HUMAN MOVEMENT
2017; 18(2): 62–67

ENERGY EXPENDITURE AND LACTATE CONCENTRATION IN SPORTS DANCERS IN A SIMULATED FINAL ROUND OF THE STANDARD STYLE COMPETITION

original paper
doi: 10.1515/humo-2017-0012

WANDA PILCH[1], ŁUKASZ TOTA[2], ILONA POKORA[3], MATEUSZ GŁOWA[4], ANNA PIOTROWSKA[1], OLGA CHLIPALSKA[4], ROXANA ZUZIAK[4], OLGA CZERWIŃSKA[1]

[1] Faculty of Rehabilitation, University of Physical Education, Krakow, Poland
[2] Institute of Biomedical Sciences, Faculty of Physical Education and Sports, University of Physical Education, Krakow, Poland
[3] Department of Physiological and Medical Sciences, University of Physical Education, Katowice, Poland
[4] Doctoral Studies, Faculty of Physical Education and Sports, University of Physical Education, Krakow, Poland

ABSTRACT
Purpose. To determine the energy expenditure in dancers and the nature of energy transformations which take place during a simulated final round of sports dance competition in standard style.
Methods. The study involved 6 sports dancing couples in highest dance classes (4 couples in S class, 2 couples in A class) according to WDSF (World Dance Sport Federation). There were two phases of the study. The first phase was to determine anthropometric indices, the second – to carry out a simulation of a tournament round in standard style. During a simulated final round of sports dance competition, heart rate (HR) and lactate concentration (La^-) were measured, respiratory indicators were recorded (VO_2, VCO_2, RER), and energy expenditure was calculated.
Results. The VO_2 values rated during each round differed statistically significantly between the group of men and women, (34.59 ± 3.82 ml · min^{-1} · kg^{-1} and 44.18 ± 4.34 ml · min-1 · kg^{-1}; F = 41.07, p = 0.01). The mean respiratory exchange ratio was 1.08 ± 0.07 in men and 1.06 ± 0.07 in women. During a round, the lactate concentration increased, and at the end, after the last dance, it reached the value of 12.9 ± 2.1 mmol · l^{-1} in women and 13,3 ± 2.7 mmol · l^{-1} in men. The energy expenditure after the completed round in men was 16.6 ± 1.3 kcal · min^{-1} and was higher than in the group of women, 10.7 ± 1.0 kcal · min^{-1} (F = 3.67; p = 0.01). The highest energy expenditure in all subsequent dances was noted during quickstep.
Conclusions. The study results complement the knowledge on the intensity of dance effort and confirm that the dance effort during sports competition is one of the heavy forms of physical activity based on aerobic and anaerobic energy processes. Therefore, the periodization of dance couple training process should considerably take into account the implementation of training loads that would help building solid aerobic and anaerobic capacity.
Key words: ballroom dance, standard style, energy expenditure, physical capacity

Introduction

Sports dance is a type of motor activity including elements of both artistic expression and sports competition. The current formula of this discipline includes ten different dances divided into two categories called styles. There are two styles: Latin dance and standard dance. The standard style dance includes five consecutive dances: English waltz, tango, Viennese waltz, foxtrot, and quickstep [1–2].

The uniqueness of sports dancing as compared with other sports disciplines lies in great diversity of movement forms which need to be performed in a strictly defined musical framework. Each dance has its individual character depending on the pace and expression of a particular piece of music. It is expressed by performing complex movement sequences with variable speed, dynamics and sudden changes of direction. Dance steps are a combination of such movements as gaits, runs, jumps, forward steps, kicks and turns carried out within a small distance between partners, in full contact of partners' torsos and hands, and in full mutual synchronization of steps [1–4].

