SLOBOZHANSKYI HERALD OF SCIENCE AND SPORT

UDK 796.011.3:796.015.6

ISSN (English ed. Online) 2311-6374
2018, №5(67), pp. 15-21
DOI: 10.5281/zenodo.2536280

Functional dichotomy (symmetry – asymmetry) of physical development in men who are engaged in triathlon

Zoya Gorenko
Boris Ocheretko
Antonina Kovelskaya

National University of Physical Education and Sport of Ukraine, Kyiv, Ukraine

Purpose: *explore the dichotomy of the physical development of men who are engaged in triathlon and long-distance running on the highway.*

Material & Methods: *under the conditions of the exercise test with a hip strength of 94 physically active men, the reaction of the cardio-respiratory system to physical activity was investigated. Body composition was determined using the bioelectric impedance method. For paired signs, the asymmetry coefficient was calculated. (C_{AS}).*

Results: *largest groups of work at the level of maximum oxygen consumption were allocated groups assess the level of fitness of athletes. With an increase in the level of physical performance, individual indicators of the maximum response of the cardiorespiratory system to stress have a multidirectional tendency. The development of the muscles of the lower extremities is characterized by right-sided asymmetry for all groups of athletes. At the same time, the value of C_{AS} increases with the increase in the level of physical performance from the 1st to the 4th group. In amateur with a high level of preparedness, a decrease in this coefficient is observed.*

Conclusion: *most amateur athletes who practice triathlon or long-distance runner on the highway have an asymmetry in their lower limbs. The most pronounced asymmetry has athletes with a performance at the level of maximum oxygen consumption of 4,0–4,5 W·kg^{-1}. In the first to fourth groups, an increase in the asymmetry of the lower extremities is observed, whereas in the group with high performance (4,6–5,5 W·kg^{-1}), the asymmetry decreases, which may be a necessary condition for achieving high results.*

Keywords: *physical performance, dichotomy (symmetry-asymmetry), physical development, triathlon.*

Introduction

The problem of studying the functional properties of an organism is one of having not only theoretical, but also practical significance in various areas of scientific knowledge – medicine, biology, psychology, as well as in the field of physical education and sports. It is known that the functional asymmetry of the muscles of the human body is one of the indicators of physical development, health, as well as coordination and coordination of movements, guided by the central nervous system. At the same time, the principle of optimal functioning and proper coordination of movements is considered one of the main ones in the process of vital activity, since it is an expression of harmony, orderliness and organization of living systems. The implementation of sports activities is closely related to the increased requirements for the functional state of the musculoskeletal system, since the latter is essential for achieving sports results and preventing possible injuries [12; 13; 17]. It was shown that functional muscular asymmetry can negatively affect the athlete's neuromuscular system, disrupting proprioception and regulation of movements, which can worsen not only the technique of their execution, but also lead to injury or diseases of the musculoskeletal system [1; 11; 20]. In addition, the data sources of the literature show that functional asymmetry can adversely affect athletic performance in various sports. In particular, basketball players have established differences in indicators of unproductive techniques in the performance of the last leading and non-leading hands [2]. The jumpers in the water show the negative effect of the asymmetry of the lower extremities on the technique of performing the jump, which is manifested in the early separation of one leg from the support and the asymmetric lift [3]. It has also been established that football players who have more than 3 years of sports experience have a large mass of tibia, a total lumbar section and voltage indices of one of the limbs, which is a consequence of constant impact-resistant gravitational loads on the supporting leg [16]. Therefore, taking into account and stabilizing the individual profile of asymmetry-symmetry of an athlete is a significant reserve in improving the efficiency of the training process and finding ways to improve the sports result [5; 12].

Purpose of the study: explore the dichotomy of the physical development of men who are engaged in triathlon and long-distance running on the highway.

