Age-related changes in bone tissue in men

Abstract. The purpose of the study was to establish age-related changes of male bone tissue. Materials and methods. The study was conducted by the Department of Clinical Physiology and Pathology of the Musculoskeletal System of the State Institution “D.F. Chebotarev Institute of Gerontology by the National Academy of Medical Sciences of Ukraine”. It involved 342 healthy men aged 20 to 89 years without osteoporosis and osteoporotic fractures or any pathology with a confirmed impact on bone tissue, as well as any somatic pathology in the sub- and decompensation. The following methods of examination were used: questionnaire, anthropometric measurements, clinical and instrumental examination. Bone mineral density (BMD) was measured by the dual-energy X-ray absorptiometry machine “Prodigy, GEHC Lunar” at the level of the entire skeleton, lumbar spine (L1-L4), proximal femur and femoral neck, distal and ultra-distal forearm bones. Results. We have detected a significant 14.8 % decrease of BMD at the level of femoral neck in the group of men aged 60–69 years, by 20 % in the group of men aged 70–79 years, and by 24.1 % in the group of men aged 80–89 years compared to the men aged 20–29 years; at the same time, at the lumbar spine there was registered a decrease of this parameter by 1.6 % in men aged 60–69 years, by 1.9 % in men of 70–79 years and by 0.8 % in men of 80–89 years, respectively. Among the examined practically healthy men, the bone tissue remained at the normal level relative to age in 67.8 %; osteopenia was detected in 27.8 %, and osteoporosis in 4.4 %. Conclusions. An age-associated BMD reduction was registered at various skeletal sites in the practically healthy men without any clinically significant factors affecting bone tissue metabolism. The most pronounced BMD loss was observed at the level of femoral neck. At the same time, 4.4 % of examined had osteoporosis without any clinical signs.

Keywords: age; bone mineral density; osteoporosis; men

Introduction

The bone ageing is a natural physiological process. The bone tissue is subject to life-long modifications due to the constant resorption and formation [1]. With ageing, the cycles and phasing of bone remodeling undergoes changes due to the accelerated resorption rates resulting in a bone loss and structural changes.

The adult skeleton is 80 % compact (cortical) and 20 % spongy (trabecular) bone. The ratio of trabecular-to-compact varies depending on the skeletal site. The long bones have a thicker cortical layer and a relatively smaller share of trabecular substance. Furthermore, the vertebral trabecular bone has a complex 3-dimensional microstructure with an irregular morphology: central and anterior-posterior vertebral site has a smaller volume of bone component than the respective posterior site [2]. The difference between these two bone types consists in its porosity: cortical bone has a porosity of 5 to 15 %, while trabecular bone has the one of 40 to 95 % [3].

The cortical bone is relatively solid and compact; it has a predominantly structural and protective role. The trabecular bone is less calcinated; it has a higher ratio of surface area-to-volume, enabling its metabolic activity, however, with ageing it may be changed due to the bone loss and increased bone porosity. A significant growth of trabecular bone in the vertebral bodies and long bone epiphyses occurs in the period between the 3rd and 4th Tanner stages of Sexual Maturity Rating (SMR). The trabecular bone is metabolically active; however, with ageing the trabecular density decreases due to the loss of bone trabeculae.

The bone modeling process starts with an intrauterine development and lasts until the closure of epiphyseal growth zone [4], which occurs as a rule by the end of the second life decade [5]. The normal peak bone mass formation is determined by the genetic, hormonal, behavioral factors (including the nutritional status and sleeping habits), mechanical load due to the physical activity, overall health and environmental influence [6, 7].

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At the older age, the bone mass rate is determined by
two key factors: the top bone mass being reached during the
skeletal formation (peak bone mass) and the rate of further
bone loss.

There are three main ageing processes leading to the re-
duced bone loss. The first one, being the most important,
is the trabecular bone loss resulting in the bone trabeculae
thinning and their microstructure deteriorating [8]. The
lifelong trabecular bone loss amounts to a half of peak bone
mass at the spine level and to a quarter of peak bone mass
at the hip level [9]. All in all, the second process resulting in
a reduced bone mass is a diminishing cortical bone mass
provides an increased porosity both via resorption cavity
growth and ageing-compromised osteon accumulation. The
third process is an accelerated resorption of the endocortical
bone surface.