Sports dancing competitions include several preliminary rounds. The number of rounds can reach six in one day. Each round consists of five consecutive dances,

Correspondence address: Łukasz Tota, The University of Physical Education in Krakow, al. Jana Pawła II 78, 31-571 Kraków, e-mail: lukasztota@gmail.com

Received: June 20, 2016
Acepted for publication: April 21, 2017

Citation: Pilch W, Tota Ł, Pokora I, Głowa M, Piotrowska A, Chlipalska O, Zuziak R, Czerwińska O. Energy expenditure and lactate concentration in sports dancers in a simulated final round of the standard style competition, Hum Mov. 2017;18(2):62–67; doi: 10.1515/humo-2017-0012.

each with a duration of 1.5–2 minutes except for Viennese waltz and Jive which last for 1–1.5 minutes. [1, 2, 5]. Because of the differences in the number of rounds in standard dance tournaments and diversified sports level of the study participants, it is difficult to estimate the mean or total energy expenditure in one competition. Therefore it seemed reasonable to determine the energy expenditure in the final round as an element of the standard style competition. Previous dance studies included an assessment of the physiological response of an organism to the effort taken during a simulated round or sports dance competition [6, 7].

In some papers issues related to energy expenditure during dancing were discussed [8–12]. To assess the amount of oxygen taken and energy used, various research tools and methods were applied, including non-calorimetric ones in which energy expenditure was estimated on the basis of a linear relationship between the effort intensity, heart rate, and oxygen uptake [9]. Some of them showed the divergence between the results obtained based on the correlation of pulse and oxygen uptake and the results obtained based on energy expenditure evaluation made using indirect calorimetry [13, 14].

Dance study papers show that many authors are interested in the assessment of physical fitness, energy expenditure, and general physical preparation of dancers specializing in various dance types [15]. Nevertheless, the papers there is no study of contestants specializing in sports dance of the standard type [6, 16].

In the light of the above information, the goal of the study was to determine the energy expenditure, nature of energy transformations, and the physiological response during the dances simulating the final round of the sports dance competition in standard style.

Material and methods

Characteristics of the respondents

The study was performed among a group of six sports dancing couples – 6 men and 6 women aged 19–25. The study participants were active dancers engaging in national and international competitions. Each participant specializes in standard style and had A or S dancing class (4 couples in S class, 2 couples in A class) according to the classification of the World Dance Sport Federation. The mean training period for the analysed group was 12.4 ± 3.0 years. The study participants trained 13.2 ± 5.3 hours a week (one training unit was approximately 2.8 ± 0.3 hours).

Research protocol

The studies were conducted in accordance with the principles of Helsinki Declaration regarding for the conduct of clinical trials in humans. The study participants were advised about the goal and the course of the research, and expressed a written consent for their participation. The athletes had valid sports medical test results, which was a condition of accession to stress tests.

During the first stage of the research, all study participants had their anthropometric indices determined: body height (BH), body mass (BM), fat mass (FM), and lean body mass (LBM).

Body mass and structure was determined with bioelectrical impedance method using a Jawon Medical body composition analyser, model IOI 353 (Korea), and body height was measured with a Martin anthropometer (USA) with accuracy up to 1 mm.

During the second study phase, a simulation of a tournament round in standard style was carried out under the conditions typical of the sports dance competition finals. During the simulation, basic respiratory parameters were measured based on the analysis of the exhaled air (direct measurement): oxygen uptake (VO_2), exhaled carbon dioxide volume (VCO_2), respiratory exchange ratio (RER). Parameters were recorded on an continuous basis.

The measurements were carried out using a portable ergospirometer, START 2000M from MES (Poland). Heart rate was recorded via telemetry using sport-tester S-610i, Polar, (Finland). Energy expenditure (EE) was determined by a portable ergospirometer START 2000M from MES (Poland). Energy expenditure was calculated using the ergospirometer's firmware by MES (Poland). The device manufacturer uses the following formula: $EE = VO_2 \times RKT$ [kJ/l], where RKT [kJ/l] = 5.1392; · RER + 15,983, VO_2 – oxygen uptake.

The simulated final round of sports dance competition covered the following sequence of five dances with 30s breaks: English Waltz, Tango, Viennese Waltz, Foxtrot, Quickstep. Each dance lasted 1 minute 40 s, except for the Viennese Waltz (1 minute 20 s). Before the simulated tournament round and after completing each dance, capillary blood was collected from a fingertip to measure the lactate concentration.