Material and Methods of the research

When conducting complex biological surveys with the participation of amateur athletes, they adhered to the Helsinki Declaration of the World Medical Association on the ethical principles of medical research with human participation as the object of study [6]. The content of the maximum test loads and procedures for measuring physiological parameters complied with international rules and requirements for biomedical research involving human subjects. Testing was conducted after a day of rest with a standardized food and drinking regime. Persons tested were familiarized with the content of tests, measurement procedures and agreed to conduct them. 94 practically healthy (according to the data of dispensary examinations) physically active men who are planning to engage in triathlon and longer run on the highway took part in the testing. The study of body composition was carried out using bioelectric impedance analysis (analyzer Tanita-BC-418MA, Japan) [14], the results of which correlate with the results of reference measurements using dual-energy x-ray absorptiometry [21]. The response of the cardiorespiratory system of the body to the physical stresses of the aerobic and anaerobic nature of energy supply was studied under standard laboratory conditions using the LE200C treadmill and the Oxoscopo Ergospirometric Complex (Viasys Healthcare, USA-Germany). Considering that measurements were made in an open system, the external breathing parameters were brought to BTPS conditions, and gas exchange – to STPD conditions. To assess physical performance, we used a test with a stepwise increasing load from an initial speed of 8 km h^{-1} every 2 minutes the speed (by 0,5 km h^{-1}) and the track inclination angle (by 0,2%) increased. Testing was carried out until the moment of "volitional fatigue" (arbitrary refusal of the subject to continue working) or to the impossibility of maintaining a given speed of movement within ±5%. According to the test results, the level of maximum oxygen consumption (VO2max), absolute and relative power of work (W, W kg^{-1}) [4] were determined. Heart rate (HR, beats min^{-1}) was recorded by radiotelemetric pulsometry (Sport Tester Polar-810i, Finland). Statistical processing of the results was performed using an application package Statistica 6.0. The data were checked for normal distribution using the Shapiro-Wilk test. Since the data had an abnormal distribution, non-parametric methods were used. To establish differences between groups, the Kruskal-Wallace test was used [10]. The asymmetry coefficient (C_{AS}) for paired signs was calculated by the formula: C_{AS}=100%(XY)/X, where X is the value of the larger of the symmetric indicators, Y is the value of the smaller of the symmetric indicators.

Results of the research

Earlier, we showed that the level of physical performance of amateur athletes depends on the length of sports training and the age at which amateurs began to systematically train, and also groups for assessing the level of fitness according to the "critical" power of work were distinguished [9]. In addition, an interrelation was established between the main indicators of physical performance and component composition of the body, as well as individual hematological parameters [7; 8]. We found that amateur athletes exhibit a sufficient level of aerobic capacity, overall working capacity, cardiac cycle efficiency, and the ability of skeletal muscles to absorb oxygen [7].

The results of these studies have shown that with relative power of work at the level of maximum oxygen consumption, all the isolated groups have significant differences among themselves (Table 1).

At the same time, with an increase in the level of physical performance, individual indicators of the maximum response of

Table 1

Indicators of physical performance in amateur athletes of different groups (Me [25%; 75%])

Indicators	Groups by relative power of critical load, W kg^{-1}				
	2,4–2,7 1-st (n=8)	2,8–3,3 2-nd (n=22)	3,4–3,9 3-rd (n=35)	4,0–4,5 4-th (n=23)	4,6–5,5 5-th (n=6)
Work power, W	226 [201; 238]	265 [250; 278] **	290 [272; 311] ▲▲▲■■■	328 [282; 358] □□□ǂǂǂ♦♦	370 [357; 392] ◊◊●●●♯♯
Maximum level of pulmonary ventilation, l min^{-1}	114,5 [98,5; 131,5]	130,5 [117,0; 142,0]	136,0 [118,0; 144,0]	144,0 [130,0; 153,0] □	153,5 [144,0; 166,0] ◊◊●●♯
Maximum level of oxygen consumption, ml min^{-1}	3172 [2878; 3747]	3763 [3265; 4030]	3890 [3568; 4237] ▲▲	3907 [37334; 4433] □□ǂ	4256 [3974; 4341] ◊◊●
Maximum level of oxygen consumption, ml $min^{-1}·kg^{-1}$	38,4 [36,6; 41,6]	43,6 [40,7; 45,7] *	47,7 [46,0; 52,7] ▲▲▲■■■	51,3 [49,2; 55,5] □□□ǂǂǂ♦♦	53,4 [47,0;59,5] ◊◊●●
Heart rate, beats min^{-1}	188 [176; 194]	183 [177; 186]	187 [177; 195]	185 [178; 189]	182 [180; 185]
O_2/HR, ml·$beats^{-1}$	18,9 [15,6; 21,8]	21,5 [18,6; 23,5]	21,9 [20,0; 26,6] ▲	24,3 [21,1; 26,7] □□ǂ	23,4 [22,2; 24,0] ◊

