Applying the Kinematic Parameters from the Bosco Jump Test to Evaluate the Athlete's Preparadness and to Select Training Parameters

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Abstract: The aim of this study was undertaken to evaluate changes in the values of the indicators describing jumps during a 60 second Bosco test applied to female 400 m runners at the beginning of the general preparation period and how they depend on the levels of activation of anaerobic glycolysis estimated with blood lactate concentration. The experiment involved 8 female 400 m runners. Power, jump height, jump time, and the contact duration were recorded with the Optojump f. Microgate srl. device (Italy). The course of the test was also recorded with a video camera coupled with the Optojump system. On each of the subjects three points were marked: the trochanterion, the tibialis lateralis, and the mallolare fibulare. An analysis of the results of the study has demonstrated that the length of exercise has a major effect on variations in the kinematic indicator values recorded during jumps in the Bosco test. An analysis of the research findings identifies the Bosco test as a sensitive tool for measuring the anaerobic endurance of the lower extremities in athletes involved in speed-endurance disciplines. Further research should concentrate on seeking relationships between the character of the applied training means and their outcomes as revealed by the Bosco test.
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Introduction

The type of muscule fibers is directly related with how fast they can be recruited for physical exercise (Aura & Komi, 1986). In sprint where high power must be developed over a short period the recruitment of the muscle fibers is a key ability allowing fast movements typical of the first phase of sprint and in jumps (Ozimek, 2005). Therefore, the jump tests are used to measure individual's predisposition for these groups of athletic disciplines and thereby to identify talented athletes. They are also used as an indication of preparedness to exercise at a level requiring high power to be developed over a short period. The development of the ability to perform sprint-type exercise is a function of biological development and the sports training one does (Gabryś et al., 2005). The extent of development of both these components determining maximal power is determined, in turn, by a structure that considerably depends on individual's genes (Komi & Bosco, 1978; Van Praagh & Franca, 1998). One of the widely used tests in sports practice that measure the power of the lower extremities is the Bosco test (Bosco et al., 1983). The test required the subject to perform multiple vertical jumps over a set period. The test measures the subject's anaerobic power using the ratio between the shortening time of the jump and the amount of the developed power (Bosco, 1983; Harley & Doust, 1994). The Bosco test is closely connected with the exercise principle utilized in the Wingate test (Bar-Or, 1987). The performance the Wingate test involves only one type of muscle work, concentric muscle action. It is therefore incapable of reflecting the subject's capacity for anaerobic metabolism exercise that mainly requires the eccentric muscle action (Hoffman et al., 2000; Sands et al., 2004; Stanula et al., 2013). The Bosco test can be treated as exercise where the measurement of power and anaerobic capacity correspond to athletes in these sports disciplines where the body mass of the athlete will not be high enough to impose high external burden in the Wingate's test (Heller, 1998; Irvin, 1992). The evaluation of the speed of growing fatigue and the resulting disturbances in the neuro-muscular coordination is very important for selecting the training load parameters and for evaluating the actual preparedness of the athlete. The Bosco test makes use of the phenomenon of fatigue that reduces the speed of muscle recruitment of in successive efforts. The effect of the mechanism is extending time of the contact with ground during concentric muscle action. Another indicator the values of which also change as a result of fatigue is the angle of the knee-joint flexion that gradually increases (Sacco, 2004). The jumping subject tries to maintain the duration of contact with ground by shortening the time of assuming the position before making a jump. The literature lacks studies investigating changes during the 60 s Bosco test in the values of kinematic indicators with respect of training periods. This study was undertaken to evaluate changes in the values of the indicators describing jumps during a 60 s Bosco test applied to female 400 m runners at the beginning of the general preparation period and how they depend on the levels of activation of anaerobic glycolysis estimated with blood lactate concentration.

