Table 1. Characteristics of 655 men and 704 women from the MRC National Survey of Health and Development with at least one bone measure and information on age at menarche or pubertal stage.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Men | | Women | |
|  | No. | Mean (SD) | No. | Mean (SD) |
| **pQCT measures** |  |  |  |  |
| **pQCT-cortical sites** |  |  |  |  |
| *50% radius* |  |  |  |  |
| Diaphysis CSA (mm2) | 547 | 155 (23) | 571 | 113 (16) |
| Medullary CSA (mm2) | 546 | 43 (14) | 569 | 35 (12) |
| Polar stress strain index (mm3) | 543 | 348 (70) | 572 | 211 (43) |
| **pQCT- trabecular sites** |  |  |  |  |
| *Distal radius (4%)* |  |  |  |  |
| Distal CSA (mm2) | 547 | 171 (34) | 566 | 133 (24) |
| **pQCT- 50% radius** |  |  |  |  |
| Cortical vBMD (mg/cm3) | 547 | 1159 (35) | 572 | 1148.2 (39) |
| **pQCT- distal radius (4%)** |  |  |  |  |
| Trabecular vBMD (mg/cm3) | 546 | 205 (41) | 565 | 173 (42) |
| Total density vBMD (mg/cm3) | 547 | 391 (67) | 566 | 332 (71) |
| **DXA measures** |  |  |  |  |
| **DXA aBMD** (g/cm2) |  |  |  |  |
| Spine L1-L4 aBMD | 652 | 1.05 (0.18) | 699 | 0.95 (0.16) |
| Total Hip aBMD | 645 | 1.00 (0.14) | 695 | 0.87 (0.13) |
| **Current body size** |  |  |  |  |
| Height (m) at 60-64y | 655 | 1.75 (0.06) | 704 | 1.62 (0.06) |
| Weight (kg) at 60-64y | 655 | 85 (13.1) | 704 | 72 (14.2) |
| **Pubertal timing indicators** |  |  |  |  |
| Age at menarche (SD) | n/a |  | 704 | 13y 0 mth (1yr 2 mth) |
|  |  | % | % | % |
| Age at menarche | n/a |  |  |  |
| 9-10 |  |  | 24 | 3.4 |
| 11 |  |  | 91 | 12.9 |
| 12 |  |  | 214 | 30.4 |
| 13 |  |  | 243 | 34.5 |
| 14 |  |  | 98 | 13.9 |
| 15-19 |  |  | 34 | 4.8 |
| Total (=100%) |  |  | 704 |  |
| Pubertal stage (14.5 year) |  |  |  |  |
| Fully mature | 168 | 25.6 |  |  |
| Advanced | 200 | 30.5 |  |  |
| Early | 222 | 33.9 |  |  |
| Pre-adolescent | 65 | 9.9 |  |  |
| Total (=100%) | 655 |  |  |  |
| Development of genitalia |  |  |  |  |
| Advanced or complete | 368 | 56.2 |  |  |
| Early | 263 | 40.1 |  |  |
| Pre-adolescent | 24 | 3.7 |  |  |
| Total (=100%) | 655 |  |  |  |
| Broken voice |  |  |  |  |
| Completely broken | 245 | 37.6 |  |  |
| Starting to break | 235 | 36.0 |  |  |
| Not yet broken | 172 | 26.4 |  |  |
| Total (=100%) | 652 |  |  |  |
| Pubic Hair |  |  |  |  |
| Profuse | 313 | 47.9 |  |  |
| Sparse | 263 | 40.3 |  |  |
| None | 77 | 11.8 |  |  |
| Total (=100%) | 653 |  |  |  |
| Axillary hair |  |  |  |  |
| Yes | 368 | 56.5 |  |  |
| No | 283 | 43.5 |  |  |
| Total (=100%) | 651 |  |  |  |
| **Covariables** |  |  |  |  |
| Smoking |  |  |  |  |
| No | 584 | 89.9 | 626 | 89.4 |
| Yes | 66 | 10.1 | 74 | 10.6 |
| Total (=100%) | 650 |  | 700 |  |
| Own adult social class |  |  |  |  |
| Non-manual | 473 | 72.2 | 562 | 79.8 |
| Manual | 182 | 27.8 | 142 | 20.2 |
| Total (=100%) | 655 |  | 704 |  |
| Age at period cessation (years) |  |  |  |  |
| 27-39 |  |  | 40 | 7.0 |
| 40-44 |  |  | 57 | 9.9 |
| 45-49 |  |  | 131 | 22.9 |
| 50-52 |  |  | 159 | 27.7 |
| 53-55 |  |  | 126 | 22.0 |
| 56-62 |  |  | 60 | 10.5 |
| Total (=100%) |  |  | 573 |  |

Table 2a. Mean and standard deviation (SD) for pQCT-derived outcomes at 60-64 years by age at menarche. WOMEN

