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Coresponding author: stefimijalkovic@gmail.com

THE INFLUENCE OF LOWER LIMBS MORPHOLOGY ON THE RESULT IN RACE WALKING

Stefan Mijalković [1], Stefan Đorđević [2], Daniel Stanković [3]

Abstract: The aim of this study was to determine the influence of lower limbs morphology on the result in race walking. The sample of participants for this study was selected from the student population of Pirot's elementary school "Vuk Karadžić". The study included 15 male participants aged 13-14, who practiced race walking in the "Pirot" athletics club. The following variables were used to assess the morphological characteristics of the lower limbs: leg length, diameter of the knee joint, thigh circumference, calf circumference and thickness of the skinfold on the calf. On the other hand, the criterion variable was the 400 m race walking performance. Linear regression analysis was used to determine the influence of the morphology of the lower limbs on the result in race walking. The results of the study indicated that based on an observation of the modality as a whole, this study found no statistically significant influence of lower limbs morphology on the result in race walking. Nevertheless, by considering particular variables, it can be claimed that the diameter of the knee joint and the thickness of the skinfold on the calf have been shown to have a statistically significant influence on the result in 400 m race walking. Exploring the intricacies of lower limb structure in race walking can provide valuable insights for training and coaching. This understanding has the potential to improve coaching methods and enhance overall performance in this distinctive sport.

Keywords: anthropometry, lower extremities, athletics, track and field

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[1] Assistant professor, Faculty of Sport and physical Education, University of Niš, Niš, Serbia, https://orcid.org/ 0000-0003-0340-4759; E-mail: stefimijalkovic@gmail.com
[2] Faculty of Sport and physical Education, University of Niš, Niš, Serbia, https://orcid.org/ 0000-0001-5109-9643, E-mail: stefan-djordjevic1@hotmail.com
[3] Faculty of Sport and physical Education, University of Niš, Niš, Serbia, https://orcid.org/ 0000-0002-6047-852X; E-mail: extremeds@gmail.com

Introduction

Race walking is a long-distance athletic discipline that requires superior endurance and technical knowledge (Gomez-Ezeiza, Granados, & Santos-Concejero, 2016; Hanley, Bissas, & Drake, 2014; Vernillo et al., 2013). Therefore, the race walking rules state that the knee must be straightened from initial ground contact until the vertical upright position and that there can be no visible loss of contact with the ground (Pavei, Cazzola, La Torre, & Minetti, 2014; Walker, Nicholson, & Hanley, 2021). Also, it can be said that race walking is a highly specialized athletic discipline that places unique demands on the human body, particularly on the morphology and biomechanics of the lower limbs (Mleczko et al., 2019). Additionally, the human lower limb is a complex structure comprising muscles, bones, ligaments and tendons, and all of which contribute to an athlete's ability to generate and transfer force during race walking (Meng et al., 2022; Silva, 2018). Namely, it was established that the athletic performance of athletes depends on the limb length, muscle strength, joint flexibility and the overall structural characteristics of the lower limbs (Walker, Nicholson, & Hanley, 2021).

It has been suggested that individual variations in lower limb morphology may have a direct influence on the efficiency and economy of race walking, affecting factors such as stride length, stride frequency, and overall gait dynamics (Raković, 2004). Furthermore, the primary lower limb muscle groups responsible for generating energy in race walking are the ankle plantarflexors, hip flexors and hip extensors (Hanley & Bissas, 2017; Walker, Nicholson, & Hanley, 2021). Also, the importance of the work carried out by the hip flexors during the late stance and early swing phases is particularly noteworthy, as it effectively minimizes pronounced velocity changes during the stance, and this aspect in race walking is further influenced by the concurrent absorption of energy by the knee extensors in the same late stance/early swing phase. (Hanley & Bissas, 2017).

It is important to understand the complicated connections between lower limb morphology and race walking performance as competitors aim for success in this highly specialized athletic discipline. Understanding the influence of lower limb morphology on race walking performance is essential for athletes, coaches and sports scientists. Unfortunately, there are only a few scientific papers dealing with this specific topic. Therefore, the aim of this study was to determine the influence of lower limbs morphology on the result in race walking.

Method

Participants

The sample of participants for this study was selected from the student population of Pirot's elementary school "Vuk Karadžić". The study included 15 male participants aged 13-14, who practiced race walking in the "Pirot" athletics club. The study included all participants who were healthy at the time of the test and voluntarily agreed to participate in the same.

Testing Procedure

The testing was carried out at the same time of day in the sports hall. The measurement organization was conducted so that each of the tests required two or more measurements and the best results were considered. The participants were barefoot with minimal clothing during the testing of anthropometric characteristics, and they were thoroughly acquainted with the tests they would be performing before the testing began. Also, measurements of paired body parts were performed on the left side of the participants' bodies. The following variables were used to assess the morphological characteristics of the lower limbs: leg length, diameter of the knee joint, thigh circumference, calf circumference and thickness of the skinfold on the calf

To assess the length of participants' legs, a Martin's anthropometer GMP 101 with an accuracy of 0.1 cm was used. The reliability and validity of this instrument had been previously reported by McKenna, Straker, & Smith (2013). Additionally, the diameters of the knee joints and the thickness of the skinfold on the calf were measured using skinfold calipers made by John Bull British Indicators, with an accuracy of 0.2 mm. Reliability and validity of the instrument were reported by Mortenson & Steinbok, (2006). Finally, calf and thigh circumferences were measured with a measuring tape. Reliability and validity of the measuring tape was previously reported by Neelly, Wallmann, & Backus, (2013).

