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TESTOVÁNÍ VÝSKOKU JEDNONOŽ A OBOUNOŽ U VÝKONNOSTNÍCH SPORTOVNÍCH GYMNASTŮ

SINGLE-LEG AND BOTH LEG JUMP TESTING FOR PERFORMANCE SPORTS GYMNASTS

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Abstract

This article deals with the comparison of jumps of the left and right lower limbs, the muscles of both lower limbs and subsequently their correlation, both in terms of jump and in terms of the amount of muscle mass. Subsequently, the laterality of the lower limbs is also assessed. The average age of probands is 8.58 years ± 1.88 years, the average height is 132.3 cm ± 11.4 cm with an average weight of 28.17 kg ± 11.93 kg. They are tested on a one-time test on the Tanita tread weight, which analyzes their percentage of fat, body water and diagnoses their segmental distribution of muscle mass. Furthermore, the probands are tested in the form of jumping measurements on the LEM 10 with ProJump jumping platform, where two jumps from the right and left lower limbs are performed for each of them, followed by one leg jump. A significant relationship between the amount of muscle mass and the jump of the probands was not demonstrated on either of the limbs measured. A total of 56% of gymnasts were found to be related between the preferred lower limb and its better reflective performance.

Keywords: body composition; laterality; measurement; talent; muscle mass

Souhrn

Tento článek se zabývá porovnáním výskoku pravé a levé dolní končetiny a následnou komparací s množstvím svalové hmoty na obou končetinách u mladých výkonnostních gymnastů. Následně se také posuzuje lateralita dolních končetin. Zajímala nás ale odrazová končetina. Testovaný vzorek byl složen z 9 výkonnostních gymnastů mladšího školního věku z oddílu TJ Merkur České Budějovice. Průměrný věk probandů je 8,58 let ± 1,88 roku, průměrná výška je 132,3 cm ± 11,4 cm s průměrnou hmotností 28,17 kg ± 11,93 kg, kteří byli jednorázově testováni na nášlapné váze Tanita, která analyzuje jejich procento tuku, tělesné vody a diagnostikuje jejich segmentální rozložení svalové hmoty. Dále byli gymnasté testováni formou měření výskoku na odrazové plošině LEM 10 with ProJump, kde byly u každého z nich provedeny dva skoky z pravé a levé dolní končetiny a následně jeden skok snožný. Významný vztah mezi množstvím svalové hmoty a výskoky probandů prokázán nebyl, a to ani na jedné z měřených končetin. Celkem u 56 % gymnastů byla zjištěna souvislost mezi preferovanou (odrazovou) dolní končetinou, a i jejím lepším odrazovým výkonem.

Klíčová slova: lateralita; měření; složení těla; svalová hmota; talent

Introduction

Gymnastics became an officially recognized sport in 1896 when it was included in the program of the first modern Olympic Games, and it has since remained a celebrated highlight of the Games (Havlíčková et al., 2006). Skolnik and Chernus (2011) note that gymnastics, along with other sports in similar categories, encompasses a wide range of competitive and training programs. For children and adolescents, it is possible to examine the specific components of sports training and their unique characteristics. Conditioning training includes strength training, as well as speed, endurance, flexibility,

and coordination exercises. For young athletes, it is beneficial to prioritize skill acquisition approaches that simplify these skills (for example, through play), apply them comprehensively, and offer a variety of suitable activities (Piňos, 2007). Additionally, training should be adapted to the athletes' age (Bahenský & Bunc, 2018; Bahenský et al., 2021). In this context, the research focused on comparing the jump performance of the right and left lower limbs and the subsequent comparison with the muscle mass of both limbs in young competitive gymnasts from the Merkur České Budějovice clubs. At this level, gymnasts compete in national championships and cup competitions and engage in daily 3-hour training sessions. This rigorous training places higher demands on agility, joint mobility, strength, and, importantly, the development of jump capabilities (explosive strength) in the lower limbs. Accordingly, the study also examined lower limb laterality (preferred jumping leg) in these gymnasts and compared it with their jump performance. Laterality can be morphological or functional. Morphological laterality evaluates asymmetries in body parts and organs (Mohr et al., 2003). Functional laterality, understood as the asymmetry of motor (hand, foot) or sensory (eye, ear) paired organs, is characterized by the preferential use of one paired organ (Hatta et al., 2005). Correct terminology defines the dominant limb in terms of laterality as the more skillful one, which is typically the non-jumping leg. The aim of this pilot project is to compare the jump performance of the right and left lower limbs and subsequently assess the muscle mass in both limbs in young competitive gymnasts. Additionally, the project aims to determine the laterality of the lower limbs and its relationship with jump performance.