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Age at menarche | | | | | | | |
|  |  | 9-10 | 11 | 12 | 13 | 14 | 15-19 | Total  sample | p-value\* |
|  | No. | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) |  |
| pQCT |  |  |  |  |  |  |  |  |  |
| Distal CSA mm2 (4%) | 566 | 132 (23) | 132 (24) | 130 (24) | 134 (25) | 136 (24) | 129 (24) | 133 (24) | .3 |
| Diaphysis CSA  Mm2 (50%) | 571 | 111 (12) | 113 (17) | 115 (17) | 111 (16) | 112 (14) | 112 (18) | 113 (16) | .3 |
| Medullary CSA  Mm2 (50%) | 570 | 31 (9) | 34 (13) | 37 (13) | 36 (12) | 35 (12) | 35 (13) | 35 (12) | .7 |
| Polar SSI  mm3 (50%) | 572 | 212 (34) | 217 (45) | 214 (45) | 207 (42) | 208 (39) | 211 (39) | 211 (43) | .1 |
| Total vBMD  mg/cm3 (4%) | 566 | 351 (82) | 339 (69) | 340 (74) | 322 (70) | 318 (64) | 337 (69) | 332 (71) | .01 |
| Trabecular vBMD mg/cm3 (4%) | 565 | 178 (40) | 177 (41) | 179 (46) | 169 (41) | 168 (35) | 158 (40) | 173 (42) | .004 |
| Cortical vBMD  mg/cm3 (50%) | 572 | 1157 (33) | 1146 (44) | 1146 (40) | 1149 (40) | 1152 (33) | 1151 (40) | 1148 (39) | .5 |
| DXA |  |  |  |  |  |  |  |  |  |
| Lumbar spine aBMD  g/cm2 | 699 | 0.98 (0.14) | 0.98 (0.18) | 0.95 (0.16) | 0.95 (0.16) | 0.92 (0.15) | 0.91 (0.16) | 0.95 (0.16) | .006 |
| Total hip aBMD  g/cm2 | 695 | 0.90 (0.14) | 0.90 (0.13) | 0.87 (0.12) | 0.86 (0.13) | 0.85 (0.12) | 0.84 (0.12) | 0.87 (0.13) | .001 |
|  |  |  |  |  |  |  |  |  |  |

\*p-values from regression models with logged bone outcomes and including age at menarche in months since birth as a continuous variableTable 2b. Mean and standard deviation (SD) for pQCT-derived and DXA-derived outcomes at 60-64 years by pubertal stage at 14.5 years. MEN

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Pubertal stage | | | |  |  |
|  |  | Fully mature | Advanced | Early | Pre-adolescent | Total  sample | p-value |
|  | No. | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) |  |
| pQCT |  |  |  |  |  |  |  |
| Distal CSA mm2 (4%) | 547 | 172 (38) | 174 (31) | 170 (33) | 167 (32) | 171 (34) | .3 |
| Diaphysis CSA  Mm2 (50%) | 547 | 159 (25) | 155 (21) | 152 (22) | 153 (22) | 154 (23) | .01 |
| Medullary CSA  Mm2 (50%) | 546 | 45 (16) | 44 (14) | 41 (12) | 41 (14) | 43 (14) | .02 |
| Polar SSI  mm3 (50%) | 543 | 358 (77) | 349 (64) | 342 (72) | 340 (61) | 348 (70) | .03 |
| Total vBMD  mg/cm3 (4%) | 547 | 403 (71) | 384 (67) | 388 (64) | 397 (71) | 391 (67) | .3 |
| Trabecular vBMD mg/cm3 (4%) | 546 | 216 (43) | 205 (41) | 201 (40) | 197 (41) | 205 (41) | <.001 |
| Cortical vBMD  mg/cm3 (50%) | 547 | 1153 (37) | 1159 (35) | 1161 (33) | 1162 (31) | 1159 (35) | .03 |
| DXA |  |  |  |  |  |  |  |
| Lumbar spine aBMD  g/cm2 | 652 | 1.08 (0.18) | 1.04 (0.19) | 1.05 (0.17) | 1.01 (0.15) | 1.05 (0.18) | .02 |
| Total hip aBMD  g/cm2 | 645 | 1.02 (0.14) | 1.00 (0.16) | 0.99 (0.14) | 0.97 (0.15) | 1.00 (0.14) | .01 |

\*p-values from regression models with logged bone outcomes and including pubertal stage as a continuous variable

Table 3a. Percentage difference in DXA-derived and pQCT-derived outcomes for a five-year difference in age at menarche , additionally adjusted for current height and weight, smoking and adult social class. WOMEN