The reference analysis demonstrates the age-related
changes of bone tissue in men. It leads to its strength deteri-
roration and osteoporotic fracture risk increase. At present,
the reference sources cite various factors and mechanisms
of age-related changes of bone tissue: from the genetic to
behavioral ones, the latter associated with lifestyle aspects
[6, 7]. Furthermore, there are unexplored facts of the age-
associated bone mineral density changes: age of initiation,
rates and localization of bone loss, as well as the factors pro-
moting the age-associated bone changes.

The purpose of this study is to determine the age-associ-
ated bone changes in men.

Materials and methods

The study was held at the Department of Clinical Physi-
ology and Pathology of Locomotor Apparatus of the State
Institution "Dmitry F. Chebotarev Institute of Gerontology
of the National Academy of Medical Sciences of Ukraine".
The study involved 342 practically healthy men aged from
20 to 89 years (mean age – 53.54 ± 16.65 years, mean height
– 175.97 ± 7.19 cm, mean body weight – 85.48 ± 13.64 kg,
mean body mass index (BMI) - 27.59 ± 4.01 kg/m²) with
no osteoporosis or osteoporotic fractures, no pathology
with a confirmed effect on the bone tissue: rheumatologic
conditions, hereditary connective tissue conditions, en-
docrine conditions, oncological conditions, inflammatory
intestinal conditions, a history of bariatric surgeries, HIV/
AIDS, alcohol addiction, chronic obstructive pulmonary
disease (COPD), renal insufficiency, glucocorticoid use
and a somatic pathology at the sub- or decompensated
stage. The study was approved by the Ethics Committee
of the SI "Dmitry F. Chebotarev Institute of Gerontology
of the National Academy of Medical Sciences of Ukraine" (as
of 01.07.2014, protocol №58). The examined male sub-
jects were subdivided into various age groups: 20-29, 30-39,
40-49, 50-59, 60-69, 70-79 and 80-89 years. The anthro-
pomeric characteristics of the examined male subjects are
presented in Table 1.

The following accepted examination tools were used:
questionnaires, clinical and anthropometric trials, dual-energy
x-ray absorptiometry (DXA). The clinical trial was held by
ruling out the diseases and conditions, which have a con-
firmed effect on the bone tissue. The bone mineral density
(BMD) was measured at the level of total skeleton, lumbar
spine (L₁-L₄), proximal and femoral spine, distal and ultra-
distal forearm by DXA («Prodigy, GEНС Lunar» machine,
Madison, USA, 2005).

For men of 50 years and older, the BMD measurement
was performed in line with the WHO criteria, determining
the T-score at the lumbar spine, proximal femur and femo-
ral neck (the lowest index). The T-score values under -2.5
SD correspond with osteoporosis, the T-score values within
-2.5 SD and < -1 SD correspond with the low BMD (os-
teopenia), the T-score values over -1 SD correspond with
the normal BMD. For men under 50 years, the BMD is
measured by Z-score at the lumbar spine, proximal femur
and femoral neck (the lowest index) in line with the Interna-
tional Society of Clinical Densitometry recommendations.
The Z-score of > -2 SD corresponds with the BMD within
the reference values for a certain age, the Z-score of < -2 SD
corresponds with the low BMD (under the reference values
for a certain age) [10, 11].

The statistical analysis was performed by means of Sta-
istica 10 (Serial Number: STA999K347150-W) and MED-
CALC® (open access online resource: https://www.medcalc.
org/calc). The difference of group values was determined
by means of a one-way ANOVA analysis of variance, Stu-
dent’s t-test for the independent samples, Mann–Whitney
U test. The difference of sample distribution was evaluated
by means of χ² test. The findings are presented as mean val-
ues and their standard deviation (M±SD). The differences
between indices were considered significant whenever p <
0.05.

| Table 1. Anthropometric characteristics of the examined male subjects depending on their ages |
|---|---|---|---|---|
| indices | Age groups | Age, years | Height, cm | Body weight, kg | BMI, kg/m² |
| 20–29 (n = 37) | 25.6 ± 2.5 | 180.2 ± 6.0 | 82.0 ± 12.9 | 25.2 ± 3.2 |
| 30–39 (n = 37) | 34.9 ± 2.7 | 180.4 ± 6.4 | 86.2 ± 10.8 | 26.5 ± 2.9 |
| 40–49 (n = 54) | 44.3 ± 2.8 | 178.8 ± 6.4 | 87.7 ± 15.4 | 27.4 ± 4.3 |
| 50–59 (n = 62) | 54.5 ± 2.9 | 175.7 ± 6.3 | 87.9 ± 13.5 | 28.5 ± 4.5* |
| 60–69 (n = 59) | 64.8 ± 3.1 | 173.5 ± 6.5* | 87.6 ± 13.8 | 29.0 ± 3.9* |
| 70–79 (n = 53) | 73.7 ± 2.7 | 171.4 ± 6.2* | 81.7 ± 12.2 | 27.8 ± 3.5 |
| 80–89 (n = 40) | 83.8 ± 2.3 | 170.3 ± 7.6* | 76.8 ± 12.6 | 26.4 ± 3.1 |

