



EVALUATION OF AEROBIC CAPACITY AND ENERGY EXPENDITURE IN FOLK DANCERS

doi: 10.2478/humo-2013-0007

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ABSTRACT

Purpose. The aim of the study was to evaluate the aerobic capacity and energy expenditure of folk dancers. **Methods.** The aerobic capacity (VO_{2max}) of four male and four female folk dancers was measured by an incremental treadmill test and energy expenditure was assessed by the linear relationship between heart rate and oxygen uptake as based on indirect calorimetry. **Results.** The dancers presented good aerobic capacity (VO_{2max}), with men achieving values of $51.8 \pm 7.39 \text{ ml} \cdot \text{kg}^{-1}$ and women $43.43 \pm 3.81 \text{ ml} \cdot \text{kg}^{-1}$. Steady-state heart rate during folk dancing was $167.8 \pm 16.68 \text{ b} \cdot \text{min}^{-1}$ ($85.0\% \pm 8.68\% \text{ HR}_{max}$) for men and $178.3 \pm 5.62 \text{ b} \cdot \text{min}^{-1}$ ($91.0\% \pm 3.83\% \text{ HR}_{max}$) for women, with energy expenditure at $14.54 \pm 2.09 \text{ kcal} \cdot \text{min}^{-1}$ and $10.08 \pm 2.03 \text{ kcal} \cdot \text{min}^{-1}$, respectively. **Conclusions.** The exercise intensity performed during folk dancing is close to the threshold of decompensated metabolic acidosis. Folk dancing can be quantified as a difficult (for men) and very difficult (for women) form of physical activity; dancers should be physically well-prepared for the high exercise intensity present in folk dancing.

Key words: energy expenditure, calorimetry, oxygen intake, dance

Introduction

Movement paired with music (dancing) is one of the most popular forms of physical activity among all ages. In particular, dancing is a form of physical activity that differs in terms of style and technique (ballet, ballroom, modern, or aerobic dancing) as well as the energy pathways that are used during work. Depending on the type of dance and its duration, the effort exerted when dancing requires not only an efficient cardiorespiratory system (both aerobic and anaerobic pathways) but also significant muscle strength and power [1, 2]. Previously published data on the levels of physical fitness of dancers and the physiological response during dancing focused mainly on modern and ballroom dancing, ballet, and aerobic dance workouts [3–13]. These studies found that the aerobic fitness level of dancers can be considered as average and characteristic of individuals practicing non-endurance sports [3, 5, 9, 13]. These results may be due in part to the specific nature of the types of dance that were observed, whose movement sequences, although dynamic, can be considered short-lasting with energy provided by the phosphagen (ATP and phosphocreatine) and anaerobic (glycolytic) systems. In these studies, rarely was research conducted on motion sequences lasting for a few minutes or longer [9, 14]. Although dancing involves the same large muscle groups, the energy pathways that are involved can differ depending on dance style, intensity, technique, and duration. Therefore, the physiological responses measured

for one form of dancing cannot be indiscriminately compared with other styles. What is more, in the available literature on the subject, few studies have directed their attention on studying the physiological responses of one of the oldest and most defined forms of dance, folk dancing, which combines physical movement and a culture's traditions and customs integrated with ancestral legacy and rituals, individual for each geographic region in terms of style, garment, and song. The development of folk dance is rooted in historical change and the concept of ethnic identity, created by centuries of tradition passed down from generation to generation. Some of the most basic elements of folk dancing include jumping, spinning, and gliding steps, which are usually performed with a partner and with other dance pairs in a circle or following each other in a dance chain.

Due to the relatively significant amount of physical movement involved in folk dancing, the aim of this study was to measure the aerobic capacity of folk dancers as well as determine their physiological response and energy expenditure when performing a standard folk dance.

Material and methods

For the purpose of the study, four female and four male dancers (four dance pairs) aged 21–23 years were recruited from the Krakowiak Folk Dance Team, a traveling university dance team. The participants' somatic characteristics were measured prior to testing, while aerobic capacity and energy expenditure were determined when completing the 'Mazur' folk dance.

