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MORPHOMETRIC CHARACTERISTICS OF THE VASTUS MEDIALIS MUSCLE OF THE QUADRICEPS FEMORIS MUSCLE OF THE THIGH ACCORDING TO THE DATA OF THE ULTRASOUND STUDY

МОРФОМЕТРИЧНА ХАРАКТЕРИСТИКА ПРИСЕРЕДНЬОГО ШИРОКОГО М'ЯЗА ЧОТИРИГОЛОВОГО М'ЯЗА СТЕГНА ЗА ДАНИМИ УЛЬТРАЗВУКОВОГО ДОСЛІДЖЕННЯ

Резюме. З метою морфометричного порівняння об'єму присереднього широкого м'яза чотириголового м'яза стегна досліджено 48 юнаків, віком від 16 до 18 років, де основну групу становлять 32, контрольну – 16 студентів.
У результаті проведеного порівняння морфометричних параметрів присереднього широкого м'яза чотириголового м'яза стегна за даними ультразвукового дослідження встановлено, що об'єм м'яза професійних футболістів більший на 14,3% від об'єму м'яза студентів, які відвідували секцію з футболу та на 39,3% від об'єму м'яза студентів контрольної групи, а також встановлено, що об'єм присереднього широкого м'яза чотириголового м'яза стегна в верхній третині більший у студентів, які відвідували секцію з футболу на 29,2% порівняно зі студентами контрольної групи.
За результатами об'єму присереднього широкого м'яза чотириголового м'яза стегна в середній третині встановлено, що об'єм м'яза професійних футболістів більший на 17,0% від об'єму м'яза студентів, які відвідували секцію з футболу та на 36,1% від об'єму м'яза студентів контрольної групи, а також встановлено, що об'єм присереднього широкого м'яза чотириголового м'яза стегна в середній третині студентів, які відвідували секцію з футболу на 23,0% більший, на відміну від об'єму присереднього широкого м'яза чотириголового м'яза стегна студентів контрольної групи.
За результатами об'єму присереднього широкого м'яза чотириголового м'яза стегна в нижній третині встановлено, що об'єм присереднього широкого м'яза чотириголового м'яза стегна в нижній третині професійних футболістів на 19,2% більший, порівняно зі студентами, які відвідували секцію з футболу та на 44,5% від об'єму м'яза студентів контрольної групи, а також встановлено, що об'єм присереднього широкого м'яза чотириголового м'яза стегна в нижній третині у студентів, які відвідували секцію з футболу на 31,3% більший, порівняно зі студентами контрольної групи.
Ключові слова: нижня кінцівка, скелетні м'язи, м'язи, анатомія, морфометрія, ультразвукове дослідження, спортсмени, людина.

It is known that in order to achieve a certain success in sports, in addition to studying biometric, anthropometric indicators and the development of biomechanical technologies, morphometry is important for planning future sports achievements. It should be noted that in the field of sports, information about muscle morphology is very valuable for diagnosis or further studies after treatment or training [1-4].

The muscle structure and distribution play a central role in determining sports results, especially in sports involving speed and strength [5, 6].

The ultrasound imaging is a tool commonly used to visualize soft tissue structures, which allows for the quantitative determination of muscle size and structure. These morphological variables are important determinants of muscle strength and range of tension [7-9].

It is the four thigh muscles that make up the quadriceps femoris that allow players to sprint or maintain a steady run during a game. The development of these muscles makes players faster and also provides more power for kicking [10-15].

So, ultrasound examination of the vastus medialis quadriceps femoris muscle in order to establish the morphometric parameters of this muscle in football players for recommendations on sports selection is relevant and requires further study.

There are almost no studies on the morphometric parameters of the vastus medialis quadriceps femoris muscle using ultrasound.

The purpose of the study was to establish the volume of the vastus medialis muscle of the quadriceps femoris muscle in order to determine sports orientation and selection for professional football.

Material and methods. The study was conducted on 48 young men aged 16 to 18. The main group consists of 32 young men, of whom Group I – 16 players of the team of masters of sports of Ukraine in football «University», Chernivtsi and Group II – 16 students of the I-II courses of the Faculty of Physical Culture, Sports and Rehabilitation of Yuriy Fedkovych Chernivtsi National University. Group III – a control group, which consisted of 16 students of the I-II courses of the medical faculties of Bukovina State Medical University.

