ECRONICON OPEN ACCESS

EC ORTHOPAEDICS
Research Article

Women's Swimming: Peculiarities of the Size of the Osseous Pelvis and a Number of Morphological Index Values

Konstantin Anatolyevich Bugaevsky*

The Petro Mohyla Black Sea State University, Nikolaev, Ukraine

***Corresponding Author**: Konstantin Anatolyevich Bugaevsky, The Petro Mohyla Black Sea State University, Nikolaev, Ukraine.

Received: April 25, 2022; **Published:** May 30, 2022

Abstract

The study of medical and biological peculiarities of the organism of women of different age groups, especially taking into account the adaptive sexual somatotypes formed in them, is very relevant and in demand. Also, due to the fact that swimming, in all its forms, has a direct intensive effect on the bony, muscular ligament structures and ligament apparatus, both upper and lower limb girdles in women professionally engaged in swimming. A special adaptive change in this kind of women's sport, undergoes their bony pelvis. The study of anatomical and morphofunctional changes in the female bone pelvis is of special interest for specialists dealing with this problem, which led to our study and subsequent writing of this article based on its results.

Keywords: *Female Athletes; Adolescence; Bone Pelvis; Pelvis Size; Anthropometric Indicators; Sex Somatotypes*

Introduction

Modern women's sport with its numerous medical and biological problems and not completely solved problems of adaptation of athletes in different age groups to physical loads and restructuring of organs and systems occurring in their bodies, especially related to morphofunctional somatic changes, has for many years been the object of close attention, both domestic and foreign researchers [1-20]. This directly applies to such a cyclic sport as swimming [3,4,15-18]. This sport attracts a significant number of teenage girls, female athletes of adolescent age, young and older women, of different age groups. The training process requires considerable physical effort, both in their frequency and in their volume and intensity. Virtually all systems of the female body are subjected to tremendous stress. First of all, it concerns the respiratory and cardiovascular systems, as well as the bone and musculoskeletal systems, which undergo the most active adaptive changes. Somatically, the changes that occur directly lead to an increase in the volume and size of the chest, shoulder girdle, upper and lower extremities, with an increase in muscle and bone mass, the number of alveolar lung tissue, and adaptive changes in the hematopoietic system. All this leads to compensatory restructuring of the female athletes' body relief - broad shoulders, a powerful muscular frame of the torso, arms and legs. The endocrine and reproductive systems are the most directly involved. There is an adaptive decrease in estrogen levels, and an increase in androgens, which are necessary for female athletes to achieve better results, both during training and competition. Hyperandrogenism and adaptive masculinization, as a consequence of restructuring of the female athletes of all age groups, gradually leads to a decrease in estrogenic background, with such phenomena of menstrual disorders as hypomenorrhea, oligomenorrhea, opsomenorrhea, which is expressed clinically in the formation of persistent hypomenstrual syndrome. Sometimes, some female athletes form adaptive secondary amenorrhea, against the background of their ongoing masculinization. All these questions are highly demanded and relevant to specialists dealing with the issues of adaptive medical and biological processes in female athletes of different age groups. To achieve the set goal of the study, we used methods such as anthropometry, pelviometry, with the determination of three transverse and two longitudinal external dimensions of the pelvis, with the determination of the degrees of narrowing of the pelvis, indicators of the pelvic

index, calculation of a number of morphofunctional index values, such as the index of sexual dimorphism, andromorphy index, masculinization index, indices of relative pelvic width and pelvic-humeral index.

Aim of the Study

Establishment of existing individual changes in the anatomical and anthropometric indicators and the results of morphological and functional index values, in the group of adolescent athletes engaged in swimming, as representatives of the identified, different sex somatotypes.

Materials and Methods

The study was conducted, with the involvement of 257 female youth athletes from Ukraine, professionally engaged in swimming. The sports experience of female swimmers ranges from 4 to 8 years. The control group consisted of 260 female adolescents who were not involved in any sport. The age parameters in both groups were almost the same: 20.37 ± 1.14 for young female swimmers and 21.37 ± 0.49 for non-sports. It should also be noted that all 517 girls from both groups who took part in the study gave their voluntary consent to participate in it.

