Anatomic Variations of the Hip Joint in Soldiers of Different Ages

Variaciones Anatómicas de la Articulación Coxal en Soldados de Diferentes Edades

Boris Banjevic

SUMMARY: Anatomic variations in hip joint are one of the risk factors for the occurrence of osteoarthritis of that part of locomotor system. Due to different age structure and a special way of conducting physical activity in the army, it is justified to presume the presence of even other risk factors which relate to the aging process, carrying of oversize weight and performing higher amplitudes of movement under load. The objective of the study related to determining the existence of eventual anatomic variations in the hip joint in soldiers of different age. This cross-sectional study covers 240 soldiers of Montenegro Army, divided into 8 age groups. Gathered data for morphological measures hip width and hip circumference were processed using the basic statistics, multivariate and univariate of variance and Tukey’s Honestly Significant Difference test-HSD. The differences were considered statistically significant for ps0.05. It was determined that for both morphological measures there are differences between soldiers of certain age. This is confirmed also by drastic deviations between certain age groups obtained for the defined level of statistical significance. The most pronounced is the detection of the annual increase of hip width of soldiers which is higher for 0.38 mm compared to general population. Based on the obtained results the existence of anatomic variations in soldiers’ hip joints is stated. The confirmed anatomic changes in conjunction with other risk factors may lead to hip osteoarthritis, i.e to soldiers’ health condition impairment. It is necessary to conduct longitudinal studies on the same examinees with precise diagnostics.

KEY WORDS: Anatomic Variations; Hip Joint; Differences; Soldiers; Age.

INTRODUCTION

There are numerous studies which highlight that anatomic variations in the hip joint in conjunction with risk factors (years of age, muscle weakness, joint decentralization, obesity, excessive physical exertion and loading of body segments) may lead to multifactorial disease marked as hip osteoarthritis (Ganz et al., 2003). Marching with body borne loads is an integral aspect of military training and has been suggested as a leading cause of musculoskeletal injuries (Knapik et al., 1996). The hip joint experiences a large change in position over the gait cycle and any study of the hip and pelvis must therefore consider the changing loading conditions at different points in the gait cycle (Shanel, 2020). Birrell & Haslam (2009) and Park et al. (2013) found that males increased hip abduction-adduction and internal-external rotation as carried load increased during walking. This kind of movements in conjunction with external load, in time, can cause anatomic variations, which relates to unnatural contact of morphologically changed proximal femur with the rim of normal or changed acetabulum. The said contact leads to initial damage of acetabular labrum and after that even to the damage of the adjacent joint cartilage, which represents the introduction in the development of hip osteoarthritis (Andjelkovic, 2015). Attwells et al. (2006) point out that, except with marching workout, the carrying of heavy military burden during various movements of soldiers causes musculoskeletal pains because of increased muscle strain and tensions owing to changes in the body posture necessary to counterbalance the changes in the position of the center of mass that happens when additional weight is placed around the torso. In addition to the previous risk factor for the occurrence of anatomic variations in the hip joint, the process of biological aging and maturity of the body is distinguished as the primary factor. Namely, the study (Berger et al., 2011) has shown that the expansion process of pelvis and femoral head continues even after the skeleton maturity and the cessation of growth in length and has confirmed the exact data that in the period from 20 until 80 years of age the pelvis widens for 20mm. Bearing in mind the evident risk factors in the army (the carrying of large loads and different age structure), which could lead to anatomic variations in the hip joint and impairment of the health

1 University of Montenegro, Faculty for Sport and Physical Education, Niksic, Montenegro.

Received: 2022-07-29     Accepted: 2022-08-17
condition of soldiers, a research question has been logically placed which relates to determining the existence of eventual variations of the hip joint with soldiers of different age. This has reasonably been included in the regular monitoring of morphological characteristics of soldiers compared to the age, army branch and military specialty. Though the measurement has been conducted in one time point, bearing in mind the set objective, we can talk about significant preliminary study. In case of confirming the said differences, appropriate conclusions shall be made, adequate guidelines shall be sent to the military organization and recommendations shall be given for the realization of future studies.

