УДК 374
ББК 75.1

DOI 10.24411/2500-0365-2020-15115

RACE WALKING: MORPHOLOGICAL AND MOTOR-FUNCTIONAL PARAMETERS AS SUCCESS FACTORS

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Race walking is an athletic discipline of aerobic character, which diverse from moderate to high intensity forms and is characterised by high energy consumption. The result in race walking depends on the morphological, motor and functional potentials (aerobic and anaerobic capacity, function of the cardio-vascular and the respiratory system) of the walker, as well as the technique used by the competitors. The sample included 25 male students, on the third year of studies at Faculty of Physical Education and Sport, East Sarajevo. Variables were measured to evaluate morphological and motor-functional parameters (Body height; Body weight; Body Mass Index; Running 100 m, 200 m, 400 m, 800 m). The result in race walking at 2000 m was defined as a criterion variable. The aim of the study was to determine the influence of morphological and motor-functional parameters on the resultant performance in race walking. Multiple regression analysis was applied to process the data, which showed a statistically significant influence of the predictor variables ($p < 0.010$) on the criterion of ($R = 0.785$; $R^2 = 0.613$).

Keywords: *race walking, students, running, morphological dimensions, motor-functional abilities, influence.*

Introduction

Race walking, as an athletic discipline, was first included into the competition program at the 1908 London Olympics after advancing from the original "walking" betting races that were popular during the 18th century in England [1]. The first competitions that were held had different distances, especially walking at 10 000 m, until 1956, when the 20 km race was added to an already existing 50 km race, which first appeared in 1932 [2]. The performance of speed walkers continued to improve relatively continuously, until major improvements were made by Mexican walkers in 1968, such as walking in straight lines and large pelvic rotations. Before that, walking seemed like normal walking, but at a faster pace [3].

Today, race walking or as some people call it "fast" walking is a cyclical, moderate to high intensity movement that takes place in the sagittal plane. According to IAAF definition, "race walking is a step-by-step process during which in no moment during the race a loss of contact of competitors with the ground occurs visible to the naked eye. The stopper leg must be stretched (not bent at the knee) from the first contact with the ground until it reaches the vertical position". Unlike running, in which each step contains a flight phase, an unrestrained phase (flight) should never occur in walking, i.e. the walker must maintain contact with the ground (either with one or both feet) throughout the movement [2; 4]. The kinetic structure of walking belongs to the space of cyclic motions, characterized by the fact that each cycle represents a series of specifically connected spatial motions that are alternately repeated using the surface of a solid support [5].

Chwala [6] defines race walking as a periodic movement that is divided into a support phase (depreciation and reflection) and a swing phase (acceleration and braking) characterized by synchronized cranial and caudal extremity movements. Basically, race walking is based on ordinary walking, but it also has its own peculiarities: higher speed of movement (14—15 km/h), greater coordination of movement, complete straightening of the foot at the moment of placement on the ground, more pronounced movement of the pelvis (especially around the vertical axis) and the shoulder girdle as well as the active movements of the arms, which are constantly bent in the back and forth direction [2; 7—9]. At high walking speeds, there is also a lack of a double-support phase (transitions to the flight phase). Regardless of the fairly high intensity of movement (180—230 steps/min.), movements in race walking should not be abrupt and sharp.

According to Hoga [10], the method of race walking that is determined by the IAAF rules is not a naturally acquired human skill because normal walking and running are acquired in childhood. It is common for competitors to learn the technique of walking as directed by the coach. Therefore, the number of walkers who have techniques which are good enough to participate in and complete the race in international or national competitions, without disqualification, depends on the trainers who can properly train the walking technique during the course of the course. However, the technique of race walking is usually taught by a small number of coaches in many countries and is based on their own experience as competitors. In order to increase the number of race walkers who can walk with proper technique, it is important to establish a methodology for teaching race walking technique. A good walker is characterized by the smoothness of movement, especially in shoulder and pelvic movements. Some previous studies [11] that analysed race walking competitions concluded that success in these competitions was associated with the ability to achieve and maintain high walking speeds without lactate accumulation in the blood, i.e. in aerobic mode. However, opinions are divided on this issue as well [12]. High speed walking in competition is one of the most important factors for achieving greater performance in race walking. Although this factor should be analysed above all, previous research into the race walking technique has begun to analyse race walking, explaining the differences between sport and normal walking and the difference between race walking and running [13—16].

