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Anatomic Variations of the Hip Joint in Soldiers of Different Ages

Variaciones Anatómicas de la Articulación Coxal en Soldados de Diferentes Edades

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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 $p \leq 0.05$. 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

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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 viariables, 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 previsouly 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.

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

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

Age category	Variable	Minimum	Maximum	Mean
1st age group (18-21)	Hip width (hw)	27.5	34.5	31.7
	Hip circumference (hc)	74.5	97.9	85.9
2nd age group (22-26)	Hip width (hw)	29.5	37.6	32.9
	Hip circumference (hc)	79.1	103.0	90.6
3rd age group (27-31)	Hip width (hw)	29.4	36.5	33.1
	Hip circumference (hc)	83.9	100.3	92.5
4th age group (32-36)	Hip width (hw)	29.6	38.6	33.5
	Hip circumference (hc)	83.5	108.5	94.3
5th age group (37-41)	Hip width (hw)	31.4	37.4	33.6
	Hip circumference (hc)	83.0	109.7	95.6
6th age group (42-46)	Hip width (hw)	30.0	43.2	33.8
	Hip circumference (hc)	81.2	111.2	95.7
7th age group (47-51)	Hip width (hw)	28.3	42.9	34.2
	Hip circumference (hc)	82.5	115.5	98.2
8th age group (52-57)	Hip width	30.5	38.5	34.2
	Hip circumference	84.1	122.0	98.3

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 circunference 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.

p	2nd	3rd	4th	5th	6th	7th	8th
1st	.380	.619	**.022***	**.014***	**.004***	**.000***	**.000***
2nd		1.00	.938	.892	.715	.260	.211
3rd			.788	.703	.474	.119	.092
4th				1.00	1.00	.933	.899
5th					1.00	.965	.942
6th						.996	.992
7th							1.00

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.

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

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 (Stojanovic, 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 performance 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 precise 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.

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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 factores de riesgo que se relacionan con el proceso de envejecimiento, 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 anatómicas 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 diferencia significativa de Tukey. Las diferencias fueron consideradas estadísticamente significativas para $p \leq 0,05$. Se determinó que para ambas medidas morfológicas existen diferencias entre soldados de cierta edad. Esto fue confirmado también por las desviaciones drásticas entre ciertos grupos de edad obtenidos para el nivel definido de significación estadística. El más pronunciado es la detección del aumento anual del ancho de cadera de los soldados, que es superior en 0,38 mm en comparación con la población general. En base a los resultados obtenidos se afirma la existencia de variaciones anatómicas en las articulaciones coxales de los soldados. Los cambios anatómicos confirmados junto con otros factores de riesgo pueden conducir a la osteoartritis de cadera, es decir, al deterioro del estado de salud de los soldados. Es necesario realizar estudios longitudinales en los mismos examinados con diagnósticos precisos.

PALABRAS CLAVE: Variaciones Anatómicas; Articulación coxal; diferencias; Soldados; Edad.

REFERENCES

Andjelkovic, Z. *Morphological Changes of the Femoral Head and Neck as Factor of Early Osteoarhritis and Surgical Treatment.* Unpublished Doctoral Dissertation. Nis, University of Nis, 2015.

Attwells, R. L.; Birrell, S. A.; Hooper, R. H. & Mansfield, N. J. Influence of carrying heavy loads on soldiers' posture, movements and gait. *Ergonomics, 49(14)*:1527-37, 2006.

Banovic D. *Injuries in Sports.* Belgrade, Professional Book, 2006.

Berger, A. A.; May, R.; Renner, J. B.; Viradia, N. & Dahners, L. E. Surprising evidence of pelvic growth (widening) after skeletal maturity. *J. Orthop. Res., 29(11)*:1719-23, 2011.

Birrell, S. & Haslam, R. The effect of military load carriage on 3-D lower limb kinematics and spatiotemporal parameters. *Ergonomics, 52(10)*:1298-304, 2009.

Ganz, R.; Parvizi, J.; Beck, M.; Leunig, M.; Nötzli, H. & Siebenrock, K. A. Femoroacetabular impingement: a cause for osteoarthritis of the hip. C*lin. Orthop. Relat. Res., (417)*:112-20, 2003.

Glavac, B. *Motor Abilities, Morphological Status and Life Habits of Members of the Serbian Armed Forces*. Unpublished Doctoral Dissertation. Belgrade, University of Belgrade, 2015.

Guyton, A. *Medical Physiology*. Belgrade, Medical Book, 1985.

Jukic, I.; Vucetic, V.; Aracic, M.; Bok, D.; Dizdar, D.; Sporis, G. & Krizanic, A. *Diagnostics of Physical Fitness of Soldiers.* Zagreb, Faculty of Kinesiology, University of Zagreb, 2008.

Knapik, J.; Harman, E. & Reynolds, K. Load carriage using packs: a review of physiological, biomechanical and medical aspects. *Ergonomics, 27(3)*:207-16, 1996.

Leimbach, W.B. Beyond the interceptor system. M*arine Corps Gazette, 90(9)*:81-2, 2006.

Park, H.; Branson, D.; Petrova, A.; Peksoz, S.; Jacobson, B.; Warren, A.; Goad, C. & Kamenidis, P. Impact of ballistic body armour and load carriage on walking patterns and perceived comfort. *Ergonomics, 56(7)*:1167-79, 2013.

Polcyn, A. F.; Bensel, C. K.; Harman, E. A.; Obusek, J. P. & Pandorf, C. *Effects of Weight Carried by Soldiers: Combined Analysis of Four Studies on Maximal Performance, Physiology, and Biomechanics.* US Army Soldier and Biological Chemical Command, 2001.

Shanel, S. *Biomechanics of the Hip and Pelvis and Predictors of Injury during Military Load Carriage Morphological Changes of the Femoral Head and Neck as Factor of Early Osteoarhritis and Surgical Treatment.* Unpublished Doctoral Dissertation. London, Imperial College London, 2020.

Stojanovic, M. *Biology of Human Development with the Basics of Sports Medicine.* Belgrade, Faculty of Sport and Physical Education, University of Belgrade, 1987.

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