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ENERGY BALANCE AND BODY COMPOSITION FACTORS IN ADOLESCENT BALLET SCHOOL STUDENTS

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The aim of this study was to asses the impact of professional education in a ballet school on total energy expenditure, energy balance and nutritional status of pupils. In 44 girls ($\bar{x}$ age = 13±1) from a professional elite Dance School (BSD) and 29 girls ($\bar{x}$ age = 13±1) selected from a local primary school, constituting the control group (CG), daily energy expenditure (TEE) – by 24-h heart rate monitoring method (HR), and energy intake (DEI) – by 24-h dietary recall (record), were estimated. Subjects were also assessed for body composition using BIA method and simple anthropometrical indices, and skinfold thickness. The ballet school dancers TEE values were significantly greater than those of the control group (11.04±1.3 MJ/24 h *vs.* 9.47±1.3 MJ/24 h, $p<0.001$), while the DEI of the BSD was significantly lower than that of the CG (8.68±2.25 MJ/24 h *vs.* 9.52±1.38 MJ/24 h, $p< 0.001$). Thus, energy balance of BSD was far from even (-2.35±2.14 MJ/24 h). The energy balance results correlated with BMI, skinfolds thickness and body fat content data. All these parameters for the BSD were significantly lower when compared to the CG (BMI: 17.1±1.6 *vs.* 19.3±1.3; $p<0.001$, body fat: 14.5%±4.1 *vs.* 28%±2.9; $p<0.001$, skinfold thickness 7.0 mm±1.3 *vs.* 8.0 mm±1.1; $p<0.001$). The young ballet dancers were exposed to relatively intensive physical performance, had a high daily energy expenditure that was not compensated for by energy intake. The girls from the ballet school are prone to increased health risks due to prolonged negative energy balance.

INTRODUCTION

Education in a ballet school requires regular and intensive physical exercise. The energy cost of such exercise is comparable to that in many sports. Energy malnutrition of sportsmen is a rare phenomenon but there are still groups of athletes that are at high risk of negative energy balance because of the perceived need to "diet" as a strategy for maintaining the lowest possible body mass [Benardot *et al.*, 1989; Eliakim *et al.*, 2001; Higet, 1989; Steen Nelson & Brownell, 1990; Young *et al.*, 1994]. A very lean figure is the prerequisite for ballet dancers to succeed in this profession. Hence, children and teenagers attending specialized artistic ballet schools decide to reduce their food intake and sometimes even resort to purging behaviours (vomiting, using laxatives and diuretics) in order to maintain a very low body mass [Eliakim *et al.*, 2001]. The resulting prolonged energy inadequacy may seriously influence physical development and result in lower physical efficiency of the developing body.

This paper attempts to determine the extent to which ballet school education has an impact on the daily energy expenditure of the school dancers, and whether the caloric value of their food rations is adequate for intensive physical activity.

MATERIALS AND METHODS

The characteristic of the studied populations: a/ 44 schoolgirls, aged 13±1 years, from a professional elite Dance School in Poznań, Poland; b/ 29 schoolgirls, aged 13±1 years, with the correct relationship between height and body weight, selected from a local primary school – control group (CG). None of the girls from CG were specifically engaged in planned or structured exercise training programmes, but many were participants in leisure activities. Before the study, the children and the parents were informed of all aspects of the study, and they gave their written consent in each case. The study was approved by the Poznań Medical Ethics Committee.

The characteristic of the studied populations is shown in Table 1.

TABLE 1. Subject characteristics.

Parameter	Ballet school dancers x (SD)	Control group x (SD)
Number	44	29
Age [years]	13±1	13±1
Height [cm]	158±8	163±5
Weight [kg]	42±9	52±6

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Anthropometry. Weight and height were measured using a Rad Wag WPT 150.0 electronic balance and an anthropometer. Participants were dressed in minimal clothing during the measurements, which were acquired to the nearest 0.5 kg and 0.5 cm, respectively. Biceps, subscapular and suprailiac skinfolds measurements were performed on the right side of the body, as described by Christensen *et al.*, [1983] and Railly *et al.*, [1995] to a precision of 0.1 mm, using a Harpenden skinfold caliper. The mean of three measurements was used as the representative value.

Bioelectrical Impedance Analysis. The analysis of body composition – percentage of adipose tissue (FM) and lean body mass (FFM) was performed by bioelectric impedance technique using BIA 101S, AKERN – RJL bioanalyser, under the conditions recommended by Lukaski *et al.* [1985] with the subjects lying in a supine position, after an overnight fast. The measurements were conducted in the morning hours.

Measurement of energy balance. Heart rate (HR), monitored continuously over 2–3 days using short range radio telemetry (PE4000 Polar Sport Tester, Kempele, Finland), was used as estimate of daily energy expenditure (TEE). For each subject the relationship between HR and VO_2 was established. Measurments were carried out ≥2 h postprandially and after the subject had rested for 30 min after arriving at the laboratory. Results were obtained by simultaneous measurement of HR and VO_2 for the following activities carried out sequentially: lying in supine position, sitting quietly, standing quietly, continuous graded exercising on a treadmill and a cycle ergometer.

After preliminary editing to remove spurious HR data, daily energy expenditure (TEE) was calculated from HR using the Flex HR method, which has been fully described elsewhere [Ceesay *et al.*, 1989; Livingstone 1990; Livingstone *et al.*, 1992; Spurr *et al.*, 1988]. This method requires the definition of a Flex HR for each subject, above which there is a good correlation between HR and VO_2 but below which there is a poor correspondence between the two parameters. Flex HR was calculated as the mean of the highest HR for the resting activities (supine, sitting and standing) and the lowest HR of the exercise activities [Livingstone *et al.*, 1992].