When it comes to the structure and ratio of muscle fibres in walkers, it can be assumed that they are mainly dominated by red fibres, because in intensity and length (from 80 minutes to up to 3 hours) walkers are similar to runners at 10,000 m and to marathon runners. Studies have shown that during walking all the muscles of a person are activated, and the cardiovascular system works in an optimal mode [2].

According to Dvorak et al. [17] race walking is a specific endurance discipline where a walker completes 98 % of the course in an aerobic regime. Walker load intensity at 50 km takes about 93—97 % of the anaerobic threshold and in the 20 km race there is an increase of 104 % of the anaerobic threshold [18]. Due to the fact that walkers at 20 km finish the race in about 1.5 hours and races at 50 km in about four hours, the intensity achieved on the track is very high (average HR 175bpm, average HR^{max} 185 bmp). This is also reflected in the body of the walker after the race by negative subjective feelings (feeling of fatigue). Also it is possible to objectively monitor changes in the chemical composition in the body of the competitor and related physiological processes, such as increased heart rate at rest or changes in body temperature. It is also necessary to take into account the subjective feeling of the competitor, where it seems that the effects of exhaustion should be erased by a sufficiently long rest, in which all necessary functions are gradually normalized [19]. The length and frequency of the steps most often increases with increasing of the walking speed [2; 20].

According to [3] the development and maintenance of efficient walking is crucial in the unique movement of race walking. It is important that when walking, some effort should be made to avoid greater variations in the sagittal plane and lateral displacements of the centre of gravity of the body in the horizontal plane. Movement should be steady, perpendicular because of the economy of movement and without excessive energy consumption. Success in race walking requires a high level of technical ability and physical endurance, where any inefficiency in the movement of a race walker increases energy costs and the risk of an early fatigue. Therefore, it is best to walk with optimal parameters of the length and frequency of the steps, taking into account the individual characteristics of the walker (body height, body mass, BMI, functional abilities and of course the movement technique).

The idea behind this study stems from the fact that race walking is one of the athletic disciplines taught at all faculties of physical education and sport in Athletics 1 module, where students learn and perfect the technique of race walking through the practical part of teaching. The main objective of the study was to determine the magnitude and significance of the influence of morphological and motor-functional parameters on the results in student race walking.

Method

The study included 25 male students on the third year of studies at Faculty of Physical Education and Sport, who are physically healthy without any somatic changes and injuries to the locomotor apparatus, which could have a negative impact on the measurement results.

The following variables (predictors) were measured to evaluate morphological and motor-functional parameters

1. Body height-BH (cm)
2. Body weight- BW (kg)

3. Body Mass Index-BMI (kg/m²)
4. Running 100 m (sec)
5. Running 200 m (sec)
6. Running 400 m (sec)
7. Running 800 m (min)

Criterion variable is a result in race walking at the length of 2000 m (Walking 2 km).

The measurements were conducted in the 2016/17 school year during the practical lectures on the subject of Athletics 1. The basic central and dispersion parameters were calculated for all subjects. Multiple regression analysis was applied (STATISTICA, Version 10,0) as a multivariate method.

Results

The obtained research results showed significantly higher heterogeneity in quantitative numerical parameters of motor-functional abilities of students in relation to morphological parameters (Table 1). The results are justified, given that this is a chronologically uniform sample of students, in relation to their motor and functional abilities, which are often justified indicators of their physical condition, i.e. physical abilities. Out of the variables that evaluated the motor-functional space, the highest homogeneity of results was expressed when running 100 m (Coef.Var = 7.72).

The highest average homogeneity was manifested in the morphological space, and the body height variable is a leading variable (BH = 3.24), while body mass (BW = 9.52) and total BMI (BMI = 9.08) indicated significant heterogeneity of the results. Heterogeneity of the defined sample is also confirmed by the values of the range of minimum and maximum results. In terms of average results, it can be concluded that they are consistent with the results of previous studies conducted on the same population. This is a sample that is in the phase of change in terms of motor and functional space, as opposed to for example body height recording stagnation over this period with respect to weight and total BMI. Also the results in race walking (Mean = 14.88 min) are a consequence of previous changes of the defined parameters.

The heterogeneity of the results is also evident — Coef.Var. = 8.60 (Table 2). Perhaps this is the expected result, since the resultant success, in addition to the specified parameters of the morphological, motor-functional space, depends on the technique of movement, especially if longer distances are involved [21]. At shorter distances, more pronounced influence of anaerobic-aerobic abilities and frequency of movement is still manifested, while morphological indicators are not fully expressed, e.g. body weight. This is especially visible in beginners, who are not race walkers [22] but come from various other fields of sports disciplines, the most common sports games, martial arts, athletic racing, jumping and throwing disciplines.