Traditional methods of anthropometry were used to measure the external dimensions of the bone pelvis – pelvimetry (PM), with the determination of their pathological changes, both according to the classification of narrow pelvis and according to the degree of narrowing [7,11,13,19,20]. Also, the index method was used, with the determination of a number of morphofunctional index values necessary for the ongoing study. Thus, in particular, the following was conducted: the masculinization index (IM) and sex dimorphism index (SDI) were determined according to the method of J. Tanner and W. Marshall (1968) [3,5,6,8,19,20] with subsequent somatotyping of female athletes. In addition, we used the method of literary-critical analysis of available sources of information, both domestic and foreign, the method of mathematical statistics of the results obtained, both in the study and control groups. Girls of adolescent age (n=260) not engaged in sports made up the control group by random sampling. It has been determined that girls who swim are significantly taller than their peers.

Results

In the study of anthropometric indicators in female swimmers, important morphological data are anatomical and anthropometric values of both upper and lower limb belts, as well as body length and weight of girls. Weight and height proportions, ratios of longitudinal and transverse dimensions of the upper and lower limbs, including shoulder width (ShW) and pelvic bone width (PBW), with its external transverse and longitudinal dimensions, revealed after pelviometry, and morphofunctional index values of female athletes are also essential. The results of the obtained anthropometric indices are shown in table 1, at $p \leq 0.05$.

Indicator name	Study group (n = 257)	Control group (n = 260)
Body length, cm	173,23 ± 1,14	163,2 ± 1,73
Body weight, kg	67,32 ± 1,04	64,35 ± 0,47
Length of the upper limb, cm	73,0 ± 0,73	67,12 ± 1,07
Length of lower limb, cm	92,7 ± 1,47	89,46 ± 1,08
Shoulder width (bicromial size), cm	40,12 ± 0,67	34,69 ± 1,11
Pelvic width (bicurious size), cm	27,24 ± 0,51	28,05 ± 0,37

Table 1: *Anthropometric indicators in the studied groups.*

The average body length of the female swimmers was 173.23 ± 1.14 cm, in the control group - 163.2 ± 1.73 cm. Also, female athletes have a larger body weight of 67.32 ± 1.04 kg than non-athletes, 64.35 ± 0.47 kg. However, it should be noted that young female athletes differ significantly in terms of body size from world-class female swimmers [15,16,18]. body size indicators from world-class female swimmers [15,16,18]. In the studied female athletes, the indicators of upper limb length - 73.0 ± 0.73 cm; lower limb length - 92.7 ± 1.47 cm; bicromial size (shoulder width) - 40.12 ± 0.67 cm exceeded the values of the control group ($p \leq 0.05$). Individual external dimensions of the bone pelvis, when analyzed, were compared with the normal values for this age group, namely: distantia spinarum (normal 25 - 26 cm), distantia cristarum (normal 28 - 29 cm), distantia trochanterica (normal 31 - 32 cm) and conjugata externa (Bodelock diameter - 20 - 21 cm, conjugata vera - 11 cm [1,7,8,11-13,19,20].

Continuing anthropometric measurements in the study and control groups, we carried out pelvimetric measurements of the external dimensions of the bone pelvis - three transverse and two longitudinal, carried out according to the classical technique used in obstetrics, anatomy and sports morphology [1,7,8,11-13,19,20].

The results of the pelvimetry in the studied group of female athletes and in the control group are shown in table 2, at ($p \leq 0.05$).

Indicator name	Study group (n = 257)	Control group (n = 260)
Distancia spinarum, cm	24,06 ± 0,71	25,22 ± 0,61
Distancia cristarum, cm	27,24 ± 0,51	27,91 ± 0,42
Distancia trochanterica, cm	30,43 ± 0,59	30,17 ± 0,11
Conjugata externa, cm	16,89 ± 0,02	19,92 ± 0,56
Conjugata vera, cm	10,02 ± 0,23	10,54 ± 0,83

Table 2: *Pelvimetric indices in the studied groups.*

The results of pelvimetry revealed differences in the group of female swimmers and in the control group: distancia spinarum (iliac spinous size) - 24.06 ± 0.71 cm and, respectively, 25.22 ± 0.61 cm; distancia cristarum (pelvic-crestal size) - 27.24 ± 0.51 cm and 27.91 ± 0.42 cm; distancia trochanterica (intervertebral dimension), 30.43 ± 0.59 cm, and 30.17 ± 0.11 cm; conjugata externa (external conjugate), 16.89 ± 0.02 cm, and 19.92 ± 0.56 cm; conjugata vera (true conjugate), 10.02 ± 0.23 cm and 10,54 ± 0.83 cm.

