Energy expenditure and nutrition status of ballet, jazz and contemporary dance students

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ABSTRACT

Purpose: To evaluate of the energy expenditure in 3 types of dance classes (ballet, Jazz, and contemporary), as well as of the daily energy balance depending on dance type.
Materials and methods: 40 females attending dance classes with a median age of 21.0 (19.0-25.0) and 10 males with a median age of 27.0 (20.0-28.0) participated in this study. The energy cost of each dance class was measured using the BodyMedia SenseWear Sensor and total daily energy expenditure was evaluated using a 3-day recording of physical activity. The dietary intake was evaluated with a 3-day food diary recording. Statistical analysis was performed using the SPSS software.
Results: Median energy expenditure varied from 306 (277-328) Kcals/class for contemporary dance to 327 (290-355) Kcals/class for ballet and 369 (333-394) Kcals/class for jazz for females with significant differences between significant differences between contemporary and jazz classes. For males, energy expenditure was 508 (447-589) Kcals/class and 564 (538-593) Kcals/class for ballet and jazz classes, respectively. Females had lower values for all anthropometric measurements, energy intake, macronutrient intakes, and energy expenditure, compared with males. The anthropometric characteristics did not differ between dance types. Both female and male dance students were in a negative energy balance.
Conclusions: The use of sensors such as BodyMedia SenseWear together with keeping daily diaries make measurement of physical activity in dancing reliable and accurate. Exercise expenditure differs across types of dance in females but not in males. Both sexes had inadequate energy and carbohydrate intakes.
Key words: Energy balance, dietary intake, Body Media SenseWear, dance

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INTRODUCTION

The World Health Organization (WHO) defined physical activity (PA) as "bodily movement produced by skeletal muscles that requires energy expenditure," while physical inactivity reaches the fourth place as a risk factor for global mortality [1]. A large number of methods, with differences in validity and reliability, can be used for PA assessment, with the two most used methods being self-report questionnaires and wearable sensors, such as accelerometers [2]. It is well established that PA contributes to a healthy lifestyle by preventing and modifying chronic diseases like obesity, metabolic syndrome, type II diabetes, cardiovascular diseases, and some types of cancer [3].

Aerobic dance consists one of the most favored adult fitness activities, especially for women, and it could be a cardiovascular training alternative if performed according to the guidelines of the American College of Sports Medicine (ACSM) [4]. The amount of energy expenditure during a bout of aerobic dance varies according to the intensity of the exercise and style. Thus, dance exercise may require a variety of cost from 4 to 11 kcal/minute [5]. Various forms of dance have been found to be as effective as traditional modalities, such as jogging, meeting the ACSM guidelines for weight modification and maintenance.

Energy expenditure measurement in order to assess energy balance as well as fuel utilization and thermogenesis during exercise is required [6]. According to Levine et al. [7], there was a significant thermogenic potential of fidgeting-like at low workloads, which contributes substantially to the energy balance. Energy expenditure increased while sitting without motion by 4%, while fidgeting while seated by 54%, standing motionless by 13%, and fidgeting while standing by 94%, compared with the metabolic rate in the supine position.

Two categories of physical activity assessing methods are widely used: subjective (i.e. physical activity questionnaires and diaries) and objective methods (i.e. measures of energy expenditure, physiologic measures, and motion sensors). Nowadays, technological advances can provide precision in measurements of energy expenditure in free-living individuals by using wearable devices. In other words, wearable sensors give information about the total amount, frequency, duration, and intensity of physical movement [8]. Tri-axial accelerometers detect body displacement electronically in three axes and are an objective and reliable method for measuring the intensity of movement and physical activity pattern. Thus, data obtained using tri-axial accelerometers were well correlated with total daily energy expenditure, measured using doubly labeled water divided by basal metabolic rate (BMR) [9].

There is a paucity of data regarding anthropometric measurements of energy costs of dancing and energy balance assessments in dance students, and to the best of our knowledge there is no such study in Greece. Thus, the purpose of our study was to assess (i) the energy expenditure in three types of dance (ballet, jazz, and contemporary) using wearable sensors and physical activity records; (ii) energy intake using food diaries. For all the participating individuals, a number of anthropometric measurements were recorded.