Multiple regression analysis of Race walking indicates to a statistically significant correlation between the overall system of morphological and motor-functional parameters and the results of student walking (Table 2). The regression coefficient of multiple correlation (R = 0.785) and the coefficient of determination (R^2 = 0.613 %) indicate that the common variability between morphological and motor-functional parameters and sports walking is conditioned by the applied predictor system with about 61 %, while the remaining 39 % is conditioned by other factors which were not covered by this research. This could relate to other parameters from the field of morphology, motor-functional space and especially the technique of student race walking. By analysing the values of the regression coefficients (b*) in the system of predictor variables of the regression function, the greatest contribution of morphological parameters (BH,

Table 1

Basic statistical morphological and motor-functional parameters

Parameters	Mean	Min	Max	Rang	Coef. Var. %
100 m	12,95 ± 1,00	11,48	15,76	4,28	7,72
200 m	28,05 ± 3,11	23,30	34,16	10,86	11,08
400 m	65,32 ± 6,73	55,10	84,22	29,12	10,31
800 m	2,56 ± 0,29	2,28	3,33	1,05	10,92
BH (cm)	182,20 ± 5,89	172,00	193,00	21	3,24
BW (kg)	79,68 ± 7,59	64,00	95,00	31	9,52
BMI (kg/cm²)	24,01 ± 2,18	20,42	28,36	7,94	9,08
Walking 2 km	14,88 ± 1,28	13,05	17,33	4,28	8,60

Table 2

Regression Summary for Dependent Variable: Walking 2km

	b*	Std. Err. of b*	Partial — Cor.	*b*	Std. Err. — of *b*	t (17)	**p*-value
Intercept				–106,69	89,83	–1,19	0,25
100	0,28	0,30	0,22	0,35	0,39	0,91	0,44
200	0,20	0,26	0,16	0,05	0,08	0,67	0,51
400	0,53	0,27	0,43	0,10	0,05	1,97	0,05*
800	–0,28	0,23	-0,38	–0,02	0,02	–1,22	0,24
BH (cm)	2,83	2,26	0,29	0,62	0,49	1,25	0,23
BW (kg)	–4,04	3,34	–0,28	–0,68	0,56	–1,21	0,24
BMI (kg/m²)	3,66	3,23	0,28	2,27	1,90	1,20	0,25

$R = 0{,}785$; $R^2 = 0{,}613$; $F(7{,}17) = 3{,}880$; *level of significance $p < 0{,}010$