Methods

The experiment involved 8 female 400 m runners. Their mean body height was 167.9 cm (range 165-172 cm), mean body mass 55.1 kg (range 49-60 kg), BSA 1.62 m^2 (range 1.53-171 m^2), BMI 19.5 $kg \cdot m^{-2}$ (range 17.78-21.16 $kg \cdot m^{-2}$). The exercise test was selected to correspond to an exercise regularly occurring in the training of the subjects. A vertical jump performed in series is used as a training means in the period of preparation. The tested subjects exercised for 60 s according to the Bosco test protocol. Exercise was preceded by a standard 25 minute warm up before track and field training (Ozimek, 2005). Power, jump height, jump time, and the contact duration were recorded with the Optojump f. Microgate srl. device (Italy). The course of the test was also recorded with a video camera coupled with the Optojump system. On each of the subjects three points were marked: the trochanterion, the tibialis lateralis, and the mallolare fibulare. In the Optojump programme the minimal angle between these points in the stage preceding each take-off was marked. Each subject did also three single jumps of that type before the Bosco test commenced. The parameters in the highest jump were used as reference values for analysing changes in the kinematic parameters of the test jumps. Before the exercise, directly afterwards and in the 4^{th} and 8^{th} seconds after its completion capillary blood samples (20 ml) were taken from the fingers' tips of the subjects. Blood lactate concentration was analysed with the Biosen C-line analyser (EKF Germany). Lactate concentrations in whole blood were determined with EKF Lactate Reactive (EKF Germany). The results of the study were processed with statistical methods, calculating mean values, standard deviations, variance coefficients and the deviations of the means from the reference values at 10 second intervals. Additionally, the coefficients of correlation between the amounts of the kinematic structure of the jumps and physiological and biochemical indicators recorded during the ramp test.

Results

Figures 1-5 present mean values at 10 second intervals during the 60 s Bosco test. Table 1 shows the values of descriptive statistics for the analysed parameters.

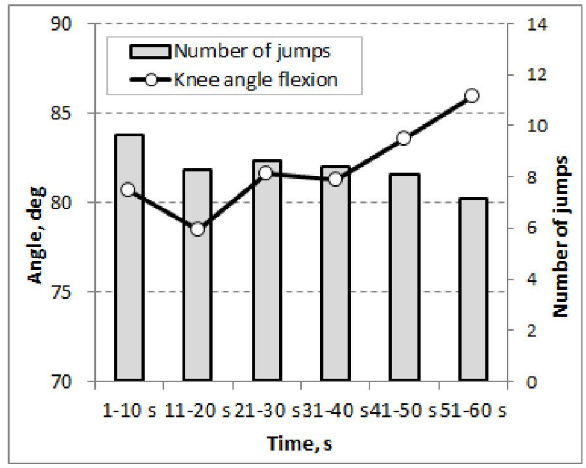

Figure 1a. The knee angle flexion at successive 10 second intervals during the Bosco test.

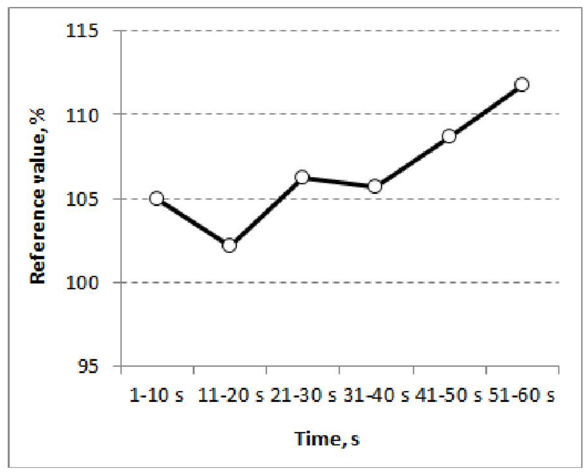

Figure 1b. Changes in the knee flexion angle in relation to the its reference value.