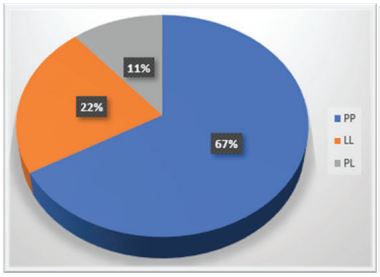
Methods

Sample Characteristics: The tested sample consisted of 9 young competitive gymnasts from the TJ Merkur České Budějovice club in the early school-age category. The average age of the participants was 8.58 years ± 1.88 years, with an average height of 132.3 cm ± 11.4 cm and an average weight of 28.17 kg ± 11.93 kg. Data were obtained using a Tanita BC 418 MA segmental analyzer and an LEM 10 force plate with ProJump. This sample was purposefully selected based on performance level (10–15 hours of training per week, participation in cup and championship competitions, including the Czech Republic Championship – higher performance class for juniors). All participants were in good physical condition at the time of testing, with no injuries or rehabilitation processes ongoing. Consent was obtained from the parents of all participants, and test results were made available to them upon request. All procedures were conducted in accordance with ethical standards.

Research Design: In this study, we cannot classify it as a true experiment in the strict sense of the term. The selection of the research sample was not random; rather, it was predetermined and intentionally selected by us. Ježek et al. (2006) and Shadish et al. (2002) note that such sampling is typical for a quasi-experiment. This selection partially threatens internal validity; however, Thomas and Nelson (1996) state that, despite this, we still retain control over the independent variable. Due to the young age of the gymnasts, it was not possible to conduct the Wingate test, so the study focused solely on assessing jump ergometry, body composition, and laterality. Testing was conducted in the exercise diagnostics laboratory at the Department of Physical Education at JCU. Participants were tested in the afternoon, generally at the same time between 3 and 5 PM, prior to training, and at least three hours after a major meal. Both the participants and their parents were informed about the entire testing procedure, and participants' current health status and parental consent were confirmed through questionnaires. All tests were performed in a standardized manner. Body composition measurements, specifically examining body fat percentage and the distribution of muscle mass between the right and left limbs, were conducted using the Tanita BC 418 MA scale. The Jumpmax test on the LEM 10 force platform with ProJump was used to measure maximum jumps from the right and left limbs, as well as a two-legged jump; the test was repeated twice, with hands on the hips, and the higher result was used for statistical analysis. This testing was supervised by competent laboratory personnel. Another objective was to determine the laterality of the lower limbs. The test was conducted at Gymcentrum Merkur České Budějovice, where the take-off leg was assessed by having participants kick a ball over a short distance, perform a single-leg jump to a bar, and execute a lunge from either leg. Pearson's correlation coefficient, a parametric test, was used for statistical analysis.

Results

Obrázek 1./ Figure 1.
Shoda odrazové dolní končetiny a odrazového výkonu./ Conformity of rebound lower limb and rebound performance.

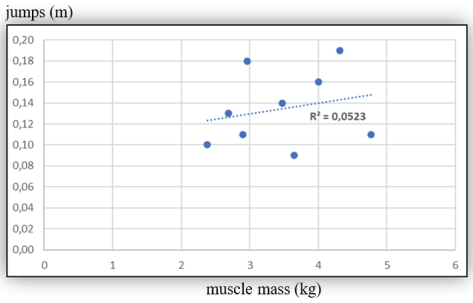


	rebound lower limb	best rebound performence	equally
Participant 1	left	right	no
Participant 2	right	right	yes
Participant 3	right	right	yes
Participant 4	right	right/left	equally
Participant 5	right	right/left	equally
Participant 6	left	left	yes
Participant 7	right	right	yes
Participant 8	right	right	yes
Participant 9	left	right	no

In this study, we aimed to determine whether the preferred take-off limb of competitive gymnasts would correspond to the strength performance of the right or left limb (rebound performance). It was found that approximately half of the gymnasts showed a correlation between the preferred take-off limb and superior rebound performance, while the other half did not. Thus, the result is inconclusive, and the hypothesis cannot be confirmed.