The respondents of the main group were practically healthy young men – masters of sports of Ukraine, who systematically trained and participated in the championships of Ukraine among higher educational institutions, under the guidance of the team coach and student-football players, who, in addition to the physical activity that was part of the program of their specialty, attended football sections.

Also, apart from playing football, the subjects of the main group did not engage in other sports.

The subjects of the control group were also practically healthy young men who were loaded with hours of physical education, according to the program of their specialty and did not do any additional sports.

The average body weight of the subjects is 78.50±2.26 kg, height – 180.40±2.36 cm.

All respondents underwent a morphometric study using ultrasound diagnostics of the vastus medialis muscle of the quadriceps muscle of the thigh using the VolusonTM E 10 device (Austria), in 2D linear sensor mode, at the Bazismed medical center in Chernivtsi. The length, width and depth (in the upper, middle and lower thirds) were determined.

The length of the medial vastus quadriceps femoris muscle was determined from the lower segment of the interacetabular line and the adjacent part of the anterior surface of the femur, the medial lip of the rough line and the medial intermuscular septum of the thigh to the common tendon of the quadriceps femoris muscle. The width was determined between the edges in the widest part of the muscle. The depth was determined in the upper, middle and lower thirds of the muscle (Fig. 1).

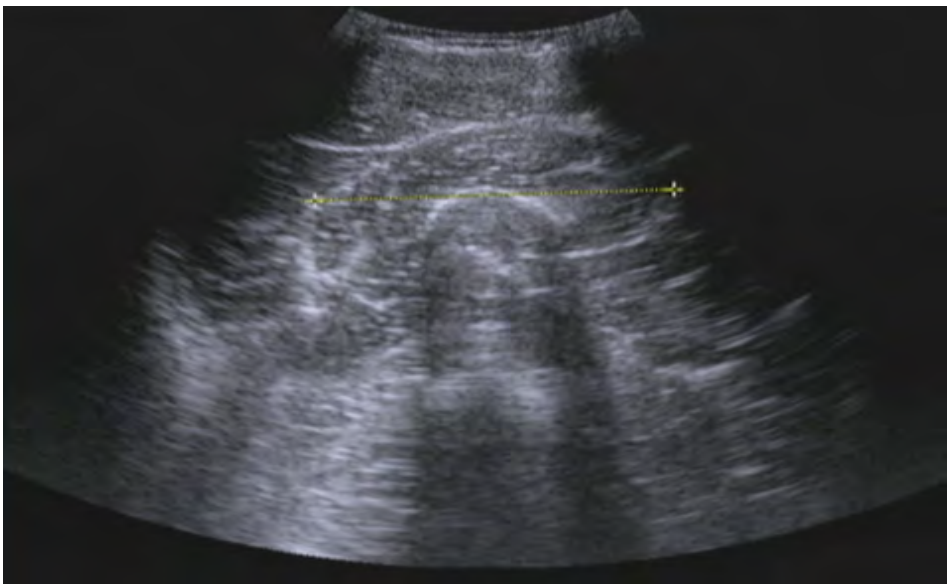

Fig. 1. Frontal section of the thigh of a young man D., 18 years old. Ultrasound was used to examine the structure of the vastus medialis muscle of the quadriceps femoris, namely its echogenicity, echostructure, blood flow, and acoustic density

Tables 1, 2, 3 (volume of the vastus medialis muscle of the quadriceps femoris in the upper, middle and lower third (mm^3), for each group display the mean (mean), 95% confidence interval limits for the mean (lower, upper), standard deviation (SD), and standard error (SE). A vertical height meter was used to measure height. Body weight (weighing) was carried out on floor scales (electronic).

One-way ANOVA was used to identify significant differences in mean volume values between groups of respondents.

Table 1

Mean values of m. vastus medialis of the quadriceps femoris muscle in the upper third (mm^3)

Group	Mean	lower	Upper	SD	SE
I	1246711.2	1118600.0	1374822.4	343088.19	62639.05
II	1068139.1	1046755.6	1089522.6	57266.06	10455.30
III	756440.3	667224.2	845656.4	247452.33	43743.80

Group I – professional football players;
Group II – students who attended the football section;
Group III – control group.