The average value of the external conjugate in the group of female swimmers, was less than the average normal anatomical parameters for this age group, which indirectly indicates the presence of flat pelvis variants [1,2,6-8,11-13,19,20]. The index of masculinization (IM) is the ratio of the intercromial size (ShW) to the intervertebral size (distancia trochanterica). The value of IM, according to a number of researchers, does not depend on the initial type of female constitution, in its values reflecting the content of sex steroids (estrogens/testosterone) and their ratio in a woman's body [5,9,10]. The IM values, depending on the age of female athletes, intensity and duration of training, change downward. In female athletes in cyclic sports, including women's swimming, the IM is 1.40 - 1.45, while in the population the "norm" value of IM varies from 1.15 to 1.23 [5,9,10]. The results of the study are shown in table 3, at ($p \leq 0.05$).

Indicator name	Study group (n = 257)	Control group (n = 260)
Index Masculinization (IM)	1,33 **±** 0,02	1,04 **±** 0,02
Relative Pelvic Width Index (RPWI)	15,90 **±** 0,02	16,35 **±** 0,23
Pelvic-Shoulder Index (PShI)	68,03 **±** 0,11	79,39 **± 1,07**
Andromorphic Index (AI)	60,33 **±** 0,21	33,43 **±** 0,04
Pelvic Index (PI)	100,45 ± 0,01	104,92 ± 0,34
Sexual Dimorphism Index (SDI)	94,62 ± 0,21	65,66 ± 1,07

Table 3: *Indicators of morphofunctional index values in the studied groups.*

Discussion

Turning to the discussion and analysis of the results of the study, it should be noted: It has been determined that girls who swim are significantly taller than their peers and also have a higher body mass. In addition, female athletes, compared with their peers who do not swim, have significantly more noticeable length of the upper and lower extremities. Differences in the values of such two latitudinal, transverse body dimensions as the width of the shoulders (bicromial size) and the width of the pelvis (bicrestral size) are noticeable. In the studied group of female athletes-swimmers of young age, significantly exceeds similar sizes, in their peers who are not engaged in sports. With pelvic width dimensions, the picture is just the opposite. Female athletes not only have a smaller pelvic width (bicurious size) than the norm in the population and when compared to their non-athletic peers, they also have a significantly smaller shoulder width (bicromial size). Their figure has a similarity with the male (masculine type of figure - broad shoulders - narrow pelvis [1,2,6-8,11-13,19,20]. In the control group, the type of figure is different - the width of the pelvis is greater than the width of the shoulders, which corresponds to the physiological for women, feminine type of figure [1,3,7,11,12].

The IM values in the "conditionally acceptable" corridor of 1.45 to 1.53 indicate an emerging delay in sexual development of female athletes against the background of progressing hyperandrogenism [3,4,15-18]. The study found that swimmers had a higher IM (1.33 ± 0.02) than their non-swimmer counterparts (1.04 ± 0.02; $p < 0.05$), indicating a persistent tendency toward hyperandrogenism in most of the swimmers and a tendency to maintain a stable hormonal balance between estrogens and androgens in non-swimmers.

The values of such morphofunctional index value, the relative pelvic width index (RPWI) as a result of dividing the intercrestal size (cm) by the body length (cm), in female athletes was 15.90 ± 0.02, which corresponds to the signs of stenopyelia, or narrow pelvis [1,3,7,11,12] and in the non-athletes group - 16.35 ± 0.23, which corresponds to the values of metriopyelia, or normal pelvis [1,3,7,11,12].

The index value of the pelvic-shoulder index (PShI), as the percentage ratio of the ShW to the PBW [1,3,7,11,12], in female athletes was 68.03 ± 0.11, which corresponds to the type of figure, in the form of an inverted trapeze - wide shoulders - narrow pelvis [1,3,7,11,12].

The andromorphic index (AI), the values of which are used to identify the hypergynoid type (value less than 67.5), the orthogynoid type (from 67.5 to 73.5), and the android type (over 73.5) [1,3,7,11,12]. In the group of sportswomen its index was 60.33 ± 0.2 (hypergynoid type), and in the non-athletes - 33.43 ± 0.04. This is 1.8 times less than in their female peers engaged in swimming.