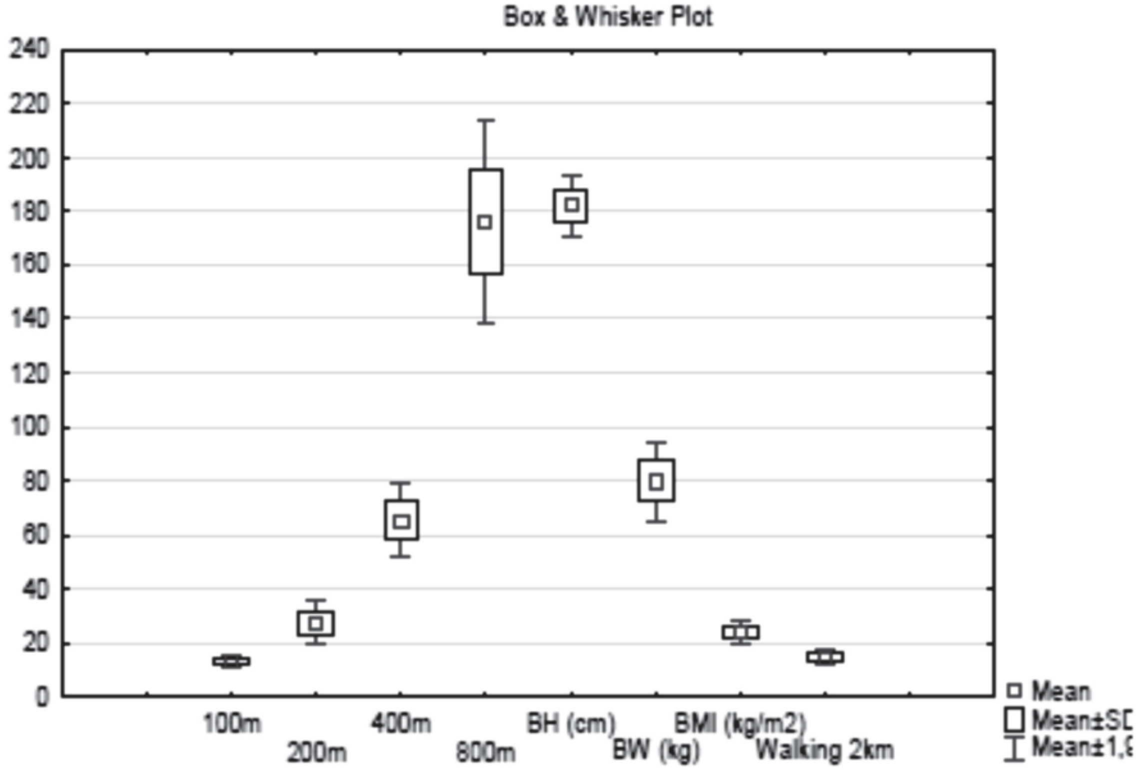

Figure 1

BW, BMI) is evident, where body mass is predominant by its negative influence ($b^* = -4.04$), unlike BMI ($b^* = 3.66$) and body height ($b^* = 2.83$) that have a direct positive impact. It can be concluded that underweight students achieved lower scores in sports walking, although this was not statistically significant at the given level.

Out of the motor-functional parameters defined in the regression function, a slightly weaker influence on the resultant performance was achieved. A 400 m running variable can be singled out, and it also records the statistical significance of the regression function ($b^* = 0.53$; $p < 0.05$). By analysing the largest individual contribution (t) in explaining the criteria of each variable, the order would be the same as for the regression coefficients and partial correlation values, where the highest individual positive or negative influence was achieved by the running variables 400 m ($t = 1.97$), i.e. body mass ($t = -21$). Based on the analysis of variance ($F = 3{,}880$), it can be concluded that the regression variability is statistically significantly higher than the residual variability at both levels, which indicates to and guarantees the statistical significance of the regression relation. Based on the value of b-intercept (–106.29), it is a stochastic linear model that records a slight nega-

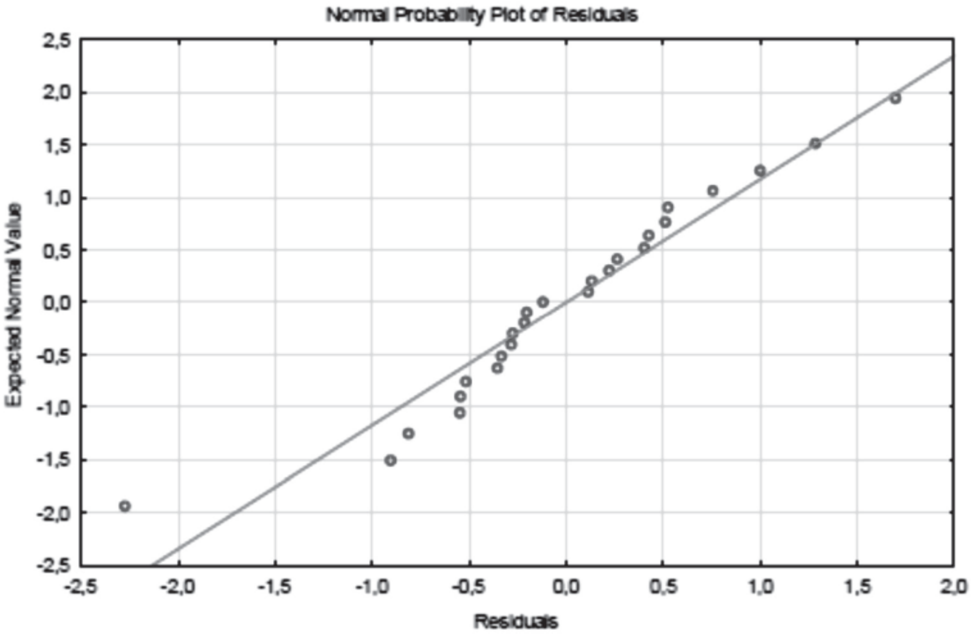

Figure 2

tive inverse regression function where *b* intercept (–106.29) is <0.

Discussion

This study was conducted with the aim of determining the influence of morphological and motor-functional parameters on the results of students race walking, where multiple correlations between systems with a significant coefficient of determination over 60 % were confirmed. It is evident that the variables of the morphological space had a bipolar influence, that is, body height had a direct and body mass had an inverse effect. This is in line with the results of some previous studies [23; 24].