MATERIALS AND METHODS

Population sample

This was a random study. Dancers volunteered to participate in the study by responding to a posted announcement in a dance school in Thessaloniki, Greece. Participants were informed about the protocols of the study. All athletes were instructed to follow their usual activity and nutrition prior to the study. Forty female dancers (8 adolescents and 32 adults) attending dance classes for more than two years (14 jazz, 16 ballet, and 10 contemporary dancers), and 10 adult males (6 jazz, 4 ballet dancers) with median age of 21 (19.0-25.0) years and 27 (20.0-28.0) years, respectively, participated in this study**.** The study was carried out in Thessaloniki, Greece, in 2014.

All participants gave their written consent prior to the start of the study, which received approval by the Ethics Committee of the Alexander Technological Educational Institute in Thessaloniki, Greece.

Anthropometric measurements

An experienced dietician performed all the anthropometric measurements in the morning, with participants in minimal clothing. Height was measured to the nearest 0.5 cm using a stadiometer, with an accuracy of 0.5 cm (SECA 220, Seca Corporation. Columbia. USA). Body weight was measured using a calibrated digital scale, with an accuracy of ±100g (Seca 707, Seca Corporation, Columbia, USA). Body Mass Index (BMI) was calculated as body weight divided by the square of height (kg/m^2). Waist circumference was measured with a tape midway between the top of the iliac crest and the bottom of the rib cage at the end of gentle expiration. Hip circumference was measured with a tape over the greater trochanters. Both circumferences were measured over naked skin. The Waist to Hip Ratio (WHR) was defined as waist circumference (cm)/hip circumference (cm), with results >=1.0 and >=0.85 indicating obesity for males and females, respectively, according to the WHO [10].

Physical activity

The assessment of physical activity was performed using wearable sensors and physical activity records. The energy cost of each dance session (ballet, Jazz, and contemporary) was measured with the BodyMedia SenseWear Sensor and the records were analyzed in SenseWear Software 7.0. Furthermore, total daily energy expenditure was estimated for three consecutive days (two weekdays and one weekend day) from the completed physical activity records for the same days. Ainsworth et al. [11] tables were used to estimate the energy cost for each activity. Basal metabolic rate was estimated with the use of the Harris & Benedict equations [12].

Dietary intake

All subjects kept a three-day food diary, which consisted of two weekdays and one weekend day, in order to reflect valid results and typical intake [13]. The days of assessing dietary intake and physical activity were the same. A registered dietitian provided verbal and written instructions on how to complete their food diaries. The use of food models helped the subjects estimate the quantity of foods. A computerized nutrient analysis program "Food Processor" (version 7.4) with Greek foods included was used for the analysis of food records. Macronutrient intake was expressed as a percentage of the Recommended Dietary Allowance (RDA) [14] in order to assess the adequacy of micronutrient intake.

Statistical analysis

Statistical analysis was performed using SPSS version 17.0 (SPS Inc., Chicago, IL, USA). Due to the small sampling size, nonparametric tests were applied. Mann-Whitney U tests for two independent samples were performed to compare the two sexes. In order to examine differences between the three dance types, the Kruskal-Wallis test was used. Results are presented as median, along with the 1st and 3rd quartile (corresponding to 25% and 75% of data). Dancers' life style (profession, cooking, daily activity, marital status, etc.) was investigated in concert with gender effect using cross-tabulated information and chi-square statistical analysis**.** Statistical significance was set at $p<0.05$.

RESULTS

Age distribution of male and female dancers is presented in Figure 1. 16% of the sample was adolescents, and all of them female.

Female dancers had statistically lower median values for weight, height, BMI (Body Mass Index), wrist, waist circumferences, WHR ($p<0.01$), and hip circumference ($p<0.05$) when compared with male dancers (Table 1).

