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Ballroom dancing is more intensive for the female partners due to their unique hold technique

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In this study, we tested the hypotheses that, relative to the maximum capacities, ballroom dancing is more intensive for females than males, and that the hold technique (female vs. male) regulates dancing intensity. Ten dance couples were tested in a maximal treadmill test, competition simulation, and stationary dance hold position. Peak heart rate and relative oxygen consumption were measured during the tests, except that oxygen consumption was not measured during competition simulation. Regardless of gender, heart rate increased similarly in the treadmill test and in the competition simulation. In the treadmill test, females achieved an oxygen consumption of 78% of the males ($p < 0.05$). Compared with males, females achieved 14% higher heart rate ($p < 0.05$) and similar oxygen consumption during the hold position. Heart rate during competition simulation relative to maximum was greater for females than males. Both heart rate and oxygen consumption measured during the hold, relative to maximum, were greater for females than males. It is concluded that lower class ballroom dancers perform at their vita maxima during competition simulation. Using heart rate as an intensity indicator, ballroom dancing is more intensive for females because of their unique hold technique.

Keywords: dance, intensity, lactate, heart rate, oxygen consumption, artistic performance

Introduction

For most people, dancing is an ancient form of human movement for the expression of tradition, culture, and social relationships. Recently, various modalities developed to high-level performance sport. Though competitive dancers are ranked according to their artistic performance and the technical requirements of any given modality, the physiological and psychological demands of performing their choreography have dramatically increased (1, 15, 17). Koutedakis and Jamurtas (8) were among the first authors who scientifically focused on this problem, and they named the competitive dancers "performing athletes".

Ballroom dance (BD) is a classic and popular form of dancing, and it is a discipline of the worldwide recognized dancesport competitions listed by the World DanceSport

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Federation (WDSF). BD consists of five dances (slow waltz, tango, viennese waltz, slow foxtrot, and quickstep), and the WDSF regulates the tempo and the duration of the dances. The duration has lately increased to 90–120 s/dance, challenging the couples' physiological limits. Remarkably high maximal aerobic capacity (50–66 $ml \cdot kg^{-1} \cdot min^{-1}$) and peak heart rate (192–198 bpm) during competition simulation have been measured recently in top-class dancers, suggesting high demands on physical condition in BD (9, 10). Furthermore, the intensity seems to be higher during tango and quickstep, and lower during slow waltz, viennese waltz, and slow foxtrot, probably because the first two dances comprise forceful and rapid movements. However, data are available only from a study in which these dances were danced in a competition sequence without allowing full recovery (10).

BD is a special co-educated sport, where male and female partners as couples maintain a hand-hold position and move as one throughout the dances (23). Instead of their individual technique, the judges evaluate the common artistic performance during competitions. A unique feature of this sport is that the direction of the steps of the male and the female partners is either identical (in open position), or the steps are mirror images of each other (in closed position) (16), and the concept is that path and travel distance during steps is equal (24) otherwise the hold technique is disturbed, compromising the artistic performance. In such cases, the absolute step rate, length, and speed [factors of mechanical workload, which influence exercise intensity (22)] are the same. However, male ballroom dancers have higher cardiorespiratory and muscular capacities than females (9, 10), suggesting that the conditioning level of the female partner could limit the overall performance of the couple during BD, an exercise, which requires similar mechanical workload in the two genders. Our theories are confirmed only by some of the studies that aimed to characterize the physiological response of male vs. female dancers. It was demonstrated that top-level female dancers' cardiorespiratory system was equally or less stressed than that of males during a competition simulation (3, 10). In contrast, in a later study, Liiv et al. (9) found that BD was more intensive for the female partner. Furthermore, in an early study, females tended to achieve higher heart rates in all of the five dances (2). The discrepancy and the magnitude of differences between genders in these studies may result from differences in competitors' level, or from using different experimental settings and intensity indicators. Still, the idea is that in dance couples, males are exposed to smaller cardiovascular stress because of the uniform mechanical workload but smaller physiological workload during BD.

A feature that distinguishes the individual technique of the partners in BD is that while males maintain the head and the upper body in upright position during the hold, females perform a lateral flexion and a hyperextension both in the trunk and the neck to increase the aesthetic appearance (Fig. 1) (6, 7, 14). This posture has to be maintained throughout the dances. Its technique requires forceful isometric contractions in the upper body muscles, which may further increase the energy demand in the female partner (12), an unrecognized and uncontrolled factor in previous research.