The criterion variable of this study was the 400 m race walking performance. The assessment of race walking was carried out in the schoolyard (circular track of 200m) after warming up the participants. The results were collected by a handheld stopwatch. Reliability and validity of the instrument was previously reported by Hetzler, Stickley, Lundquist, & Kimura, (2008). The test could be performed by a maximum of 5 participants at the same time. The participants were instructed to walk two laps from a standing start position behind the starting line upon the cue from the measurer. Additionally, it was required for the participants to walk at their maximum speed. The measurer recorded the time of the race walking after the completion of two laps.

Data analysis

The data were processed in the statistical package Statistica 10. The data were presented by descriptive statistics. The normality of data distribution was determined using skewness and kurtosis. Skewness refers to the symmetry of the distribution of values around the arithmetic mean (Ma & Genton, 2004). If the distribution is normal, the value of skewness is 0 (zero). Furthermote, kurtosis refers to the elongation or flatness of the distribution, and the value of this test revolves around 2.75. If the result of Kurtosis is significantly greater than 2.75 (leptokurtic distribution), it means that the results are highly concentrated. On the other hand, if the result is significantly less than 2.75 (platykurtic distribution), it means that the results are highly dispersed (Cain, Zhang, & Yuan, 2017). Therefore, Pearson's correlation analysis was used to determine the relationship between predictor and criterion variables of this study. The correlation coefficient was presented as follows (Hopkins, Marshall, Batterham, & Hanin, 2009): trivial ($0<r<0.1$), small ($0.1<r<0.3$), moderate ($0.3<r<0.5$), large ($0.5<r<0.7$), very large ($0.7<r<0.9$) and almost perfect ($0.9<r<1$). Finally, linear regression analysis was used to determine the influence of lower limb morphology on the results in race walking.

Result

Table 1 contains information about descriptive statistics: mean, minimum (Min), maximum (Max) range, standard deviation, skewness and kurtosis.

Table 1. Basic statistical parameters

Variables	Mean	SD	Min	Max	Range	Skewness	Kurtosis
LL	99.65	5.34	93.50	116.50	23.00	2.41	7.44
DKJ	7.88	0.89	6.34	9.56	3.22	0.39	-0.39
TC	43.67	3.78	38.50	53.30	14.80	1.20	1.79
CC	33.97	2.38	31.20	40.30	9.10	1.28	2.34
TSC	13.22	1.76	10.14	16.52	6.38	0.02	-0.60
RW400	158.80	22.57	116.00	184.00	68.00	-1.16	0.22

Legend: SD - standard deviation; LL – leg length; DKJ - diameter of the knee joint; TC - thigh circumference; CC - calf circumference; TSC - thickness of the skinfold on the calf; RW400 – race walking at 400 meters.

By analyzing Table 1, which presents the central and dispersion parameters of the applied tests assessing the morphological parameters of the lower limbs (predictor variables) and the criterion variable (400m race walking), it is noticeable that the results of all variables demonstrate effective discriminative capability. This is evident as they consistently fall within a range of approximately 3 to 5 standard deviations (SD). Additionally, it can be observed that the data distributions in the areas around the mean are quite symmetric, as the skewness results mainly fall within the range between -1 and 1. the distribution is more skewed to the left side only in the case of the variable leg length. However, kurtosis indicates that the distribution for the same variable is highly concentrated, and slightly more concentrated for the variable calf circumference, while it is normal (mesokurtic) for the other variables. This is not surprising because the study includes a group of school-aged children, and some of them are more actively involved in race walking, while others are less involved.

Table 2 shows the relationship between the predictor and criterion variables (each with each) in the Pearson's correlation analysis matrix of intercorrelations and cross-correlations.

Table 2. Pearson's correlation analysis

Variables	LL	DKJ	TC	LLC	TLLSF	RW400
LL	1.00					
DKJ	-0.06	1.00				
TC	0.48	0.28	1.00			
CC	0.63*	0.36	0.86*	1.00		
TSC	-0.01	0.53*	0.30	0.42	1.00	
RW400	-0.28	-0.07	-0.02	0.04	0.56*	1.00

Legend: * - statistically significant correlation (p<0.05); LL – leg length; DKJ - diameter of the knee joint; TC - thigh circumference; CC - calf circumference; TSC - thickness of the skinfold on the calf; RW400 – race walking at 400 meters.