MATERIAL AND METHOD

This study represents a cross-sectional research which is part of monitoring of morphological characteristics of soldiers. The said monitoring has been realized recently in the Army of Montenegro and previously there were no data with the said examinees. The data were gathered during 2019 in different army units, and the sample of examinees was made up of 240 male soldiers, divided into 8 age groups (Table I).

The sample of measures consisted of morphological indicators hip width (hw) and hip circumference (hc). The said measures were taken in accordance with the Protocol for anthropometric testing of soldiers (Jukic et al., 2008).

The basic descriptive variable parameters were calculated, and to test the potential differences in them between the subsamples of examinees, a multivariate analysis of variance has been carried (MANOVA), while in the second step, to determine the differences between groups on individual variables, a univariate analysis of variance has been applied (ANOVA). In order to determine the real source of variability among the groups, in further analysis the procedure has been conducted which tests individual differences between each of the calculated arithmetic means, i.e. classic analysis of variance (F-test) has been supplemented with the post hoc test with Tukey’s model to determine differences (Tukey’s Honestly Significant Difference test-HSD). The realized level of significance for previously stated statistical procedures is $p \leq 0.05$. Statistical analyses were performed using the SPSS program, version 20.0.

RESULTS

The basic descriptive parameters of morphological variables for soldiers of different age were shown in Table II. The following results have been obtained: 1st age group (hw=31.7; hc=85.9); 2nd age group (hw=32.9; hc=90.6); 3rd age group (hw=33.1; hc=92.5); 4th age group (hw=33.5; hc=94.3); 5th age group (hw=33.6; hc=95.6); 6th age group (hw=33.8; hc=95.7); 7th age group (hw=34.2; hc=98.2); 8th age group (hw=34.2; hc=98.3).

Table I. Examinee’s sample.

<table>
<thead>
<tr>
<th>Subsample/ Age category</th>
<th>1st (18-21)</th>
<th>2nd (22-26)</th>
<th>3rd (27-31)</th>
<th>4th (32-36)</th>
<th>5th (37-41)</th>
<th>6th (42-46)</th>
<th>7th (47-51)</th>
<th>8th (52-57)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>18-21</td>
<td>22-26</td>
<td>27-31</td>
<td>32-36</td>
<td>37-41</td>
<td>42-46</td>
<td>47-51</td>
<td>52-57</td>
</tr>
<tr>
<td>No. of examinees</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Years average</td>
<td>20.0</td>
<td>23.9</td>
<td>29.3</td>
<td>34.6</td>
<td>39.1</td>
<td>44.2</td>
<td>47.8</td>
<td>56.3</td>
</tr>
</tbody>
</table>

Table II. The basic descriptive parameters of morphological variables for soldiers of different age.

