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ABSTRACT

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MORPHOMETRIC CHARACTERISTICS OF THE VASTUS LATERALIS MUSCLE OF THE QUADRICEPS GROUP OF THE THIGH ACCORDING TO ULTRASOUND RESEARCH

The structure and distribution of muscles play a central role in determining athletic performance, especially in sports involving speed and strength.

Objective: To determine the volume of the vastus lateralis muscle (part of the quadriceps femoris) in relation to sports orientation and selection for professional football.

Materials and Methods: A total of 48 young men were studied, including 16 players from the Ukrainian professional football team “Universytet” (Chernivtsi), 16 first- and second-year students of the Faculty of Physical Culture, Sports and Rehabilitation at Yuriy Fedkovych Chernivtsi National University, and 16 first- and second-year medical students of Bukovinian State Medical University. All participants underwent morphometric assessment using ultrasound imaging of the vastus lateralis muscle of the quadriceps femoris. Measurements included length, width, and depth.

Results: In the upper third of the muscle, the volume in professional football players was 14.3% greater than in students attending football training and 39.3% greater than in control group students.

In the middle third, the muscle volume in professional football players was 17.0% greater than in students attending football training and 36.1% greater than in control group students.

In the lower third, the volume of the vastus lateralis in professional football players was 19.2% greater than in students attending football training and 44.5% greater than in control group students.

Conclusion: Ultrasound examination of the vastus lateralis muscle to determine its volume in the upper, middle, and lower thirds has practical significance for identifying sports orientation and selecting candidates for professional football.

Keywords: lower limb, skeletal muscles, muscles, anatomy, morphometry, ultrasound examination, athletes, students, human.

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

Структура та розподіл м'язів відіграють центральну роль у визначенні спортивних результатів, особливо в видах спорту, що включають швидкість та силу.

Мета: встановлення об'єму бічного широкого м'яза чотириголового м'яза стегна щодо спортивної орієнтації та відбору у професійний футбол.

Матеріали та методи: досліджено 48-м юнаків, з них 16 гравців команди майстрів спорту України з футболу «Університет», м. Чернівці та 16 студентів I-II курсів факультету фізичної культури, спорту та реабілітації Чернівецького національного університету імені Юрія Федьковича і 16 студентів I-II курсів медичних факультетів Буковинського державного медичного університету. Усім проведено морфометричне дослідження за допомогою ультразвукової діагностики бічного широкого м'яза чотириголового м'яза стегна. Встановлювали довжину, ширину та глибину.

За **результатами** об'єму бічного широкого м'яза чотириголового м'яза стегна в верхній третині 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. За результатами об'єму бічного 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. За результатами об'єму бічного широкого м'яза чотириголового м'яза стегна в нижній третині встановлено, що об'єм бічного 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.

Підсумовуючи, можна зробити **висновок**, що ультразвукове дослідження широкого бічного м'яза стегна для визначення об'єму в верхній, середній та нижній третині має практичне значення з метою визначення спортивної орієнтації та відбору у професійний футбол.

Ключові слова: нижня кінцівка, скелетні м'язи, м'язи, анатомія, морфометрія, ультразвукове дослідження, спортсмени, студенти, людина.

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INTRODUCTION

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

The four thigh muscles that make up the quadriceps femoris are responsible for allowing 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 [10–14].

It is known that to achieve a certain level of 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 follow-up studies after treatment or training [1–4].

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

So, ultrasound examination of the vastus lateralis quadriceps muscle 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 works devoted to the study of the morphometric parameters of the vastus lateralis quadriceps muscle using ultrasound.

MATERIALS AND METHODS

The study was conducted on 48 young men aged 16 to 18. The main group consisted 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.

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 selection of subjects was carried out according to general anthropometric parameters (total and partial).

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

All respondents underwent a morphometric study using ultrasound diagnostics of the vastus lateralis muscle of the quadriceps femoris. The length, width and depth were determined. The length was determined from the lower part of the greater trochanter, the upper segment of the interacetabular line, the ischial tuberosity, the upper segment of the lateral lip of the rough line and the lateral intermuscular membrane to the common tendon of the quadriceps 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.

The Tables 1, 2, 3 for each group display the mean, 95% confidence interval limits for the mean (lower, upper), standard deviation (SD), and standard error (SE).