The lactate concentration was measured in plasma by an enzymatic method using a Lactate PAP set from BioMérieux (France), and a Spekol 11 spectrophotometer, Carl Zeiss Jena (Germany). Reference values for arterial blood: 0.5–1.6 mmol · l^{-1}, linearity: up to 10 mmol · l^{-1}, detection limit: 0.07 mmol · l^{-1}.

The study participants performed dance efforts in a sports hall during morning hours, at least 2 hours after a meal, dressed up in a uniform equivalent to the one used during the competition. Before the round, participants engaged in a 5-minute warm up.

Statistical analysis

All the calculations and analyses were carried out in Statistica 10.0 for Windows, by StatSoft (USA). After determining mean values and standard deviations, the distribution was tested for normality using Shapiro-Wilk test.

To examine the differences between the studied groups of men and women, as well as differences of various physiological indicators among individual dances, Mann-Whitney U test was used. To examine the differences among subsequent dances in the group of women and the group of men, variance analysis (ANOVA) with repeated-measure factor was used. The results were recognized as statistically significant at the level of $p < 0.05$.

Results

Table 1 shows the mean values of the selected somatic parameters of the study participants.

All the somatic indicator values differed statistically significantly between the groups of women and men.

The mean values of one minute oxygen uptake (VO_2), heart rate (HR) and respiratory rate (RER) are shown in Table 2.

The mean values of one minute oxygen uptake and the heart rate differ statistically significantly for each subsequent dance between the group of women and men. Furthermore, significant differences were observed in the group of male dancers in the oxygen uptake and heart rate between English waltz and Viennese waltz ($p = 0.01$, $F = 2.81$), and between English waltz and quickstep ($p = 0.02$, $F = 3.11$).

In the group of female dancers, significant differences in oxygen uptake ($p = 0.02$, $F = 5.27$) and in heart rate ($p = 0.01$, $F = 18.7$) were observed only between English waltz and quickstep (Table 3).

Table 1. Somatic characteristics of respondents

Characteristics of the respondents	♂ $\bar{x} \pm SD$	♀ $\bar{x} \pm SD$	$p_{♂-♀}$
Number of dancers	6	6	
Age (years)	22.5 ± 2.07	21.0 ± 1.89	ST
BH (cm)	182.0 ± 3.58	170.2 ± 5.12	0.01
BM (kg)	70.2 ± 3.82	55.6 ± 7.21	0.01
FM (kg)	8.7 ± 3.09	11.3 ± 3.11	0.01
LBM (kg)	61.5 ± 3.21	44.3 ± 4.69	0.01

BH – body height; BM – body mass, FM – fat mass, LBM – lean body mass, ♂ – men, ♀ – women, * $p < 0.05$ difference between a group of ♂ and ♀ ($p_{♂-♀}$), $\bar{x} \pm SD$ – arithmetical mean and standard deviation, NS – not statistically significant difference

Table 2. Mean values of the analysed physiological indicators during the whole simulated round

Indicator	♂ $\bar{x} \pm SD$	♀ $\bar{x} \pm SD$	$p_{♂-♀}$
VO_2 (ml · kg^{-1} · min^{-1})	44.18 ± 4.34	34.59 ± 3.82	0.01
HR (b · min^{-1})	180.4 ± 6.88	183.8 ± 5.41	ST
RER	1.08 ± 0.07	1.06 ± 0.07	ST

VO_2 – one minute oxygen uptake, HR – heart rate, RER – respiratory exchange ratio, ♂ – men, ♀ – women, * $p < 0.05$ difference between a group of ♂ and ♀ ($p_{♂-♀}$), $\bar{x} \pm SD$ – arithmetical mean and standard deviation, NS – not statistically significant difference