The characterisation of the knee flexion angles recorded during a 60-s series of jumps indicates shows changes in the parameters starting with 40^{th} second of exercise. For the first 40 s of exercise its values are similar to the reference value and deviations fall in the range of 0-5%. During the 5^{th} and 6^{th} 1-sec intervals, i.e. between 40 and 60 seconds of exercise, the values of the angle considerably increase, in excess of 10% of the reference value. Therefore, after 40 seconds of exercise, a change in the thigh position against the leg brings about a change in the muscle work conditions during the exercise.

Table. 1. Jump kinematic indicators during the Bosco test recorded at 10 s intervals.

Parameter	Time interval [s]	Mean	Min	Max	SD
Knee-joint angle [°]	1-10	80.69	69.82	91.11	7.36
	11-20	78.50	61.63	93.67	10.84
	21-30	81.63	70.89	95.56	9.55
	31-40	81.26	65.78	92.57	9.89
	41-50	83.55	67.00	94.86	9.27
	51-60	85.92	68.13	98.00	10.55
Time of contact with the ground [s]	1-10	0.67	0.53	1.04	0.16
	11-20	0.75	0.60	1.05	0.13
	21-30	0.78	0.62	1.15	0.16
	31-40	0.83	0.63	1.29	0.20
	41-50	0.86	0.67	1.28	0.21
	51-60	0.93	0.56	1.57	0.30
Flight time [s]	1-10	0.48	0.41	0.52	0.04
	11-20	0.46	0.41	0.50	0.03
	21-30	0.43	0.39	0.47	0.03
	31-40	0.41	0.37	0.47	0.04
	41-50	0.38	0.32	0.44	0.05
	51-60	0.36	0.28	0.43	0.05
Jump height [cm]	1-10	28.88	21.89	33.29	3.85
	11-20	26.19	20.39	31.15	3.70
	21-30	23.06	18.25	27.60	3.61
	31-40	20.73	16.68	26.54	3.52
	41-50	17.88	12.81	24.27	4.06
	51-60	8.13	6.00	10.00	1.46
Power [$W \cdot kg^{-1}$]	1-10	15.96	9.66	22.96	4.63
	11-20	20.52	18.09	24.10	2.54
	21-30	17.92	15.04	21.48	2.06
	31-40	16.24	13.67	19.13	2.02
	41-50	14.80	13.04	17.51	1.62
	51-60	13.14	10.72	15.68	1.65

During the 60 s Bosco test a constant increase in the time of contact with the ground can be observed during the 10 sec intervals. The shortest time of the contact is accompanied by the greatest number of jumps, which occurs in the first 10 s of work. The number of jumps stabilizes then between 10 and 40 seconds of exercise – in that period the time of contact with the ground increases steadily, but the increase does not exceed 0.03 s on average. With the 40 s of exercise the number of jumps starts decreasing (from 8,23 to 7,08) and the time of contact clearly grows longer (from 0.83 to 0.96 s). The character of the changes in the time of contact during successive take-offs indicates that until the 10th second of this exercise work is carried out with the shortest time of contact with the ground, but from the 40 second the time is considerably longer. This allows three zones of work to be distinguished because of the time: 0-10 s very short, 10-40 s – short, and 40-60 s extended.

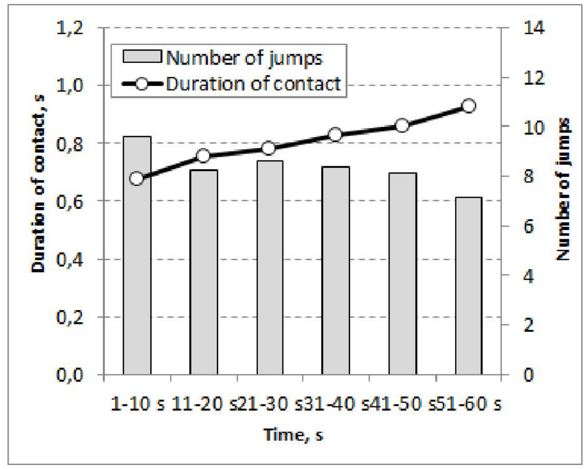

Figure 2. The number of jumps and the duration of contact with the ground successive 10 s intervals during the Bosco test.