Table 2

Mean values of m. vastus medialis of the quadriceps femoris muscle in the middle third (mm^3)

Group	Mean	lower	Upper	SD	SE
I	1042325.5	934962.8	1149688.2	287522.60	52494.20
II	865596.9	834342.6	896851.3	83700.72	15281.59
III	666458.8	626125.0	706792.7	111871.24	19776.23

Group I – professional football players;
Group II – students who attended the football section;
Group III – control group.

Table 3

Mean values of m. vastus medialis of the quadriceps femoris muscle in the lower third (mm^3)

Group	Mean	lower	Upper	SD	SE
I	1023318.1	841067.5	1205568.8	488076.17	89110.11
II	826649.7	797781.7	855517.8	77310.17	14114.84
III	567742.6	510636.3	624848.9	158391.76	27999.97

Group I – professional football players;
Group II – students who attended the football section;
Group III – control group.

Results of the study and their discussion. After conducting a search for scientific works in the field of morphometric research of the vastus medialis muscle of the quadriceps femoris muscle of football players, using ultrasound research, it was concluded that there are very few scientific works in this area.

Gayovich V. V. (2014), studied, using ultrastructural studies, the features of denervation processes in the muscles of the limbs, as well as the reason for the greater tolerance of the muscles of the limbs to denervation in the experiment. Morphometric analysis was performed on electron micrographs by studying morphometric indicators (cross-sectional area of muscle fibers as an indicator of their edema and dystrophy; number of muscle fiber nuclei (myonuclei); area of muscle fiber nuclei as a marker of hypotrophic changes; cross-sectional area of structural elements of the microcirculatory bed as an indicator of changes in regional microcirculation of satellite cells, destruction of sarcomeres of contractile myofibrils and dilation of hemocapillaries and venules of the muscle). As a result of the study, denervation processes were accompanied by replacement of the denervated muscle with stromal elements [1].

According to our ultrasound data of the medial vastus medialis muscle of the quadriceps muscle of the thigh of professional football players and the subjects of the control group, it was found that the echostructure of the medial vastus medialis muscle of the thigh in respondents of all groups is not disturbed, echogenicity is normal, blood flow is normal, and acoustic density is normal.

So, according to the results of the study, it was found that the average value of the volume of the medial vastus medialis muscle of the thigh in the upper third for the first group is 1246711.2 mm^3, the 95% confidence interval for the average is (1118600.0; 1374822.4) and this means that with a probability of 95%, the value of the volume of the medial vastus medialis muscle of the thigh in the upper third for new subjects from among professional football players will be in the range from 1118600.0 to 1374822.4 mm^3.

So, it was found that the value of the volume of the vastus medialis muscle of the thigh in the upper third for professional football players is 1246711.2±343088.19 (if using SD) or 1246711.2±62639.05 if using SE.

One-way analysis of variance showed that there is a statistically significant difference in the mean values of the assessment of the volume of the vastus medialis muscle of the quadriceps femoris in the upper third between the groups

(F_{Welch} (2,43.08) = 28.32, p < 0.001).

The value of ω2p = 0.54, 95% CI = (0.36; 1.00), shows that the volume of the vastus medialis muscle of the quadriceps femoris in the upper third has a strong effect on the groups of subjects (Fig. 2).

