THE INFLUENCE OF SPORTS ACTIVITY ON THE IMPORTANCE OF THE SEXUAL SOMATOTYPE OF ATHLETES IN PAIRED WOMEN'S ACROBATICS AND GYMNASTICS

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Abstract

The article presents research materials relating to the study of the individual characteristics of the 2D:4D finger index in young athletes in pair female acrobatics and gymnastics.
The aim of the study is to study and comparatively analyze the features of the 2D: 4D finger proportions in the "upper" and "lower" female partners in paired female acrobatics and among the female athletes involved in artistic gymnastics, referred to adolescence; confirmation of the influence of the 2D:4D finger ratio on the athletic capabilities of athletes and the formation of their sexual somatotype.
It has been proved that the presence in these groups of female athletes with certain values of the inverse, andromorphic sexual somatotype indicates an increased level of testosterone in the body of these athletes and inverse adaptive changes with the formation of masculinization phenomena in them.
Research methods and organization. To conduct research on the features of the 2D:4D finger proportions in the "upper" and "lower" female partner athletes in paired female acrobatics and in athletes engaged in artistic gymnastics, the following methods were used: anthropometric method to determine: IPD) and somatotyping according to the classification of J. Tanner and W. Marshall; 2) measurement and comparison of II and IV fingers of the hands of athletes using the finger ratio method according to J.T. Menning – 2D:4D Digit Ratio; 3) as well as the method of literary analysis, using available sources of information; 4) method of mathematical statistics.
Organization of the study. This study was conducted in 2019-2020 with the involvement of 31 pairs of acrobats and 59 athletes involved in artistic gymnastics in Ukraine (Nikolaev and Poltava). "Lower" acrobats and gymnasts (n=90) - adolescent – 19.35±1.07 years; "Upper" acrobats (n=31) – pubertal age – 14.68±1.14 years ($p \leq 0,01$). Their experience in these sports ranged from 2.5 to 10 years. The level of sportsmanship – from I-III sports category to a candidate for master of sports, master of sports.
Research results. After carrying out the study of the necessary anthropometric measurements for each participant (indicators of the width of the shoulders and pelvis, the length of the II and IV fingers of both hands) and processing the obtained anthropometric values, the values of the sexual dimorphism index (SDI) in each study group were determined by mathematical recalculation.

Keywords*: pair female acrobatics, gymnastics, sportswomen, finger proportion, morphological masculinization*

Introduction

The study of medical and biological characteristics of modern women's sports of the highest achievements is a priority and an object of study among specialists in morphologists, biologists, sports doctors, endocrinologists and, among many coaching teams, actively working with women's sports teams.

Sports specialists – sports morphologists, biologists, sports doctors, endocrinologists, as well as coaching teams who work with women's sports teams pay

close attention to the study of biomedical characteristics in modern women's sports of the highest achievements, and the object of these studies is a priority direction of scientific research (Willis, 2006).

These studies should be based on understanding the clear mechanism of adaptive processes occurring in the body of female athletes of different age groups, as well as the results and reasons that cause these changes. All this requires researchers to use reliable, adequate, and easy-to-use algorithms and markers in their work to determine the processes of masculinization and adaptive restructuring of the female body, its organs, and systems (Dolomatov et al., 2018; Sataieva et al., 2018; Sataieva et al., 2019).

Recently, scientists in many countries have been conducting numerous studies in various types of modern women's sports, concerning the identification of the effectiveness of the existing markers of masculinization in female athletes during their intense physical exertion (Gozhenko et al., 2018a; Gozhenko et al., 2018b).

Methods

In this study, along with the generally accepted and widely used methods in biomedical and anatomical and morphological studies in the field of modern women's sports and the problems of adaptation of the body of athletes, the following methods were used in a complex - determination of the finger proportion 2D: 4D Digit Ratio, determination of morphofunctional index values , such as the index of sexual dimorphism according to the classification of J. Tanner and W. Marshall, andromorphy index and masculinization index.

The results obtained, of course, would be even more informative, with the additional conduct of the necessary laboratory studies, with the quantitative determination of the concentration in the body of athletes of the level of sex steroids, both testosterone and its fractions, and estrogens, as well as a comparative analysis of the results obtained (Ziółkowska-Łajp et al., 2012; Zaitsev, Ivonina, 2013; Mandrikov et al., 2015; Sarafinyuk et al., 2018; Tatarczuk et al., 2018; Tkachuk et al., 2019).