Notes (tables 1-6): results presented as M ± SD; * – significant differences in comparison with a group of subjects aged 20-29 years (p < 0.05).

Results

The greatest BMD values at the hip level were revealed in the age group of 20-29 year-old practically healthy men: 1.145 ± 0.110 g/cm². The age-dependent analysis of the femoral BMD found a significant decrease of this parameter in the age group of 40-49 years compared to the group of 20-29 years (p < 0.001); in the age group of 50-59 years compared to the group of 20-29 years (p < 0.001) and 30-39 years (p = 0.01); in the age group of 60-69 years compared to the group of 20-29 years (p < 0.001) and 30-39 years (p = 0.04); in the age group of 70-79 years compared to the group of 20-29 years, 30-39 years (p < 0.001 for both groups) and 40-49 years (p = 0.02).

The lowest BMD values at the femoral neck level were registered in the age group of 80-89 years – 0.869 ± 0.134 g/cm² compared to the group of 20-29 years (p < 0.001), 30-39 years (p < 0.001) and 40-49 years (p = 0.01) (Table 2).

Both at the level of femoral neck and at the level of proximal femur, the greatest BMD values were registered in the age group of 20-29 years. The significant BMD decrease at the proximal femur level was registered in the male age group of 70-79 years – 1.030 ± 0.156 g/cm² compared to the age group of 20-29 years (p = 0.005) and of 80-89 years – 0.979 ± 0.173 g/cm² compared to the age group of 20-29 years (p = 0.004) and 30-39 years (p = 0.03) (Table 3).

The greatest BMD values at the total skeletal level were revealed in the age group of 30-39 year-old practically healthy men. The significant decrease of BMD values were found only in the age group of 80-89 years in comparison to the age group of 20-29 years (p = 0.05) and 30-39 years (p = 0.008); the difference being 8.7 % and 10.0 % respectively (Table 4).

The practically healthy men who were examined revealed no significant age-associated BMD differences at the lumbar spine level (Table 5). However, at the distal forearm level there were significantly higher BMD values registered in the age group of 40-49 years – 0.916 ± 0.137 g/cm² (p = 0.02), age group of 50-59 years – 0.919 ± 0.118 g/cm² (p = 0.02), and age group of 60-69 years – 0.952 ± 0.115 g/cm² (p = 0.02) in comparison to the age group of 20-29 years (Table 6).

The age-related bone changes were revealed at various skeletal sites in the group of examined men. The greatest BMD decrease was observed at the femoral neck level: in the age group of 40-49 years it was by 11.8 %, in the age group of 50-59 years it was by 13.8 %, in the age group of 60-69 years it was by 14.8 %, in the age group of 70-79 years it was by 20.0 %, and in the age group of 80-89 years it was by 24.1 %, in comparison with the group of 20-29-year-old men. At the proximal femur level, the greatest BMD decrease amounted to 11.2 % in the age group of 70-79 years and to 15.6 % in the age group of 80-89 years, in comparison with the group of 20-29-year-old men. However, at the lumbar spine the BMD decrease was 1.6 %, 1.9 % and 0.8 % in the age groups of 60-69 years, 70-79 years and 80-89 years respectively, which may be associated with the age-related growth of spinal degenerative-dystrophic changes. The significant decrease of total skeleton BMD was registered only in the age group of 80-89 years; it amounted to 8.7 % in comparison with the age group of 20-29 years and to 10.0 % in comparison with the age group of 30-39 years.