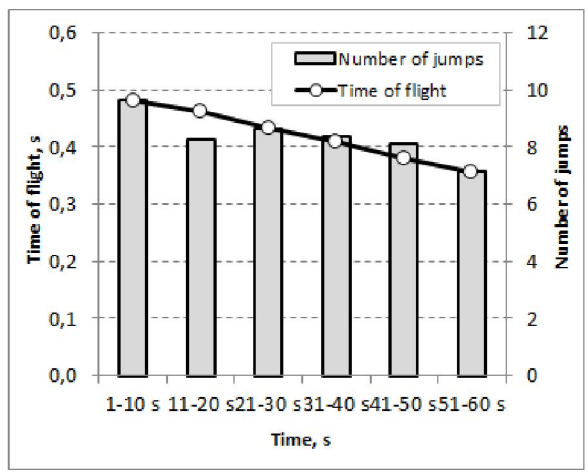

Figure 3a. Time of flight during successive 10-s intervals of the Bosco test.

The flight time during a jump maintains characteristics similar to changes in the time of the take-off with a reversed sign. The longer time of work in the 60 s exercise, the shorter the flight. Already after 10 s of exercise the time of flight becomes shorter by 15% compared with its reference value The total decrease in the flight time vis-à-vis the reference value was 37%. A stable number of jumps between 11 and 50 s of exercise (an average of 8.25-8.13) is accompanied by a flight time decreasing from 0.461 s to 0.537 s. The flight time changes during the whole exercise had a linear character, so intervals with more intensive changes or stabilisation cannot be distinguished.

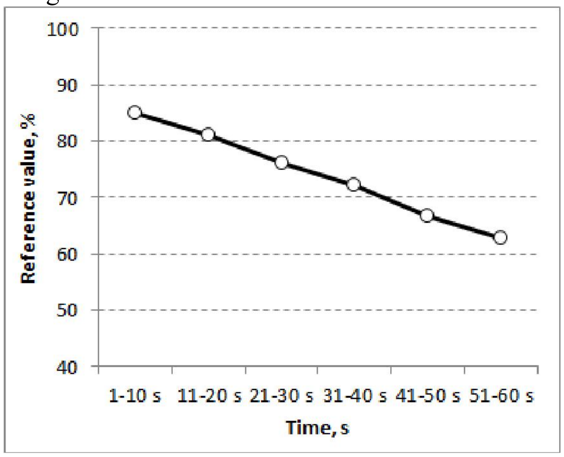

Figure 3b. Changes in the flight time in relation to the reference value.

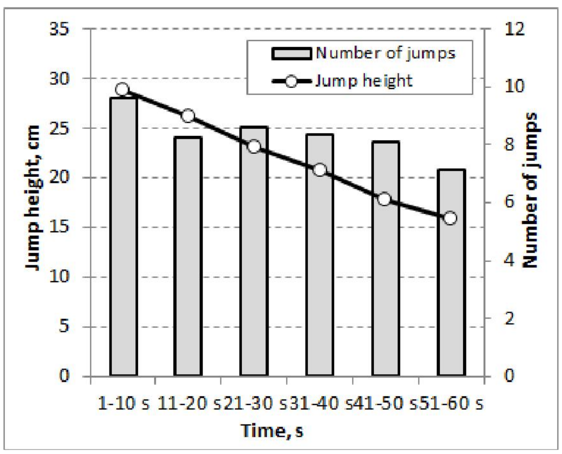

Figure 4a. Jump height during 10 s intervals of the Bosco test.