When conducting research in the conditions of mobility of athletes and considering the high cost of laboratory tests, we plan to rely on express methods with the determination of the necessary laboratory parameters in the saliva of athletes who will be involved in this study.

Modern women's sports are relevant among young people. It attracts more and more supporters to its ranks, becoming in demand in any age category, incl. and in athletes of puberty and adolescence. In order to achieve success and victories in their chosen sport, young athletes need intensive and regular training, which will contribute to improving their sports skills, the formation of perseverance and character, which is achieved through intense physical and psycho-emotional stress (Bugaevsky, 2018; Oleynik, Lebedeva, 2019). Finger index and psychological characteristics in women in shooting sports. Modern trends and topical issues in the development of shooting sports: Sat. materials of the III All-Russian with international participation scientific and practical conference dedicated to the 40th anniversary of the Federal State Budgetary Educational Institution of Higher Education "VGIFK", June 5, 2019. Voronezh: Elist Publishing House, 38-42. The study of anthropometric and morphofunctional characteristics in female athletes-acrobats was addressed by such authors as: Taboada-Iglesias et al., 2015; Shukevich, 2016; Bachynska, 2018; Bereslavskaya et al., 2019; Vilyansky, 2019 and in women's artistic gymnastics: Massidda et al., 2013.

For many modern sports, incl. and for paired female acrobatics, artistic gymnastics, it is characteristic that young athletes are selected. This is done by the coach, who initially takes into account the initial natural data of the athlete associated with her anatomical and morphological indicators. So, the specificity of these sports suggests its own requirements for the age of athletes, their length and body weight, shoulder and pelvic width, as an anthropometric component of the sexual dimorphism index and the corresponding sexual somatotype (Almeida et al., 2013; Davydov et al., 2013; Kochetkova, Oparina, 2014; Gjonbalaj et al., 2018; Bugaevsky, 2018; Oleynik, Lebedeva, 2019; Borysova et al., 2020; Eksterowicz, Napierała, 2020).

The study of anthropometric and morphofunctional indicators in athletes of different age groups, in different types of women's sports, were addressed by such authors as: Nadeina et al., 2011; Nenenko et al., 2014; Burdukiewicz et al., 2016; Alonso-Fernández et al., 2017; Cosmin et al., 2017; Bakhareva et al., 2018; Konstantinos et al., 2019; Bugaevsky, 2021a; Bugaevsky, 2021b).

For example, for the selection of "lower" acrobats, girls of an older, youthful age, strong constitution, with strong upper and lower limbs are selected, capable of holding the "upper" partner while performing all elements of the performance program. They, most often, will have either a mesomorphic, or, in some cases, an andromorphic sexual somatotype. And for the "upper" acrobat, who is younger than her partner, the important criteria will be lower body length and weight, length and strength of the upper limbs - the initial gynecomorphic sexual somatotype. Both partners must have a perfect vestibular apparatus and psychological compatibility (Muse, Sherin, 2012). Model anthropometric parameters of the body of athletes in sports acrobatics. Physical culture, health care and education: materials of the

IV All-Russian scientific-practical conference with the international. participation dedicated to the memory of V.S. Pirusky. Tomsk, 113-117.

In recent years, the method of determining the finger proportion 2D:4D according to the methodology and criteria of J.T. Menning, which allows, even at an early age, to select promising athletes and female athletes (Bugaevsky, 2018; Oleynik, Lebedeva, 2019; Muse, Sherin, 2012; Manning, 2002; Voracek, 2010; Kniga, Trotskaya, 2015; Oleynik, 2009; Perepelkin et al., 2018; Rybalko et al., 2020; Butovskaya, Burkova, 2020).

The aim of the study is to study and comparatively analyze the features of the 2D: 4D finger proportions in the "upper" and "lower" female partners in paired female acrobatics and among the female athletes involved in artistic gymnastics, referred to adolescence; confirmation of the influence of the 2D:4D finger ratio on the athletic capabilities of athletes and the formation of their sexual somatotype.