This folk dance, alongside the Krakowiak, Oberek, Kujawiak, and Polonez, is one of the national folk dances

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of Poland. It is a lively dance with a characteristic rhythm performed in triple meter and includes sliding steps, jumps, and spins. Some of the most common, yet impressive, dance pieces include paired and chain dancing and dance figures such as the 'Handkerchief Figure', 'lightning-fast' spins, a braiding dance and different types of men's jumps. This dance also has an accent on the second or third beat, making it one of the most difficult Polish folk dances to perform. Adding to its difficulty is the general tempo of the music, which is very dynamic (placing a heavy workload on dancers), and the fact that the piece requires dancers to cover large distances. This is especially so for male dancers, as their dance style is used to mimic elements of imagination, energy, and chivalry when leading their partner. For women, this dance is considered to be somewhat less taxing, as their dance motif is based more on gracefully following the male partner in certain steps and 'admiring' his prowess.

The dancers in the present study first submitted themselves to a medical examination to determine if they had any conditions that could prevent them from participating in the study. Afterwards, the dancers morphological characteristics were measured, including body height (BH), body mass (BM), body fat percentage (FAT%), body fat mass (FM), fat-free body mass (FFM), and total body water content (TBW). These measures were assessed using a Tanita Body Composition Analyzer (Tanita, Japan), which estimates body composition by bioelectrical impedance analysis. Body height was measured using Martin's method to an accuracy of 1 mm. In addition, the body mass index (BMI) was also calculated for each participant. An overview of the participants' characteristics is provided in Table 1.

Next, the participants' maximal oxygen uptake (VO_{2max}) was measured by an incremental test performed on a treadmill (h/p/cosmos, Saturn, Germany), where

the workload was incrementally increased until reaching exhaustion. This test was used to determine aerobic capacity, where maximum oxygen uptake was determined at the level when oxygen uptake did not increase despite increased workload. Based on the changes in respiratory rates during the test, the ventilatory thresholds were also determined and, with it, the threshold of decompensated metabolic acidosis (TDMA) [15, 16]. The test began with a four-min warm-up at a speed of $6 \text{ km} \cdot \text{h}^{-1}$ for the women and $7 \text{ km} \cdot \text{h}^{-1}$ for the men dancers. The speed was then systematically increased every two minutes by $1.2 \text{ km} \cdot \text{h}^{-1}$ for women and $1.5 \text{ km} \cdot \text{h}^{-1}$ for men until they reached exhaustion and were unable to continue. Respiratory function (including oxygen uptake [VO_2] and minute ventilation [V_E]) of the participants was measured with a Medikro 919 ergospirometer (Medikro, Finland). Heart rate (HR) was continually measured using a heart rate monitor (Polar, Finland).

A few days rest after the incremental test, the participants were assessed in terms of their dance intensity. The participants danced the Mazur folk dance for a total of eight minutes (after a short warm-up) in their folk costumes while heart rate was recorded.

Energy expenditure (EE) was assessed by a method based on indirect calorimetry, which determines the amount of burned calories by oxygen consumption during physical effort. Normally, 4.7 to 5.05 kcal of energy is expended per one liter of consumed oxygen during physical effort, but this depends on an individual's respiratory quotient. Due to the difficulty in simultaneously measuring all participants when dancing, oxygen uptake was calculated using a simplified method that assesses the metabolic cost of physical effort by a physiological linear relationship between the work intensity (workload) and heart rate, and the linear relationship between oxygen uptake and heart rate. Using

Table 1. Participants' age and somatic characteristics

M – men W – women	Age (years)	BH (cm)	BM (kg)	BMI (kg/m ²)	FAT (%)	FM (kg)	FFM (kg)	TBW (kg)
M1	23.8	192	89.4	24.3	14.1	12.6	76.8	56.2
M2	21.4	182	65.3	19.7	8.4	5.5	59.8	43.8
M3	23.7	178	81.3	25.7	16.7	13.6	67.7	49.6
M4	23.1	173	72.3	24.2	17.1	12.4	59.9	43.9
\bar{x}	23.00	181.3	77.08	23.48	14.08	11.03	66.05	48.38
SD	1.11	8.06	10.507	2.610	4.010	3.721	8.066	5.879
W1	22.3	175	64.1	20.9	25.5	16.4	47.7	34.9
W2	21.3	172	51.1	17.3	12.6	6.4	44.7	32.7
W3	23.3	168	59.3	21.0	21.7	12.9	46.4	34
W4	22.9	175	59.4	19.4	21.1	12.5	46.9	34.3
\bar{x}	22.53	172.5	58.48	19.65	20.23	12.05	46.43	33.98
SD	0.74	3.32	5.403	1.729	5.444	4.154	1.269	0.929