Remark:
** – p<0,05, ** – p<0,01 – group 2 regarding to group 1;*
▲▲ – p<0,01, ▲▲▲ – p<0,001 – group 3 regarding to group 1;
□ – p<0,05, □□ – p<0,01, □□□ – p<0,001 – group 4 regarding to group 1;
◊ – p<0,05, ◊◊ – p<0,01 – group 5 regarding to group 1;
■■■ – p<0,001 – group 3 regarding to group 2;
ǂ – p<0,05; ǂǂǂ – p<0,001 – group 4 regarding to group 2;
● – p<0,05, ●● – p<0,01, ●●● – p<0,001 – group 5 regarding to group 2;
♦♦ – p<0,01 – group 4 regarding to group 3;
♯ – p<0,05, ♯♯ – p<0,01 – group 5 regarding to group 3.

the cardiorespiratory system to stress had a multidirectional tendency. So, if the maximum levels of pulmonary ventilation and oxygen consumption increase in each subsequent group, the HR indicators, although they do not have significant differences between themselves, in the 4th group were less corresponding in the 1st and 3rd groups, and the median values HR 5th group was the lowest among all other groups (Table 1). The oxygen pulse rate (O_2/HR) in the 5th group of athletes was also smaller than the previous one and had significant differences between the groups (Table 1). In general, such dynamics of indicators indicates that athletes with the highest level of physical fitness, the effectiveness of the heart cycle is growing not due to an increase in heart rate, but due to an increase in systolic volume, which is consistent with the data of other authors [22].

We also carried out an analysis of body composition in different groups of physical performance in amateur athletes. The results showed that in age and height athletes of different groups do not differ among themselves, and there are significant differences in body weight only between athletes of the 2nd and 4th groups (Table 2).

Indicators of body mass index athletes in the first three

Table 2

Body composition of amateur athletes in different groups of physical performance (Me [25%; 75%])