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Organization of the study. This study was conducted in 2019-2020 with the involvement of 31 pairs of acrobats and 59 athletes involved in artistic gymnastics in Ukraine (Nikolaev and Poltava). "Lower" acrobats and gymnasts (n=90) - adolescent – 19.35±1.07 years; "Upper" acrobats (n=31) – pubertal age – 14.68±1.14 years ($p \leq 0,01$). Their experience in these sports ranged from 2.5 to 10 years. The level of sportsmanship – from I-III sports category to a candidate for master of sports, master of sports.

Results

After carrying out the study of the necessary anthropometric measurements for each participant (indicators of the width of the shoulders and pelvis, the length of the II and IV fingers of both hands) and processing the obtained anthropometric values, the values of the sexual dimorphism index (SDI) in each study group were determined by mathematical recalculation. The subsequent somatotyping made it possible to determine the belonging of each of the athletes to a certain sexual somatotype. The data of certain values of the width of the shoulders and the pelvis in the studied groups of athletes with values ($p \leq 0.05$) are presented in table 1.

Table 1. Values of the width of the shoulders and pelvis in the studied groups of acrobats and athletes involved in artistic gymnastics

Indicator name	**Shoulder width (cm)**	**Pelvis width (cm)**
"Upper" acrobats (n=31)	25,21±0,43	26,14±0,53
"Lower" acrobats (n = 31)	33,76±0,64	27,03±0,19
Female Artistic Gymnastics (n=59)	32,86±0,89	27,95±1,12

Analysis of the obtained studies of measuring the width of the shoulders and pelvis in all athletes indicates that they all have an anatomically narrow pelvis (ANP), as evidenced by a decrease in the transverse size of the pelvis (inter-crestal) and does not correspond to its existing anatomical norm in 28-29 cm.

In the "lower" gymnasts, and in girls doing artistic gymnastics, the shoulder width exceeds the size of the pelvic width, which is not typical for the feminine body type (Bugaevsky, 2018).

All athletes of pubertal age ("upper" acrobats), the shoulder width was less than the size of the pelvis, which corresponds to the female type of figure. After carrying out a mathematical calculation of the values of the width of the shoulders and the width of the pelvis according to the formula proposed by J. Tanner and W. Marshall (1968), according to their classification, somatotyping of all athletes was carried out, the results of which are presented in table 2.

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Table 2. Revealed sex somatotypes in the studied groups

Indicator name	**Gynecomorphic sexual somatotype**	**Mesomorphic sexual somatotype**	**Andromorphic sexual somatotype**
"Upper" acrobats (n=31)	27 (87.10%) female athletes	4 (12.90%) female athletes	__
"Lower" acrobats (n = 31)	__	26 (83.87%) female athletes	5 (16.13%) female athletes
Female Artistic Gymnastics (n=59)	2 (3.39%) female athletes	54 (91.53%) female athletes	3 (5.08%) female athletes

It was determined that the value of SPD in the group of female athletes with more than 5 years of experience, the indices are different: in the "upper" acrobats it is 84.27±0.69% (gynecomorphic sexual somatotype), in the "lower" acrobats – 81, 33 ±1.07 % (mesomorphic sexual somatotype), female gymnasts – 80.74±1.17% (mesomorphic sexual somatotype) (table 3, fig. 1).

Table 3. Revealed sex somatotypes in the studied groups of female athletes who have been involved in professional sports for more than 5 years

Indicator name	**Gynecomorphic sexual somatotype (GSS)**	**Mesomorphic sexual somatotype (MSS)**	**Andromorphic sexual somatotype (ASS)**
"Upper" acrobats (n=31)	26 (84.27%) female athletes	4 (12.9%) female athletes	1 (3.2%) female athletes
"Lower" acrobats (n=31)	__	25 (81.33%) female athletes	6 (16.13%) female athletes
Female Artistic Gymnastics (n=59)	2 (3.39%) female athletes	48 (80.74%) female athletes	9 (15.25%) female athletes