Taken together, in BD, the female partner's physiological capacities could limit a couple's overall performance, and the female's hold technique might contribute to the greater relative energy demand, if any. Here, we evaluated the physiological responses of lower class competitive dancers during a vita maxima test, a competition simulation, and for the first time in this study, during maintaining a stationary hold position. We hypothesized that (i) relative to the vita maxima physiological variables, the male vs. female partners' responses would be smaller during competition simulation. To investigate whether hold technique regulates the physiological

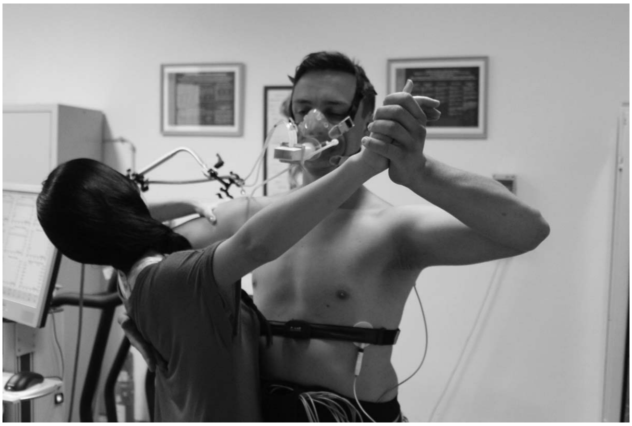

Fig. 1. Cardiorespiratory testing during ballroom dance hold maintained in a stationary position

demand during dancing, we further hypothesized that (ii) the physiological responses during the hold position relative to the vita maxima, values would be less for males vs. females.

Methods

Participants

Ten amateur dancesport couples recruited from local dance clubs participated in this study. At the time of the experiment, they were competing in B (two couples) and C (eight couples) categories at the national level, and none of them were in international ranking. The couples had been dancing together for 2.1 ± 1.7 years, trained 7.2 ± 0.7 h/week at the time of research, and participated in 11.3 ± 3.1 competitions within the past year. Table I shows the descriptive characteristics of the participants. It was required that participants maintain their normal training routine and nutrition during the experiment and avoid any unusual exercise. It was also required not to perform any physical activity (neither dance nor other practice) at least 16 h before each test session. After giving information about the experiment, a written

Table I. Gender characteristics

	Males	**Females**
	($n = 10$)	**($n = 10$)**
	Mean ± SD	**Mean ± SD**
Age (years)	24.8 ± 7.4	20.5 ± 4.1
Height (cm)	181.8 ± 5.1	169.8 ± 4.6*
Weight (kg)	71.1 ± 10.8	56.6 ± 7.7*
Body fat (%)	8.6 ± 4.9	18.6 ± 4.2*
BMI (kg·m^{-2})	21.5 ± 2.7	19.5 ± 2.0
Training experience (years)	8.0 ± 2.4	8.4 ± 1.9

*Significant difference between genders ($p < 0.005$)

informed consent was signed to agree to participate in this study, which was approved by the university ethical committee. The dancers declared that they were free of any orthopedic injuries and illness.

Procedures

The couples were tested in three sessions, each separated by at least 48 h. Sessions were conducted in the mornings between 9:00 and 12:00. In every session, participants were seated comfortably for 5 min. Afterward, lactate level was measured from finger tip capillary blood using Lactate Scout analyzer (SensLab, Leipzig, Germany).

In session 1, before any exercise testing, body weight and height were measured. Body fat percentage was assessed using bioelectrical impedance analysis (InBody 720, Biospace, Korea). After this, the subjects performed a maximal graded Bruce treadmill test for evaluating maximal cardiorespiratory capacities (4). A polar system (RS800™, Polar Electro, Kempele, Finland) set at a sampling frequency of 1 Hz and a spiroergometric system (Cardiovit AT-104, Schiller-Diamed, Hungary) were used for measuring peak heart rate (HR_{max}) and peak oxygen consumption (VO_{2max}), respectively, during the treadmill test. Blood lactate level was also determined immediately after the test.