BH – body height; BM – body mass; BMI – body mass index; FAT – body fat; FM – fat mass; TBW – total body water content

the heart rate/oxygen uptake data recorded during the incremental treadmill test, the steady-state heart rate was recorded for each participant when dancing and then paired to their oxygen uptake rate. This allowed the results of the incremental treadmill test to estimate the volume of oxygen uptake with the exercise intensity (based on heart rate) presented when dancing. It was assumed, for later analysis, that the energy cost of dancing was 5 kcal expended for every liter of consumed oxygen.

Results

Incremental treadmill test results

Mean maximum heart rate (HR_{max}) for the men dancers was $197.8 \pm 4.43 \text{ b} \cdot \text{min}^{-1}$, while the women

dancers had a mean maximum heart rate of $196.0 \pm 9.76 \text{ b} \cdot \text{min}^{-1}$. Absolute maximum oxygen uptake for the men was $3.97 \pm 0.66 \text{ L} \cdot \text{min}^{-1}$, this value was lower for women and averaged at $2.53 \pm 0.27 \text{ L} \cdot \text{min}^{-1}$. VO_{2max} relative to body mass for men was $51.80 \pm 7.38 \text{ mL} \cdot \text{kg}^{-1}$, while for women $43.43 \pm 3.81 \text{ mL} \cdot \text{kg}^{-1}$.

The men dancers reached the threshold of decompensated metabolic acidosis at an exercise intensity of $88.61\% \pm 5.03\% HR_{max}$ and $81.87\% \pm 10.57\% VO_{2max}$; for the women dancers these values were $92.66\% \pm 1.79\% HR_{max}$ and $85.11\% \pm 6.41\% VO_{2max}$. Oxygen uptake at the TDMA level for men averaged at $41.83 \pm 1.10 \text{ mL} \cdot \text{kg}^{-1}$ with a heart rate of $175.3 \pm 11.08 \text{ b} \cdot \text{min}^{-1}$. In women, oxygen uptake at TDMA averaged at $36.81 \pm 2.09 \text{ mL} \cdot \text{kg}^{-1}$, while heart rate was $181.5 \pm 6.24 \text{ b} \cdot \text{min}^{-1}$. The test results for each participant (averaged for men and women) are provided in Tables 2 and 3.

Table 2. Incremental treadmill test duration, distance covered, and the maximal values of the analyzed parameters for the male and female folk dancers

M – men W – women	t (min:s)	Distance (m)	HR_{max} ($\text{b} \cdot \text{min}^{-1}$)	VO_{2max} ($\text{L} \cdot \text{min}^{-1}$)	VO_{2max} ($\text{mL} \cdot \text{kg}^{-1}$)	VE_{max} ($\text{L} \cdot \text{min}^{-1}$)
M1	12:48	2059	193	4.13	46.4	143.5
M2	14:52	2580	202	2.99	45.7	102.8
M3	16:37	3056	195	4.34	53.6	158.4
M4	17:19	3259	201	4.43	61.5	166.4
\bar{x}	15:24	2738.5	197.8	3.97	51.80	142.78
SD	02:01	534.97	4.43	0.66	7.387	28.289
W1	14:19	2053	200	2.81	43.9	93.3
W2	12:30	1680	206	2.36	46.2	90.5
W3	10:45	1075	183	2.24	37.9	82.8
W4	14:26	2065	195	2.70	45.7	80.4
\bar{x}	13:00	1718.3	196.0	2.53	43.43	86.75
SD	01:44	464.59	9.76	0.27	3.813	6.134

t – time; HR_{max} – maximal heart rate; VO_{2max} – maximal oxygen uptake; VE_{max} – maximal pulmonary ventilation