Among the practically healthy men who were examined, the bone tissue was within the age normal bounds in 67.8 %; osteopenia was registered in 27.8 %, osteoporosis diagnosed

### Table 2. Femoral neck bone mineral density of the examined men depending on their ages

<table>
<thead>
<tr>
<th>Age groups, years</th>
<th>BMD, g/cm²</th>
<th>T-score, SD</th>
<th>Z-score, SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–29</td>
<td>1.145 ± 0.110</td>
<td>0.6 ± 0.8</td>
<td>0.4 ± 0.8</td>
</tr>
<tr>
<td>30–39</td>
<td>1.095 ± 0.108</td>
<td>0.2 ± 0.8</td>
<td>0.2 ± 0.8</td>
</tr>
<tr>
<td>40–49</td>
<td>1.010 ± 0.128*</td>
<td>-0.4 ± 0.9</td>
<td>-0.2 ± 0.9</td>
</tr>
<tr>
<td>50–59</td>
<td>0.987 ± 0.133*</td>
<td>-0.6 ± 1.0</td>
<td>-0.1 ± 1.0</td>
</tr>
<tr>
<td>60–69</td>
<td>0.976 ± 0.132*</td>
<td>-0.7 ± 1.0</td>
<td>0.2 ± 0.9</td>
</tr>
<tr>
<td>70–79</td>
<td>0.916 ± 0.140*</td>
<td>-1.2 ± 1.1</td>
<td>0.1 ± 1.0</td>
</tr>
<tr>
<td>80–89</td>
<td>0.869 ± 0.134*</td>
<td>-1.5 ± 1.0</td>
<td>0.2 ± 0.9</td>
</tr>
</tbody>
</table>

### Table 3. Proximal femur bone mineral density of the examined men depending on their ages

<table>
<thead>
<tr>
<th>Age groups, years</th>
<th>BMD, g/cm²</th>
<th>T-score, SD</th>
<th>Z-score, SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–29</td>
<td>1.160 ± 0.099</td>
<td>0.5 ± 0.7</td>
<td>0.4 ± 0.7</td>
</tr>
<tr>
<td>30–39</td>
<td>1.133 ± 0.108</td>
<td>0.2 ± 0.7</td>
<td>0.2 ± 0.7</td>
</tr>
<tr>
<td>40–49</td>
<td>1.070 ± 0.136</td>
<td>-0.2 ± 1.0</td>
<td>-0.1 ± 0.9</td>
</tr>
<tr>
<td>50–59</td>
<td>1.064 ± 0.146</td>
<td>-0.2 ± 1.1</td>
<td>0.0 ± 1.0</td>
</tr>
<tr>
<td>60–69</td>
<td>1.084 ± 0.147</td>
<td>-0.1 ± 1.1</td>
<td>0.3 ± 1.0</td>
</tr>
<tr>
<td>70–79</td>
<td>1.030 ± 0.156*</td>
<td>-0.5 ± 1.1</td>
<td>0.3 ± 1.0</td>
</tr>
<tr>
<td>80–89</td>
<td>0.979 ± 0.173*</td>
<td>-0.8 ± 1.2</td>
<td>0.6 ± 1.1</td>
</tr>
</tbody>
</table>
in 4.4%. In the age groups of 20-29 years and 30-39 years, there was no BMD decrease registered (Z-score ≤ -2.0 SD at the lumbar spine or femoral neck or proximal femur), while in the age group of 40-49 years it was revealed in 4.7% cases.

While distributing the examined men into the groups according to their bone tissue state (normal, osteopenia, osteoporosis), in the age group of 50-59 years osteoporosis was diagnosed in 1.3%, in the age group of 60-69 years in 3.4%, in the age group of 70-79 years in 17.0%, in the age group of 80-89 years in 11.8% (Fig. 1).

Among the men, osteoporosis was significantly more frequently diagnosed in the age group of 70-79 years ([CI: 95% CI: 5.98-27.9], \( \chi^2 = 10.6, p = 0.001 \)) and in the age group of 80-89 years ([CI: 95% CI: 0.20-33.1], \( \chi^2 = 4.82, p = 0.02 \)) rather than in the age group of 50-59 years.