Table 3. Mean values of the physiological indicators for individual dances

	♂		♀		$p_{♂-♀}$
	VO_2 (ml · min^{-1} · kg^{-1}) $\bar{x} \pm SD$	HR (b · min^{-1}) $\bar{x} \pm SD$	VO_2 (ml · min^{-1} · kg^{-1}) $\bar{x} \pm SD$	HR (b · min^{-1}) $\bar{x} \pm SD$	VO_2 (ml · min^{-1} · kg^{-1})
A	41.4 ± 3.41	169.5 ± 4.03	31.2 ± 2.51	176.8 ± 4.38	0.01
B	44.1 ± 4.46	178.7 ± 6.80	33.5 ± 4.72	182.3 ± 5.50	0.01
C	46.1 ± 3.07	183.2 ± 3.94	35.9 ± 3.97	186.3 ± 4.93	0.02
D	43.1 ± 3.35	181.8 ± 4.57	34.0 ± 2.99	183.8 ± 5.78	0.01
E	46.2 ± 3.19	187.8 ± 2.04	36.5 ± 3.19	189.5 ± 3.01	0.01
p	*A–C, (0.01) *A–E, (0.02)	*A–C, (0.01) *A–E, (0.01)	*A–E, (0.02)	*A–E, (0.01)	

A – English waltz, B – tango, C – Viennese waltz, D – foxtrot, E – quickstep, VO_2 – one minute oxygen uptake, HR – heart rate, ♂ – men, ♀ – women, * $p < 0.05$ difference between a group of ♂ and ♀ ($p_{♂-♀}$) and among individual dances, $\bar{x} \pm SD$ – arithmetic mean and standard deviation

Table 4. Energy expenditure at the end of the subsequent dances in a round

	♂	♀	$p_{♂-♀}$
	EE (kcal · min^{-1}) $\bar{x} \pm SD$	EE (kcal · min^{-1}) $\bar{x} \pm SD$	
A	14.3 ± 1.0	9.0 ± 1.4	0.01
B	15.7 ± 1.6	9.4 ± 0.9	0.01
C	16.4 ± 1.0	10.0 ± 1.1	0.01
D	15.3 ± 1.6	9.5 ± 1.5	0.01
E	16.6 ± 1.3	10.7 ± 1.0	0.01
p	*A–C, (0.02) *A–E, (0.01)	*A–E, (0.03)	

EE – energy expenditure, A – English waltz, B – tango, C – Viennese waltz, D – foxtrot, E – quickstep, ♂ – men, ♀ – women, * p <0.05 among the group of ♂ and ♀ ($p_{♂-♀}$) , and among dances, $\bar{x} \pm SD$ – arithmetic mean and standard deviation

Table 5. Average concentration and increments of lactate after each of the dances during a round simulation

	♂		♀		$p_{♂-♀}$
	La increase (mmol · l^{-1}) $\bar{x} \pm SD$	La concentration (mmol · l^{-1}) $\bar{x} \pm SD$	La increase (mmol · l^{-1}) $\bar{x} \pm SD$	La concentration (mmol · l^{-1}) $\bar{x} \pm SD$	La increase (mmol · l^{-1})
0		1.4 ± 0.3		1.4 ± 0.2	
A	4.9 ± 1.5	6.3 ± 2.0	5.6 ± 1.4	7.0 ± 1.6	5.63
B	1.3 ± 0.4	7.6 ± 2.7	1.1 ± 0.2	8.1 ± 1.5	1.71
C	1.1 ± 0.2	8.7 ± 1.6	1.3 ± 0.2	9.4 ± 2.0	2.19
D	3.1 ± 0.8	11.8 ± 1.7	2.6 ± 0.3	12.0 ± 2.0	2.28
E	1.5 ± 0.2	13.3 ± 2.7	0.8 ± 0.2	12.9 ± 2.1	0.19
p	0–A*, (0.01) C–D*, (0.02)	0–A*, (0.01) C–D*, (0.02)	0–A*, (0.01) C–D*, (0.03)	0–A*, (0.01) C–D*, (0.02)	

0 – initial lactate level, A – after English waltz, B – after tango, C – after Viennese waltz, D –after foxtrot, E – after quickstep, ♂ – men, ♀ – women, * p < 0.05 difference between a group of ♂ and ♀ ($p_{♂-♀}$) and among individual dances, $\bar{x} \pm SD$ – arithmetic mean and standard deviation

Table 4 shows energy expenditure (EE) values after completing subsequent dances in the group of women and men. The EE results for each dance differed statistically significantly between the group of women and men. Statistically significantly differences were observed between subsequent dances (A–C, $p = 0.02$, $F = 19.41$ and A–E, $p = 0.03$, $F = 2.59$ in the group men and A–E $p = 0.03$, $F = 1.97$ in the group of women). Energy expenditure had the highest values during quickstep both in the group of male and female dancers (Table 4).

