 (19)	68 (23)
moderately	17 (12)	21 (10)	17 (6)
quite a bit	7 (5)	6 (3)	7 (2)
extremely	2 (1)	0 (0)	1 (0)

Table E15. Persistence group of taxi drivers in the follow-up of the longitudinal study. Standard multivariate logistic regression for the association between neck pain during the past 12 months and various individual and work-related risk factors in taxi drivers. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Factors	Taxi drivers (n=48)
	OR (95% CI)
Age (yr)	
≤36	1.00 (-)
37-46	0.18 (0.01-3.16)
>46	0.55 (0.04-8.49)
Smoking (n):	
non-smokers	1.00 (-)
ex-smokers/smokers	2.95 (0.59-14.68)
Trunk twisted	
not at all	1.00 (-)
yes	0.49 (0.11-2.08)
Previous job with:	
Physical demands	
no	1.00 (-)
yes	0.99 (0.20-4.88)
Psychosomatic distress status	
healthy	1.00 (-)
medium	2.78 (0.30-25.55)
poor	2.70 (0.47-15.52)

Table E16. Multivariate logistic regression of neck pain in the 12 months on alternative measures of daily and total cumulative vibration exposure to whole-body vibration in taxi drivers in the persistence group of the one-year follow-up period. Each measure of whole-body vibration exposure was included as a third based design variable, assuming the lowest quartile as the reference category. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Measures of WBV exposure	Taxi drivers (n=48)		
	T1	T2	T3
Daily driving time (h)			
OR	1.00	31.42	45.75
(95% CI)	(-)	1.21-814.40	2.18-959.21
$A_{dom}(8)$ (ms^{-2} r.m.s.)			
OR	1.00	34.89	44.73
(95% CI)	(-)	1.39-873.59	2.06-969.85
VDV_{dom} ($ms^{-1.75}$)			
OR	1.00	5.60	10.25
(95% CI)	(-)	0.57-55.14	1.10-95.44
Exposure duration (yr)			
OR	1.00	2.26	0.31
(95% CI)	(-)	0.35-14.79	0.04-2.40
$\sum[t_i]$ (h $\times 10^3$)			
OR	1.00	30.75	1.47
(95% CI)	(-)	1.39-682.56	0.13-16.62
$VDV_{Total\text{-}dom}$ ($ms^{-1.75}$)			
OR	1.00	6.84	1.23
(95% CI)	(-)	0.63-74.3	0.11-14.36

Odds ratio are adjusted for age, smoking, twisting, psychosomatic distress

Table E17. Incidence group of police drivers in the follow-up of the longitudinal study. Standard multivariate logistic regression for the association between neck pain during the past 12 months and various individual and work-related risk factors in police drivers. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Factors	Police drivers (n=146)
	OR (95% CI)
Age (yr)	
≤36	1.00 (-)
37-46	1.53 (0.56-4.17)
>46	2.10 (0.60-7.34)
Previous job with:	
Sitting	
no	1.00 (-)
yes	1.53 (0.59-3.93)
Psychosomatic distress status	
healthy	1.00 (-)
medium	2.35 (0.79-6.98)
poor	2.87 (0.92-8.95)

Table E18. Multivariate logistic regression of neck pain in the 12 months on alternative measures of daily and total cumulative vibration exposure to whole-body vibration in police drivers in the incidence group of the one-year follow-up period. Each measure of whole-body vibration exposure was included as a third based design variable, assuming the lowest quartile as the reference category. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Measures of WBV exposure	Police drivers (n=146)		
	T1	T2	T3
Daily driving time (h)			
OR	1.00	2.51	1.90
(95% CI)	(-)	0.55-11.49	0.53-6.87
$A_{dom}(8)$ (ms^{-2} r.m.s.)			
OR	1.00	2.12	1.72
(95% CI)	(-)	0.47-9.65	0.47-6.25
VDV_{dom} ($ms^{-1.75}$)			
OR	1.00	2.17	1.75
(95% CI)	(-)	0.47-9.93	0.48-6.34
Exposure duration (yr)			
OR	1.00	2.23	3.96
(95% CI)	(-)	0.53-9.29	0.85-18.38
$\sum[t_i]$ ($h \times 10^3$)			
OR	1.00	9.38	8.66
(95% CI)	(-)	0.79-110.88	1.00-74.99
$VDV_{Total\text{-}dom}$ ($ms^{-1.75}$)			
OR	1.00	9.73	7.23
(95% CI)	(-)	0.85-94.23	0.80-65.72