Table 1 – Mean values of m. vastus lateralis volume in the upper third (mm³)

Group	Mean	lower	Upper	SD	SE
I	1716747	1688934.9	1744560	74483.43	13598.75
II	1383190	1324319.8	1442061	1576558.03	28784.29
III	1104279	982801.2	1225757	336934.94	59562.24

Table 2 – Mean values of m. vastus lateralis volume in the middle third (mm³)

Group	Mean	lower	Upper	SD	SE
I	1328522	1302357	1354687	70071.2	12793.19
II	1295277	1243182	1347372	144492.4	25542.90
III	1184121	1072561	1295681	298763.5	54546.50

Table 3 – Mean values of m. vastus lateralis volume in the lower third (mm³)

Group	Mean	lower	Upper	SD	SE
I	973530.7	853995.8	1093066	331545.52	58609.52
II	936896.1	853446.5	1020346	223482.0	40802.04
III	773532.0	673384.0	873680	268201.3	48966.63

Note: I group – professional football players; II group – students who attended the football section; III group – control group

To identify significant differences in mean volume values between groups of respondents, one-way analysis of variance (one-way ANOVA) was used.

RESULTS. The results of the average values of the volume of the vastus lateralis muscle in the upper, middle and lower third (mm³), for each group reflect the average value (mean), the limits of the 95% confidence interval for the mean (lower, upper), the standard deviation (SD), and the standard error (SE).

According to our data on ultrasound of the vastus lateralis muscle of professional football players, students who attended the football section and the subjects of the control group, it was established that the echostructure of the vastus lateralis muscle in the subjects of all groups is not disturbed, the echogenicity is normal, the blood flow is normal, and the acoustic density is normal.

According to the results of the study, it was found that the average value of the volume of the vastus lateralis muscle in the upper third for the first group is 1716747 mm³, the 95% confidence interval for the average is (1688934.9; 1744560) and this means that with a probability of 95%, the value of the volume of the vastus lateralis muscle in the upper third for the new study participants from among professional football players will be in the range from 1688934.9 to 1744560 mm³. The average value of the volume of the vastus lateralis muscle in the middle third for the first group is 13285522 mm³, the 95% confidence interval for the average is (1302357; 1354687) and this means that with a probability of 95% we can state that the value of the volume of the vastus lateralis muscle in the middle third for the new subjects from among professional football players will be in the range from 1302357 to 1354687 mm³.

Also, the average value of the volume of the vastus lateralis muscle in the lower third for the first group is 973530.7 mm³, the 95% confidence interval for the average is (853995.8; 1093066.3) and this means that with a probability of 95% we can state that the value of the volume of the vastus lateralis muscle in the lower third for the new subjects from among professional football players will be in the range from 853995.8 to 1093066.52 mm³. The results of the study showed that

the average value of the volume of the vastus lateralis muscle in the upper third for the second group is 1383190 mm³, the 95% confidence interval for the average is (1324319.8; 1442061) and this means that with a probability of 95% we can state that the value the volume of the vastus lateralis muscle in the upper third for new subjects from among students who attended the football section will be in the range from 1324319.8 to 1442061 mm³. The average value of the volume of the vastus lateralis muscle in the middle third for the II group is 12952774 mm³, the 95% confidence interval for the average is (1243182; 1347372) and this means that with a probability of 95% we can state that the value of the volume of the vastus lateralis muscle in the middle third for new subjects from among students who attended the football section will be in the range from 1243182 to 1347372 mm³.

Also, the average value of the volume of the vastus lateralis muscle in the lower third for group II is 936896.1 mm³, the 95% confidence interval for the average is (853446.5; 1020346) and this means that with a probability of 95% we can state that the value of the volume of the vastus lateralis muscle in the lower third for the new subjects from among the students who attended the football section will be in the range from 853446.5 to 1020346 mm³.

According to the results of the study, it was found that the average value of the volume of the vastus lateralis muscle in the upper third for the control group is 1104279 mm³, the 95% confidence interval for the average is (982801.2; 1225757) and this means that with a probability of 95% we can state that the value of the volume of the vastus lateralis muscle in the upper third for the new subjects from among the students of the control group will be in the range from 982801.2 to 1225757 mm³. The average value of the volume of the vastus lateralis muscle in the middle third for students in the control group is 1184121 mm³, the 95% confidence interval for the average is (1072561; 1295681) and this means that with a probability of 95% we can state that the value of the volume of the vastus lateralis muscle in the middle third for new subjects from among students in the control group will be in the range from 1072561 to 1295681 mm³.

Also, the average value of the volume of the vastus lateralis muscle in the lower third for students in the control group is 773532.0 mm³, the 95% confidence interval for the average is (673384.0; 873680) and this means that with a probability of 95% we can state that the value of the volume of the vastus lateralis muscle in the lower third for new subjects from among students in the control group will be in the range from 673384.0 to 873680 mm³.

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 lateralis muscle in the upper third between the groups (FWelch (2,48.71) = 94.72, p < 0.001).

The value of $\omega^2p = 0.78$, 95% CI = (0.69; 1), shows that the volume of the vastus lateralis muscle in the upper third has a strong effect on the groups of subjects (Fig. 1).