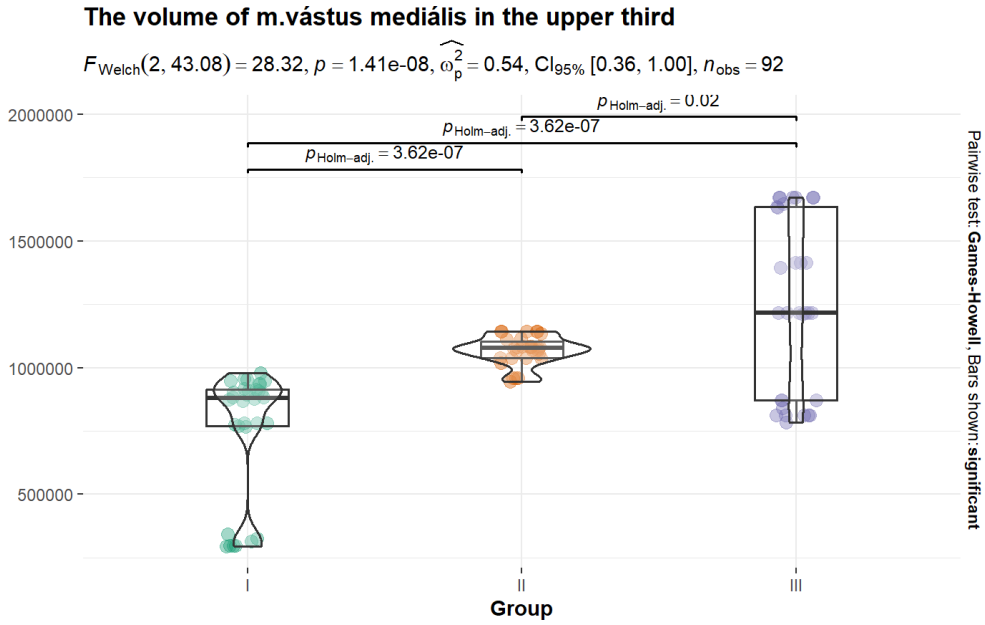

Fig. 2. The difference between the mean values of the assessment of the vastus medialis of the quadriceps femoris muscle volume in the upper third

For interpretation, the Discovering Statistics Using IBM SPSS Statistics scale was used: ES < 0.01 – Very small, 0.01<=ES < 0.06 – Small, 0.06<=ES <0.14 – Medium, ES>= 0.14 – Large.

As a result of the Games-Howell post hoc test, it was found that the average value of the volume of the vastus medialis muscle of the quadriceps femoris muscle in the upper third differed significantly between groups I and II (p<0.001), I and III (p<0.001), II and III (p=0.02) (Fig. 3).

One-way analysis of variance showed that there was a difference in the mean values of the assessment of the volume of the vastus medialis quadriceps muscle in the middle third between the two groups (F_{Welch} (2,53.14) = 42.09, p = 1.11e-11).

The value of ω2p = 0.59, CI = (0.45; 1.00), shows that the volume of the vastus medialis quadriceps muscle in the middle third also has an effect on the groups of respondents (Fig. 3).

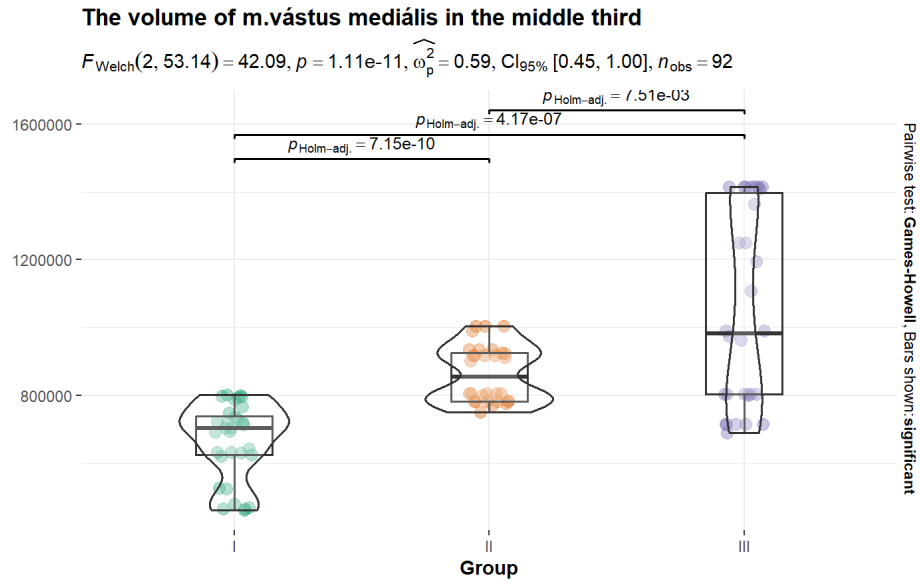

Fig. 3. The difference between the mean values of the assessment of the vastus medialis of the quadriceps femoris muscle volume in the middle third

As a result of the Games-Howell post hoc test, it was found that the mean value of the volume of the vastus medialis quadriceps muscle in the middle third was significantly different between groups I and III ($p < 0.001$), II and III ($p < 0.001$).