### Discussion

The status of bone mineral density keeps changing in the group of practically healthy men with their advancing age; however, at various skeletal sites it is happening in a different manner. At the level of femoral neck and proximal femur, the greatest BMD values were found in the age group of 20-29 years. With ageing, the femoral neck BMD is diminishing; its values in the male age group of 40-49 years and older are significantly lower than the values of those aged 20-29 years. In the subjects aged 40-49 years, this index is lower by 11.8% (\( p = 0.005 \)); in the subjects aged 50-59 years, this index is lower by 13.8%; in the male subjects aged 60-69 years, this index is lower by 14.8% (\( p < 0.001 \)); in the subjects aged 70-79 years and 80-89 years, this index is lower by 20.0% (\( p < 0.001 \)) and 24.1% (\( p < 0.001 \)), respectively. However, at

<table>
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<th>Z-score, SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–29</td>
<td>1.283 ± 0.086</td>
<td>0.9 ± 1.1</td>
<td>0.7 ± 0.9</td>
</tr>
<tr>
<td>30–39</td>
<td>1.303 ± 0.083</td>
<td>1.0 ± 1.0</td>
<td>0.7 ± 0.9</td>
</tr>
<tr>
<td>40–49</td>
<td>1.252 ± 0.101</td>
<td>0.5 ± 1.3</td>
<td>0.1 ± 1.1</td>
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<tr>
<td>50–59</td>
<td>1.247 ± 0.106</td>
<td>0.4 ± 1.4</td>
<td>0.0 ± 1.2</td>
</tr>
<tr>
<td>60–69</td>
<td>1.256 ± 0.111</td>
<td>0.5 ± 1.4</td>
<td>0.5 ± 1.2</td>
</tr>
<tr>
<td>70–79</td>
<td>1.226 ± 0.119</td>
<td>0.1 ± 1.5</td>
<td>0.5 ± 1.4</td>
</tr>
<tr>
<td>80–89</td>
<td>1.172 ± 0.137*</td>
<td>-0.3 ± 1.5</td>
<td>0.7 ± 1.3</td>
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</tbody>
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<th>Z-score, SD</th>
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</thead>
<tbody>
<tr>
<td>20–29</td>
<td>1.291 ± 0.133</td>
<td>0.6 ± 1.1</td>
<td>0.5 ± 1.1</td>
</tr>
<tr>
<td>30–39</td>
<td>1.302 ± 0.115</td>
<td>0.7 ± 1.0</td>
<td>0.4 ± 0.9</td>
</tr>
<tr>
<td>40–49</td>
<td>1.223 ± 0.169</td>
<td>0.0 ± 1.4</td>
<td>-0.1 ± 1.3</td>
</tr>
<tr>
<td>50–59</td>
<td>1.215 ± 0.178</td>
<td>0.0 ± 1.5</td>
<td>0.0 ± 1.4</td>
</tr>
<tr>
<td>60–69</td>
<td>1.281 ± 0.215</td>
<td>0.5 ± 1.8</td>
<td>0.7 ± 1.6</td>
</tr>
<tr>
<td>70–79</td>
<td>1.277 ± 0.239</td>
<td>0.5 ± 2.0</td>
<td>1.0 ± 1.9</td>
</tr>
<tr>
<td>80–89</td>
<td>1.292 ± 0.210</td>
<td>0.6 ± 1.7</td>
<td>1.6 ± 1.5</td>
</tr>
</tbody>
</table>

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<th>T-score, SD</th>
<th>Z-score, SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–29</td>
<td>0.791 ± 0.066</td>
<td>-0.1 ± 0.9</td>
<td>-0.1 ± 0.9</td>
</tr>
<tr>
<td>30–39</td>
<td>0.848 ± 0.089</td>
<td>0.1 ± 0.8</td>
<td>0.1 ± 0.8</td>
</tr>
<tr>
<td>40–49</td>
<td>0.916 ± 0.137*</td>
<td>-0.1 ± 1.0</td>
<td>0.0 ± 1.0</td>
</tr>
<tr>
<td>50–59</td>
<td>0.919 ± 0.118*</td>
<td>-0.1 ± 1.0</td>
<td>0.1 ± 1.0</td>
</tr>
<tr>
<td>60–69</td>
<td>0.952 ± 0.115*</td>
<td>-0.1 ± 1.0</td>
<td>0.5 ± 1.1</td>
</tr>
<tr>
<td>70–79</td>
<td>0.880 ± 0.128</td>
<td>-0.7 ± 1.1</td>
<td>0.3 ± 1.0</td>
</tr>
<tr>
<td>80–89</td>
<td>0.792 ± 0.167</td>
<td>-1.3 ± 1.4</td>
<td>0.4 ± 1.3</td>
</tr>
</tbody>
</table>
the proximal femur level, the changes occur more gradually. The significantly lower indices were registered only in the age groups of 70-79 years (by 11.2 and 9.0 %) and in the age group of 80-89 years (by 15.6 and 13.6 %) compared to the BMD indices registered in the age groups of 20-29 years and 30-39 years, respectively.