Indicators	Groups of amateur athletes				
	1-st (n=8)	2-nd (n=22)	3-rd (n=35)	4-th (n=23)	5-th (n=6)
Age years	37,5 [31,5; 47]	35,5 [31; 40]	33 [30; 40]	31 [29; 33] □ǂ	34,5 [33; 36]
Height, cm	178 [174; 180]	181 [173; 184]	180 [176; 183]	180 [175; 185]	176 [176; 178]
Body weight, kg	79,5 [74,2; 86,3]	84,7 [78,3; 89,1]	78,9 [74,2; 85,2]	75,1 [69,7; 85,7] ǂ	77,4 [71,4; 78,6]
Body mass index, kg m^{-2}	25,5 [24,3; 27,1]	26,2 [24,0; 28,1]	24,9 [23,9; 26,2]	23,5 [22,0; 24,9] □□ǂǂǂ♦♦	24,5 [23,1; 25,2]
Fat content, %	19,6 [17,1; 21,8]	20,1 [15,4; 22,9]	16,7 [13,2; 16,4]	12,6 [10,4; 15,9] □□□ǂǂǂ♦♦	12,7 [11,0; 16,7] ◊●
Fat mass, kg	16,2 [13,8; 17,9]	16,5 [12,3; 20,3]	12,8 [11,2; 16,4] ■	9,3 [7,8; 12,0] □□ǂǂǂ♦♦	10,7 [7,9; 13,1] ◊●
Weight without adipose tissue, kg	64,2 [62,3; 68,1]	67,7 [65,4; 71,6]	67,1 [61,6; 72,3]	65,1 [60,9; 73,9]	64,9 [63,6; 68,2]
Water content, kg	46,9 [45,6; 49,8]	49,8 [47,2; 52,4]	49,2 [45,1; 52,9]	47,6 [44,5; 54,1]	47,5 [46,5; 49,9]
Water content, %	58,9 [57,2; 60,7]	58,5 [56,5; 61,9]	61,3 [59,0; 63,9]	64,0 [61,6; 65,6] □□□ǂǂǂ♦	63,9 [60,9; 65,1] ◊●
Segmental body composition analysis					
Right leg					
Fat content, %	17,5 [15,2; 18,5]	17,8 [13,5; 20,1]	14,8 [12,6; 17,9]	11,4 [9,9; 13,0] □□□ǂǂǂ♦♦♦	13,6 [9,3; 16,3] ◊
Fat mass, kg	2,3 [2,0; 2,5]	2,4 [1,8; 3,0]	2,0 [1,6; 2,4]	1,5 [1,2; 1,8] □□□ǂǂǂ♦♦	1,9 [1,2; 2,1] ◊●
Weight without adipose tissue, kg	10,9 [10,4; 11,9]	11,9 [10,9; 12,1]	11,5 [10,8; 12,2]	11,3 [10,5; 12,6]	11,0 [10,9; 11,2]
Estimated muscle mass, kg	10,3 [9,9; 11,0]	11,3 [10,3; 11,5]	10,9 [10,3; 11,6]	10,7 [10,0; 11,9]	10,5 [10,3; 10,6]
Left leg					
Fat content, %	17,2 [15,7; 18,9]	17,3 [13,4; 20,3]	15,5 [12,6; 18,0]	12,0 [10,9; 13,9] □□□ǂǂǂ♦♦	14,0 [11,2; 16,3] ◊

Table 2 continued

Fat mass, kg	2,25 [2,0; 2,4]	2,4 [1,8; 3,0]	2,0 [1,6; 2,3]	1,5 [1,3; 1,8] □□ǂǂǂ♦♦	1,9 [1,3; 2,1] ●
Weight without adipose tissue, kg	10,7 [10,2; 11,6]	11,6 [10,8; 11,9]	11,2 [10,5; 12,0]	10,9 [10,3; 12,1]	10,7 [10,5; 10,8]
Estimated muscle mass, kg	10,2 [9,7; 10,9]	11,0 [10,3; 11,3]	10,6 [10,0; 11,4]	10,4 [9,8; 11,5]	10,2 [10,0; 10,2]
Right arm					
Fat content, %	18,0 [16,4; 20,8]	17,4 [15,3; 18,7]	15,5 [13,3; 17,0] ▲■	14,5 [11,8; 15,7] □□□ǂǂǂ♦	14,3 [12,7; 15,7] ◊●
Fat mass, kg	0,85 [0,75; 0,96]	0,8 [0,7; 0,9] **	0,7 [0,6; 0,9]	0,6 [0,5; 0,8] □□ǂǂǂ♦	0,65 [0,5; 0,7] ◊●
Weight without adipose tissue, kg	3,7 [3,6; 3,9]	4,1 [3,8; 4,2]	3,9 [3,7; 4,4]	3,8 [3,5; 4,4]	3,8 [3,7; 3,9]
Estimated muscle mass, kg	3,5 [3,4; 3,7]	3,8 [3,6; 4,0]	3,7 [3,5; 4,1]	3,6 [3,3; 4,1]	3,6 [3,5; 3,7]
Left arm					
Fat content, %	18,2 [16,3; 19,9]	17,7 [15,7; 19,8] ***	16,3 [14,4; 17,7] ▲	15,2 [12,3; 16,1] □□ǂǂǂ♦	14,1 [11,8; 15,4] ◊●
Fat mass, kg	0,9 [0,75; 1,0]	0,9 [0,7; 1,0] **	0,8 [0,6; 0,9] ■	0,6 [0,5; 0,8] □□ǂǂǂ	0,7 [0,6; 0,8] ●
Weight without adipose tissue, kg	3,8 [3,7; 4,1]	4,1 [3,8; 4,2]	3,9 [3,8; 4,5]	3,9 [3,4; 4,4]	3,9 [3,7; 4,3]
Estimated muscle mass, kg	3,6 [3,4; 3,8]	3,9 [3,6; 4,0]	3,7 [3,6; 4,2]	3,6 [3,2; 4,2]	3,7 [3,5; 4,0]
Torso					
Fat content, %	21,2 [18,1; 23,6]	21,4 [16,3; 25,4] ***	17,7 [12,8; 20,4] ■	12,8 [10,2; 17,4] □□ǂǂǂ♦	13,3 [11,2; 16,7] ◊●
Fat mass, kg	9,7 [8,1; 11,1]	9,9 [7,3; 12,4] ***	7,2 [5,7; 9,8] ■	5,9 [3,9; 7,3] □□ǂǂǂ♦	5,8 [4,3; 7,3] ◊◊●
Weight without adipose tissue, kg	35,6 [34,2; 36,9]	37,3 [35,2; 39,2]	36,8 [33,3; 39,6]	36,2 [33,3; 40,5]	35,6 [34,5; 38,2]
Estimated muscle mass, kg	34,2 [32,9; 35,5]	35,9 [33,8; 37,7]	35,4 [32,0; 38,1]	34,8 [32,0; 38,9]	34,2 [33,2; 36,7]