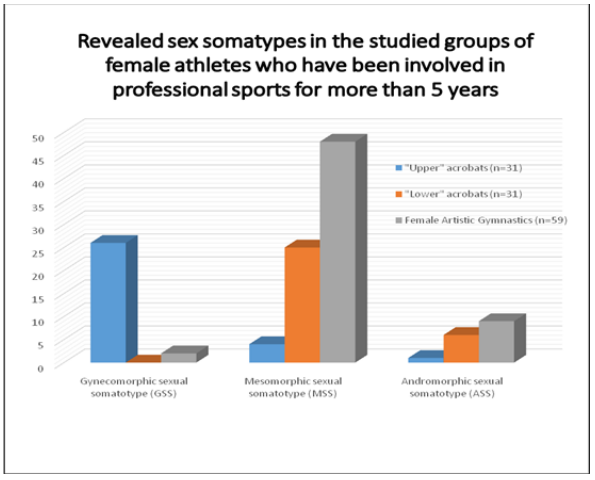

Figure. 1. Dynamics of changes in sex somatotypes in the studied groups of female athletes

It has been established that the overwhelming majority of adolescent acrobats, specially selected for the role of "upper" in paired sports acrobatics, after 5 years of professional sports have a physiological gynecomorphic sexual somatotype, and only 5 athletes already have a transitional mesomorphic sexual somatotype, which, in our opinion, due to factors such as age (growing up) and loss of fat mass due to intense physical activity. In turn, among young acrobats and gymnasts, athletes with a mesomorphic sexual somatotype prevail – 25 (81.33%) and 48 (80.74%) female athletes, respectively. For them, athletes were identified – 6 (16.13%) and 9 (15.25%) with an inverse, that is, andromorphic sexual somatotype, which is due, as we believe, to the duration, frequency and intensity of sports and competitions, sometimes, in our opinion, excessive.

Also, all female athletes had II and IV fingers of both hands measured in strict accordance with the methodology according to J.T. Manning (2D:4D Digit Ratio), 1998 (Voracek, 2010; Kniga, Trotskaya, 2015; Oleynik, 2009; Rybalko et al., 2020).

The initial criterion, according to the author, was the derivative of the sizes of these fingers. For women, normally, the value of the ratio of 2 toes to 4 is 0.96-0.99 or the proportion 2D>4D (Voracek, 2010; Kniga, Trotskaya, 2015).

It is believed that 2D: 4D indicators are below 0.99, corresponds to the male type, and is interpreted as a sign of masculinization in female athletes (Voracek, 2010; Kniga, Trotskaya, 2015; Oleynik, 2009; Rybalko et al., 2020).

In turn, the proportion 2D>4D, with a value ranging from 0.96 to 1.1, is considered to be a sign of femininity – femininity. The proportion 2D=4D, at which the length of the index and ring fingers is equal, is interpreted as a sign of mesomorphism. 2D: 4D proportions in female athletes greater than 0.99 are considered not only a sign of masculinization, but also a sign of an increase in the level of testosterone in the body - the male steroid sex hormone (Voracek, 2010; Kniga, Trotskaya, 2015; Oleynik, 2009; Rybalko et al., 2020).

The obtained results of the finger ratio in each of the studied groups of athletes are presented in table. 4, fig. 2 at ($p \leq 0.05$).

Table 4. Revealed proportions of 2D: 4D Digit Ratio in the study groups

Indicator name	**2D>4D Digit Ratio (≤0,96)**	**2D=4D Digit Ratio**	**2D<4D Digit Ratio (<0,99)**
"Upper" acrobats (n=31)	28 (90.32%) female athletes	3 (9.68%) female athletes	___
"Lower" acrobats (n=31)	___	25 (80.65%) female athletes	6 (19.35%) female athletes
Female Artistic Gymnastics (n=59)	2 (3.39%) female athletes	55 (93.22%) female athletes	2 (3.39%) female athletes