One-way analysis of variance showed that there was a difference in the mean values of the volume assessment of the vastus medialis quadriceps muscle in the lower third between the two groups (FWelch (2,48.05) = 37.40, p = 1.61e-10).

The value of ω2p = 0.59, CI = (0.43, 1.00), shows that the volume of the vastus medialis quadriceps muscle in the lower third also has an effect on the two groups of subjects (Fig. 4).

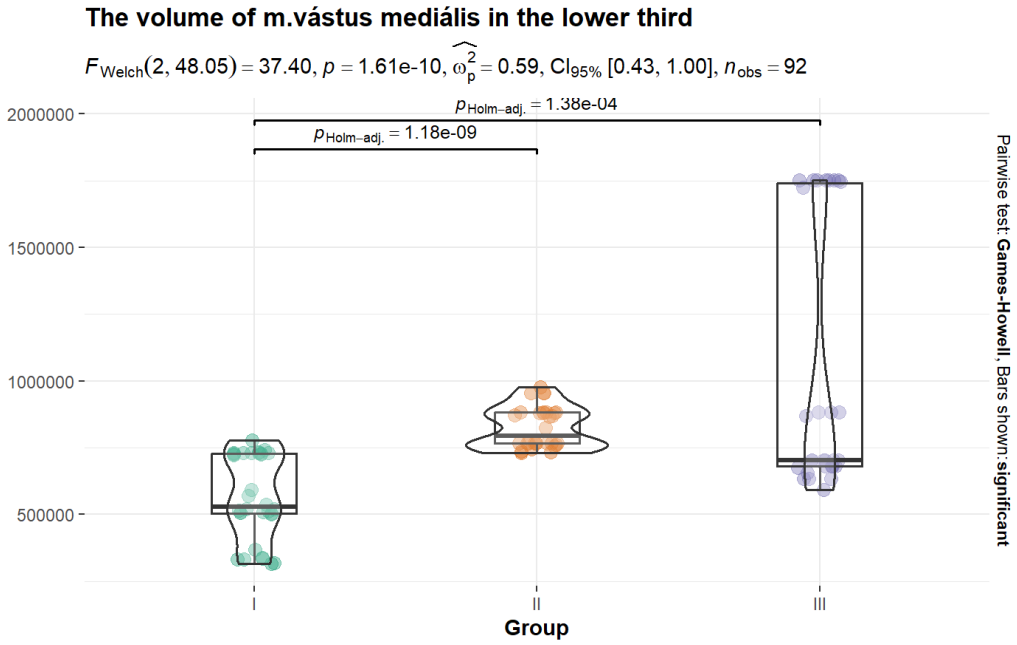

Fig. 4. The difference between the mean values of the assessment of the vastus medialis of the quadriceps femoris muscle volume in the lower third

As a result of the Games-Howell post hoc test, it was found that the mean value of the volume of the vastus medialis quadriceps muscle in the lower third was significantly different between groups I and III ($p < 0.001$), II and III ($p < 0.001$).

So, according to the results of the volume of the medial vastus quadriceps muscle in the upper third, a difference was established between professional football players and students who attended the football section, where a larger volume in the upper third is noted in professional football players by 14.3%, compared to students who attended the football section, as well as with the control group, where a larger volume of the medial vastus quadriceps muscle in the upper third is noted in professional football players by 39.3% compared to students in the control group.

There is also a difference between students who attended the football section and the control group, where a larger volume of the medial vastus quadriceps muscle in the upper third is noted in students who attended the football section by 29.2%, compared to students in the control group.

According to the results of the volume of the medial vastus quadriceps muscle in the middle third, there is also a difference between the groups, namely, in professional football players, the muscle volume is 17.0% larger than the muscle volume of students who attended the football section and 36.1% larger than the muscle volume of students in the control group.