Remark:
*** – p<0,01, *** – p<0,001 – group 2 regarding to group 1;*
▲ – p<0,05 – group 35 regarding to group 1;
□ – p<0,05, □□ – p<0,01, □□□ – p<0,001 – group 4 regarding to group 1;
◊ – p<0,05, ◊◊ – p<0,01 – group 5 regarding to group 1;
■ – p<0,05 – group 3 regarding to group 2;
ǂ – p<0,05; ǂǂǂ – p<0,001 – group 4 regarding to group 2;
● – p<0,05 – group 5 regarding to group 2;
♦ – p<0,05, ♦♦ – p<0,01, ♦♦♦ – p<0,001 – group 4 regarding to group 3.

groups were higher, while the 4th and 5th ones were within the age range [23]. At the same time, athletes of the 4th and 5th groups, the absolute and relative fat content, both in individual segments of the body, and in general, was statistically significantly lower than the corresponding indices in other groups (Table 2). That is, the higher the level of general physical performance of an amateur athlete, the lower his fat content. Our results are consistent with the data of other authors who obtained similar data on the negative association of fat content and developed load capacity for representatives of other sports [18; nineteen]. The relative water content of the athletes of the 4th and 5th groups was also significantly higher in this way in men with a lower level of physical performance (Table 2).

In addition, we analyzed the relationship between the level of physical performance and manifestations of the asymmetry of the physical development of amateur athletes on the sagittal plane. The results indicate that the development of the muscles of the lower extremities is characterized by right-sided asymmetry for all groups of athletes (Table 3). At the same time, the value of C_{AS} increases with the increase in the level of physical performance from the 1st to the 4th group. But fans with a high level of preparedness have a decrease in this ratio. This suggests that the increase in the level of physical performance in amateur athletes leads to a decrease in the asymmetry of the physical development of the lower limbs along the sagittal plane.