In session 2, a competition simulation was performed in an indoor hall. Because no standardized warm-up has been described in BD studies yet, the warm-up in the present experiment was similar to the procedure frequently used by the couples during competitions or practices. This consisted of 10 min of stretching, followed by performing all the five choreographies (see later) individually (without the partner) for 45 s with 15 s rests. Finally, the waltz choreography was danced with the partner for 1 min. After warm-up, the couples rested for 10 min before the simulation started. The simulation was similar to that used by Liiv et al. (10) with the exception that our couples danced only one round of each of the five dances. Briefly, the choreographies were danced for 1:45 min with 15 s recoveries in the sequence of waltz, tango, viennese waltz, slow foxtrot, and quickstep, following WDSF regulations. Every couple dressed in their training costume and danced in their competition shoes for the same music, and a dance coach gave verbal encouragement to them to enhance the artistic performance. During the simulation, the polar system was used to determine the peak heart rate (HR_{sim}), which can be used as an indicator of physiological strain during high intensity dance activity (21). Lactate was measured immediately after the last dance.

In session 3, the couples were required to stand in a stationary hand-hold closed position and maintain their hold as they would perform during the waltz (Fig. 1). Similar to the competition simulation, this test comprised five repetitions of holds with 1:45 min of duration for each and with 15 s rests between repetitions. During the hold, peak oxygen consumption (VO_{2hold}) and peak heart rate (HR_{hold}) were determined with the same equipments described in session 1. Lactate was measured 5 min after the last repetition. In a pilot test, we took measurements every minute and we have found that lactate peaks in the fifth minute. Because in the hold position, it was possible to measure only one participant's respiratory function at a time, the couples were asked to report in the laboratory once more to test the partner. The gender sequence of this testing was randomized across couples. A dance coach was also present to verbally encourage the couples to satisfy the artistic requirements.

Statistical analyses

All variables were tested for normality and homogeneity. The anthropometric characteristics were compared between genders using independent samples *t*-tests. To characterize the physiological responses, a multivariate analysis of variance (ANOVA) was applied to peak HR and lactate data to test the interaction and main effects on gender (male and female) and test condition (max, sim, and hold) factors. In case of significant interaction, the Bonferroni adjustment was used to compare mean differences. Because of the results of the homogeneity test, peak VO_2 in the hold and simulation test conditions was compared between genders using a non-parametric Mann–Whitney *U* test. To test hypothesis 1, sim/max ratios were determined for peak HR and were compared between genders using independent *t*-tests. To test hypothesis 2, hold/max ratios were calculated for peak HR and were compared between genders using paired *t*-tests. To characterize relative oxygen consumption and anaerobic stress during the hold, the hold/max ratios were also determined for VO_2 and lactate. The statistical significance was set at $p < 0.05$.

Results

Comparisons in anthropometric characteristics between genders are presented in Table I. Resting lactate measured in all sessions for both genders ranged between 1.4 and 1.7 $mmol{\cdot}l^{-1}$. HR measured at the onset of the test in the three test conditions for males and females were 85 ± 17 vs. 94 ± 16 bpm (hold), 113 ± 21 vs. 118 ± 25 bpm (simulation), and 94 ± 21 vs. 101 ± 9 bpm (vita maxima), respectively.

Acute physiological responses under the three test conditions are presented in Fig. 2. Significant gender ($F = 4.1$; $p = 0.048$) and test condition ($F = 244.1$; $p = 0.000$) main effects as well as interaction ($F = 3.5$; $p = 0.037$) were found for peak HR. The *post-hoc* test showed that when genders were combined, HR_{sim} and HR_{max} were similar, but HR_{hold} was significantly smaller compared with either HR_{sim} ($p = 0.000$) or HR_{max} ($p = 0.000$). HR_{hold} was greater for females vs. males ($p = 0.014$) (Fig. 2). VO_{2max} was significantly greater for males than for females ($p = 0.000$). There was no difference in VO_{2hold} between genders. Significant test condition main effect was found for lactate ($F = 82.1$; $p = 0.000$), and the *post-hoc* comparisons revealed that lactate response was different under all three test conditions ($p < 0.05$). The gender did not affect the lactate responses (Fig. 2).

HR_{sim}/HR_{max} (Fig. 3), HR_{hold}/HR_{max}, and VO_{2hold}/VO_{2max} (Fig. 4) ratios were significantly smaller for males vs. females ($p < 0.01$). None of the calculated ratios in lactate differed between genders (Figs. 3 and 4).