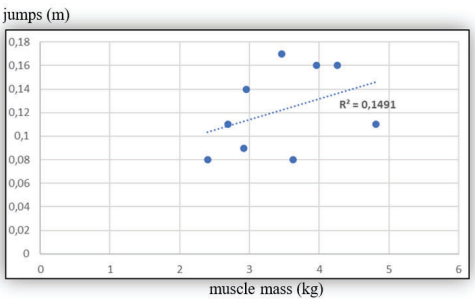
Obrázek 2./ Figure 2.
Porovnání výsledků Jumpmax testu s množstvím svalové hmoty na pravé dolní končetině./ Comparison of Jumpmax test results with muscle mass on the right lower limb.

	muscle mass (kg) (right lower limb)	better of two jumps (m)
Participant 1	2,96	0,18
Participant 2	2,38	0,10
Participant 3	4,31	0,19
Participant 4	4,00	0,16
Participant 5	4,77	0,11
Participant 6	3,47	0,14
Participant 7	2,90	0,11
Participant 8	2,69	0,13
Participant 9	3,65	0,09



Obrázek 3./ Figure 3.
Porovnání výsledků Jumpmax testu s množstvím svalové hmoty na levé dolní končetině./ Comparison of Jumpmax test results with muscle mass on the left lower limb.

	muscle mass (kg) (left lower limb)	better of two jumps (m)
Participant 1	2,95	0,14
Participant 2	2,4	0,08
Participant 3	4,26	0,16
Participant 4	3,96	0,16
Participant 5	4,81	0,11
Participant 6	3,46	0,17
Participant 7	2,92	0,09
Participant 8	2,69	0,11
Participant 9	3,63	0,08



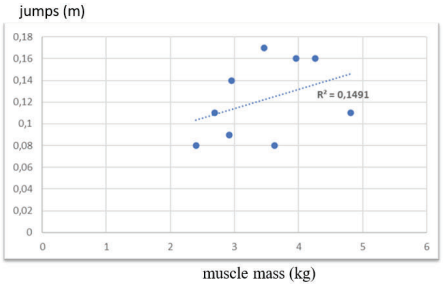
In Figure 2, we can observe a comparison of gymnasts' values for the better of two tested jumps in the Jumpmax test for the right limb and the muscle mass of that limb. The blue dots in the graph represent the individual participants and their respective results. The X-axis shows the muscle mass of the right lower limb in kilograms, while the Y-axis represents the height of the better jump for the right lower limb in meters. According to the Pearson correlation coefficient calculation for the right

lower limb, based on muscle mass and jump height in the Jumpmax test, a value of r = 0.229 was obtained, indicating a weak linear relationship.

In Figure 3, we can observe a comparison of gymnasts' values for the better of two tested jumps in the Jumpmax test for the left limb and the muscle mass of that limb. The blue dots in the graph represent the individual participants and their respective results. The X-axis shows the muscle mass of the left lower limb in kilograms, while the Y-axis represents the height of the better jump for the left lower limb in meters. According to the Pearson correlation coefficient calculation for the left lower limb, based on muscle mass and jump height in the Jumpmax test, a value of r = 0.386 was obtained, indicating a moderate linear relationship.

Obrázek 4./ Figure 4.
Porovnání výsledků Jumpmax testu s množstvím svalové hmoty pro obě dolní končetiny./ Comparison of Jumpmax test results with muscle mass for both lower limbs.

	muscle mass (kg) (bouth lower limbs)	better of two jumps (m)
Participant 1	5,91	0,25
Participant 2	4,78	0,19
Participant 3	8,57	0,32
Participant 4	7,96	0,31
Participant 5	9,58	0,25
Participant 6	6,93	0,3
Participant 7	5,82	0,28
Participant 8	5,38	0,22
Participant 9	7,28	0,2



In Figure 4, we see a comparison of gymnasts' results in the bilateral jump (Jumpmax test) and the total muscle mass of their lower limbs. The blue points in the graph represent the individual participants and their respective outcomes. The X-axis shows the total muscle mass in the lower limbs in kilograms, while the Y-axis represents the height of the bilateral jump in meters. We can observe that three gymnasts, who had above-average muscle mass in their lower limbs, also achieved above-average jump heights. For participant #7, the jump height was higher despite having lower muscle mass, whereas for participant #9, the reverse was true. The remaining participants exhibited both lower muscle mass and jump heights. The average difference between unilateral and bilateral jump heights for these high-performance gymnasts was approximately double. While the mean jump height for the right lower limb was 0.13 m and for the left was 0.12 m, the mean bilateral jump height reached 0.26 m. According to the Pearson correlation coefficient calculation for both lower limbs, considering muscle mass and jump height in the Jumpmax test, a value of r = 0.497 was obtained, indicating a moderate linear correlation.