Table 5 shows mean lactate concentration and lactate increments between subsequent dances.

Discussion

The results of the studies conducted showed that the somatic features of the study participants (FM, LBM) were similar to those of the dancers covered by other authors' studies on similar subjects [17, 18].

Bria et al. [19] in theirs studies conducted in sports dancers showed no significant correlation between one minute oxygen uptake and heart beat in simulated dance rounds. They explained it with great variation of HR determined by the impact of external or psychological factors which can impact the obtained HR values during the dance. The authors reasoned that the heart rate should not be the only credible variable used to determine the amount of oxygen uptake VO_2 and to estimate the energy expenditure during the dance. The results obtained in this study with the direct assessment of oxygen uptake allow for a precise assessment of the energy expenditure in athletes based on credible measurement data used in studies using the calorimetric method.

Considering the fact that dance has only limited influence on physical fitness [12], the values of the measured oxygen uptake were used in reasoning about metabolic features in the study participants. The mean one minute oxygen uptake measured during the simulation were slightly lower than in other authors' studies

[5, 8, 19]. Bria et al. [19] measured the values of VO_2 of approximately 45.8 ± 6.0 ml · min^{-1} · kg^{-1} in men and 38.0 ± 8.5 ml · min^{-1} · kg^{-1} in women.

The obtained results of energy expenditure during a simulated final round of sports dance competition allow for concluding that both for men and women the effort related to sports dance was very high. Dancers consumed the most energy at the end of the tournament round, during the last dance. The values reflecting the mean energy expenditure per work performed amounted to 0.20–0.26 kcal · kg^{-1} · min^{-1} in men and 0.19–0.21 kcal · kg^{-1} · min^{-1} in women, which indicates that it was higher than in other dance forms [11–13] and was closest to the folk dance (0.18 kcal · kg^{-1} · min^{-1}) [20]. Similar results of the same indicators in individual dances were obtained in previous studies by Liiv et al. [5]. In turn, Bria et al. [19] showed that the greatest loads, expressed in energy expenditure in the group of men dancing in standard style, were observed in the middle of the round, in Viennese waltz. Other researchers reached similar conclusions in their papers, also classifying sports dance as a very heavy physical activity [8, 9].

To refine the reasoning on metabolic features of the study participants during the final round of sports dance competition, in addition to energy expenditure, the measurements of the respiratory exchange ratio (RER) and the lactate concentration have been analysed. The mean value of RER for the whole simulated dance round was 1.08 ± 0.07 in male dancers and 1.06 ± 0.07 ($p = 0.51$, $F = 0.80$) in female dancers. This indicates a domination of anaerobic nature of metabolic transformations in obtaining energy during a simulated round of sports dance competition. These results were additionally confirmed by an increased lactate concentration after the end of the dance round. Bearing in mind the short break breaks between individual dances (30 seconds), which take place during sports dance competitions and which also took place in our studies, it can be accepted that the total accumulation of lactate in blood reveals after the end of the dance round in standard style. In our studies, the lactate concentration after the last dance was 13.3 ± 2.7 mmol · l^{-1} in men, and 12.9 ± 2.1 mmol · l^{-1} in women.