Also, by comparison, a difference in the volume of the medial vastus quadriceps muscle in the middle third was established between groups II and III, where the volume of the medial vastus quadriceps muscle in the middle third of students who attended the football section is 23.0% larger, in contrast to the volume of the medial vastus quadriceps muscle in the middle third of students in the control group.

According to the results of the volume of the medial vastus quadriceps muscle in the lower third, there is an obvious difference between professional football players and students who attended the football section, where the volume of the medial vastus quadriceps muscle in the lower third in professional football players is 19.2% larger than in students who attended the football section and 44.5% larger than in students in the control group.

There is also a difference in the comparison between groups II and III, since the volume of the medial vastus quadriceps muscle in the lower third in students who attended the football section is 31.3% larger than in students in the control group.

In summary, it can be concluded that ultrasound examination of the vastus medialis muscle of the quadriceps femoris to determine the volume in the upper, middle, and lower thirds has practical value in terms of recommendations for determining sports orientation and selection for professional football.

Conclusions. 1. According to the results of the volume of the vastus medialis of the quadriceps femoris muscle in the upper third, it was found that the muscle volume of professional football players is 14.3% larger than the muscle volume of students who attended the football section and 39.3% larger than the muscle volume of students in the control group. 2. By comparison, it was found that the volume of the vastus medialis of the quadriceps femoris muscle in the upper third is larger in students who attended the football section by 29.2% compared to students in the control group. 3. According to the results of the volume of the vastus medialis of the quadriceps femoris muscle in the middle third, it was found that the muscle volume of professional football players is 17.0% larger than the muscle volume of students who attended the football section and 36.1% larger than the muscle volume of students in the control group. 4. By comparison, it was found that the volume of the medial vastus quadriceps femoris muscle in the middle third of students who attended the football section was 23.0% larger, in contrast to the volume of the medial vastus quadriceps femoris muscle of the control group students. 5. According to the results of the volume of the medial vastus quadriceps femoris muscle in the lower third, it was found that the volume of the medial vastus quadriceps femoris muscle in the lower third of professional football players was 19.2% larger, compared to students who attended the football section and 44.5% larger than the volume of the muscle of students in the control group. 6. By comparison, it was found that the volume of the medial vastus quadriceps femoris muscle in the lower third of students who attended the football section was 31.3% larger, compared to students in the control group.

References

1. Haiovych VV. Osoblyvosti strukturnykh zmin skeletnykh miaziv kintsivok pry tryvalii denervatsii v eksperymenti. Visnyk ortopedii, travmatolohii ta protezuvannia. 2014;4:42-6.

3. Ezeiza J, Tam N, Torres-Unda J, Granados C, Santos-Concejero J. Anthropometric characteristics of top-class Olympic race walkers. Journal of Sports Medicine and Physical Fitness. 2019; 59(3):429-33. https://doi.org/10.23736/S0022-4707.18.08363-9.

4. Gardasevic J, Bjelica1 D, Vasiljevic I, Corluka M, Arifi F, Sermaxhaj S. Morphological Characteristics and Body Composition of the Winners of the Soccer Cup of Bosnia and Herzegovina and Kosovo. Sport Mont 2020;18(1):103-5. DOI 10.26773/smj.200219.

5. Gusic M, Popovic S, Masanovic B, Radakovic M. Sport-specific morphology profile: differences in anthropometric characteristics among elite soccer and handball players. Sport Mont. 2017;15(1):3-6. http://www.sportmont.ucg.ac.me/clanci/SM_februar_2017_Gusic.pdf.

6. Hyka A, Bicoku E, Mysliu A, Cuka A. The Association of Sprint Performance with Anthropometric Parameters in Youth Soccer Players. Sport Mont. 2017;15(1):31-3. http://www.sportmont.ucg.ac.me/clanci/SM_februar_2017_Hyka.pdf.

7. Karatieieva SYu, Slobodian OM, Tsurkan IM, Kozlovska GO, Grodetskyy VK. Comparative morphometric characteristics of the rectus femoris muscle of the hipaccording to the data of the ultrasound study. Svit medytsyny ta biolohiyi. 2024;2(88):71-6. DOI: 10.26724/2079-8334-2024-2-88-71-76.