Also, the motor-functional parameters confirmed different influence on the results of walking, which is related to aerobic-anaerobic processes in the body, the mode of energy consumption and the degree of adoption of the technique of race walking students. Considering the number of hours spent in training for race walking, it can be said that the results are satisfactory, that is, a significant multiple correlation was recorded between the defined systems. However, what can be can be more discussed is the importance of kinematic parameters realizing, as well as the function of organ systems, performance in race walking and, of course, the technical performance of each individual, since considerable heterogeneity of results is present (Figure 3).

Race walking takes place in aerobic mode, with medium to high intensity, at distances of 3 to 10 km and on the Olympic Games at 20 and 50 km. The basic principle that defines end results in race walking is the time (speed) in which a certain distance is travelled, i.e. the relationship between frequency and stride length, that is, intramuscular coordination and a flexible kinetic mechanism, which allows walkers to increase their efficiency with minimal energy expenditure [25].

Although it occurs in the sagittal plane, there are also some differences between ordinary and sports walking. According to some authors [2; 4; 8; 9; 26; 27] the speed of movement of top competitors exceeds 2—3 times the speed of ordinary walking (average of 4—5 km/h). The length of the walking step is 75—90 cm and the race walking step length is 105 to 130 cm, which correlates with the length of the caudal extremities and the muscle strength of the walker. In normal walking, the step frequency is 110—120 steps/min., and in race walking it is 180—230 steps/min. In normal walking, vertical deviations range from 4 to 6 cm and horizontal (lateral) range from 2 to 12 cm. However, for walkers with a well-developed technique, these oscillations are greatly reduced by the use of a solid surface reaction (*Rp*) that moves the racer's body forward on the basis of inertially reactive forces [2].

According to Korčok & Pupiš [28], specific kinematics are the result of the rules of athletic walking where repetition of continuous contact with the ground and knee extension is based on the claim of economical kinetic activity. It is known that

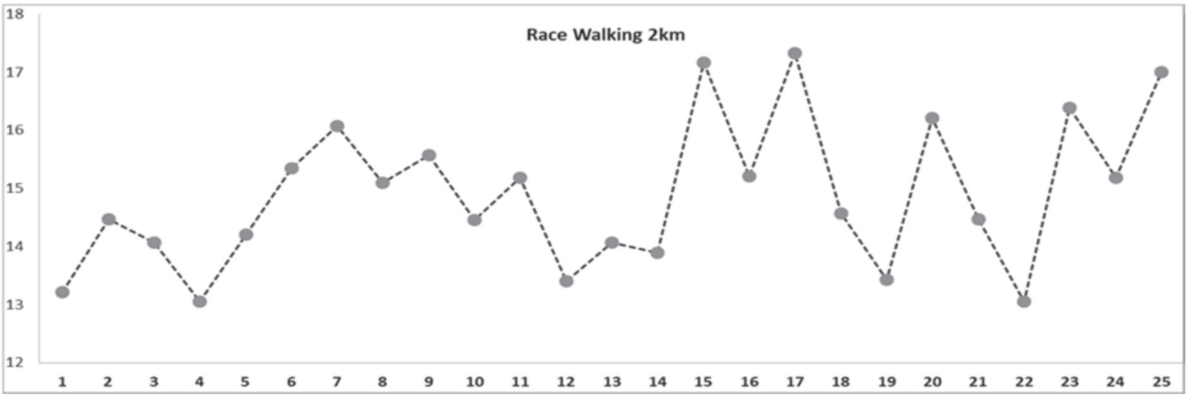

Figure 3. Distribution of students' scores of the variable Race walking

the dynamics of race walking is achieved by prolonging the walking step, the support time and reducing of the frequency. We only notice irregularities in kinematic parameters by reaching the walking speed at the required pace, which is characteristic of a given discipline. Considering the aforementioned dynamics of the walking step, a walking technique is possible by developing intramuscular and muscular coordination and utilizing the flexible movement of the kinetic composition of the organism [21]. It is these specificities that are evident in our study, where students have neglected this important segment, which could result in a better result due to poor walking technique.