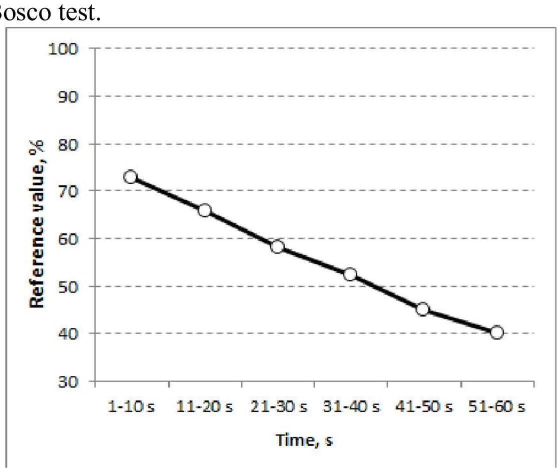

Figure 4b. Changes in jump height in relation to the reference value.

The jump height changes have a similar character as changes in the flight time. Compared with the reference value the decrease was greater, though. Already in the first 10 s interval the mean value of a jump was smaller than the reference value by 17%, but in the last time interval (51-60 s) the values account for only 40% of the reference value.

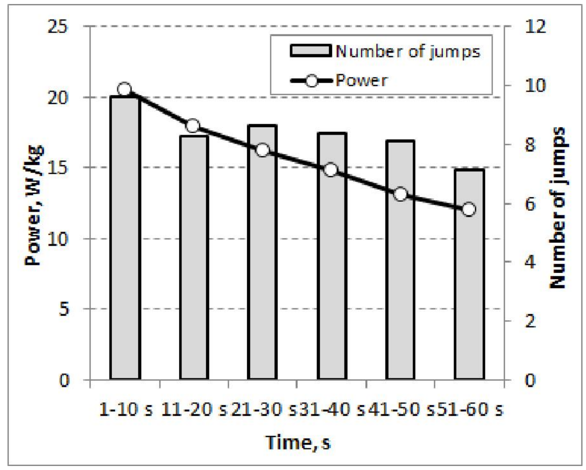

Figure 5. Power in the successive 10-s intervals of the Bosco test.

An analysis of changes in power developed in the successive 10 s periods did not find them to be similar to those in the number of jumps done. A linear decline in the amount of developed power could be observed (from 20.5 to 12 $W \cdot kg^{-1}$ b.w.), whereas the number of jumps, after falling in the 11-20 s of exercise, did not change until the 50 s of exercise.

A statistically significant correlation was found between LA values recorded in minutes 4 and 8 after post-exercise restitution and the values of the knee-joint angle determined for intervals from 21 to 60 s of the Bosco test (Fig. 6).

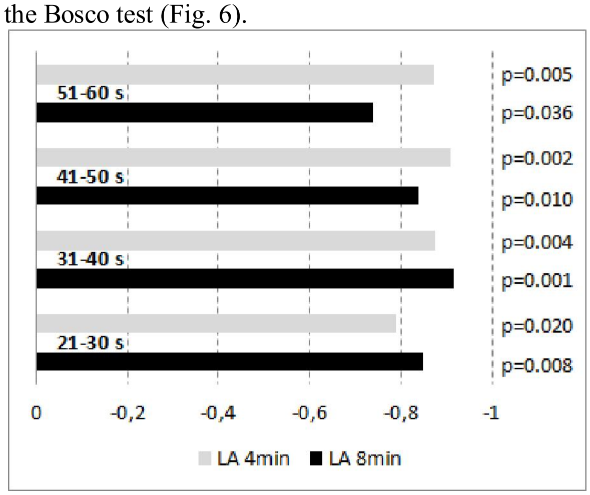

Figure 6. Relationships between LA values and values of the knee-joint angle.