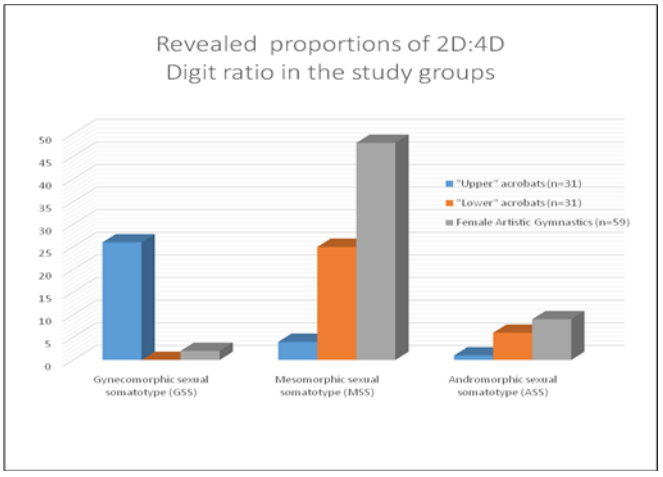

Figure. 2. Revealed proportions of 2D:4D Digit Ratio in the study groups

The analysis of the results obtained indicates that in adolescent acrobats, the data on the 2D: 4D finger ratio, which indicates the femininity of this group of acrobats, is confirmed by the determination of practically the same number of representatives of the gynecomorphic sexual somatotype in them. The number of athletes with a mesomorphic sex somatotype and digital proportions - 2D=4D - also coincides. The same coincidence of sex somatotypes and digital proportions was found in the "lower" acrobats and gymnasts of adolescence.

Discussion

The fact that the digital proportions of athletes involved in sports is a marker of morphological masculinization, according to scientists (Oleynik, 2009; Oleinik, Lebedeva 2019; Musa M., Sherin, 2012; Bugaevsky et al., 2019), researching martial arts, sports acrobatics, sambo. This was confirmed by studies of the features of the finger proportions 2D:4D in "upper" and "lower" female partner athletes in paired female acrobatics and in athletes involved in artistic gymnastics. Indicators of finger indexing 2D: 4D of most female athletes corresponds to the male type, which is explained as a sign of masculinization in female athletes or a sign of femininity, as indicated by the sign of mesomorphism. There are many examples when girls-athletes and women-athletes, as a result of systematic and regular professional sports, show signs of masculism, hormonal imbalances, which leads to a change in the sexual somatotype, menstrual irregularities, etc. This confirms the impact of professional sports on the health of many female athletes (Goranovic et al., 2021; Okun et al., 2020; Andrieieva et al., 2020; Bojanic et al., 2020; Kutáč et al., 2017; Szark-Eckardt et al., 2019; Szark-Eckardt et al., 2017; Eksterowicz et al., 2017; Szary et al., 2015; Kandel et al., 2014).

Conclusions

It has been established that the use of IPD values and the determination of sex somatotypes by the method of J. Tanner and W. Marshall, together with the determination of the finger ratio 2D: 4D Digit Ratio by the method of J.T. Manning is an effective method for determining morphological masculinization and inversions of sexual dimorphism in female athletes in such sports as pair acrobatics and gymnastics.

2. It was determined that in 25 (81.33%) "lower" acrobats, and in 55 (80.74%) girls involved in artistic gymnastics, the mesomorphic sexual somatotype prevails, as a result of adaptation to intense physical and psycho-emotional stress in training and competitive period.

3. The presence in the groups of athletes with certain values of an inverse, andromorphic sexual somatotype, confirmed by the revealed proportions 2D:4D, indicates an increased level of testosterone in the body of these athletes and inverse adaptive changes with the formation of masculinization phenomena in them.

4. Research confirms the influence of sports activity on the sexual somatotype and hormonal transformations in female athletes as a result of an increase in testosterone levels in the body as a result of adaptation to intense physical and psycho-emotional stress during the training-competitive period, which led to the formation of morphological masculinization.

References

Almeida, A., Santos, H., Castro, P., Rizzo, J., Batista, G. (2013). Somatotype analysis of physically active individuals. J Sports Med Phys Fit., 53, 268–273.

Alonso-Fernández, D., Lima-Correa, F., Gutierrez-Sánchez, Á., De Vicuña, O. (2017). Effects of a high-intensity interval training protocol based on functional exercises on performance and body composition in handball female players. Journal of Human Sport and Exercise, 12(4), 1186-1198.

Andrieieva, O., Yarmak, O., Palchuk, M., Hauriak, O., Dotsyuk, L., Goraşcenco, A., ... & Galan, I. (2020). Monitoring the morphological and functional state of students during the transition from middle to high school during the physical education process. Journal of Physical Education and Sport, 20(1), 2110-2117.