The importance of economical walking technique is especially evident during a competition, when the length of step that ranges from 90 to 110 cm is achieved, at a frequency of 200 to 220 steps/min., i.e. 16,500 steps on a 20 km track [28]. Practice shows that the inheritance effect of the walking pace economy is more important than years of training. According to Brodani, et al. [21] one must work not only on the physical fitness of the competitor, but also on the technique of walking kinetic manifestation. The rational technique is characterized by minimizing the decrease in velocity within the contact of the vertical line. This stage influences the level of special fitness of the thigh flexors and gluten muscles [29], and an overall higher level of special abilities (24). It can be said that these parameters were also decisive in the students' performance. They showed considerable heterogeneity in terms of morphological and motor-functional parameters and walking technique, which is a consequence of the time of the training process. Homogeneity is evident when running 100 m, and with increasing distance (up to 800 m) this decreases. Generally, students have better developed anaerobic abilities of alactate type and consequently higher homogeneity of results. With the extension of the section, aerobic-anaerobic abilities and other mechanisms that, in conjunction with body mass, can disrupt the movement technique and lead to fatigue of the body are included in the energy supply.

Movement technique is the key to the success of top walkers. Although modern race walking is a very prominent form of walking, there are similarities in the way that efficiency is optimized at every step, to reduce the vertical and lateral oscillations of the body's focus (30). According to Whittle [22], lateral and vertical oscillations of the walker are the basic determinants of race walking, and the most important are rotation and tilt of the pelvis. For typical people walking at the usual frequency and step length, the pelvis rotation is about 4° on each side (8° in total), but that value increases markedly with increasing movement speed [30]. The pelvic tilt has also been found to increase in race walking compared to normal walking and running [16], to reduce pelvic movement through minimal vertical oscillations TT [31] and help to reduce the occurrence of lifting [32].

In addition to pelvic rotation, pelvic tilt is one of the main mechanisms of compensation in race walking, and it counteracts the negative effects of knee extension on the movement of the centre of mass [33]. First, the rotation of the pelvis around the vertical axis drives each hip joint forward while the hip flexes back with the hip extension [22]. This results in less hip flexion and extension required as part of the stride length when it comes from anterior-posterior pelvic motions rather than angular motion [30], where movement also increases efficiency by reducing the vertical displacement of the centre of gravity of the body. Second, the inclination of the pelvis is the way it rotates around the anterior-posterior axis, in a way in which the hip of the pendulum leg is below the position of the standing leg, where lowering of one side of the pelvis leads to a general lowering of the centre of gravity of the body [22]. Effective control of the pelvic girdle is especially important during the increasing of the speed of race walking, as the rotation of the pelvis increases the length of steps [13; 34] and the frequency of steps [35] because it allows additional muscle groups to be used while moving the legs forward, and not just because of the greater range of the walking step [36].

By analysing performance in 20 km walking in the last fifteen years, the number of male athletes faster than (1:21.00) and female faster than (1:31.00) has increased significantly, resulting in more high-level walkers. A possible explanation for this trend is the tendency towards high specificities of training. Also the versions of the walking race realization have improved, which is a consequence of a more successful training methodology, i.e. conducting high-intensity training in the quality area (without loss of volume), the use of combined endurance and strength training to improve muscle components and the need for proper knowledge of internal control of lactate threshold, both for training planning and for coping with high specialization. In terms of walking, there is insufficient scientific evidence to formulate coaching recommendations for coaches and athletes alike.

This is especially evident when considering the many methodological factors associated with sports walking that match the technical and regulatory aspects with common physiological determinants of long-range performance: Maximum oxygen consumption — VO^2 max, Lactate threshold, Energy consumption and Maximum oxygen consumption percentage — VO^2 max. We are mainly lacking specific knowledge, and coaches should be a shift from the mainstream findings of the race walking training literature, by combining practical experience with theoretical knowledge, because very often physiological stress, energy use or physiological determinants are important for race walking performance [37].

Conclusion

The research was carried out with the aim of analysing the influence of morphological and motor-functional parameters on the results of successful walking of 2km for the students of Physical Education and Sport. A total of 8 predictor variables (Body height; Body weight, BMI, Running 100 m, 200 m, 400 m, 800 m) and the Race walking 2 km criterion variable were applied.

Based on the obtained results of the multiple regression analysis, a significant correlation multiple of the two systems over 78 was confirmed, thus confirming the significant impact of the defined predictor set at about 61 %. An inverse relationship with body mass (BW) is visible, as well as a direct influence of body height (BH), Body Mass Index and all running disciplines. The results are quite heterogeneous in terms of the criterion variable, as expected. Students did not have enough time to perfect the technique of race walking, and their results were largely dependent on their current anaerobic and aerobic-anaerobic abilities, which were manifested through running parameters and of course movement techniques, although not thoroughly analysed in this research.