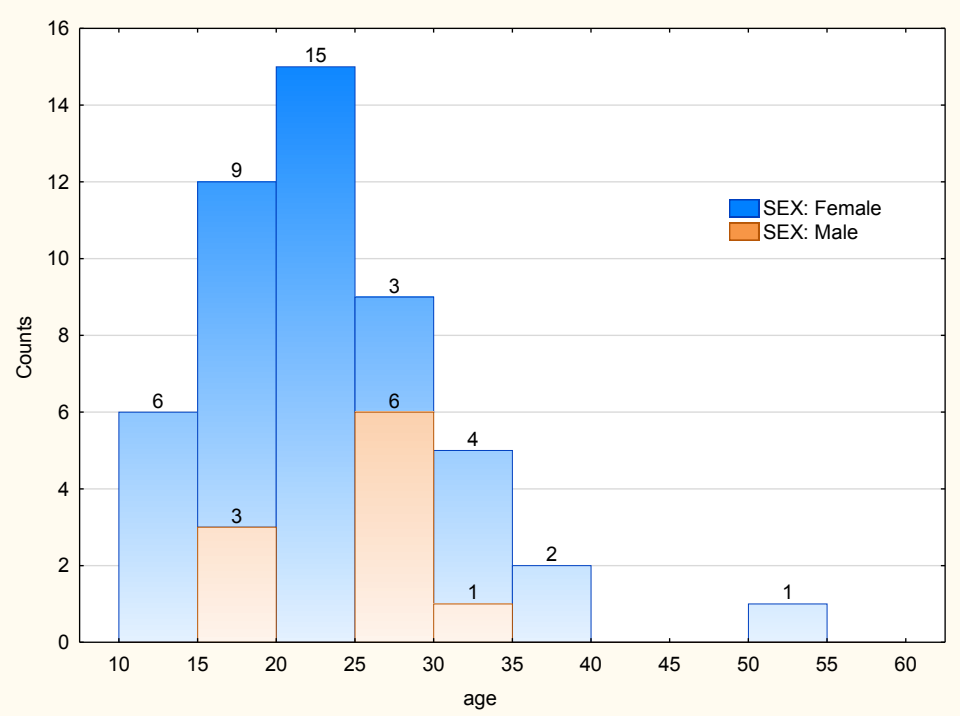

Figure 1. Age distribution of male and female dancers. Females are positively skewed and males negatively

Table 1. Anthropometric characteristics, according to sex (median and quartiles 1st and 3rd)

	Men n=10	**Women n=40**
Age (yrs)	27.0 (20.0-28.0)	21.0 (19.0-25.0)
Weight (Kg)	78.0 (61.70-81.60)**	55.80 (49.90-59.45)**
Height (cm)	185.0 (173.0-185.50)**	165.0 (160.0-169.0)**
BMI (Kg/m^2)	22.79 (20.62-23.99)**	19.77 (18.92-20.85)**
Wrist circumference (cm)	18.0 (15.0- 18.5)**	14.75 (14.0-15.0)**
Waist circumference (cm)	89.0 (79.0-90.0)**	70.50 (67.50-75.25)**
Hip circumference (cm)	101.0 (91.0-102.0)*	91.0 (89.0-96.50)*
Waist-to-hip ratio	0.87 (0.84-0.88)**	0.76 (0.75-0.81)**

*p <0.05. **p<0.01

As shown in Table 2, female dancers also had statistically lower median BMR (p<0.01) than male dancers. Both male and female dancers had less energy intake (EI) than their energy expenditure, resulting in a negative energy balance, with males having higher negative values than females (p<0.05). Male dancers had statistically significant higher values in energy intake and higher consumption in grams of protein, fat, and dietary fiber than females (p<0.05).

Table 2. Energy and macronutrient intake and energy expenditure, according to sex (median and quartiles 1st and 3rd)

	Men n=10	**Women n=40**
Basal Metabolic rate (Kcal)	1882 (1645-1882)**	1376 (1330-1429)**
Energy Intake (EI) (Kcal)	2297 (1703-2374)*	1708 (1381-2097)*
Energy Balance (Kcal)	-1115 (-2153 - -647)*	-526 (-857- -190)*
Protein (g)	131.24 (54.01-146.40)*	68.89 (49.36-82.0)*
Protein (g/Kg BW)	1.68 (0.88-1.69)	1.19 (0.97-1.64)
Protein (%EI)	21.16 (9.10-30.83)	14.81 (12.86-17.89)
Carbohydrates (g)	244.97 (146.90-324.02)	209.08 (156.90-261.67)
Carbohydrates (g/Kg BW)	3.56 (1.88-5.25)	3.51 (2.80-5.40)
Carbohydrates (%EI)	41.04 (34.51-54.59)	46.78 (41.25-57.62)
Fat (g)	108.09 (68.41-127.97)*	71.21 (60.76-85.37)*
Fat (g/Kg BW)	1.52 (0.88-1.75)	1.31 (1.09-1.64)
Fat (%EI)	36.16 (36.16-40.97)	39.16 (29.46-43.25)
Saturated Fat (g)	31.33 (25.25-41.11)	24.53 (18.69-38.72)
Alcohol (g)	0.0 (0.0-0.0)	0.0 (0.0-0.0)
Dietary Fiber (g)	21.30 (19.23-23.36)*	16.98 (12.05-20.30)*