The lactate level after exercise points to the intensity of anaerobic glycolysis and its participation in the generation of energy during work (Katz & Sahlin, 1988; Heigenhauser & Parolin, 1999; Stallknecht, 1998; Brooks, 1986). The higher the lactate level recorded after exercise, the smaller the knee-joint flexion angle recorded before take-off from 20 s of exercise. This type of relationship and the course of changes in the knee-joint angle during the whole test (steadily increasing values and growing fatigue induced by the performed work) point to anaerobic glycolytic capacity being important for jump kinematics. This provides grounds for concluding that individuals with a greater anaerobic glycolytic capacity are more resistant to fatigue and can exercise longer with the optimal conditions of the thigh-leg system.

Discussion and Conclusions

An analysis of the results of the study has demonstrated that the length of exercise has a major effect on variations in the kinematic indicator values recorded during jumps in the Bosco test. In the tested subjects, the angle of the knee-joint flexion increased by 5^o after 40 s of exercise. Until 20 s of exercise the values of the parameter were similar to their reference value. With the growing fatigue the difference between the reference value and the recorded also increased. The knee-joint flexion angle steadily increased, to account for 110% of the reference value in the last 10 s of the test. In McNeal et al.'s study of 2010 on a group of athletes specialising in jumps and throws an inverse relationship between flight duration and the length of contact with the ground during a series of jumps done during 60 seconds was found.

The authors' own studies have also shown that that the decreasing number of jumps is accompanied by an increasingly long take-off time (Fig. 2) and increasing flight time (Fig. 3). Starting with the first 10 s work interval, the flight time increases in relation to its reference value. This points out that it is a very sensitive indicator of fatigue, showing a reduction in the ATP-PCR energy reserves (Gabryś, 2000). That efficient identification of changes in the degree of recruitment of this source is crucial for sprinter's effort, because it allows setting the maximum time of exercise aimed to form this area of preparation. Compared with the results' of authors' own research on the jump height (Fig. 4) and power (Fig. 5) changes, the attention is drawn to lower values achieved in the first 10 s interval than in the second interval by Sands et al. (2012) studying figure skaters. In this study, a decline in power and jump height could be observed starting with the first 120 s interval.

An analysis of the research findings identifies the Bosco test as a sensitive tool for measuring the anaerobic endurance of the lower extremities in athletes involved in speed-endurance disciplines. Further research should concentrate on seeking relationships between the character of the applied training means and their outcomes as revealed by the Bosco test.

Practical recommendations

In the current examination of athlete's preparedness to handle training loads the Bosco test can be used as a trial generating indicators for exercise parameters to be established. This observation applies to lactic and glycolytic anaerobic exercise:

- the time in which the angle between the thigh and the leg changes during a jump in the Bosco test indicate the longest time of exercise at maximal intensity allowing the parameters of optimal muscle work to be maintained for a single effort;

- changes in the time of contact with the ground during successive take-offs in the Bosco test indicate that exercises can be divided into three groups. Group I consists of exercises with short contact time, in group II the contact time is medium and in group III long. The duration of exercise should be selected in a way so that the purpose of training is consistent with the athlete's ability to maintain the correct temporal structure of movement, one element of which is the take-off time.

The Bosco test allows an indirect evaluation of the level of the anaerobic glycolytic capacity. The greater the capacity, the longer the time of exercising under optimal conditions of the thigh-leg arrangement during jumps done with maximum power.

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Reference

1. Aura O, Komi PV. Effects of prestretch intensity on mechanical efficiency of positive work and on elastic behavior of skeletal muscle in stretch-shortening cycle exercise. *Int J Sport Med* 7(3): 137–143, 1986.
2. Bar-Or O. The Wingate anaerobic test: An update on methodology, reliability, and validity. *Sport Med* 4: 381–394, 1987.