<table>
<thead>
<tr>
<th>Age category</th>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st age group (18-21)</td>
<td>Hip width (hw)</td>
<td>27.5</td>
<td>34.5</td>
<td>31.7</td>
</tr>
<tr>
<td></td>
<td>Hip circumference (hc)</td>
<td>74.5</td>
<td>97.9</td>
<td>85.9</td>
</tr>
<tr>
<td>2nd age group (22-26)</td>
<td>Hip width (hw)</td>
<td>29.5</td>
<td>37.6</td>
<td>32.9</td>
</tr>
<tr>
<td></td>
<td>Hip circumference (hc)</td>
<td>79.1</td>
<td>103.0</td>
<td>90.6</td>
</tr>
<tr>
<td>3rd age group (27-31)</td>
<td>Hip width (hw)</td>
<td>29.4</td>
<td>36.5</td>
<td>33.1</td>
</tr>
<tr>
<td></td>
<td>Hip circumference (hc)</td>
<td>83.9</td>
<td>100.3</td>
<td>92.5</td>
</tr>
<tr>
<td>4th age group (32-36)</td>
<td>Hip width (hw)</td>
<td>29.6</td>
<td>38.6</td>
<td>33.5</td>
</tr>
<tr>
<td></td>
<td>Hip circumference (hc)</td>
<td>83.5</td>
<td>108.5</td>
<td>94.3</td>
</tr>
<tr>
<td>5th age group (37-41)</td>
<td>Hip width (hw)</td>
<td>31.4</td>
<td>37.4</td>
<td>33.6</td>
</tr>
<tr>
<td></td>
<td>Hip circumference (hc)</td>
<td>83.0</td>
<td>109.7</td>
<td>95.6</td>
</tr>
<tr>
<td>6th age group (42-46)</td>
<td>Hip width (hw)</td>
<td>30.0</td>
<td>43.2</td>
<td>33.8</td>
</tr>
<tr>
<td></td>
<td>Hip circumference (hc)</td>
<td>81.2</td>
<td>111.2</td>
<td>95.7</td>
</tr>
<tr>
<td>7th age group (47-51)</td>
<td>Hip width (hw)</td>
<td>28.3</td>
<td>42.9</td>
<td>34.2</td>
</tr>
<tr>
<td></td>
<td>Hip circumference (hc)</td>
<td>82.5</td>
<td>115.5</td>
<td>98.2</td>
</tr>
<tr>
<td>8th age group (52-57)</td>
<td>Hip width (hw)</td>
<td>30.5</td>
<td>38.5</td>
<td>34.2</td>
</tr>
<tr>
<td></td>
<td>Hip circumference</td>
<td>84.1</td>
<td>122.0</td>
<td>98.3</td>
</tr>
</tbody>
</table>
By testing the significance of differences of applied morphological variables between examinee’s age groups, a statistically significant difference has been established, since the value of Wilks’ Lambda amounted .706, which during F approximation 6.27 gives the significance of difference at the level of $P<0.05$.

F value of the hip width was 4.90 and hip circumference 13.13 and P significance level was 0.000. It was concluded that both applied morphological variables contribute to such difference.

Based on the results of Tukey’s test for the variable hip width (hw) shown in Table III, it was concluded which groups significantly deviate in the analyzed variable compared to the others. Those are:

Soldiers of 1st age group (hw=31.7) compared to soldiers: of 4th age group (hw=33.5), 5th age group (h =33.6), 6th age group (hw=33.8), 7th age group (hw =34.2) and 8th age group (hw=34.2).

Based on the results of Tukey’s test for the variable hip circumference (hc) shown in Table IV, it was found which groups significantly deviate in the analyzed variable compared to the others. Those are:

Soldiers of 1st age group (hc=85.9) compared to soldiers: of 3rd age group (hc=92.5), 4th age group (hc=94.3), 5th age group (hc=95.6), 6th age group (hc=95.6), 7th age group (hc=98.2) and 8th age group (hc=98.3);

Soldiers of 2nd age group (hc=90.6) compared to soldiers: of 5th age group (hc=95.6), 6th age group (hc=95.7), 7th age group (hc=98.2) and 8th age group (hc=98.3);

Soldiers of 3rd age group (hc=92.5) compared to soldiers: of 7th age group (hc=98.2) and 8th age group (hc=98.3).

Table III. Tukey’s test for the variable hip width.