According to the pelvic index (PI), which is the result of summing up the three transverse and one longitudinal (conjugata externa) dimensions of the bone pelvis, in female athletes its average value was 100.45 ± 0.01 cm, which fits the parameters of a narrow pelvis, and in the non-athletes group - 104.92 ± 0.34 cm, which corresponds to the parameters of a normal pelvis [1,3,7,11,12,17,18].

The mean values of the Sex Dimorphism Index (SDI) were determined on the basis of ShW and PBW indices, followed by somatotyping. The average SDI value in the group of female athletes was 94.62, which indicates an inverse physiological, andromorphic sexual somatotype [1,3-5,7,11,12,17,18] and in non-athletes - 65.66, which corresponds to the physiological, gynecomorphic sexual somatotype [1,3-5,7,11,12,17,18].

At the same time, 133 (51.75%) of the investigated female athletes of the given age had andromorphic sexual somatotype and 124 (48.25%) had inverse mesomorphic sexual somatotype, with the revealed values close to the upper maximum value, while there was not a single female athlete with a physiological gynecomorphic sexual somatotype. In turn, in the group of non-athletes there were no girls with a pathological andromorphic sexual somatotype. Girls with physiological, gynecomorphic sexual somatotype prevailed - 231 (88,85%) and only 29 (11,15%) with values of mesomorphic sexual somatotype close to its lower indices.

Analyzing the obtained data, we would like to note that in the group of young female athletes, taking into account the period of their intensive training in this sport, and a sufficiently large volume of loads, on the background of adaptive somatic changes, invert-

ed forms and types of bone pelvis were formed. Such changes are noted by almost all researchers involved in the study of this issue [1,2,5,6,8,13,14,19,20]. Thus, in the studied group of female athletes (n = 257), only 4 (1.56%) of them had external pelvic dimensions that corresponded to the physiological parameters for this age group of women [1,2,5,6,8,13,14,19,20]. In 253 (98.44%) female swimmers, an anatomically narrow pelvis (ANP), which is characterized by a decrease of 1.5 - 2 cm in at least one of the external dimensions of the bony female pelvis, was determined [1,2,5,6,8,13,14,19,20]. In female athletes with ANP (n = 253) multiple, often combined changes in the shape and type of their pelvis were identified, namely: a simple flat pelvis in 59 (23.32%) female athletes, a transversely narrowed pelvis in 47 (18.58%) female athletes, a generally uniformly narrowed pelvis in 26 (10.28%) female athletes and, mixed "erased" pelvic shapes, with a decrease of 0.5 - 1 cm in the number of longitudinal and/or transverse external dimensions of the female bone pelvis in 121 (47.83%) [1,2,5,6,8,13,14,19,20]. A similar trend is noted in many reputable contemporary studies dealing with the biomedical problems of modern women's sport. When analyzing the longitudinal indices of the bone pelvis (conjugate externa and conjugate vera), the following degrees of pelvic contraction were determined (according to the classification of degrees of pelvic contraction according to A.F. Palmow): degree I constriction (true conjugate 10.5 - 9.1 cm) [1,2,5,8,11-13] was determined in 189 (74.70%) female athletes with ANP, and degree II constriction (true conjugate 9.0-7.6 cm) [1,2,5,8,11-13] in the remaining 64 (25.30%) female athletes involved in swimming.

In the control group (n = 260), normal pelvis was determined in 174 (66.92%) girls, ANP in 86 (33.08%), simple flat pelvis in 13 (5.0%), transverse constricted pelvis in 20 (7.69%), common constricted pelvis in 15 (5.77%), "erased" pelvic forms in 38 (14.2%) girls under investigation. Degree I constriction, of 86 girls with ANP, was determined in 76 (88.37%), and in 10 (11.623%) girls from the control group with ANP. The obtained data convincingly show that pathological, inverted, including combined forms of the bone pelvis with a large number of constrictions of I-II degrees prevail among female athletes in comparison with the control group.

Conclusion

1. The representatives of andromorphic somatotype dominate in the group of the young female swimmers - 133 (51,75%), and 124 (48,25%) have mesomorphic somatotype, with a complete lack of physiological gynecomorphic female athletes in the whole study group.

2. Young female athletes have broad shoulders and narrow pelvis, with the shape of the torso in the form of "inverted trapeze", which is confirmed by the obtained values of all conducted morphofunctional index values.