3. Bosco C,. Luhtanen P, Komi PV. A simple method for measurement of mechanical power in jumping. *Eur J Appl Physiol Occup Phys* 50: 273–282, 1983.
4. Bosco C. Adaptive response of human skeletal muscle to simulated hypergravity condition. *Acta Physiol Scand* 124: 507–513, 1985.
5. Brooks G. The lactate shuttle during exercise and recovery. *Med Sci Sports Exerc* 18(3): 360–368, 1986.
6. Gabryś T, Szmatlan-Gabryś U, Ficek K. Biomedical conditioning training of young athletes. *COS*, Warszawa, 2004. (in polish).
7. Gabryś T. Anaerobic capacity of sportsmen. Training, control, ergogenic. *AWF Katowice*. Katowice, 2000. (in polish).
8. Harley RA, Doust JH. The development of a field test assessing power endurance of the leg extensor muscles during sets of repeated jump. *J Sports Sci* 12:139, 1994.
9. Heigenhauser GJ, Parolin ML. Role of pyruvate dehydrogenase in lactate production in exercising human skeletal muscle. *Adv Exp Med Biol* 474: 205–18, 1999.
10. Heller J, Tuma Z, Dlouha R, Bunc V, Novakova H. Anaerobic capacity in elite male and female gymnasts. *Acta Univ Carol Gym* 34(2): 75–81, 1998.
11. Hoffman JR, Epstein S, Einbinder M, Weinstein Y. A comparison between the Wingate anaerobic power test to both vertical jump and line drill tests in basketball players. *J Strength Cond Res* 14: 261–264, 2000.
12. Irvin R, Major J, Sands WA. Lower body and torso strength norms for elite female gymnasts. In: *USGF Sport Science Congress Proceedings*. JL. McNitt-Gray, R. Girandola, J. Callaghan, eds. Indianapolis, USGF Publications, 1992. pp. 5–12.
13. Katz A, Sahlin K. Regulation of lactic acid production during exercise. *J Appl Physiol* 65(2): 509–518, 1988.
14. Komi PV, Bosco C. Utilization of elastic energy in jumping and its relation to skeletal muscle fiber composition in man. In: *Biomechanics VI-A*. E. Asmussen, K. Jorgensen, eds. Baltimore, MD: University Park Press, 1978. pp. 79–85.
15. McNeal J, Sands W, Stone H. Effects of Fatigue on Kinetic and Kinematic Variables During a 60-Second Repeated Jumps Test. *Int. J. Sports Physiol. Perform.* 5: 218–229, 2010.
16. Moffatt RJ, Surina B, Golden B, Ayres N. Body composition and physiological characteristics of female high school gymnasts. *Res Q Exercise Sport* 55(1): 80–84, 1984.
17. Ozimek M. Short runs. in: Athletics - Textbook for students, teachers and coaches, eds. T. Gabryś, Z. Borek. AWF Katowice, 2008. pp. 9–89. (in polish).
18. Sacco I. Influence of ankle devices in the jump and landing biomechanical responses in basketball. *Revista Brasileira de Medicina do Esporte* São Paulo, 10(6): 453–458, 2004.
19. Sands W, Kimmel W, McNeal J, Murray S, Stone M. A comparison of pairs figure skaters in repeated jumps. *J Sports Sci Med* 11: 102–108, 2012.
20. Sands WA, McNeal JR, Ochi M, Urbanek T, Jemni M, Stone M. Comparison of the Wingate and Bosco anaerobic tests. *J Strength Cond Res* 18:810–815, 2004.
21. Stallknecht B, Vissing J, Galbo H. Lactate production and clearance in exercise. Effects of training. A mini-review. *Scand J Med Sci Sports* 8(3): 127–31, 1998.
22. Stanula A, Gabryś T, Szmatlan-Gabryś U, Roczniok R, Maszczyk A, and Pietraszewski P. Calculating lactate anaerobic thresholds in sports involving different endurance preparation. J Exerc Sci Fit 11(1): 12–18, 2013.
23. Van Praagh E, Franca N. Measuring maximal short-term power output during growth. In: *Pediatric anaerobic performance*. E. Van Praagh, eds. Champaign, IL: Human Kinetics, 1998. pp. 155–189.

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