The lactate concentration measurements after the end of the simulated final round were slightly higher as compared with the results obtained by other authors in similar studies [5, 8, 19, 21]. At the same time, it should be noted that the athletes included in the quoted papers were ranked higher in the general WDSF ranking, which might suggest that there is a correlation of the fitness level, results achieved, and the level of physical endurance in sports dancers. A similar relationship was shown by Guidetti et al. [22] who noted that less advanced dancers had a higher component of anaerobic metabolism of energy processes as compared with more advanced dancers. A the same time, Liiv et al. [5] and Klonova et al. [23] did not find a correlation between VO_2max values in contestants and their international ranking position. However, it should be noted that they did not analyse technical skills of individual dancers which are also subject to assessment by judges, and also influence optimizing the use of energy resources during physical activities. What is more, the final result and rank depends on the judges' scores, as it is the case in figure skating or artistic gymnastics. Despite the guidelines and couple evaluation schemes clearly defined by regulations, scores are issued on the basis of individual experience and knowledge of judges, and therefore include some elements of subjective assessment. Nevertheless, this does not change the fact that the measured values of one minute oxygen uptake, energy expenditure, and lactate concentration show how high the level of physical preparation should sports dancers feature. Thus based on the obtained results, it should be concluded that in addition to the training units that help develop the elements of the dance technique which currently dominate in the process of dancer preparation, athletes should also employ such training methods which in a carefully planned manner would shape appropriate capacity components in them, both aerobic and anaerobic.

Other researchers reached similar conclusions [5, 20, 24]. Liiv et al. [19] postulated that a high level of aerobic capacity is essential to competing in sports dance at the highest level. Maciejczyk and Feć [20] made similar observations in their paper on folk dancers. The also stressed the necessity of shaping both aerobic and anaerobic characteristics of physical capacity. Bria et al. [19] showed that sports dancers should use more specific training programs to improve an inadequate level of aerobic capacity and low tolerance of body acidification, as these two have a direct influence on scores in competitions. Similar problem of inadequate preparation of athletes for making efforts in other dance areas was pointed out by Wyon and Redding [25], and Guidetti et al. [22]. Also Blanksby and Reidy [9], as a result of the obtained data, put special emphasis on the importance of the physical preparation of dancers, although their values of individual indicators during dance were lower than those measured in this work.

The results of this study are of great importance for ballroom coaches and dancing instructors dealing with youth sports at each qualification level. A large amount of physical strain which occurs when participating in sports competitions should encourage trainers and instructors to develop comprehensive training programs which would take into account the nature of the work occurring during the standard dance competition. The results of this study should contribute to the development of integrated training plans covering not only specialized training, but also a comprehensive preparation.

Conclusions

The study results complement knowledge on the intensity of dance effort and confirm that the dance effort is one of the heavy forms of physical activity based on aerobic and anaerobic energy processes. With appropriately designed training programs covering shaping oxygen capacity and tolerance to internal homeostasis changes induced by the production of lactate in dance players could help optimize the work during sports competitions. Quickstep was characterized by the highest energy expenditure in both groups during the final dance round – in both male, and female dancers.