Bachynska, N. (2018). Construction of the annual cycle of educational and training process in pair-group types of sports acrobatics in the aspect of sexual dimorphism. Trends and prospects for the development of science and education in the context of globalization, 3, 393–396.

Bakhareva, N., Baibakov, S., Yulmukhametov, D., Gordeeva, E., & Bakhareva, A. (2018) Somatotypological characteristics in representatives of different age periods and its importance in sports orientation. Kuban Scientific Medical Bulletin, 25(6), 32-37.

Bereslavskaya, N., Pilyuk, N., Whistler, G., Zhigailova, L. (2019). Analysis of the main indicators of training loads of highly qualified acrobats - representatives of women's groups in the competitive period of training. Physical culture, sports - science and practice, 1, 14–19.

Bojanic, D., Ljubojevic, M., Krivokapic, D., Nokic, A., & Tabakovic, M. (2020). Differences in morphological characteristics and body composition between of two elite volleyball players in Montenegro. Journal of Physical Education and Sport, 20(3), 1301-1306.

Borysova, O., Nagorna, V., Mytko, A., Peretyatyko, A., Polishchuk, L. (2020). The influence of sexual dimorphism on the choice of tactical decision in the playing situation in individual sports. Journal of Physical Education and Sport, 20(Supplement issue 1), 308 – 311. doi: http://dx.doi.org/10.7752/jpes.2020.s1042