Conclusions / Discussion

In most locomotives included in the triathlon and stadium race, the main work is performed by the muscles of the lower extremities. The muscles of the upper limbs are involved only at the triathlon swimming stage. In stair race, the muscles of the hands do not perform a significant amount of work, so their development during the training is practically not happening. The time of the swimming stage in the triathlon competitions is considerably shorter than the cycling and running stages, and the developed muscles of the hands, although helping to increase the speed of swimming, become an additional mass at other stages. So it is shown that a decrease in the mass of the limbs that perform the movement, as well as a decrease in the amount of fat and inactive muscle mass leads to a decrease in the energy cost of running [15]. In our opinion, the limited training loads on the muscles of the upper extremities are caused by the need to reduce inactive muscle mass when running and cycling and determines the constancy of the asymmetry factors of the upper limbs in groups with different specific power levels at the maximum oxygen consumption level (Table 3).

But, with the development of the functional capabilities of the muscles of the lower extremities, the volume and intensity of the training loads on them are significantly higher for such arm muscles. When performing training exercises, a redistribution of the load between the muscles of the left and right side in favor of the stronger half can occur. Asymmetry of the load leads to uneven development of muscles and an increase in asymmetry in groups from first to fourth in terms of aerobic power. In a group with a high level of aerobic power, the increase in capacity is due to the equalization of the functional capabilities of the muscles of the left and right lower limbs in connection with the achievement of the boundaries of functional

Table 3

Value of the asymmetry coefficient (C_{AS}) in the lower and upper limbs relative to the sagittal plane in different groups of amateur athletes (M±SD)

Indicators	Groups	Fat mass, kg	WA, kg	EMM, kg
Right leg	1	2,29±0,45	11,01±0,79	10,45±0,73
	2	2,33±0,76	11,73±1,08	11,12±1,02
	3	2,05±0,73	11,56±1,12	10,96±1,05
	4	1,53±0,36	11,64±1,50	10,92±1,08
	5	1,70±0,50	11,15±0,98	10,57±0,91
Left leg	1	2,21±0,41	10,84±0,79	10,28±0,72
	2	2,34±0,71	11,43±1,04	10,85±0,97
	3	2,50±0,68	10,98±2,05	10,68±1,05
	4	1,59±0,37	11,13±1,10	10,56±1,03
	5	1,72±0,52	10,85±0,87	10,30±0,84
C_{AS}, %	1	3,13	1,59	1,68
	2	3,49	2,02	1,91
	3	3,99	2,62	2,57
	4	5,28	3,23 □□‡‡	3,24 □‡‡♦
	5	3,74	2,62	2,53
Right arm	1	0,84±0,15	3,69±0,31	3,49±0,31
	2	0,84±0,21	4,02±0,46	3,77±0,43
	3	0,74±0,23	4,03±0,55	3,79±0,52
	4	0,63±0,17	3,93±0,50	3,70±0,46
	5	0,60±0,18	3,85±0,36	3,65±0,36
Left arm	1	0,86±0,16	3,75±0,40	3,54±0,37
	2	0,89±0,23	4,06±0,49	3,82±0,47
	3	0,75±0,26	4,06±0,61	3,82±0,58
	4	0,65±0,18	3,94±0,57	3,71±0,56
	5	0,63±0,19	3,95±0,52	3,72±0,45
C_{AS}, %	1	1,028	1,032	1,022
	2	1,058	1,013	1,019
	3	1,059	1,020	1,022
	4	1,056	1,020	1,024
	5	1,028	1,032	1,022

Remark:
WA – weight without adipose tissueEMM – estimated muscle mass;
□ – $p<0,05$, □□ – $p<0,01$ – group 4 regarding to group 1;
‡ – $p<0,05$; ‡‡ – $p<0,01$ – group 4 regarding to group 2;
♦ – $p<0,05$ – group 4 regarding to group 3.

reserves, enhances endurance at the work of the legs. Also, lower indicators of asymmetry of the lower extremities may be a necessary condition for achieving high levels of functionality characteristic of the fifth group. This can be achieved through specially organized technical training. The difference in factors that increase aerobic performance in the group with its highest level in comparison with other groups, and a decrease in the asymmetry of the lower extremities in the athletes under study may be interrelated phenomena.