<table>
<thead>
<tr>
<th>p</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
<th>6th</th>
<th>7th</th>
<th>8th</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>.380</td>
<td>.619</td>
<td><strong>.022</strong></td>
<td><strong>.014</strong></td>
<td><strong>.004</strong></td>
<td><strong>.000</strong></td>
<td><strong>.000</strong></td>
</tr>
<tr>
<td>2nd</td>
<td>1.00</td>
<td>.938</td>
<td>.892</td>
<td>.715</td>
<td>.260</td>
<td>.211</td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td>.788</td>
<td>.703</td>
<td>.474</td>
<td>.119</td>
<td>.092</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4th</td>
<td>1.00</td>
<td>1.00</td>
<td>.933</td>
<td>.899</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td>1.00</td>
<td>.965</td>
<td>.942</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6th</td>
<td></td>
<td>.996</td>
<td>.992</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7th</td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend: age groups – 1st (18-21), 2nd (22-26), 3rd (27-31), 4th (32-36), 5th (37-41), 6th (42-46), 7th (47-51), 8th (52-57); p – realized level of significance; * – existence of significant differences.

Table VI. Tukey’s test for the variable hip circumference.

<table>
<thead>
<tr>
<th>p</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
<th>6th</th>
<th>7th</th>
<th>8th</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>.094</td>
<td>.002*</td>
<td>.000*</td>
<td>.000*</td>
<td>.000*</td>
<td>.000*</td>
<td>.000*</td>
</tr>
<tr>
<td>2nd</td>
<td>.934</td>
<td>.319</td>
<td>.049*</td>
<td>.047*</td>
<td>.000*</td>
<td>.000*</td>
<td></td>
</tr>
<tr>
<td>3rd</td>
<td>.962</td>
<td>.572</td>
<td>.585</td>
<td>.006*</td>
<td>.013*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4th</td>
<td>.993</td>
<td>.994</td>
<td>.145</td>
<td>.229</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5th</td>
<td>1.00</td>
<td>.589</td>
<td>.728</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6th</td>
<td></td>
<td>.576</td>
<td>.716</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7th</td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Legend: age groups – 1st (18-21), 2nd (22-26), 3rd (27-31), 4th (32-36), 5th (37-41), 6th (42-46), 7th (47-51), 8th (52-57); p – realized level of significance; * – existence of significant differences.

DISCUSSION

Based on the obtained results, it is concluded that there are permanently linearly increasing values of hip width and circumference from the category of military recruits to the oldest soldiers which are near to retirement. In addition, explicit differences are noticeable between soldiers of certain age groups, which is an undeniable indicator of changes happening at the hip joint and indirectly on the pelvic ring. By comparing the changes of hip width with general population (Berger et al., 2011) with the equivalent in this study, significantly higher and more dynamic changes with members of the army are found. Namely, with people out of the military organization, changes were determined of 0.33 mm annually, i.e. 20 mm in total for the period of 60 years. However, the annual increase of the hip width is detected with soldiers for 0.71 mm, i.e. the total 28 mm for the period of 39 years. Bearing in mind that there are no similar studies
in other armies which are with their objective directed to
determining the said differences, then we remain deprived
of the possibility of comparison, which would be significant
in making certain conclusions. However, such dynamic
changes lead us to conclude that there are anatomic variations
in the hip joint with soldiers of different age, which confirms
two risk factors (joint decentralization and aging process)
for the occurrence of the hip osteoarthritis (Štojanovic, 1987).
According to Leimbach (2006), an infantry soldier typically
carries 45 to 68 kg of items in addition to body armor and it
is known that hip joint contact forces were found to increase
in males by as much as 30 % when walking with 49kg
(Polcyn, 2001). Actually, by performing movements of
higher amplitudes (flexions, adductions and internal
rotations) under load in the hip joint, small morphological
changes happen which in time can cause the premature
continuous contact of proximal femur and acetabulum,
which represents the introduction to the hip osteoarthritis
(Banovic, 2006). With this the possibility of existence of
even a third risk factor is confirmed for the occurrence of
the said degenerative changes on the soldier’s hip joint.
Bearing in mind that complementary effect of risk factors
leads to the creation of assumptions for the occurrence of
disease (Guyton, 1985), we can say that there are predictable
risks with soldiers in the sense of osteoarthritis i.e.
impairment of their health condition. This kind of risks
which are daily present due to permanent training and per-
formance of tasks of army members, should be channeled
and reduced to the smallest possible measure. Due to the
fact that military profession does not represent only
profession but also a life style (Glavac, 2015), the
recommendation for a military organization would relate
to the priority reduction of load carried by soldiers,
controlling the amplitude of certain movements under load
and adequate application of physical activity in the sense
of preventing certain conditions (muscle weakness and obesity) which could additionally contribute to the occurrence of osteoarthritis.