Discussion

Though the first unofficial competitive BD competition took place in 1909 (20), in contrast with other types of physical activities, little data is available from scientific experiments [see the review by McCabe et al. (13)]. The fact that it is a unique co-educated sport where the common artistic performance of the two partners is evaluated calls for further research concerning the gender-specific physiological mechanisms during dancing. In this study, we have demonstrated that competitive BD is a vigorous physical activity, and lower class dancers perform at their vita maxima during a competition simulation. Our results provide evidence that, using HR as an indicator of exercise intensity, the different hold technique is responsible for the greater relative intensity for the female partner during a competition simulation.

Twenty-six years ago, Blanksby and Reidy (2) measured 185 bpm peak HR in amateur top-class and professional dancers during a competition simulation. Higher HRs (192–198 bpm)

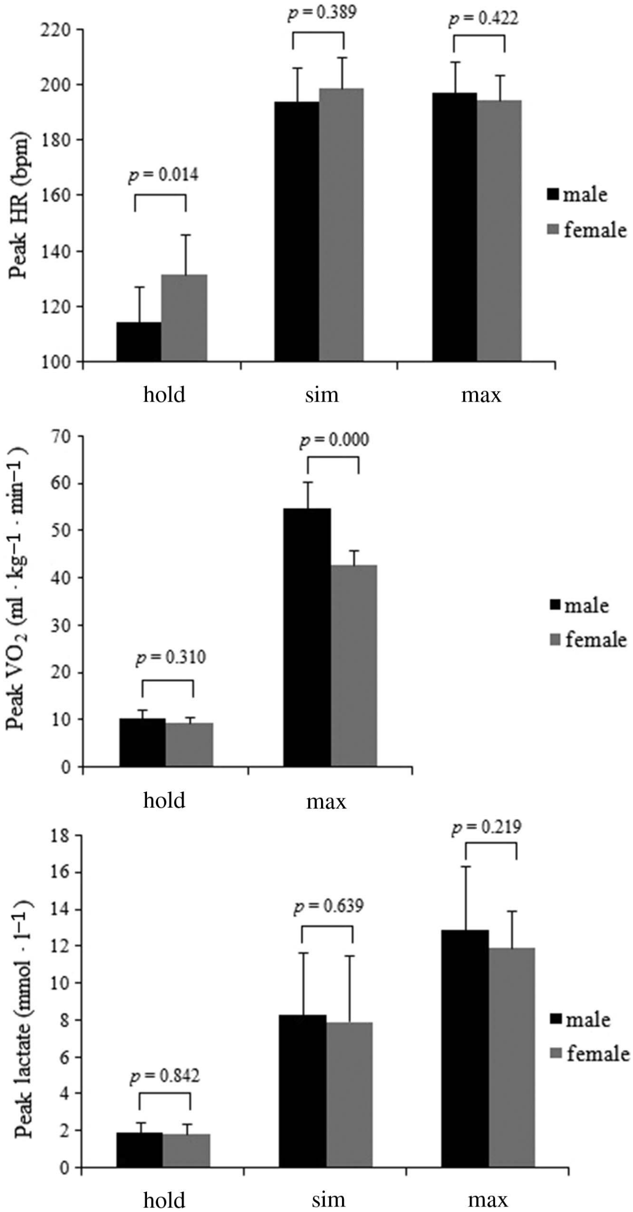

Fig. 2. Peak HR (upper), VO_2 (middle), and blood lactate level (lower) for males and females during hold, competition simulation (sim), and vita maxima (max). Data are means ± SD.

Note: VO_2 was not measured during SIM

have been measured recently in dancers at a similar level but with higher VO_{2max} suggesting that physical requirements have increased dramatically (9, 10). The HR data in our experiment (194 and 199 bpm) are in agreement with those demonstrated in other recent studies, and the high values indicate that BD challenges both the aerobic and the anaerobic energy systems similar to a vita maxima treadmill exercise test. Today, top-class dancers' maximal aerobic capacity [49–66 ml·kg^{-1}·min^{-1} (9)] is remarkably higher than that of dancers of the same level in the 1980s [42–52 ml·kg^{-1}·min^{-1} (2)], and our lower class dancers still achieved a VO_{2max}