Table 2 presents the intercorrelations of all applied variables. The analysis reveals that only 4 coefficients are statistically significant, with 3 within the morphological domain and one related to the criterion variable. The statistically most significant correlation coefficient is between the measurements for assessing calf and thigh circumference (0.86), followed by the leg length and calf circumference (0.63), the results in 400m race walking and the thickness of the skinfold on the calf (0.56), and finally, the thickness of the skinfold on the calf and the diameter of the knee joint (0.53).

In order to determine the influence of the predictor variables (anthropometric parameters) on the criterion (sports walking for 400m), a linear regression analysis was applied. Table 3 presents the results of the linear regression analysis.

Table 3. Linear regression analysis

Variables	R	Part-R	b	Std.Err. – of b	t(9)	p-value
LL	-0.28	-0.43	-1.91	1.32	-1.44	0.18
DKJ	-0.07	**-0.60**	**-14.86**	**6.55**	**-2.27**	**0.05**
TC	-0.02	-0.15	-1.18	2.58	-0.46	0.66
CC	0.04	0.22	3.71	5.35	0.69	0.50
TSC	**0.56**	0.68	9.72	3.46	2.81	0.02

R= 0.78	**R2= 0.61**	**F(5,9)=2.86**	**p< 0.08**

Analysing Table 3, which presents the regression influences of lower limb morphology on the results in 400-meter race walking, it can be observed that there is no statistically significant influence at the multivariate level (p<0.08), despite the relatively high coefficient of multiple correlation (R=0.78). Additionally, the shared variability between the system for assessing lower limb morphology and success in 400-meter race walking is approximately 61% (R=0.78). This outcome is probably a result of the small number of participants and their varying levels of training. Nevertheless, an examination of individual regression coefficients reveals a statistically significant influence of two specific variables. Those are the thickness of the skinfold on the calf (p=0.02) and the diameter of the knee joint (p=0.05). A positive sign of the t-value in the case of the thickness of the skinfold on the calf indicates that the result in this variable and the 400m race walking concurrently increase and decrease. This suggests that participants with a lower skinfold thickness on the calf will complete the 400-meter distance more quickly. The negative sign of the t-value in the case of the knee joint diameter indicates that participants with a larger knee joint diameter will have better results in 400-meter race walking. More precisely, they will complete this distance in a shorter period of time.

Discusion

The aim of this study was to determine the influence of lower limbs morphology on the result in race walking. Based on an observation of the modality as a whole, this study found no statistically significant influence of lower limbs morphology on the result in race walking. Nevertheless, by considering particular variables, it can be claimed that the diameter of the knee joint and the thickness of the skinfold on the calf have been shown to have a statistically significant influence on the result in 400 m race walking.

The knee joint diameter emerged as a significant contributor to race walking performance. Better outcomes were linked to a larger knee joint diameter, which may indicate a biomechanical benefit. A larger knee joint diameter may provide an athlete with a wider range of motion, which could improve their force production and ability to maintain effective strides throughout the race. Also, the athletes with thinner lower leg skinfolds exhibited discernible variations in their race walking results. It is possible that reduced mass can be transferred with every phase because thinner skin folds are linked to lower subcutaneous fat levels. This finding emphasizes the relevance of body composition in race walking, with potential implications for energy expenditure and efficiency.

Similar results were achieved by Raković (2004) since he did not find a statistically significant influence of morphological characteristics on the performance in 1000m race walking, both in the initial and final measurements. Additionally, these results can be partly linked to the study by Ruhling and Hopkins (1990), who found that race walkers tend to have a relatively small body build and possess less than 10% body fat. Thinner lower leg skinfolds can be associated with a lower percentage of body fat, resulting in improved athletic performance among race walkers. Furthermore, Erdmann (2007) concluded that race walkers with excessively long lower limbs may not achieve favorable results in race walking, emphasizing the importance of an optimal leg length for performance. This is supported by Espinoza-Navarro et al. (2019), who found that ectomorphic components and morphological characteristics can influence the success of athletic performance in race walkers. In our study, the model of the lower limbs morphology did not have a statistically significant influence on sports performance. This can be explained by the small and non-selective sample of participants in our study, compared to a larger and more selectively chosen one.

The main limitation of this study is the insufficient number of participants. Additionally, the participants in this study were involved in recreational-level race walking training program. It is believed that the results of this study would be more accurate with a higher number of participants engaged in professional-level race walking training program. Therefore, the results of this study cannot be generalized and applied to all race walkers.

Conclusion

Based on the results of this study, it can be said that there was a statistically significant influence of the diameter of the knee joint and the thickness of the skinfold on the calf on the result in race walking. The capacity of an athlete to succeed in this particular athletic discipline can be influenced by having an adequate knowledge of the morphology of the lower limbs. Unraveling the complexities of lower limb morphology in the context of race walking holds the potential to inform training practices, enhance coaching strategies, and optimize athletic outcomes in this unique discipline.

Conflict of interests

The authors declare no conflict of interest.

Author Contributions

Conceptualization: D. S., Investigation: S. M., Theoretical framework: D. S., Data curation: S. M., Resources: S. Đ., S. M., Writing – original draft: D. S., S. M., Writing – review & editing: S. Đ., All authors have read and agreed to the published version of the manuscript.

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