Table 3. Time required to reach the threshold of decomposed metabolic acidosis (TDMA) and the level of analyzed parameters noted at TDMA for the male and female folk dancers

M – men W – women	t_{TDMA} (min:s)	HR_{TDMA} ($\text{b} \cdot \text{min}^{-1}$)	VO_{2TDMA} ($\text{L} \cdot \text{min}^{-1}$)	VO_{2TDMA} ($\text{mL} \cdot \text{kg}^{-1}$)	VE_{TDMA} ($\text{L} \cdot \text{min}^{-1}$)	% VO_{2max}	% HR_{max}
M1	9:15	175	3.58	40.20	93.4	86.64%	90.67%
M2	11:45	191	2.77	42.60	75.3	93.22%	94.55%
M3	9:45	168	3.43	42.35	84.1	79.01%	86.15%
M4	10:45	167	3.04	42.20	75.6	68.62%	83.08%
\bar{x}	10:22	175.3	3.20	41.83	82.10	81.87%	88.61%
SD	01:06	11.08	0.37	1.10	8.567	10.57%	5.03%
W1	11:15	182	2.45	38.30	59.6	87.24%	91.00%
W2	9:15	188	1.80	35.30	54.8	76.41%	91.26%
W3	9:45	173	2.01	34.75	66.2	91.69%	94.54%
W4	11:45	183	2.30	38.90	47.1	85.12%	93.85%
\bar{x}	10:30	181.5	2.14	36.81	56.95	85.11%	92.66%
SD	01:11	6.24	0.29	2.09	8.046	6.41%	1.79%

t – time; HR – heart rate; VO_2 – oxygen uptake; VE – pulmonary ventilation

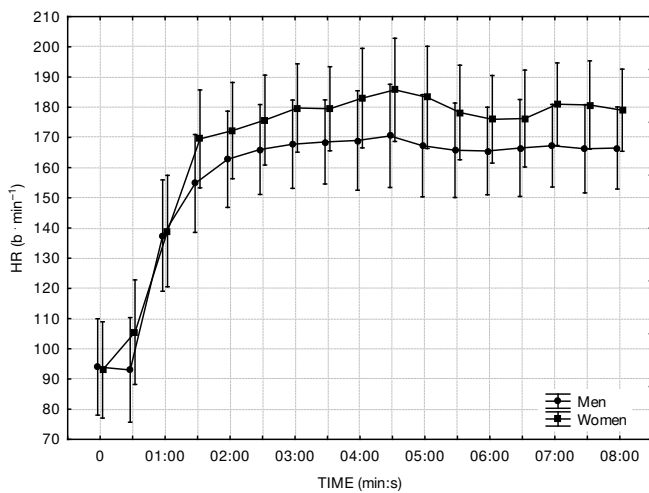


Figure 1. Changes in heart rate (HR) for male and female folk dancers when dancing

Assessing energy expenditure during folk dancing

When dancing, the steady-state heart rate for men was found to be $167.8 \pm 16.68 \text{ b} \cdot \text{min}^{-1}$, which represented $85.0\% \pm 8.68\%$ maximum heart rate. Therefore, the exercise intensity of folk dancing can be considered to almost correspond to the work intensity at the threshold of decompensated metabolic acidosis ($88.61\% \pm 5.03\% \text{ HR}_{\text{max}}$). In contrast, the heart rate for the women folk dancers was recorded to be on average $178.3 \pm 5.62 \text{ b} \cdot \text{min}^{-1}$ (Fig. 1). Here, the exercise intensity for them when dancing was $91.0\% \pm 3.83\% \text{ HR}_{\text{max}}$, which, similar to the men, was at an intensity slightly below the TDMA ($92.66\% \pm 1.79\% \text{ HR}_{\text{max}}$).