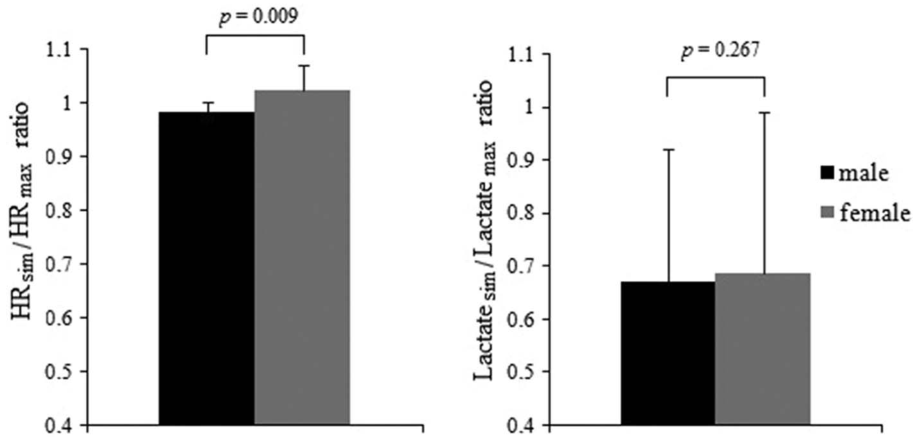

Fig. 3. Peak HR (left) and lactate (right) responses to competition simulation (sim) relative to the vita maxima (max) responses in males and females. Data are means ± SD

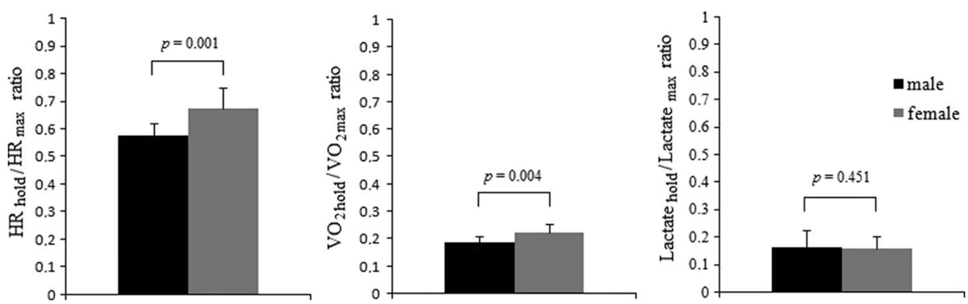

Fig. 4. Peak HR (left), VO_2 (middle), and lactate (right) responses in stationary dance hold position relative to vita maxima (max) responses in males and females. Data are means ± SD

(42–54 ml·kg^{-1}·min^{-1}) similar to those reported in the latter study. Anthropometric characteristics of elite dancers have been described previously (11), and we found very similar height, body weight, and BMI in our dancers. Examining the physiological profiles in our and in previous studies, maximum aerobic capacity seems to be one important factor that differentiates between lower and top-class dancers. Finally, it is also important to note that our dancers trained ∼ 7 h/week, while dancers from higher classes trained ∼ 12 h (10, 11), which can also be a reason for the dramatic HR elevations in our study. However, lower class dancers' profile has not been characterized yet in scientific papers, therefore, it is difficult to determine whether our sample is representative in the appropriate dancesport population.

Traveling distance (step length) could be an important regulator of BD intensity. It was found previously that male and female partners within a couple traveled similar distances in a choreography with only ∼ 1% difference between them (23) (suggesting similar absolute workload), a key finding from which our first hypothesis derives. Male dancers have greater upper body maximum strength, leg explosive strength, and better sprinting ability (9, 19), which may further diminish the dance intensity relative to their vita maxima capacities because partners move as one in full synchronicity. Finally, we found that males have lower levels of body fat, and similar BMI as females, suggesting a more favorable body composition for strenuous physical activity. To examine hypothesis 1, BD is more intensive for females vs. males, we compared their peak HR values obtained during competition simulation relative to vita maxima. We found that BD intensity for our cohort of lower class dancers was similar to their vita maxima, and slightly but significantly smaller in males (98%) than in females (102%), which supports our first hypothesis. Surprisingly, in a previous study, male and female dancers were equally stressed during a competition simulation, when their HR responses were normalized to the anaerobic threshold levels (10). At the same time, however, the same authors as well as others provided evidence that BD intensity exceeded the anaerobic threshold, challenging the dancers' anaerobic capacity (3). Therefore, to define BD intensity relative to vita maxima responses is more informative in the characterization of gender-specific physiological demand. In a later study by Liiv et al. (9), the VO_2 measured in competition simulation was normalized to the vita maxima, and the authors found that BD intensity was smaller for males than for females (76% vs. 88% of maximum), supporting our data.