Thus, the majority of amateur athletes who engage in a triathlon or stair ride along the highway have an asymmetry of the lower extremities. The most pronounced asymmetry of the lower extremities was athletes of the fourth group, that is, with working capacity at the level of maximum oxygen consumption 4,0–4,5 W·kg^{-1}. In groups with the first to fourth, an increase in the asymmetry of the lower extremities is observed, whereas in a group with a high working capacity (4,6–5,5 W·kg^{-1}) this tendency is violated, which may be a necessary condition for achieving high results.

The prospect of further research may be to establish a relationship between the indicators of asymmetry and the direction of physical and technical readiness.

Conflict of interests. The authors declare that no conflict of interest.
Financing sources. This article didn't get the financial support from the state, public or commercial organization.

References

1. Abramova, T.F., Nikitina, T.M., Kochetkova, N.I. & Krasnikov, V.A. (2013), "Features of the spatial position of the trunk, pelvis and feet of highly qualified male athletes of various sports", *Vestnik sportivnoy nauki*, No. 5, pp. 58-65. (in Russ.)
2. Aksarin, I.V. (2017), "Analysis of the rationality and effectiveness of the implementation of technical techniques by young basketball players, taking into account the functional asymmetry in the competitive activity", *Vektor nauki Tolyattinskogo gosudarstvennogo universiteta. Seriya: Pedagogika, psikhologiya*, No. 4(31), pp. 9-16. (in Russ.)
3. Antsyperov, V.V. & Ivanov, O.I. (2013), "On the role of motor asymmetry in diving", *Sovremennye problemy nauki i obrazovaniya*, No. 6, pp. 1-5. (in Russ.)
4. Aulik, I.V. (1990), *Opredelenie fizicheskoj rabotosposobnosti v klinike i sporte* [Determination of physical performance in clinics and sports], Medicina, Moscow. (in Russ.)
5. Berdichevskaya, Ye.M. & Gronskaya, A.S. (2009), "*Funktsionalnaya asimmetriya i sport*" [Functional asymmetry and sport], *Rukovodstvo po funktsionalnoy mezhpolusharnoy asimmetrii*, Nauchnyy mir, Moscow, pp. 647-691. (in Russ.)
6. World Medical Association (1964), Helsinki Declaration of the World Medical Association "Ethical Principles of Medical Research with the Involvement of Human Rights as Research Objective", availably at: http://zakon2.rada.gov.ua/laws/show/990_005
7. Horenko, Z.A., Ocheretko, B.Ie. & Kovelska, A.V. (2017), "Interconnection of indicators of physical performance and component body composition with athletes-lovers", *Slobozans`kij naukovo-sportivnij visnik*, No. 4(60), pp. 22-27, doi: 10.15391/snsv.2017-4.003. (in Ukr.)
8. Kovelska, A.V., Lysenko, O.M., Horenko, Z.A. & Ocheretko, B.Ie. (2017), "Hematologic indices at athletes and level of physical capacity", *Sportyvna medytsyna i fizychna reabilitatsiia*, No. 2, pp.74-82. (in Ukr.)
9. Lysenko, O.M., Horenko, Z.A., Kovelska, A.V., Taibolina, L.O., Ocheretko, B.Ie., Fedorchuk, S.V., Kolosova, O.V. & Khaliavka, T.O. (2017), "Criteria for evaluating the functional potential of athletes with different athletic training experience", *Visnyk Cherkaskoho universytetu*, No. 1, pp. 56-65. (in Ukr.)
10. Rebrova, O.Ju. (2002), *Statisticheskij analiz medicinskih dannyh. Primenenie paketa prikladnyh programm STATISTICA* [Statistical analysis of medical data. Application of the STATISTICA software package], MediaSfera, Moscow. (in Russ.)