Bugaevsky, K. (2018). Studying the peculiarities of the values of the finger index 2D: 4D in female athletes, who are engaged in pankration, in different age groups "Secondary vocational and higher education in the field of physical culture and sports: current state and development prospects": All-Russian scientific and practical conference. Chelyabinsk, March 29, 150-154.
Bugaevsky, K. (2020). Gimnastyka sportowa kobiet: badanie dymorfizmu płci. Polish Science Journal, 5(26), Warsaw: Sp. z o. o. "iScience", Part 1, 90-95.
Bugaevsky, K. (2021a). Studying a series morfhofunctional index values and anthropometric indicators in joung sportswomen playing volleyball. EC Orthopaedics, 12(1), 74-79.
Bugaevsky, K. (2021b) Characteristics of a number of anthropometric indicators and morphofunctional index values in handball players of different age groups. EC Orthopaedics, 12(3), 05-12.
Bugajewsky, K. (2019). Dynamika wartości dymorfizm płciowych w somatotypach u młodych sportsmenek zajmujących różne rodzaje sztuk walki. Polish Science Journal 10, Warsaw: Sp. z o.o. "iScience". 107–112.
Burdukiewicz, A., Pietraszewska, J., Andrzejewska, J., Stachoń, A. (2016). Morphological optimization of female combat sports athletes as seen by the anthropologists. Anthropological Review, 79(2), 201–210.
Butovskaya, M., Burkova V. (2020). 2D:4D ratios as marker of prenatal androgenization and its predictor validity for anthropologists and evolutionary psychologists: "Pro" and "contra". Anthropology, 2, 26-40.
Cosmin, S., Mihaela, R., Claudiu, A. (2017). Anthropometric Characteristics, Body Composition and Physical Performance of Female Cadet Volleyball Players. Journal of Physical Education and Sport, 16, 664-667.
Davydov, V., Trifonov, A., Yuzhikova, O. (2013) Model characteristics of some morphological and functional indicators of acrobats of various specializations. Physical culture: upbringing, education, training. 3, 65–68.
Dolomatov, S., Sataieva, T., Zukow, W., Kondakova, Y., & Ramazanova, E. (2018). Ecological aspects of molecular mechanisms of epigenetic rearrangement of humoral systems of the renal function regulation. Ecological Questions, 29(2), 71-89. doi: http://dx.doi.org/10.12775/EQ.2018.013.
Eksterowicz, J., Napierała M. (2020). Sexual dimorphism of the selected somatic features of students attending physical education course in Kazimierz Wielki University during the years 2006-2017. Journal of Physical Education and Sport, 20(1), 242–248. doi: http://dx.doi.org/10.7752/jpes.2020.01032.
Eksterowicz, J., Napierała, M., & Zukow, W. (2017). The assessment of the female student physique in accordance with Heath-Carter method. Collegium antropologicum, 41(2), 143-150.
Gjonbalaj M., Georgiev G., Bjelica D. (2018). Differences in anthro-pometric characteristics, somatotype components, and functional abilities among young elite Kosovo soccer players based on team position. International Journal of Morphology. 1, 41-47.
Goranovic, K., Lilić, A, Karišik, S., Eler, N., Anđelić, M., & Joksimović M. (2021). Morphological characteristics, body composition and explosive power in female football professional players. Journal of Physical Education and Sport, 21, 81-87.
Gozhenko, A., Biryukov, V., Gozhenko, O., Zukow, W. (2018a). Health as a space-time continuum. Journal of Education, Health and Sport, 8(11), 763-777. doi: http://dx.doi.org/10.5281/zenodo.2657000.
Gozhenko, A., Biryukov, V., Muszkieta, R., Zukow, W. (2018b). Physiological basis of human longevity: the concept of a cascade of human aging mechanism. Collegium antropologicum, 42(2), 139-146.
Kandel, M., Baeyens, P., Clarys, P. (2014). Somatotype, training and performance in ironman athletes. Euro. J. Sport Sci., 37(3), 301–308.
Kniga, E., Trotskaya, K. (2015). Sexual dimorphism of the ratio of the second and fourth fingers. Sat. materials scientific – practical. conf. from intern. participation «Actual problems of modern medicine». Minsk. 947–951.
Kochetkova, E., Oparina, O. Kochetkova, N. (2014). Features and problems of sexual dimorphism in sport. Modern scientific research and innovation. 7, 15–20.
Konstantinos, N., Panagiotis, M., Bayios, A. Ioannis, B. (2019). Morphological characteristics of adolescent elite female handball and volleyball players. Journal of Physical Education and Sport, 19(Supplement issue 4), 1502–1507. doi: http://dx.doi.org/10.7752/jpes.2019.s4217.
Kutáč, P., Sigmund, M., & Botek, M. (2017). Changes in selected morphological characteristics in elite ice hockey players during an eight-week conditioning program. Journal of Physical Education and Sport, 17(3), 2059-2066.
Mandrikov, V., Samusev, R., Zubareva, E., Rudaskova, E., Adelshina T. (2015). To the question of inversion of sexual dimorphism indices in representatives of masculine sports. Bulletin of Volgograd State Medical University, 4(56), 76–78.
Manning, J. (2002). Digit Ratio : A Pointer to Fertility, Behavior and Health. NJ: Rutgers University Press, 2002. 178 p.
Massidda, M., Toselli, S., Brasilli, P., Calò, C. (2013). Somatotype of elite Italian gymnasts. Coll Antropol., 37(3), 853–85.
Muse, M. Sherin, V. (2012). Model anthropometric parameters of the body of athletes in sports acrobatics. Physical culture, health care and education: materials of the IV All-Russian scientific-practical conference with the international participation dedicated to the memory of V.S. Pirusky. Tomsk, 113-117.
Nadeina, S. Klotz , V., Zvyagintsev L. et al. (2011). Determination of morphological and functional characteristics in athletes with different somatotypes according to the classification of J. Tanner. Izvestiya AltSU, 3-2, 26-29.
Nenenko, N., Abramova, O., Chernitsina, N., Kuchin, R. (2014). Study of sex-dependent characteristics of female athletes, representatives of feminine, maculine and neutral sports. Modern problems of science and education. 6, 15–25.
Okun, D., Korolova, M., Stadnik, S., Rozhkov, V., Mulyk, K., Grynova, T., ... & Petrenko, I. (2020). Selection of girls for canoe slalom on the basis of morphological and functional indicators during puberty. Journal of Physical Education and Sport, 20(6), 3497-3503.
Oleynik, E. (2009). Finger proportions in female athletes involved in martial arts as a marker of morphological masculinization. Scientific notes of the P.F. Lesgaft, 8(54), 96-98.
Oleynik, E., Lebedeva A. (2019). Finger index and psychological characteristics in women in shooting sports. Modern trends and topical issues in the development of shooting sports: Sat. materials of the III All-Russian with international participation scientific and practical conference dedicated to the 40th anniversary of the Federal State Budgetary Educational Institution of Higher Education "VGIFK", June 5, 2019. Voronezh: Elist Publishing House, 38-42.