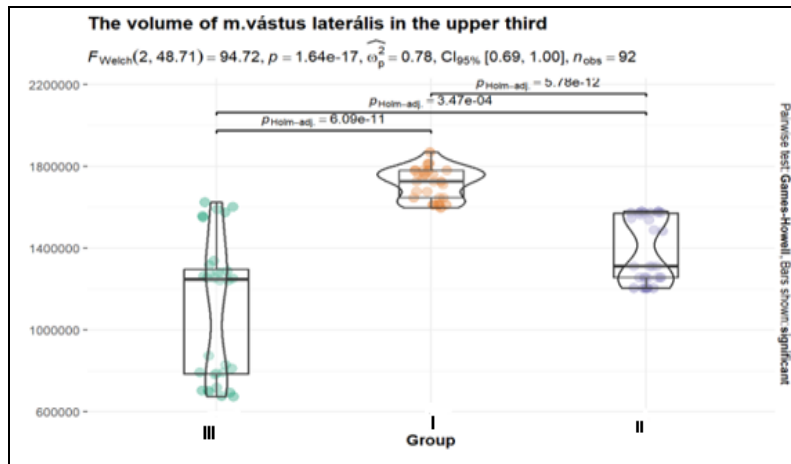


Fig. 1. The difference between the mean values of the assessment of the vastus lateralis muscle volume in the upper third

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 lateralis muscle in the upper third was significantly different between groups I and II (p ≥ 0,05), I and III (p < 0.001), II and III (p = 0.02).

One-way analysis of variance showed that there was a difference in the mean values of the assessment of the volume of the vastus lateralis muscle in the middle third between the two groups (FWelch (2,48.85) = 3.68, p = 0.03).

The value of $\omega^2p = 0.09$, CI = (0.00; 1.00), shows that the volume of the vastus lateralis muscle in the middle third also has an effect on the groups of respondents (Fig. 2).

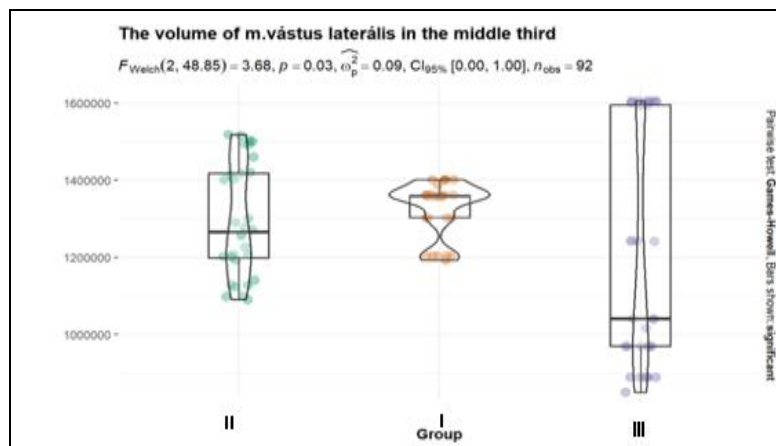


Fig. 2. The difference between the mean values of the assessment of the vastus lateralis muscle volume in the middle third

As a result of the Games-Howell post hoc test, it was found that the mean value of the volume of the vastus lateralis 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 is a difference in the mean values of the assessment of the

volume of the vastus lateralis muscle in the lower third between the two groups ($F_{Welch}(2, 58.47) = 4.45, p = 0.02$).

The value of $\omega_2^2 p = 0.10, CI = (1.37e-03, 1.00)$, shows that the volume of the vastus lateralis muscle in the lower third also has an effect on the two groups of subjects (Fig. 3).

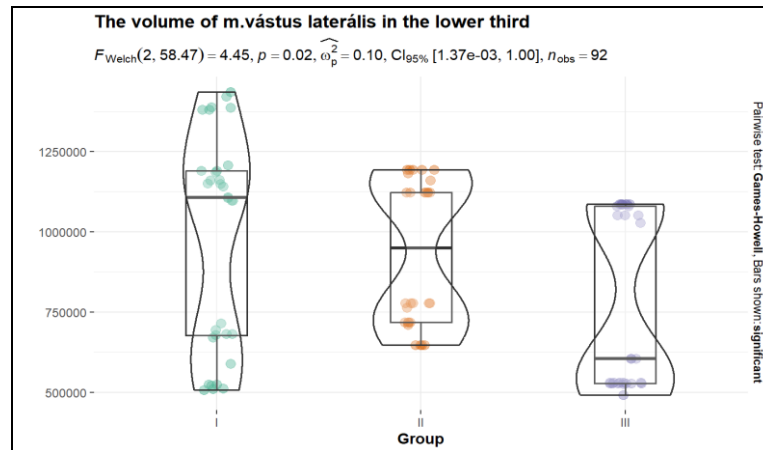


Fig. 3. The difference between the mean values of the assessment of the vastus lateralis muscle volume in the lower third

As a result of the Games-Howell post hoc test, it was found that the mean value of the volume of the vastus lateralis muscle in the lower third was significantly different between groups I and III ($p < 0.001$), II and III ($p \geq 0.05$).