Similar to previous data on professional dancers in this study, the absolute lactate response during the competition simulation was ~ 8 mmol·l^{-1}, smaller than during vita maxima (12–13 mmol·l^{-1}) (3, 9, 10). In competition simulation in males and females, we found uniform lactate elevations relative to vita maxima (~ 68%), suggesting a lack of gender-specific response. This is in agreement with previous findings; however, explanation was not given by the authors (3, 9). It is possible that BD practice routines do not involve maximal intensity anaerobic activities and the anaerobic capacity developed similarly in the two genders. We speculate that the vigorous isometric contractions in the female hold technique may contribute to the lactate elevation. In one female subject, for example, the peak lactate during simulation was remarkably high (16 mmol·l^{-1}). It is possible that females physiologically adapted to the long-term exposure of dance practices, approaching their male partner's maximum anaerobic capacity in part because of the different hold technique, or as a compensation for the smaller aerobic capacity. Taken into consideration, the physiological data on ballroom dancers seem that females' smaller aerobic power might be one limiting factor in the overall dance performance.

The aesthetic appearance of the hold in BD is one of the most important evaluation factors during a competition, and the maintenance of this frame for females requires the activation of the core and upper body muscles (18). It has been suggested that the isometric contractions of the muscles involved restrict blood flow and induce neuromuscular fatigue, compromising the hold (12). This is the first study that measured the physiological responses of ballroom dancers in a stationary hold position. We found that the hold itself elevated HR and VO_2, and the small but significant lactate accumulation suggests that some of the energy is supplied through glycolytic pathway. The uniform lactate response in the two genders can be explained by the fact that females' hold technique requires greater muscle activation (12).

VO_2 is commonly used to evaluate the energy expenditure during a particular aerobic activity (5), while HR is an intensity indicator in all-out physical activities. It is important to mention that while our female dancers achieved higher HR during the hold, the VO_2 was similar in the two genders. This suggests that similar energy supply was achieved with greater HR in females. Using HR as an intensity indicator in the hold, the significant difference between genders supports our second hypothesis that the hold technique regulates the physiological stress during the hold position. Furthermore, to characterize the relative energy expenditure and intensity of the hold, VO_2 and HR measured during the hold were normalized to those measured during vita maxima. In this study, five sets of 1:45-min hold were performed at 18% and 22% of VO_{2max} and at 58% and 68% of HR_{max} for males and females, respectively. It is important to note, however, that the higher HR in female dancers could be a consequence of the smaller body height: because males are taller, females' hands are placed higher on the males' shoulder, activating a baroreceptor response and an HR elevation to normalize blood pressure.

An important limitation in this study is that though dancers were encouraged to perform at their maximum, it was uncontrolled whether they failed to maintain their artistic technique during competition simulation and hold. The technique impairment could be an involuntary compensation mechanism to preserve energy at the end phase of a competition. Furthermore, even though females' hold technique shown in Fig. 1 is typical and it is remarkably different from the males' technique, it may not be consistent throughout the dances because it may change dynamically (more or less expressed). Another limitation is that practices often involve individual dances, during which intensity parameters could involuntarily differ between partners. Finally, physiological impacts of other individual physical activities have not been controlled either.

In conclusion, BD is a vigorous form of exercise, which challenges both the aerobic and the anaerobic energy supply systems of the participant. Lower class competitive dancers perform at their vita maxima during BD. A novel finding in this study is that the hold technique regulates the relative intensity during BD, which is greater for females, suggesting that they are exposed to greater cardiovascular stress during the choreographies. The results are informative for dance coaches and conditioning specialists in the physical preparation of competitive ballroom dancers. Moreover, because BD is a form of physical activity that evokes remarkable physiological responses, it could be beneficial in developing cardiovascular fitness in the general population.

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