Shana E. McCormack [12] claims that the greatest bone mass accumulation coincides with the pubertal stage and accounts for 57-60 % peak bone mass. About 32-35 % total bone mass of the adult person is being accumulated during 2 years before and 2 years after the maximum growth rate, while in the late adolescence 7-10 % bone mass are added after the linear growth end [12]. The greatest increase of bone is associated with the age of 12.5 ± 0.90 years in girls and 14.1 ± 0.95 years in boys [13]. Having completed the stage of sexual maturity, the adult subjects accumulate about 90 % skeletal mineral content [14]. However, the mineral density of cortical layer and bone density continue growing after the growth zone closure. This stage lasts during the third life decade.

By the ultrasound densitometry data, the male Ukrainian population reaches the peak bone mass at the age of 25-26 years (V. V. Povoroznyuk., 1998) [15]. The males accumulate a greater peak bone mass, surpassing the female indices by 8-10 % [16], which explains a lower future fracture risk.

With ageing, the bone gets stiffer, while the cross-section area (trabecular surface subject to the mechanical load distribution) diminishes. Due to this fact, the load exerted at the unit of bone area increases, leading to a bone deformation. The bones with a low bone mineral density have an increased fracture risk.

Our study demonstrates that the lumbar spine BMD did not differ across various age groups (20-89 years) in males. The absence of age-related differences may be attributed to the growing degenerative changes at the lumbar spine level (osteoarthritis, spondylolisthesis, spondyloarthritis) attended by the osteophyte development. Under the abovementioned conditions, the BMD measurement sums up the vertebral and osteophyte density, resulting in an increased BMD. In light of the abovementioned facts, the male BMD measurements should be performed at the femoral neck and/or lumbar spine in order to rule out the degenerative-dystrophic vertebral change effects while interpreting the X-ray densitometry data.

With physiological ageing, the bone resorption starts exceeding the bone formation; the bone mass gradually diminishing due to the thinning trabeculae and diminished

Fig.1. Distribution of the examined males according to their bone mineral density (normal, osteopenia, osteoporosis)
trabecular network’s density [17, 18]. By the age of 80 years old, one loses about 25-30 % cortical and 20 % trabecular bone making up the accumulated peak bone mass. The cortical bone of the practically healthy males is modifying in a different way, as compared to the trabecular one. According to our findings, at the distal forearm level, where cortical bone tissue predominates, the highest indices were found in the age group of 60-69 years. At this level, the BMD indices of 40-49, 50-59 and 60-69 year-old subjects were significantly higher than the ones of 20-29-year-old subjects (by 15.8 %, 16.2 % and 20.4 %, respectively). The multidirectional modifications of various skeletal sites affected the total skeleton BMD. The highest BMD indices were registered in the practically healthy men aged 30-39 years. The significant reduction of total skeleton BMD was found only in the male subjects of 80-89-year-old age (by 8.7 % and 10.0 %, respectively) in comparison with 20-29-year-old males and 30-39-year-old males. The age-related BMD changes result in an increased osteoporosis frequency among the males of older age groups. As far as the “osteoporosis” diagnosis is based on the lumbar spine, femoral neck or proximal femur BMD indices, the age-related changes made to at least one parameter results in an overall age-related osteoporosis frequency. The low BMD (Z-score ≤ -2.0 SD) was not revealed in the age groups of 20-29 and 30-39 years; in the age group of 40-49 years it was diagnosed in 4.7 % cases. The osteoporosis (T-score ≤ -2.5 SD) was diagnosed in 4.4 % cases: in 1.3 % subjects aged 50-59 years; in 3.4 % subjects aged 60-69 years; in 17.0 % subjects aged 70-79 years; in 11.8 % subjects aged 80-89 years. Similar values were registered across other populations. For instance, in the UK male population, the osteoporosis prevalence is 1 %, in the Japanese population it is 4 %, in the Canadian population it is 3 %, and in the French population it is 8 % [19]. The age-related BMD reduction is caused not only by the hormonal changes, but also the reduced physical activity and frequent bed confinement affecting the life quality, genetic disorders, VDR polymorphism, and bad habits: smoking and alcohol addiction. The smoking provokes the BMD reduction in various manners: via the hormonal balance, reduced parathyroid hormone and Vitamin D rate, Calcium absorption disorders, reduced sexual hormone rates, as well as increased cortisol rate. All the above-mentioned factors also increase the osteoporosis risk.