It is concluded that with Montenegrin soldiers there
are anatomic variations in the hip joint which in conjunction
with other risk factors may lead to the occurrence of
osteoarthritis in that part of the movement system. The
limitations of the study relate to the obtained results of
preliminary type, which as such cannot be used to make pre-
cise conclusions. However, they are acceptable because they
bring very interesting information for science and military
practice, and therefore commit to the realization of longitudinal studies with the same examinees. This would
include also the application of radiographic methods, in order
to provide, in addition to the adequate diagnostics, the
prevention and slowing down of certain conditions and possible diseases.

ETHICS STATEMENT. Ethical review and approval was
not required for the study on human participants in
accordance with the local legislation and institutional
requirements.

BANJEVIC, B. Variaciones anatómicas de la articulación coxal

RESUMEN: Las variaciones anatómicas en la articulación
coxal son uno de los factores de riesgo de la osteoartritis de
esa zona del sistema locomotor. Debido a la diferente estructura
respecto a la de edad y una forma especial de realizar la actividad
física en el ejército, se justifica presumir la presencia de otros fac-
tores de riesgo que se relacionan con el proceso de envejecimien-
to, el transporte de peso sobredimensionado y la realización de
mayores amplitudes de movimiento bajo carga. El objetivo del
estudio fue determinar la existencia de eventuales variaciones ana-
tómicas en la articulación coxal en soldados de diferentes edades.
Este estudio transversal incluyó 240 soldados del Ejército de
Montenegro, divididos en 8 grupos de edad. Los datos recopilados
para las medidas morfológicas del ancho y la circunferencia de la
articulación coxal se procesaron utilizando las estadísticas básicas,
la varianza multivariada y univariada y la prueba HSD de di-
fereencia significativa de Tukey. Las diferencias fueron considera-
das estadísticamente significativas para p<0,05. Se determinó que
para ambas medidas morfológicas existen diferencias entre solda-
dos de cierta edad. Esto fue confirmado también por las desviacio-
nes drásticas entre ciertos grupos de edad obtenidos para el nivel
definido de significación estadística. El más pronunciado es la de-
tección del aumento anual del ancho de cadera de los soldados,
que es superior en 0,38 mm en comparación con la población ge-
neral. En base a los resultados obtenidos se afirma la existencia de
variaciones anatómicas en las articulaciones coxales de los solda-
dos. Los cambios anatómicos confirmados junto con otros facto-
res de riesgo pueden conducir a la osteoartritis de cadera, es decir,
al deterioro del estado de salud de los soldados. Es necesario reali-
zar estudios longitudinales en los mismos examinados con diag-
nósticos precisos.

PALABRAS CLAVE: Variaciones Anatómicas; Articu-
lación coxal; diferencias; Soldados; Edad.

REFERENCES

Andjelkovic, Z. Morphological Changes of the Femoral Head and Neck
as Factor of Early Osteoarthritis and Surgical Treatment. Unpublished
Doctoral Dissertation. Nis, University of Nis, 2015.
Attwells, R. L.; Birell, S. A.; Hooper, R. H. & Mansfield, N. J. Influence
of carrying heavy loads on soldiers’ posture, movements and gait.
Berger, A. A.; May, R.; Renner, J. B.; Viradia, N. & Dahners, L. E. Surprising
evidence of pelvic growth (widening) after skeletal maturity. J. Orthop.