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Unadjusted | | | Adjusted for height & weight | | | Additionally adjusted for smoking and adult social class | | |
|  | No. | % diff | 95% CI | p-value | % diff | 95% CI | p-value | % diff | 95% CI | p-value |
| **pQCT measures** |  |  |  |  |  |  |  |  |  |  |
| **pQCT-cortical sites** |  |  |  |  |  |  |  |  |  |  |
| *50% radius* |  |  |  |  |  |  |  |  |  |  |
| Diaphysis CSA (mm2) | 567 | -2.5 | -7.1 to 2.12 | .3 | -3.3 | -7.5 to 1.0 | .1 | -3.3 | -7.6 to 0.9 | .1 |
| Medullary CSA (mm2) | 565 | 0.8 | -10.4 to 12 | .9 | -2.2 | -13.4 to 8.9 | .7 | -2.5 | -13.7 to 8.7 | .7 |
| Polar stress strain index (mm3) | 568 | -4.1 | -10.6 to 2.5 | .2 | -4.9 | -11.1 to 1.2 | .1 | -4.9 | -11.1 to1.3 | .1 |
| **pQCT- trabecular sites** |  |  |  |  |  |  |  |  |  |  |
| *Distal radius (4%)* |  |  |  |  |  |  |  |  |  |  |
| Distal CSA (mm2) | 562 | 3.6 | -2.7 to 9.9 | .3 | 2.0 | -4.1 to 8.0 | .5 | 2.1 | -3.9 to 8.2 | .5 |
| **pQCT- 50% radius** |  |  |  |  |  |  |  |  |  |  |
| Cortical vBMD (mg/cm3) | 568 | 0.2 | -0.9 to 1.4 | .7 | 0.4 | -0.8 to 1.5 | .5 | 0.4 | -0.7 to 1.6 | .5 |
| **pQCT- distal radius (4%)** |  |  |  |  |  |  |  |  |  |  |
| Trabecular vBMD (mg/cm3) | 561 | -11 | -19.3 to -2.5 | .01 | -8.0 | -16.6 to 0.5 | .07 | -8.1 | -16.7 to 0.5 | .07 |
| Total density vBMD (mg/cm3) | 562 | -8 | -15.1 to -0.9 | .03 | -5.5 | -12.7 to 1.7 | .1 | -5.7 | -12.9 to 1.5 | .1 |
| **DXA measures** |  |  |  |  |  |  |  |  |  |  |
| **DXA aBMD** (g/cm2) |  |  |  |  |  |  |  |  |  |  |
| Spine L1-L4 aBMD | 695 | -7.2 | -12.4 to -2.1 | .006 | -4.8 | -9.9 to 0.3 | .06 | -4.8 | -9.9 to 0.3 | .06 |
| Total Hip aBMD | 691 | -8.2 | -12.6 to -3.8 | <.001 | -4.3 | -8.3 to -0.3 | .04 | -4.2 | -8.1 to-0.1 | .04 |

Table 3b. Percentage difference in DXA-derived and pQCT-derived outcomes comparing pre-adolescent with fully mature males at 14.5 years, additionally adjusted for current height and weight, smoking and adult social class. MEN

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Unadjusted | | | Adjusted for height & weight | | | Additionally adjusted for smoking and adult social class | | |
|  | No. | % diff | 95% CI | p-value | % diff | 95% CI | p-value | % diff | 95% CI | p-value |
| **pQCT measures** |  |  |  |  |  |  |  |  |  |  |
| **pQCT-cortical sites** |  |  |  |  |  |  |  |  |  |  |
| *50% radius* |  |  |  |  |  |  |  |  |  |  |
| Diaphysis CSA (mm2) | 542 | -5.0 | -8.7 to -1.2 | .009 | -3.8 | -7.1 to -0.4 | .03 | -3.8 | -7.1 to -0.5 | .03 |
| Medullary CSA (mm2) | 541 | -9.9 | -18.6 to -1.3 | .02 | -8.4 | -16.8 to -0.02 | .05 | -8.5 | -16.9 to -0.2 | .046 |
| Polar stress strain index (mm3) | 538 | -6.1 | -11.4 to -0.8 | .02 | -4.3 | -9.0 to 0.5 | .08 | -4.4 | -9.0 to 0.3 | .07 |
| **pQCT- trabecular sites** |  |  |  |  |  |  |  |  |  |  |
| *Distal radius (4%)* |  |  |  |  |  |  |  |  |  |  |
| Distal CSA (mm2) | 542 | -2.7 | -8.1 to 2.7 | .3 | -1.8 | -7.1 to 3.5 | .5 | -1.7 | -6.9 to 3.6 | .5 |
| **pQCT- 50% radius** |  |  |  |  |  |  |  |  |  |  |
| Cortical vBMD (mg/cm3) | 542 | 0.9 | 0.1 to 1.7 | .02 | 0.8 | 0.1 to 1.6 | .04 | 0.8 | 0.02 to 1.6 | .04 |
| **pQCT- distal radius (4%)** |  |  |  |  |  |  |  |  |  |  |
| Trabecular vBMD (mg/cm3) | 541 | -9.2 | -14.7 to -3.8 | .001 | -8.9 | -14.4 to -3.5 | .001 | -9.2 | -14.6 to-3.7 | .001 |
| Total density vBMD (mg/cm3) | 542 | -1.5 | -6.0 to 3.1 | .5 | -1.3 | -5.9 to 3.2 | .6 | -1.6 | -6.1 to 3.0 | .5 |
| **DXA measures** |  |  |  |  |  |  |  |  |  |  |
| **DXA aBMD** (g/cm2) |  |  |  |  |  |  |  |  |  |  |
| Spine L1-L4 aBMD | 647 | -4.5 | -8.5 to -0.4 | .03 | -2.7 | -6.4 to 1.1 | .2 | -2.6 | -6.4 to 1.2 | .2 |
| Total Hip aBMD | 640 | -4.5 | -8.0 to -1.0 | .01 | -2.5 | -5.6 to 0.7 | .1 | -2.6 | -5.7 to 0.5 | .1 |