References

1. Kozloff E.H. Edward Payson Weston and the 1861 Inauguration: the feats of the "pedestrians" of the 19th century continue to astonish historians of running. *Marathon and Beyond*, 2004, no. 8 (6), pp. 122—138.

2. Pavlović R. *Atletika 1* [Athletics 1]. SIA. Niš, 2014 (In Serbian).

3. Hanley B., Bissas A., Drake A. The Biomechanics Of Efficient Race Walking. *M. Pupiš et al. (ed.) World race walking research*. 2011. Pp. 171—192.

4. Stanković, D., Raković A. *Atletika* [Athletics 1]. Niš, Fakultet sporta i fizičkog vaspitanja, 2010. (In Serbian).

5. Dodig M. *Modeli i modeliranje tjelovježbovnih procesa* [Models and modeling of exercise processes] Rijeka, Sveučilište u Rijeci, 2002. (In Serbian).

6. Chwała W. Influence of space-time parameters on oscillations of the general center of gravity OSC in the function of increasing speed of sports walk in the group of master class walkers. *Urbanik Cz., Mastalerz A. (ed.) Biomechanics of sport and rehabilitation — selected issues*. Oficyna Drukarska Jacek Chmielewski, University of Physical Education in Warsaw, 2009. Pp. 29—43.

7. Šnajder V., Milanović D. *Atletika hodanja i trčanja-strukturalna i biomehanička analiza atletike* [Walking and Running Athletics-Structural and Biomechanical Analysis of Athletics]. Zagreb, Kineziološki fakultet, 1991 (In Serbian).

8. Idrizović K. *Atletika I i II* [Athletics I, II]. Univerzitet Crne Gore, Biblioteka biomedicinskih nauka, 2010. (In Serbian).

9. Mihajlović I. *Atletika* [Athletics]. Novi Sad, Fakultet sporta i fizičkog vaspitanja, 2010. (In Serbian).

10. Hoga K. Mechancal Energy Flow Between Body Segments On Race Walking. *M. Pupiš et al. (ed.) World race walking research*. 2011. Pp. 113—129).

11. Yoshida T., Udo M., Iwai K., Muraoka I., Tamaki K.,Yamaguchi T., Chida M. Physiological determinants of race walking performance in female race walkers. *British Journal of Sports Medicine*, 1989, no. 23 (4), pp. 250—254.

12. Drake A., James R. Prediction Of Race Walking Performance Via Laboratory And Field Tests. *M. Pupiš et al. (ed.) World race walking research*. 2011. Pp. 71—79.

13. Murray M.P., Guten G.N., Mollinger L.A., Gardner G.M. Kinematic and electromyographic patterns of Olympic race walkers. *The American Journal of Sports Medicine*, 1983, no. 11 (2), pp. 68—74.

14. Fenton R.M. *Race walking ground reaction forces*. Research Center for Sports, Del Mar, California, 1984. Pp. 61—70.

15. White S.C., Winter D.A. Mechanical power analysis of the lower limb musculature in race walking. *International Journal of Sport Biomechanics*, 1985, no. 1 (1), pp. 15—24.

16. Cairns M., Burdette R., Pisciotta J., Simon S. A biomechanical analysis of racewalking gait. *Medicine and Science in Sport and Exercise*, 1986, no. 18 (4), pp. 446—453.

17. Dvorák M. et al. Methodical sheets 18. *Preparation of Czechoslovak pedestrians for the Olympic Games in Seoul — 1988*. Prague, VMOÚU ŠTV, 1990. P. 72.

18. Pupiš M., Čillík I. Load intensity at endurance performance. *Athletics 2005*. Prague, Falon, 2005.

19. Pupiš M. The Intensity of Race Walker Load At Various, Performances at 20 and 50 Km. *M. Pupiš et al. (ed.) World race walking research*. 2011. Pp. 7—25.

20. Wiesław C., Wacław M., Krzysztof K. The Modern Instruments of Kinematic and Kinetic Technique Evaluation at the Competitors Practicing Race Walking. *M. Pupiš et al. (ed.) World race walking research*. 2011. Pp. 193—212.

21. Brodáni J., Šelinger P., Vavák M. Athletic Walking In Terms Of Kinematic Parameters Of Walking Step. *M. Pupiš et al. (ed.) World race walking research*. 2011. Pp. 162—170.