11. Sedochenko, S.V., Germanov, G.N. & Sabirova, I.A. (2015), "The influence of sport on the features of functional muscular asymmetry in swordsmans and tennis players", *Uchenye zapiski universiteta im.P.F. Lesgafta*, No. 2(120), pp. 139-143. (in Russ.)
12. Khudik, S.S., Chikurov, A.I., Voynich, A.L. & Radaeva, S.V. (2017), "Functional asymmetry as a biological phenomenon associated with sporting results", *Vestnik Tomskogo gosudarstvennogo universiteta*, No. 421, pp. 193-202. (in Russ.)
13. Carpes, F.P., Mota, C.B. & Faria, I.E. (2010), "On the bilateral asymmetry during running and cycling – a review considering leg preference", *Phys. Ther. Sport*, No. 11(4), pp. 136-42.
14. Cheng, M.F., Chen, Y.Y., Jang, T.R., Lin, W.L., Chen, J. & Hsieh, K.C. (2016), "Total body composition estimated by standing-posture 8-electrode bioelectrical impedance analysis in male wrestlers", *Biol. Sport*, No. 33, pp. 399-405.
15. Fletcher, J.R. & MacIntosh, B.R. (2017), "Running economy from a muscle energetics perspective", *Front.Physiol.*, Vol. 8, pp. 433.
16. Hart, N.H., Nimhpius, S., Weber, J., Spiteri, T., Rantalainen, T., Dobbin, M. & Newton, R.U. (2016), "Musculoskeletal asymmetry in football athletes: a product of limb function over time", *Med Sci Sports Exerc*, No. 48(7), pp. 1379-87, doi: 10.1249/MSS.0000000000000897.
17. Krykała, M., Leszczyński, P., Grześkowiak, M., Podgyrski, T., Woźniewicz-Dobrzyńska, M., Konarska, A., Strzelczyk, R., Lewandowski, J., Konarski, J.M. (2018), "Does field hockey increase morphofunctional asymmetry? A pilot study", *Homo*, No. 69 (1-2), pp. 43-49.
18. Nicolaidis, P.T. (2014), "Body mass index and body fat per cent are associated with decreased power output in soccer players", *Cent Eur J Med.*, No. 7(6), pp. 783-789.
19. Nicolaidis, P.T. & Ingebrigtsen, J. (2013), "The effect of excess body mass on physical fitness in adolescent and adult male handball players", *Indian J Physiol Pharmacol*, Vol. 57(4), pp. 369-379.
20. Ogurkowska, M. & Kawałek, K. (2016), "Pathological changes in the lumbar intervertebral discs among professional field hockey players", *J. Sports. Med. Phys. Fitness*, No. 56, pp. 85-91.
21. Pietrobelli, A., Rubiano, F., St-Onge, M. & Heymsfield, S. (2004), "New bioimpedance analysis system: improved phenotyping with whole-body analysis", *Eur. J. Clin. Nutr.*, No. 58, pp. 1479-84.
22. Rowell, A.L. (1993), *Human cardiovascular control*, Oxford University Press, New York.
23. Schutz, Y., Kyle, U.U.G. & Pichard, C. (2002), "Fat-free mass index and fat mass index persrntiles in Caucasian aged 18-98 y", *Int. J. Obes.*, No. 26, pp. 953-60.

Received: 07.09.2018.
Published: 31.10.2018.

Information about the Authors

Zoya Gorenko: *PhD (Physiology of Human and Animals); National University of Physical Education and Sports of Ukraine: 1 Fizkultury str., Kyiv, 02000, Ukraine.*

ORCID.ORG/0000-0003-3500-4055
E-mail: geminiz@ukr.net

Boris Ocheretko: *PhD (Physical Education and Sport); National University of Physical Education and Sports of Ukraine: 1 Fizkultury str., Kyiv, 02000, Ukraine.*
ORCID.ORG/0000-0001-7953-1143
E-mail: borisocheretko@gmail.com

Antonina Kovelskaya: *PhD (Oncology); National University of Physical Education and Sports of Ukraine: 1 Fizkultury str., Kyiv, 02000, Ukraine.*
ORCID.ORG/0000-0001-6236-4203
E-mail: kovelskaya@ukr.net