8. Karatieieva S. Yu, Slobodian O.M, Moseychuk Yu. Yu, Muzyka N. Ya, Slobodian K.V, Moroz O. O. Dynamic comparison the lower extremities length in students education in higher institutions. Wiadomosci Lekarskie. 2024; LXXVII(3):456-61. DOI: 10.36740/WLek202403113.

9. Kerr A, Slater GJ, Byrne N. Impact of food and fluid intake on technical and biological measurement error in body composition assessment methods in athletes. Br J Nutr. 2017 Feb;117(4):591-601. doi: 10.1017/S0007114517000551.

10. Masanovic B, Bavcevic T, Bavcevic I. Comparative Study of Anthropometric Measurement and Body Composition between Junior Soccer and Volleyball Players from the Serbian National League. Sport Mont 2019;17(1):9-14. DOI 10.26773/smj.190202.

11. Pavlović R, Mihajlović I, Radulović N, Nikolić S. Anthropometric parameters of elite male runners sprint: are body height and body weight good predictors of results. Health, sport, rehabilitation, 2022;8(3):64-74. DOI: https://doi.org/10.34142/HSR.2022.08.03.05.

12. Thomas D, Erdman K, Burke L. American College of Sports Medicine joint position statement. Nutrition and athletic performance. Medicine and Science in Sports and Exercise. 2016;48(3);543-68. https://doi.org/10.1249/MSS.0000000000000852.
13.Vujkov S, Casals C, Krneta Z, Drid P. Ultra short-term heart rate recovery after maximal exercise in two different body positions in elite male judokas compared to students of the sport faculty. Sport Mont. 2016;14(1):7-11. http://www.sportmont.ucg.ac.me/clanci/SM_feb_2016_Vujkov.pdf.
14. Wakahara T, Ema R, Miyamoto N, Kawakami Y. Inter- and intramuscular differences in training-induced hypertrophy of the quadriceps femoris: association with muscle activation during the first training session. Clin. Physiol. Funct. Imaging. 2015;37(4):405-12. DOI:10.1111/cpf.12318.
15. Weide G, van der Zwaard S, Huijing PA, Jaspers RT, Harlaar J. 3D Ultrasound Imaging: Fast and Cost-effective Morphometry of Musculoskeletal Tissue. J Vis Exp. 2017 Nov 27;(129):55943. doi: 10.3791/55943.

MORPHOMETRIC CHARACTERISTICS OF THE VASTUS MEDIALIS MUSCLE OF THE QUADRICEPS FEMORIS MUSCLE OF THE THIGH ACCORDING TO THE DATA OF THE ULTRASOUND STUDY

Abstract. In order to morphometrically compare the volume of the vastus medialis quadriceps femoris muscle, 48 young men aged 16 to 18 years were studied, where the main group consisted of 32 students and the control group consisted of 16 students.
As a result of the comparison of the morphometric parameters of the vastus medialis quadriceps femoris muscle according to ultrasound data, it was found that the muscle volume of professional football players is 14.3% larger than the muscle volume of students who attended the football section and 39.3% larger than the muscle volume of students in the control group, and it was also found that the volume of the vastus medialis quadriceps muscle in the upper third is larger in students who attended the football section by 29.2% compared to students in the control group.
According to the results of the volume of the medial vastus quadriceps muscle in the middle third, it was found that the muscle volume of professional football players is 17.0% larger than the muscle volume of students who attended the football section and 36.1% larger than the muscle volume of students in the control group, and it was also found that the volume of the medial vastus quadriceps muscle in the middle third of students who attended the football section is 23.0% larger, in contrast to the volume of the medial vastus quadriceps muscle of students in the control group.
According to the results of the volume of the medial latissimus dorsi muscle of the quadriceps femoris in the lower third, it was found that the volume of the medial latissimus dorsi muscle of the quadriceps femoris in the lower third of professional football players was 19.2% larger than that of students who attended the football section and 44.5% larger than that of the muscle of students in the control group, and it was also found that the volume of the medial latissimus dorsi muscle of the quadriceps femoris in the lower third of students who attended the football section was 31.3% larger than that of students in the control group.
Key words: lower limb, skeletal muscles, muscles, anatomy, morphometry, ultrasound examination, athletes, human.

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