*p<0.05. **p<0.01

According to Table 3, female dancers had statistically higher median intake of fruits (p<0.01) and milk (p<0.05), while male dancers had higher median consumption of vegetables, meat and meat products (p<0.05), and fat (p<0.01).

Table 3. Food groups serving intake, according to sex (median and quartiles 1st and 3rd)

	Men n=10	**Women n=40**
Bread and cereal (servings/day)	6.55 (4.90-8.20)	6.25 (4.20-7.75)
Vegetables (servings/day)	5.20 (3.30-6.70)*	2.25 (0.90-3.05)*
Fruits (servings/day)	0.0 (0.0-0.0)**	1.80 (0.95-3.50)**
Meat and products (servings/day)	5.05 (0.80-5.10)*	1.10 (0.70-2.40)*
Milk (servings/day)	0.25 (0.0-0.50)*	1.95 (1.20-3.40)*
Added Fats (servings/day)	18.05 (14.50-21.60)**	7.20 (3.95-12.20)**

*p<0.05, **p<0.01

Analysis between the three types of dances was performed independently for the two sexes and is shown in Tables 4 and 5. Female ballet dancers were younger than contemporary dancers, whereas female jazz dancers had higher median exercise expenditure (in Kcals) than contemporary dancers ($p<0.05$) Male ballet dancers had no significant differences in anthropometric characteristics or energy expenditure according to dance type (Table 5).

Table 4. Anthropometric characteristics of female dancers according to dance type (median and quartiles 1st and 3rd). Different letters denote statistically significant differences among dance types

	Jazz n=14	**Ballet n=16**	**Contemporary n=10**
Age (yrs)	21.0 (19.0-30.0)*[ab]	20.50 (15.0-21.0)*[b]	24.0 (21.0- 31.0)*[a]
Weight (Kg)	54.50 (49.90-57.60)	55.80 (50.60-60.80)	53.40 (46.70-58.0)
Height (cm)	163 (160-168)	166.5 (164-170)	162.50 (160.0-170.0)
BMI (Kg/m^2)	19.90 (19.0-21.70)	20.0 (19.40-20.70)	19.60 (18.20-19.90)
Wrist circumference (cm)	15.0 (14.0-15.0)	14.80 (13.80-15.0)	14.30 (14.0-15.0)
Waist circumference (cm)	71.50 (68.0-76.0)	72.50 (68.50-76.30)	69.0 (64.0-70.0)
Hip circumference (cm)	91.0 (89.0-97.0)	94.0 (89.50-97.50)	89.50 (85.0-95.0)
Waist-to-hip ratio	0.78 (0.75-0.83)	0.77 (0.75-0.80)	0.75 (0.72-0.81)
Basal Metabolic rate (Kcal)	1371 (1330-1401)	1427 (1337-1459)	1341 (1290-1380)
Energy expenditure (Kcal)/class	369 (333-394)*[a]	327 (290-355)*[ab]	306 (277-328)*[b]
Mets/class	4.20 (3.90-4.60)	3.70 (3.40-4.40)	3.70 (3.50-4.20)

*$p<0.05$

Table 5. Anthropometric characteristics of male dancers according to dance type (median and quartiles 1st and 3rd)

	Jazz n=6	**Ballet n=4**
Age (yrs)	27.0 (20.0-28.0)	27.0 (3.50-29.0)
Weight (Kg)	78.0 (61.70-84.80)	78.0 (69.90-79.80)
Height (cm)	185.0 (173.0-188.0)	182.50 (176.50-185.0)
BMI (Kg/m^2)	22.80 (20.60-24.0)	22.80 (21.70-24.0)
Wrist circumference (cm)	18.0 (15.0-18.0)	17.0 (15.50-18.0)
Waist circumference (cm)	89.0 (79.0-89.50)	86.0 (81.0-89.50)
Hip circumference (cm)	101.0 (91.0-106.0)	100.0 (95.0-101.0)
Waist-to-hip ratio	0.87 (0.84-0.88)	0.88 (0.86-0.89)
Basal Metabolic rate (Kcal)	1882 (1645-1983)	1881 (1762-1882)
Energy expenditure (Kcal)/class	564 (538-593)	508 (447-589)
Mets/class	4.90 (4.60-5.10)	4.85 (4.25-5.05)

According to the dancers' shopping and cooking habits, female dancers reported that their grandmother (2.5%), mother (55.0%), and they themselves (42.5%) cooked, while all male dancers reported that their mother did the cooking.