Perepelkin, A., Mandrikov, V., Krayushkin, A., Sidorov, D., Doronin, A., Matveeva, O. (2018). Peculiarities of finger indices of hand 1D:3D and 2D:4D in dependence on gender and type of the constitution. Journal of Volgograd State Medical University, 1(65), 56-59.
Rybalko, L., Topuzov O., Velychko L. (2020). Natural science education concept for sustainable development. The Internation Conference on Sustainable Futures: Environmental, Technological, Social and Economic Matters (ICSF 2020), Kryvyi Rig, Ukraine, Edited by Semerikov, S. E3S Web of Conferences, 166, 2020.
Sarafinyuk L., Khapitska O., Yakusheva Yu., Ivanytsia A., Sarafinyuk P. (2018). Somatotypological features of acrobat girls in different periods of ontogenesis. Biomedical and Biosocial Anthropology, 32, 43–47.
Sataieva, T., Zadnipryany, I., & Zukow, W. (2018). Sodium nitrate affects myocardium in pregnant rats and their pups. Ecological Questions, 29(4), 55-62. doi: http://dx.doi.org/10.12775/EQ.2018.029.
Sataieva, T., Zadnipryany, I., & Zukow, W. (2019). Toxic cardiac effect of cobalt chloride excessive chronic consumption in male Wistar rats. Ecological Questions, 30(3), 25-32. doi:http://dx.doi.org/10.12775/EQ.2019.016.
Shukevich, L., Zdanevich, A., Nesteruk D. (2016). Features of physical development of highly qualified athletes in paired women's sports acrobatics. Physical culture. Sport. Tourism. Motor recreation, 1(1), 90–92.
Szark-Eckardt, M., Eksterowicz, J., & Napierała, M. (2019). Male students physique in accordance with Heath-Carter method. Collegium antropologicum, 43(2), 119-126.
Szark-Eckardt, M., Napierała, M., Eksterowicz, J., Zukow, W., & Łukaszewski, R. (2017). Somatic characteristics and motor capacity of 10-Year swimming pools from Basic School No. 60 in Bydgoszcz. Collegium antropologicum, 41(3), 231-246.
Szary, M., Napierała, M., Pezala, M., Zukow, W., Cieślicka, M., Muszkieta, R., ... & Karaskova, V. (2015). Somatic features state and general performance of pupils aged 17 years with centre of vocational training and learning in Wiecbork. Journal of Education, Health and Sport, 5(5), 300-311.
Taboada-Iglesias, Y., Gutiérrez-Sánchez, A., Vernetta, M. (2015) Anthropometric profile of elite acrobatic gymnasts and prediction of role performance. J Sports Med Phys Fit., 33(3), 996–1001.
Tatarczuk, J., Asienkiewicz, R., Wandycz, A. (2018). Sexual dimorphism in physical education students of equal body height. Anthropol Anz., 75(1), 1-8. doi: http://dx.doi.org/10.1127/anthranz/2018/0754.
Tkachuk, M., Oleinik, A., Dyusenova, E. (2019). Sports morphology: textbook National State University of Physical Culture, Sports and Health named after P.F. Lesgaft, St. Petersburg. SPb.: [b.i.], 290 p.
Vilyansky, V., Bachynska, N. (2019). Peculiarities of psychophysiological indicators of highly qualified athletes taking into account sexual dimorphism (on the example of karate and sports acrobatics). Martial arts, 4(14), 35–43.
Zaitsev, D., Ivonina, Yu. (2013). Morphological indicators of sexual dimorphism in athletes of different physique. Bulletin of magistracy, 2(17), 7-9.
Ziółkowska-Łajp, E., Demuth, A. Drozdowski, M., Czerniak, U., Krzykała, M. (2012). Ocena dymorfizmu płciowego cech somatycznych i składu ciała młodzieży trenującej sporty wodne. Antropomotoryka, 59, 79-90.
Voracek, M. (2010). Digit ratio (2D:4D) and sensation seeking: New data and meta-analysis. US Tran, SG Dressler. Personality and Individual Differences, 48, 72–77.
Willis, R. (2006). Sports medicine in the growing child. Lovell & Winter's Pediatric Orthopedics. 6th ed. Philadelphia, PA: Lippincott Williams & Wilkins.

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