Odds ratio are adjusted for age, previous job with sitting, psychosomatic distress

Table E19. Persistence group of police drivers in the follow-up of the longitudinal study. Standard multivariate logistic regression for the association between neck pain during the past 12 months and various individual and work-related risk factors in police drivers. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Factors	Police drivers (n=71)
	OR (95% CI)
Age (years)	
≤36	1.00 (-)
37-46	1.18 (0.37-3.76)
>46	4.56 (0.86-24.31)
Previous job with:	
Sitting	
no	1.00 (-)
yes	1.00 (0.33-3.01)
Psychosomatic distress status	
healthy	1.00 (-)
medium	0.94 (0.26-3.35)
poor	1.79 (0.49-6.49)

Table E20. Multivariate logistic regression of neck pain in the 12 months on alternative measures of daily and total cumulative vibration exposure to whole-body vibration in police drivers in the persistence group of the one-year follow-up period. Each measure of whole-body vibration exposure was included as a third based design variable, assuming the lowest quartile as the reference category. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Measures of WBV exposure	Police drivers (n=71)		
	T1	T2	T3
Daily driving time (h)			
OR	1.00	4.87	1.08
(95% CI)	(-)	0.46-51.47	0.24-4.99
$A_{dom}(8)$ (ms^{-2} r.m.s.)			
OR	1.00	0.71	0.80
(95% CI)	(-)	0.11-4.68	0.13-4.8
VDV_{dom} ($ms^{-1.75}$)			
OR	1.00	0.71	0.80
(95% CI)	(-)	0.11-4.68	0.13-4.8
Exposure duration (yr)			
OR	1.00	1.99	3.51
(95% CI)	(-)	0.45-8.87	0.80-15.46
$\sum[t_i]$ (h $\times 10^3$)			
OR	1.00	n.a.	1.82
(95% CI)	(-)		0.45-7.38
$VDV_{Total\text{-}dom}$ ($ms^{-1.75}$)			
OR	1.00	2.98	2.91
(95% CI)	(-)	0.43-20.92	0.59-14.29

Odds ratio adjusted for age, previous job with sitting, psychosomatic distress

Table E21. Incidence group of police non-drivers in the follow-up of the longitudinal study. Standard multivariate logistic regression for the association between neck pain during past 12 months and various individual and work-related risk factors in police non-drivers. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Factors	Police non-drivers (n=191)
	OR (95% CI)
Age (yr)	
≤36	1.00 (-)
37-46	2.02 (0.65-6.26)
>46	1.66 (0.52-5.25)
Duration of work ≥ 40hrs/week	
no	1.00 (-)
yes	0.76 (0.29-1.97)
Previous job with: Physical demands	
no	1.00 (-)
yes	0.41 (0.11-1.47)
Psychosomatic distress status	
healthy	1.00 (-)
medium	2.27 (0.78-6.64)
poor	3.05 (0.88-10.49)

Table E22. Persistence group of police non-drivers in the follow-up of the longitudinal study. Standard multivariate logistic regression for the association between neck pain during past 12 months and various individual and work-related risk factors in police non-drivers. In the table are presented adjusted odds ratios (OR) and 95% confidence intervals (95% CI)

Factors	Police non-drivers (n=109)
	OR (95% CI)
Age (yr)	
≤36	1.00 (-)
37-46	1.51 (0.51-4.44)
>46	1.24 (0.45-3.39)
Duration of work ≥ 40hrs/week	
no	1.00 (-)
yes	1.81 (0.66-4.98)
Previous job with: Physical demands	
no	1.00 (-)
yes	1.2 (0.49-2.96)
Psychosomatic distress status	
healthy	1.00 (-)
medium	1.62 (0.54-4.87)
poor	4.78 (1.60-14.26)