The linear relationship between heart rate and oxygen uptake found that, when dancing, oxygen consumption in men was $2.91 \pm 0.42 \text{ L} \cdot \text{min}^{-1}$ ($37.75 \pm 2.05 \text{ mL} \cdot \text{kg}^{-1}$), while for women $2.02 \pm 0.41 \text{ L} \cdot \text{min}^{-1}$

($34.23 \pm 4.36 \text{ mL} \cdot \text{kg}^{-1}$). Therefore, the approximate total energy cost of dancing the Mazur comes to $14.54 \pm 2.09 \text{ kcal} \cdot \text{min}^{-1}$ for men and $10.08 \pm 2.03 \text{ kcal} \cdot \text{min}^{-1}$ for women. The results for each of the individuals in terms of exercise intensity and energy expenditure are presented in Table 4.

Discussion

A comparison of the energy expenditure and physiological responses present in different styles of dance is difficult. This difficulty arises from the variable nature of different types of dance, such as technique, tempo, and duration. Thus, two different dance styles can significantly differentiate in terms of the used energy pathways or the muscle strength needed to correctly execute various dance routines. For example, in ballet, the main energy pathway is primarily the anaerobic system and involves large amounts of isometric contractions, while modern dance demands of its dancers to have far better aerobic performance as well as significant muscle strength [17]. Chmelar et al. suggested that, depending on the dance style and level of expertise, dancers can exhibit large differences in $\text{VO}_{2\text{max}}$ values and maximal anaerobic power [5]. Interestingly enough, their study found that the lowest values of these parameters were found in professional ballet dancers when compared with professional modern dancers and with less experienced ballet and modern dancers.

Despite these data, the aerobic capacity of professional dancers of different styles was found to be largely similar. Numerous studies have found that the maximal oxygen uptake of dancers to be about 40 to 47 $\text{mL} \cdot \text{kg}^{-1}$, regardless of dance style [5, 11, 14, 17, 18]. The results of the present study corroborate these results ($43.43 \text{ mL} \cdot \text{kg}^{-1}$). This points to the relatively good aerobic capacity of dancers, who have often been categorized as having

Table 4. Average heart rate (HR_D), exercise intensity ($\% \text{HR}_{\text{max}}$; $\% \text{VO}_{2\text{max}}$), oxygen uptake (VO_{2D}), and energy expenditure (EE) when folk dancing

M – men W – women	HR_D ($\text{b} \cdot \text{min}^{-1}$)	$\% \text{HR}_{\text{max}}$	VO_{2D} ($\text{mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$)	VO_{2D} ($\text{L} \cdot \text{min}^{-1}$)	$\% \text{VO}_{2\text{max}}$	EE ($\text{kcal} \cdot \text{min}^{-1}$)
M1	179	93%	39.26	3.51	85%	17.55
M2	185	92%	39.05	2.55	85%	12.75
M3	152	78%	34.80	2.83	65%	14.15
M4	155	77%	37.89	2.74	62%	13.7
\bar{x}	167.8	85.0%	37.75	2.91	74.3%	14.54
SD	16.68	8.68%	2.05	0.42	12.47%	2.09
W1	181	90%	37.28	2.39	85%	11.95
W2	177	86%	29.54	1.51	63%	7.55
W3	171	94%	31.53	1.87	84%	9.35
W4	184	94%	38.55	2.29	91%	11.45
\bar{x}	178.3	91.0%	34.23	2.02	81.8%	10.08
SD	5.62	3.83%	4.36	0.41	12.23%	2.03

the aerobic capacity of athletes practicing non-endurance sports [18, 19]. This confirms the belief that the energy demands of dancing are largely met by anaerobic metabolism and help to explain the relatively low VO_{2max} values presented by dancers. Martyn-Stevens et al. [17] found that individuals practicing modern dance exhibited maximal anaerobic power values of around $8 \text{ W} \cdot \text{kg}^{-1}$, which highlights their relatively good anaerobic performance. However, the results of the present study found that the exercise intensity present in folk dancing is close to an intensity at the threshold of decompensated metabolic acidosis, which can affect an individual's ability to perform endurance activities. At the same time, the fact that this threshold occurs at such a low exercise intensity can cause fatigue to onset more quickly, especially when dancing for a longer period of time at an intensity corresponding to the TDMA. This has been confirmed by Guidetti et al. [20], who observed that untrained dancers danced more often above their individual anaerobic threshold level than more advanced dancers. These authors, at the same time, indicated the need for selecting a dance intensity (in relation to the anaerobic threshold) appropriately suited for novice dancers. Wyon and Redding [21] found that the physical fitness of many dancers was inadequate, especially when compared with the dance skills required of them, and recommended dancers take additional classes aimed at improving their physical fitness. It can therefore be surmised that the physical conditioning of dancers ought to include exercises that stimulate both aerobic (VO_{2max} , TDMA) and anaerobic capacity (MAP, muscle strength) [17].