3. In 253 (98.44%) female athletes anatomically narrow pelvis was determined, with numerous combined violations of its shape and form, with the detection in all of them, I-II degrees of pelvic narrowing, which far exceeded the changes in the pelvis of girls from the control group.

4. We believe that all the identified changes in young female athletes engaged in swimming are the result of adaptive somatic restructuring in their body, caused by a shift in their hormonal balance, from estrogenism to hyperandrogenism.

Bibliography

1. Bugaevsky KA and Bugaevskaya NA. "Study of anatomical and morphological features of the bone pelvis in young female athletes engaged in freestyle wrestling". Nauka-2020 5.11 (2016): 239-243.

2. Voronin MV., *et al*. "Principles of transversal-tapered pelvis formation in ballerinas". Volume 1 (2016): 20-23.

3. Gretz IA., *et al*. "Morphological determinants of dimorphic features of women in sports swimming". Scientific Notes of Lesgaft University 1.95 (2013): 22-26.

4. Davydov VYu., *et al*. "Body building and swimming efficiency". Methodical recommendations. Pinsk: PolessU (2018): 52.

5. Bugaevsky KA., *et al*. "Women's athletic sports: bone pelvis and its morphofunctional features in sexual somatotypes". *Ukrainian Journal of Medicine, Biology and Sports* 1.17 (2018): 276-282.

6. Medvedeva NN and Gladkaya VS. "Peculiarities of bone pelvis formation in women of the Republic of Khakassia depending on body type". Modern problems of science and education (2016): 6.

7. Nikityuk DB., *et al*. "Body mass index and other anthropological indicators of physical status taking into account age and individual-typological features of the constitution of women". *Voprosy Pitaniia* 84.4 (2015): 47-54.

8. Nichiporuk NG. "Variant anatomy of bone pelvis and genitourinary area of perineum in adult women". Mat. Structural transformations of organs and tissues in norm and under the influence of anthropogenic factors. Astrakhan: ASMU, Leon (2017): 133-135.

9. Oleynik EA and Bugaevsky KA. "Features of sexual somatotypes and a number of anthropometric indicators in female athletes in paired female acrobatics". *Man Sports Medicine* 20.2 (2020): 22-28.

10. Xiaohan Wang. "Phylogenetic Functions of Women and the Phenomenon of Female Sports". *Bulletin of Experimental Education* 4.13 (2017): 25-32.

11. Tkachuk MG., *et al*. "Sport morphology: textbook". National State University of Physical Culture, Sports and Health named after P.F. Lesgaft, Saint Petersburg. Saint Petersburg: [b.i.] (2019): 290.

12. Bugaevskiy KA., *et al*. "Female Athletic Sport Types: Bone Pelvis and its Morphofunctional Characteristics in Sexual Somatotypes". *Ukrainian Journal of Medicine Biology and Sports* 4.1 (2019): 276-282.

13. Cara L Lewis., *et al*. "The Human Pelvis: Variation in Structure and Function During Gait". *The Anatomical Record* 300.4 (2017): 633-642.

14. Kaina Louis-Charles., *et al*. "Pelvic Floor Dysfunction in the Female Athlete". *Current Sports Medicine Reports* 18.2 (2019): 49-52.

15. Loo LH., *et al*. "Anthropometric Profiles of Malaysian Elite Swimmers". In: Ibrahim F., Cheong J., Usman J., Ahmad M., Razman R., Selvanayagam V. (eds) 3rd International Conference on Movement, Health and Exercise. MoHE. 2016. IFMBE Proceedings, volume 58. Springer, Singapore (2017).

16. Platonov V. "Theoretical and methodological background for sports selection and orientation in modern elite sports". *Science in Olympic Sport* 3 (2018): 24-51.

17. Senefeld JW., *et al*. "Sex differences in youth elite swimming". *PLoS ONE* 14.11 (2019): e0225724.

18. Beat Knechtle., *et al*. "Sex Differences in Swimming Disciplines-Can Women Outperform Men in Swimming?" *International Journal of Environmental Research and Public Health* 17.10 (2020): 36-51.

19. Wobser Anna M., *et al*. "Anatomy, Abdomen and Pelvis, Bones (Ilium, Ischium, and Pubis)". StatPearls [Internet] (2020): 132.

20. Verbruggen SW and Nowlan NC. "Ontogeny of the Human Pelvis". *Anatomical Record (Hoboken)* 300.4 (2017): 643-652.

Volume 13 Issue 6 June 2022