Female dancers reported that their grandmother (2.5%), mother (52.5%), and they themselves (45.0%) did the shopping, while the respective values for male dancers were 10.0%, 70.0%, and 20.0%. According to their profession, female dancers reported that they were self-employed workers (10.0%), teachers (15.0%), and students (75.0%), while the respective values for male dancers were 50.0%, 0.0%, and 50.0% ($p<0.05$). Regarding their daily activity, female dancers revealed that 70.0% worked up to 8h/d and 30.0% over 8h/d, with males having respective values of 60.0% and 40.0%. Female dancers spent idle hours up to 5h/d at 60.0% and over 5h/d at 40%, while the respective values for men were 40.0% and 60.0%.

Sleeping and physical activity distributed differently according to sex. Thus, 70% of females slept up to 8h/d and 30.0% over 8h/d, whereas all males slept up to 8h/d ($p<0.05$).

The overwhelming majority of female dancers (82.50%) spent up to 3h/d and 17.5% over 3h/d on vigorous activities, with respective values in men 30.0% and 70.0% ($p=0.01$).

DISCUSSION

The present study revealed that female dancers had lower median values for weight, height, BMI, wrist, waist and hip circumferences, waist to hip ratio, body size, and basal metabolic rate compared with male dancers. Stensland and Sobal [15] and Yannakoulia and colleagues [16] found similar anthropometric characteristics, for all three dance types, in studies conducted in the US and Greece, respectively. Also, the dancers of the present study were taller and heavier than professional female ballet dancers from Kuala Lumpur [17], while they had similar BMI values. American professional ballet dancers [18] had similar weights, heights, and BMIs to the dancers of the present study. Furthermore, similar BMI values were found in elite adolescent female figure skaters in the USA [19] and in dancers from the US National Figure Skating Dance Team [20]. Most of the studies conclude that low body weight and BMI are a requisite in any dancing movement valued for both aesthetic and mechanical reasons [17,20]. Female Greek dancers of the study had statistically lower exercise expenditure during dance classes than male dancers. What is more, comparisons according to sex showed that females' energy expenditure was higher in jazz class compared with contemporary dance class; while in males, there was no difference in energy expenditure according to dance type. Water consumption was insufficient in both female and male dancers of the study, while female dancers drank only 0.72lt and male dancers 1.25lt during an exercise session of 1.5 hours. Athletes do not voluntarily drink adequate water to prevent dehydration during exercise, and this can provoke dehydration that compromises athletic performance. Replacement of fluids should compensate sweat and urine losses and this requires generally 200 mL to 300 mL every 15 minutes [21].

Energy intake and energy balance

Greek female dancers' intake (1708Kcal/d. 1381-2097) was quite lower than the energy intake of female ballet dancers in Krakow, according to Zulawa and colleagues [22] (1965.48Kcal/d), and slightly higher when compared with a different female group of Greek dancers, as reported by Yannakoulia et al. [18]. Also, a group of Spanish ballet dancers [23] consumed a hypocaloric diet of 1555Kcal/d, and USA female figure skaters had reports of 1416Kcal/d and 1491Kcal/d when examined by Ziegler et al. [20] and Dwyer et al. [19], respectively. As far as Greek male dancers are concerned, they had a median energy intake of 2297Kcal/d (1703-2374), while US male figure skaters appeared to have a higher energy intake (2837Kcal/d) [20]. Both Greek male and female dancers had statistically lower energy intake than energy expenditure, leading to a negative energy balance -1115 (-2153 - 647) Kcal/d for males and -526 (-857 - 190) Kcal/d for females, with males having higher negative values than females. Similarly, a negative energy balance has been demonstrated in previous Greek studies [24]–[26]. Large discrepancies between energy intake and energy requirement of athletes with a stable body weight can be attributed to underreporting or overestimation of energy needs on days with no exercise [19].