References

1. WDSF Competition Rules. World DanceSport Federation, status: June 14, 2014 WDSF AGM, Granada Spain. Available from: https://www.worlddancesport.org/Document/9032164613/WDSF_Competition_Rules.pdf [18.07.2016].
2. Grunt J, Grycmacher A, Konury T. Przepisy rywalizacji w sporcie tanecznym [in Polish]. Federacja Tańca Sportowego. Available from: http://www.ftstaniec.pl/media/files/przepisy_rywalizacji_w_sporcie_tanecznym_fts.pdf [18.05.2015].
3. Paschalis V, Nikolaidis MG, Jamurtas AZ, Owolabi EO, Kitas GD, Wyon MA et al. Dance as an eccentric form of exercise: practical implications. Med Probl Perform Art. 2012;27(2):102–106.
4. Koutedakis Y, Jamurtas A. The dancer as a performing athlete: physiological considerations. Sports Med. 2004; 34(10):651–661.
5. Liiv H, Jürimäe T, Mäestu J, Purge P, Hannus A, Jürimäe J. Physiological characteristics of elite dancers of different dance styles. Eur J Sport Sci. 2014;14(1):429–436; doi:10.1080/17461391.2012.711861.
6. Angioi M, Metsios G, Twitchett EA, Koutedakis Y, Wyon M. Effects of supplemental training on fitness and aesthetic competence parameters in contemporary dance: a randomised controlled trial. Med Probl Perform Art. 2012;27(1):3–8.
7. McCabe TR, Wyon M, Ambegaonkar JP, Redding E. A bibliographic review of medicine and science research in dancesport. Med Probl Perform Art. 2013;28(2):70–79.
8. Faina M, Bria S, Scarpellini E, Felici F. The energy cost of modern ballroom dancing. Med Sci Sport Exer. 2001; 33(5):87; doi:10.1097/00005768-200105001-00500.
9. Blanksby BA, Reidy PW. Heart rate and energy expenditure during ballroom dancing. Brit J Sports Med. 1988; 22(2):57–60.
10. Cohen JL, Segal KR, Witriol I, McArdle WD. Cardiorespiratory responses to ballet exercise and the VO_2max of elite ballet dancers. Med Sci Sports Exerc. 1982;14(3): 212–217; doi:10.1249/00005768-198203000-00011.
11. Wyon M, Head A, Sharp C, Redding E. The cardiorespiratory responses to modern dance classes: differences between university, graduate, and professional classes. J Dance Med Sci. 2002;6:41–45.
12. Wyon MA, Abt G, Redding E, Head A, Sharp NCC. Oxygen uptake during modern dance class, rehearsal, and performance. J Strength Cond Res. 2004;18(3):646–649; doi:10.1519/13082.1.
13. Redding E, Wyon M, Sherman J, Doggart L. Validity of using heart rate as a predictor of oxygen consumption in dance. J Dance Med Sci. 2004;8(3):69–72.
14. Crisafulli A, Pittau G, Lorrai L, Carcassi AM, Cominu M, Tocco F, Melis F, Concu A. Poor reliability of heart rate monitoring to assess oxygen uptake during field training. Int JSportsMed.2006;27(1):55–59;doi:10.1055/s-2005-837504.
15. Beck S, Redding E, Wyon MA. Methodological considerations for documenting the energy demand of dance activity: a review. Front Psychol. 2015, 6, 568. doi:10.3389/fpsyg.2015.00568.
16. Koutedakis Y, Jamurtas A. The dancer as a performing athlete: physiological considerations. Sport Med. 2004;34(10): 651–661.
17. Liiv H, Wyon M, Jürimäe T, Purge P, Saar M, Mäestu J. Anthropometry and somatotypes of competitive DanceSport participants: a comparison of three different styles. Homo. 2014;65(2):155–160, doi:10.1016/j.jchb.2013.09.003.
18. Liiv H, Wyon M, Jürimäe T, Saar M, Mäestu J, Jürimäe J. Anthropometry, somatotypes, and aerobic power in ballet, contemporary dance, and dancesport. Med Probl Perform Art. 2013;28(4):207–211.
19. Bria S, Bianco M, Galvani C, Palmieri V, Zeppilli P, Faina M. Physiological characteristics of elite sport-dancers. J Sports Med Phys Fitness. 2011;51(2):194–203.
20. Maciejczyk M, Feć A. Evaluation of aerobic capacity and energy expenditure in folk dancers. Hum Mov. 2013; 14(1):76–81; doi:10.2478/humo-2013-0007.
21. Chren M, Špánik M, Kyselovicová O. Blood lactate concentration of ballroom dancers according to the length of their routines. Acta Facultatis Educationis Physicae Universitatis Comenianae. 2010;50(2):43–50.
22. Guidetti L, Emerenziani GP, Gallotta MC, Da Silva SG, Baldari C. Energy cost and energy sources of a ballet dance exercise in female adolescents with different technical ability. Eur J Appl Physiol. 2008;103:315–321; doi:10.1007/s00421-008-0705-y.
23. Klonova A, Klonovs J, Giovanardi A, Cicchella A. The sport dance athlete: aerobic-anaerobic capacities and kinematics to improve the performance. Journal of Kinesiology and Exercise Sciences. 2011;21(55):31–37.
24. Martyn-Stevens BE, Brown LE, Beam WC, Wiersma LD. Effects of a dance season on the physiological profile of collegiate female modern dancers. Med Sport. 2012;16(1); 1–5; doi: 10.5604/17342260.987830.
25. Wyon MA, Redding E. Physiological monitoring of cardiorespiratory adaptations during rehearsal and performance of contemporary dance. J Strength Cond Res. 2005;19(3):611–614; doi:10.1519/14233.1.