22. Whittle M.W. *Gait Analysis: an introduction*. 2nd ed. Oxford, Butterworth-Heinemann, 1996.

23. Brodani, J., Šelinger, P. Dynamics of pedestrian step changes as the speed of walking is increased. *ATLETIKA 2001*. Banská Bystrica, UMB, 2001. P. 34.

24. Brodáni J., Vavák M., Šelinger P. The share of kinematic indicators on the speed variability of a pedestrian step. *Studia Kinanthropologica — The Scientific journal for Kinanthropology*, 2003, no. 4 (2), pp. 75—80.

25. Vanderka M. *Strength and speed skills in fitness training of athletes*. Bratislava, ICM Agency, 2008. P. 92.

26. Pavlović R. *Atletika* [Athletics]. Istočno Sarajevo, Fakultet fizičkog vaspitanja i sporta, 2010. (In Serbian).

27. Radić Z., Simeonov A. *Atletika-metodika*.[Athletics-metodic]. Skoplje, 2012. (In Serbian).

28. Korčok P., Pupiš M. *All about walking*. Banská Bystrica, Department of Physical Education and Sport, Faculty of Humanities, Matej Bel University. 2006.

29. Kampmiller T., Vavák M. Laczo E. Šelinger P. Analysis of kinematic structure of athletics walking. *Seminar for Race Walking Coaches*. Bratislava, 1998. Pp. 37—53.

30. Inman V.T., Ralston H.J., Todd F. *Human Walking*. Baltimore, Williams and Wilkins, 1981.

31. Ruhling R.O., Hopkins J.A. Race Walking. *Reilly T. (ed.) Physiology of Sports*. London, E and FN Spon, 1990. Pp. 153—171.

32. Villa F. NSA photosequences 12 and 13: race walking. *New Studies in Athletics*, 1990, no. 5 (3), pp. 63—68.

33. Polozkov A., Papanov V. On the track with Mauricio Damilano. *Soviet Sports Review*, 1982, no. 17 (1), pp. 23—25.

34. Knicker A., Loch M. Race walking technique and judging — the final report of the International Athletic Federation research project. *New Studies in Athletics*, 1990, no. 5 (3), pp. 25—38.

35. Fruktov A., Korolyov G., Ozerov V. Technique and faults in race walking. *Modern Athlete and Coach*, 1984, no. 22 (3), pp. 35—37.

36. Trowbridge E.A. Walking or running — when does lifting occur? *Athletics Coach*, 1981, no. 15 (1), pp. 2—6.

37. La Torre A., Vernillo G. (2011). The training for the 20 km. What has changed and what might change? *M. Pupiš et al. (ed.) World race walking research*. 2011. Pp. 80—94.

Поступила в редакцию 17 сентября 2019 г.

Для цитирования: Pavlović R. Race walking: morphological and motor-functional parameters as success factors / R. Pavlović, I. Mihajlović // Физическая культура. Спорт. Туризм. Двигательная рекреация. — 2020. — Т. 5, № 1. — С. 103—111.

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PHYSICAL CULTURE. SPORT. TOURISM. MOTOR RECREATION
2020, vol. 5, no. 1, pp. 103—111.

Спортивная ходьба: морфологическая и моторно-функциональная параметры как факторы успеха

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Спортивная ходьба — это спортивная дисциплина аэробного характера, от умеренной до высокой интенсивности и с высоким энергопотреблением. Результат в спортивной ходьбе зависит от морфологических, двигательных и функциональных возможностей (аэробной и анаэробной емкости, функции сердечно-сосудистой и дыхательной систем) ходока, а также от техники проведения соревнований. Выборка включала 25 студентов мужского пола, обучающихся на третьем курсе факультета физического воспитания и спорта в Восточном Сараево. Измеряли переменные для оценки морфологических и моторно-функциональных параметров (рост, масса тела; индекс массы тела; бег 100 м, 200 м, 400 м, 800 м). В качестве критериальной переменной был определен результат в беговой ходьбе на 2000 м. Цель исследования — определить влияние морфологических и моторно-функциональных показателей на результирующие показатели спортивной ходьбы. Для обработки полученных данных был применен множественный регрессионный анализ, который показал статистически значимое влияние предикторных переменных ($P < 0{,}010$) на критерий ($R = 0{,}785$; $R^2 = 0{,}613$).

Ключевые слова: *спортивная ходьба, студенты, бежать, морфологические размеры, моторно-функциональные способности, влияние.*

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