Macronutrient intake

In the present study, the median daily carbohydrate intake was 3.56 (1.88-5.25) g/Kg BW for men, and 3.51 (2.80-5.40) g/Kg BW for women. These values are much lower than the current carbohydrate recommendation for athletes (6-10g/Kg BW/day) [27], which could provoke depletion in glycogen stores over time [28]. Female dancers of the present study had lower carbohydrate consumption than adolescent female skaters (4.8g/Kg BW) [19]. Female Greek dancers in the study by Yanakoulia et al. consumed inadequate carbohydrates with reports of 47.9% EI [16]. Similarly, carbohydrate intake of both male and female US figure skating dancers was also insufficient (44% EI and 51% EI, respectively) [20]. Median protein intake of Greek dancers was 1.68 (0.88-1.69) g/Kg BW for males and 1.19 (0.97-1.64) g/Kg BW for females, values that met the respective recommendations for athletes (1.2-1.4g/Kg BW/day) [29]. Regarding fat intake, dancers in the study consumed a fat-dense diet with a median fat contribution of 36.16 (36.16-40.97) % to EI for men and 39.16 (29.46-43.25) % EI for women, respectively. These values are higher than the recommendations [27]. Female dancers of the present study had higher protein intake compared with young female dancers in the study by Yannakoulia et al. (1g/kg BW or 15.4% EI, while both groups exhibited high fat consumption [16]. Also, Spanish ballet dancers consumed a high density diet [25]. Protein and fat intake of both male and female US figure skating dancers were higher than the recommendations in the study by Ziegler et al. [20], while according to a study conducted 11 years later, by Dwyer et al. [19], USA adolescent female skaters showed lower fat

intake (23.8% EI) and similar protein intake (1.2 g/Kg BW) compared with Greek female dancers. Male dancers in the present study had significantly higher consumption of protein, Fat, and dietary fiber than female dancers. Higher protein and fat consumption by males can partly be explained by the fact that male dancers had higher consumption of meat and fat food group equivalents compared with females. Female dancers also had higher intake of fruit and milk than males.

Greek male dancers were more active during the day compared with females, as males had significantly fewer sleeping hours and significantly more hours dedicated to vigorous activity than women. A significantly higher percentage of males worked as freelancers compared with females.

The use of wearable sensors, along with keeping daily diaries, made measuring physical activity reliable and accurate. Dancing is a high energy cost exercise that should be recommended particularly to adolescents and young adults, because it contributes significantly to an increase in energy expenditure and a healthy body weight.

Future studies are needed (i) to further examine the effects of nutritional status on dancers' performance, (ii) to inform the training staff and athletes on nutritional guidelines, and (iii) to develop strategies to improve their dietary intake.

Strengths and limitations

The biggest strength of the study was the use of wearable sensors, which give information about the total amount, frequency, duration, and intensity of physical movement. Sensors are capable of detecting small movements, can be used with people of all ages, and are more accurate in general compared with self-reported PA instruments. The BodyMedia SenseWear Sensor should be added to the strengths of the study, as it is a clinically validated accelerometer and appears in more than a hundred papers regarding energy expenditure evaluation in humans [30]. Therefore, the results of this study on the energy cost of different types of dancing are reliable and accurate.

The self-reported food diaries that were used for the assessment of dietary intake are inexpensive and easily applicable, but the danger of underreporting is a well-known limitation.

With the exception of one study [15], the participants had similar anthropometric and nutritional characteristics with other published studies on dancers [16-20,22,23], although the analysis and classification of food intake has only been seen in this study.

On the other hand, conclusions based on the results cannot be generalized for the whole country, as participants were from the same city (Thessaloniki, Greece) and from the same dance school.

CONCLUSIONS

In view of the results of this study, the use of sensors such as BodyMedia SenseWear, along with keeping daily diaries, make measuring physical activity in dancing reliable and accurate. Female jazz dancers had higher exercise expenditure (in Kcals) than contemporary dancers ($p<0.05$), while male ballet dancers had no significant differences in energy expenditure according to dance type. Both male and female dancers had a negative energy balance and inadequate carbohydrate intake. In order to compensate the high-energy demands, their intakes on exercise days should be increased.

Conflicts of interest

None disclosed.

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