Table 4 . Percentage difference in DXA-derived and pQCT-derived outcomes for a five-year difference in height tempo

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Women | | | | | | Men | | | | | |
|  | Height tempo | | | | | | Height tempo | | | | | |
|  | Unadjusted | | | Adjusted for height & weight | | | Unadjusted | | | Adjusted for height & weight | | |
|  | % diff | 95% CI | p-value | % diff | 95% CI | p-value | % diff | 95% CI | p-value | % diff | 95% CI | p-value |
| **pQCT measures** |  |  |  |  |  |  |  |  |  |  |  |  |
| **pQCT-cortical sites** |  |  |  |  |  |  |  |  |  |  |  |  |
| *50% radius* |  |  |  |  |  |  |  |  |  |  |  |  |
| Diaphysis CSA (mm2) | -4.9 | -10.6 to 0.7 | .09 | -6.9 | -12 to -1.8 | .009 | -6.9 | -13.5 to -0.3 | .04 | -8.8 | -14.8 to -2.8 | .004 |
| Medullary CSA (mm2) | -1.7 | -15.9 to 12.5 | .8 | -6.4 | -20.5 to 7.7 | .4 | -16.5 | -31.8 to -1.2 | .04 | -19.3 | -34.2 to -4.4 | .01 |
| Polar stress strain index (mm3) | -7.5 | -15.6 to 0.7 | .07 | -9.8 | -17.3 to -2.3 | .01 | -8.3 | -17.5 to 1 | .08 | -10.9 | -19.3 to -2.4 | .01 |
| **pQCT- trabecular sites** |  |  |  |  |  |  |  |  |  |  |  |  |
| *Distal radius (4%)* |  |  |  |  |  |  |  |  |  |  |  |  |
| Distal CSA (mm2) | 1.6 | -6 to 9.2 | .7 | -1.7 | -8.9 to 5.5 | .7 | 3.2 | -6.5 to 12.9 | .5 | 1.9 | -7.6 to 11.4 | .7 |
| **pQCT- 50% radius** |  |  |  |  |  |  |  |  |  |  |  |  |
| Cortical vBMD (mg/cm3) | -0.6 | -2 to 0.8 | .4 | -0.5 | -1.9 to 0.9 | 0.5 | 0.7 | -0.7 to 2.1 | .3 | 0.6 | -0.8 to 2 | .4 |
| **pQCT- distal radius (4%)** |  |  |  |  |  |  |  |  |  |  |  |  |
| Trabecular vBMD (mg/cm3) | -22.2 | -32.7 to -11.8 | <.001 | -18.4 | -28.9 to -7.9 | .001 | -21.4 | -31.2 to 11.6 | <.001 | -20.6 | -30.4 to -10.8 | <.001 |
| Total density vBMD (mg/cm3) | -11.0 | -19.7 to -2.4 | .01 | -7.5 | -16.2 to 1.1 | .09 | -9.6 | -17.5 to -1.7 | .02 | -9.2 | -17.1 to -1.2 | .02 |
| **DXA measures** |  |  |  |  |  |  |  |  |  |  |  |  |
| **DXA aBMD** (g/cm2) |  |  |  |  |  |  |  |  |  |  |  |  |
| Spine L1-L4 aBMD | -13.9 | -20.4 to -7.5 | <.001 | -11.8 | -18 to -5.5 | <.001 | -9.7 | -16.9 to -2.4 | .009 | -9.7 | -16.6 to -2.9 | .006 |
| Total Hip aBMD | -9.9 | -15.5 to -4.2 | .001 | -5.9 | -10.9 to -0.9 | 0.02 | -7.0 | -13.2 to -0.9 | .03 | -6.4 | -11.9 to -0.8 | .02 |