The alcohol consumption also damages a lot of organs and tissues, including bones. In this regard, the osteoporosis is referred to as being secondary to alcoholism. The French EPIDOS study involving 5 centers, examined the women aged 79.9 ± 3.8 years, drinking 530 g alcohol daily. Their BMD values were much lower [20]. The negative alcohol effect on the bone tissue results in a reduced blood flow to the bones, osteoblast proliferation and differentiation, reducing the Calcium absorption [21]. The extra causative factors damaging the bone tissue along with alcohol consumption are insufficient physical activity and hormonal changes [22]. The BMD is subject to the nutritional disorders: a low protein and vitamin rate, namely Vitamin D deficiency. The older subjects have gastroenterological, hepatobiliary pathologies, renal disorders, oncological diseases, rheumatic diseases, and diabetes mellitus affecting the bone tissue [23, 24]. While examining 231 men, the researchers found that smoking, alcohol consumption, age, mutations in homozygous form of gene rs2412298 and presence of low-energy (fragility) fractures in the first kinship relatives increased the low-energy (fragility) vertebral fracture, and less frequently, the proximal femur fracture risk [25]. The authors claim that the low BMD values associated with genetic disorders may testify to the fact that osteoporosis in the older males has a “pediatric” origin, while age, along with the smoking and alcohol addiction, is the vertebral fracture risk factor.

Our study is limited in several regards: the significantly higher BMI of males aged 50-59 years (28.5 ± 4.5 kg/m^2) and 60-69 years (29.0 ± 3.9 kg/m^2) in comparison to the group of 20-29-year-olds. It is well-known that excessive body mass has a protective effect on the bone tissue. Another limiting factor is an absent analysis of certain factors influencing the bone loss rates (namely, genetic factors).

**Conclusions**

There is an age-associated BMD reduction described at various skeletal sites of practically healthy males, with no clinically important factors affecting the bone turnover. The most pronounced bone loss is observed at the level of femoral neck. With that, 4.4 % examined subjects had a diagnosed osteoporosis with no clinical signs.

**Conflicts of interests.** Authors declare the absence of any conflicts of interests and their own financial interest that might be construed to influence the results or interpretation of their manuscript.

**References**

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Вікові зміни кісткової тканини в чоловіків

Резюме. Метою дослідження було встановлення вікових змін кісткової тканини (КТ) у чоловіків. Матеріали та методи. Дослідження проведено на базі відділу клінічної фізіології та патології опорно-рухового апарату ДУ «Інститут геонтології імені Д.Ф. Чеботарьова НАМН України» із залученням 342 практично здорових чоловіків віком від 20 до 89 років без остеопорозу й остеопоротичних переломів, без патології з доведеним впливом на КТ, а також соматичної патології в суб- чи декомпенсованому стані. Використовували загальноприйняті методи обстеження: опитування, клінічне та антропометричне обстеження, інструментальні дослідження. Мінеральну щільність кісткової тканини (МЩКТ) визначали на рівні всього скелета, поперекового відділу хребта (L₁–L₄), проксимального відділу та шийки стегнової кістки, дистального та ультрадистального відділу кісток передпліччя методом двофотонної рентгенівської абсорбціометрії на приладі Prodigy, GE НС Lunar. Результати. Зареєстроване вірогідне зниження МЩКТ на рівні шийки стегнової кістки на 14,8 % у віці 60–69 років, на 20 % — у 70–79 років та 24,1 % — у 80–89 років порівняно з показниками чоловіків 20–29 років; то- лі дія на рівні поперекового відділу хребта виявлене зниження зазначеного показника на 1,6 % у віці 60–69 років, на 1,9 % — у 70–79 років та 0,8 % — у 80–89 років відповідно. Серед обстежених практично здорових чоловіків КТ у межах вікової норми була виявлена у 67,8 %, остеопенію мали 27,8 %, а в 4,4 % діагностований остеопороз. Висновок. Установлене віковоасоційоване зниження МЩКТ на різних ділянках скелета у практично здорових чоловіків без клінічно значущих факторів, що впливають на обмін КТ. Найбільш виражена іграча спостерігається на рівні шийки стегнової кістки, при цьому у 4,4 % обстежених встановлений остеопороз без будь-яких клінічних ознак. Ключові слова: вік; мінеральна щільність кісткової тканини; остеопороз; чоловіки