Obrázek 5./ Figure 5.
Porovnání výsledků svalové hmoty a odrazového výskoku dolních končetin po vzájemném odečtení./ Comparison of results of muscle mass and rebound jump of lower limbs after mutual deduction.

	muscle mass (kg) R-L	jump (m) R-L
Participant 1	0,01	0,04
Participant 2	-0,02	0,02
Participant 3	0,05	0,03
Participant 4	0,04	0
Participant 5	-0,04	0
Participant 6	0,01	-0,03
Participant 7	-0,02	0,02
Participant 8	0	0,02
Participant 9	0,02	0,01

After subtracting the values and calculating the Pearson correlation coefficient of r = 0.081, we can conclude that the difference in muscle mass between the right and left limbs does not correlate with the difference in jump height when rebounding from either lower limb.

Discussion

Our tested sample consists of only 9 gymnasts. For the lower limbs, 6 participants preferred jumping with their right limb, and 3 with their left. However, some children in this sample may still have undecided laterality, as confirmed by Drnková and Syllabová (1991) in their book, which states that according to some researchers studying the time factor in the development of brain hemisphere specialization, the patterns of cerebral asymmetry, speech localization, and limb laterality may not stabilize before the age of 10 or 11. Therefore, we cannot say with certainty whether this laterality is already established and valid. Laterality is primarily innate, so, conversely, laterality in this age group does not correlate with the amount of muscle mass in the lower limbs in terms of lateral asymmetry, nor with the gymnasts' performance in explosive strength of the lower limbs. Youth gymnastics training does not appear to affect laterality. This finding is consistent with similar results from Krajcigr et al. (2023) in adolescent football players.

A significant relationship between the amount of muscle mass and the jumps of the participants was not demonstrated, neither for either of the measured limbs. For the right lower limb, the correlation reached r = 0.229, indicating a weak dependency between muscle mass and jump height. For the left limb, the correlation was slightly higher at r = 0.386, reflecting a moderate dependence, but still relatively low. Similar to the study by Bahenský et al. (2021), there is no general relationship between rebound strength and the amount of muscle mass in the lower limbs. For the two-legged jump, when comparing total muscle mass, the linear relationship was the highest, with r = 0.497. However, this represented only a moderate relationship, and considering the small sample size, this result is negligible. The study therefore found no relationship between lower limb strength and muscle mass, which aligns with published results (Flanagan et al., 2007).

Regarding the distribution of muscle mass across the lower limbs of our tested competitive gymnasts, we can say that there are minimal muscle differences, with the largest difference being only 0.05 kg, which indicates a low risk of developing muscle imbalance. This statement is confirmed by Havláková (2015), who addressed the issue of unilateral sports load on muscle imbalances in younger school-aged children. She concluded that, unlike recreational or non-athletic children, competitive athletes experience these problems the least.

A balanced training regimen, which evenly stresses both dominant and non-dominant limbs, can contribute to reducing potential differences in limb involvement during physical performance and aid in the development of the required physical skills (Faigenbaum et al., 2009). Some studies suggest that the more general the movement, or the more adapted an individual is to a specific physical activity, the closer the relationship between the amount of muscle mass in the affected muscle groups and the speed-strength performance. This means that muscle mass plays a significantly larger role in speed-strength performance in movements to which an individual has adapted, compared to specific physical activities that are trained in a much shorter period than basic movement activities (Macdougall, 2003). A limitation of our work that could affect the generalizability of the results is the small sample size.

Conclusion

In conclusion, no significant dependence was found between the amount of muscle mass and jump height in the lower limbs of the participants. The hypothesis that muscle mass in competitive gymnasts would significantly correlate with rebound performance was not confirmed. Similarly, to the study by Bahenský et al. (2021), there is no general relationship between rebound strength and muscle mass in the lower limbs. Regarding the other research objectives, we were interested in whether the preferred rebound limb would correlate with the strength performance of the right/left limb in competitive gymnasts. It can be stated that only half of the gymnasts showed a connection between the preferred rebound limb and its better rebound performance. Therefore, no significant correlation was found. In terms of muscle mass distribution across the lower limbs of our tested competitive gymnasts, we can say that the muscle differences are minimal, with the largest difference being only 0.05 kg, indicating a low risk of developing muscle imbalance.

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