The estimated energy expenditure in the male and female folk dancers was found to be $14.54 \pm 2.09 \text{ kcal} \cdot \text{min}^{-1}$ and $10.08 \pm 2.03 \text{ kcal} \cdot \text{min}^{-1}$, respectively. As such, folk dancing can be quantified as a difficult (for men) and very difficult (for women) form of physical activity. Other studies have similarly classified various styles of dance as difficult due to their energy costs such as Massidda et al., who evaluated Latin American dance as having an intensity of up to 9 MET [22]. Rixon et al. [23] estimated that the energy cost of four types of aerobic exercise to be between $8\text{--}10 \text{ kcal} \cdot \text{min}^{-1}$, which could be compared with running at a speed of $8.05\text{--}8.37 \text{ km} \cdot \text{h}^{-1}$.

Another factor that could have contributed to the difficulty and high energy expenditure of the Mazur folk dance was its costume, which weighs 3.0 kg for women and 4.37 kg for men. La Torre et al. [24] found that an additional external load (10% body mass) significantly increased dancers' heart rate, oxygen uptake, and energy expenditure.

An additional factor that needs to be considered is that the classification of folk dancing as an intensive form of exercise brings renewed focus on the necessity of a proper balanced daily diet. Smith et al. [25] found that the daily energy expenditure of dancers was sig-

nificantly higher than the amount of calories they consumed. Similar data was presented by Hirsch et al. [26], who assessed the daily energy expenditure of ballet dancers to be 4617 kcal for men and 2945 for women, but finding that many dancers were undernourished in terms of their daily caloric intake, with men and women consuming only 2000 kcal and 1000 kcal, respectively.

Furthermore, Blanksby and Reidy [4] noted that the exercise intensity of modern and Latin American dance exceeds 80% VO_{2max} at a heart rate around 170–175 beats per minute. A similar work intensity (74% VO_{2max} for men and 81% VO_{2max} for women) and heart rate were recorded in the present study. However, Dahlstroem [27] reported that the average heart rate of participants taking dance classes stood at around 70% HR_{max} . One aspect that needs to be considered is the method of assessing energy expenditure based on heart rate. This study made use of the linear relationship between oxygen uptake and heart rate, which has been confirmed in a number of studies [11, 23, 28]. However, one problem that may exist is the direct comparison of measures taken on a treadmill to those when collected when dancing. Research by Scharff-Olson et al. [29] pointed to a discrepancy between these measures, where treadmill running at an intensity of 50% VO_2 correlated to 65% HR_{max} , but while dancing it was found that 50% VO_{2max} should correlate to 80% maximum heart rate. Nonetheless, the use of an ergospirometer to assess indirect calorimetry during dancing is both technically challenging and expensive and the use of simpler instruments for estimating energy expenditure does seem to fulfill its role.

Dancing is a very common leisure activity and an effective form of physical exercise that helps improve aerobic capacity and brings favorable change to body mass (reduction of body fat) [30]. As the study found, folk dancing and dancing in general requires a great deal of physical effort and dancers should present an appropriate level of physical fitness when participating in such activities. This includes monitoring fluid intake as well as having a proper balanced diet to match the energy expenditure of dancing.

Conclusions

1. The exercise intensity of the analyzed folk dance (the Mazur) was close to the threshold of decompensated metabolic acidosis.

2. Folk dancing can be thusly quantified as a difficult (for men) and very difficult (for women) form of physical activity; dancers should be physically well-prepared for the high exercise intensity of this form of dance.

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Paper received by the Editors: September 13, 2012

Paper accepted for publication: January 25, 2013

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