So, according to the results of the volume of the vastus lateralis muscle in the upper third, there is obviously a difference 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 19.2%, compared to students who attended the football section, and there is also a difference between professional football players and the control group, where a larger volume of the vastus lateralis muscle in the upper third is noted in professional football players by 35.7%, compared to the control group.

Also, there is a difference between students who attended the football section and the control group, where a larger volume of the vastus lateralis muscle in the upper third is noted in students who attended the football section by 20.2%, compared to students in the control group.

According to the results of the volume of the vastus lateralis muscle in the middle third, there is also a small difference between the groups, namely, in professional football players, the volume of the vastus lateralis muscle in the middle third is 2.5% larger than in students who attended the football section and 10.9%

larger than in students in the control group. There is a difference between groups II and III, where the volume of the vastus lateralis muscle in the middle third of students who attended the football section is 8.6% larger than in students in the control group.

According to the results of the volume of the vastus lateralis 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 vastus lateralis muscle in the lower third in professional football players is 3.8% larger than in students who attended the football section and 20.5% larger than in students in the control group, and in students who attended the football section, the volume of the vastus lateralis muscle in the lower third is 17.4% larger than in students in the control group.

DISCUSSION

In our opinion, during sports selection, it is recommended to take into account the morphometric characteristics of the vastus lateralis muscle using ultrasound, since the load on it during football is also quite large.

What do the results of our study show: it was found that the volume of the vastus lateralis muscle in the upper third for professional football players is 1716747 ± 74483.43 (if using SD) or 1716747 ± 13598.75 , if using SE. in the middle third is 1328522 ± 70071.2 (if using SD) or 1328522 ± 12793.19 , if using SE and in the

lower third is 973530.7 ± 331545.52 (if using SD) or 973530.7 ± 58609.52 , if using SE.

Also, the volume of the vastus lateralis muscle in the upper third for students who attended the football section is 1716747 ± 74483.43 (if using SD) or 1716747 ± 13598.75 if using SE, in the middle third is 1295277 ± 144492.4 (if using SD) or 1295277 ± 25542.90 if using SE and in the lower third is 936896.1 ± 223482.0 (if using SD) or 936896.1 ± 40802.04 if using SE.

Also, the volume of the vastus lateralis muscle in the upper third for the control group is 1104279 ± 336934.94 (if using SD) or 1104279 ± 59562.24 , if using SE. in the middle third is 1184121 ± 298763.5 (if using SD) or 1184121 ± 54546.50 , if using SE and in the lower third is 773532.0 ± 268201.3 (if using SD) or 773532.0 ± 48966.63 , if using SE.

So, it was found that the largest volume of the vastus lateralis muscle is in professional football players and students who attended the football section, and the smallest volume of the vastus lateralis muscle is in the control group.

In summary, it can be concluded that ultrasound examination of the vastus lateralis muscle 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 lateralis muscle of the quadriceps femoris in the upper third, it was found that the muscle volume of professional football players is 19.2% larger than the muscle volume of students who attended the football

section and 35.7% larger than the muscle volume of students in the control group.

2. By comparison, it was found that the volume of the vastus lateralis muscle of the quadriceps femoris in the upper third is 20.2% larger in students who attended the football section compared to students in the control group.

3. According to the results of the volume of the vastus lateralis quadriceps muscle in the middle third, it was found that the muscle volume of professional football players is 2.5% larger than the muscle volume of students who attended the football section and 10.2% larger than the muscle volume of students in the control group.

4. By comparison, it was found that the volume of the vastus lateralis quadriceps muscle in the middle third of students who attended the football section is 8.6% larger, in contrast to the volume of the vastus lateralis quadriceps muscle of students in the control group.

5. According to the results of the volume of the vastus lateralis muscle of the quadriceps muscle in the lower third, it was found that the volume of the vastus lateralis muscle of the quadriceps muscle in the lower third of professional football players was 3.8% larger than that of students who attended the football section and 20.5% larger than that of the muscle of students in the control group.

6. By comparison, it was found that the volume of the vastus lateralis muscle of the quadriceps muscle in the lower third of students who attended the football section was 17.4% larger than that of students in the control group.

PROSPECTS FOR FUTURE RESEARCH

Further study of anthropometric and morphometric parameters of athletes using ultrasound to solve selection and sports orientation problems.

AUTHOR CONTRIBUTIONS

All authors substantively contributed to the drafting of the initial and revised versions of this paper. They take full responsibility for the integrity of all aspects of the work.

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CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

ARTIFICIAL INTELLIGENCE DISCLOSURE

No artificial intelligence (AI) technology was used in the writing or editing of this manuscript.

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