Energy expenditure (EE) for periods during which HR was monitored was calculated as follows: energy expenditure for periods of daytime when HR≤Flex HR was calculated as equivalent to the mean of the resting VO_2 for the resting activities (lying, sitting and standing) and referred to as resting energy expenditure (REE). For the remainder of the time when HR was ≥ Flex HR, EE was calculated from the minute-by-minute recorded HR and each subjects calibration curves and referred to as activity energy expenditure (AEE). Energy expenditure during sleep (EES) was assumed to be equal to predicted basal metabolic rate (BMR) [Scofield *et al.*, 1985]. Twenty-four-hour TEE was computed by summing the EES, REE and AEE.

Dietary intake of nutrients was assessed by a 24-h dietary recall, with the use of Photographic Album of Dishes. The interview was carried out each time on the day of heart rate monitoring. Amounts were estimated using household measurements (glasses, cups, tablespoons, slices *etc*.). Energy content as well as nutritional value of daily food rations were calculated on the basis of "Food composition tables" [Ziemlański *et al.*, 1995] with the application of "Dietetyk" computer program.

Statistical analyses. The experimental data were subjected to a statistical analysis using one-way ANOVA.

RESULTS

The results presented in Table 2 show that the daily energy expenditure (TEE) of the ballet school dancers was significantly greater than that of the control group (11.04±1.3 MJ/24 h *vs.* 9.47±1.3 MJ/24 h, respectively, p<0.001). High TEE values for the ballet school dancers, expressed both in absolute values and per body mass unit values (0.26±0.05 MJ/kg b.m./24 h *vs.* 0.19±0.04 MJ/kg b.m./24 h, p<0.001), were due to ballet exercises and participation in ballet performances as a part of the professional practice. Therefore, the results obtained confirm a substantially greater physical strain in the case of the ballet dancers as compared with the controls.

TABLE 2. Daily energy intake, 24-h energy expenditure and energy balance in ballet school dancers and the control group.

Parameter	Ballet school dancers x (SD)	Control group x (SD)
BMR [MJ/24 h]	5.44±0.4	5.85±0.3
TEE [MJ/24 h]	11.04±1.3 *	9.47±1.3*
TEE [MJ/kg b. m.]	0.26±0.05*	0.19±0.04*
DEI [MJ/24 h]	8.68±2.25*	9.52±1.38*
Energy balance [MJ/24 h]	- 2.35±2.14 *	0.5±1.10 *

* – significant differences p<0.001

On the other hand, the daily energy intake (DEI) of the young ballet dancers was significantly lower than that of the girls in the control group (8.68±2.25 MJ/24 h *vs.* 9.52±1.38 MJ/24 h, p< 0.001). TEE exceeded DEI by as much as 2.35 MJ in the ballet group, but the control group was nearly in a state of energy balance (Table 2).

Approximately 11% of dancers were in balance and 25% of girls in the control group were in energy balance (Figure 1). Positive energy balance (>420 kJ/24 h) was discovered for only 9% of ballet dancers, but for 31% of girls from the control group. Moderate negative energy balance (ranging from -420 to -1260 kJ/24 h) was observed in 16% of the ballet dancers and 44% of the girls from the control group. As many as 64% of the young dancers obtained strongly negative energy balance (over -1260 kJ/24 h). Such a substantial energy deficit was not characteristic of any girl from the control group.

The energy balance results were corresponding with the BMI results and body composition characteristics of the girls (Table 3). The average BMI value for the young ballet dancers amounted only to 17.1±1.6 as opposed to the control group with the value of 19.3±1.3 (p<0.05).

The assessment of the BMI level (Figure 2) based on the criteria by Ferro-Luzzi *et al.* [1992] shows that the index values were within the acceptable range, specified for this age group, for 75% of the control group population and only 23% of the ballet school dancers.

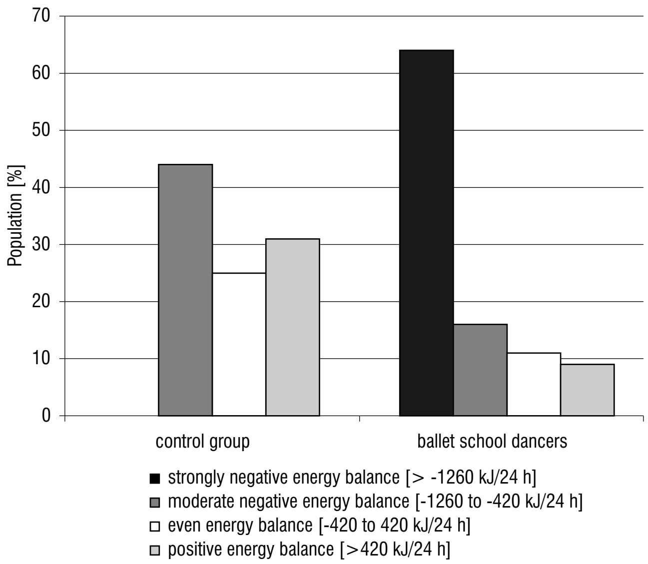

FIGURE 1. Distribution of energy balance in each group.

TABLE 3. Body composition characteristics of ballet school dancers and controls.

Parameter	Ballet school dancers x (SD)	Control group x (SD)
FM [%]	14.5±4.1 *	28.0±2.9 *
FFM [%]	85.2±3.5	72.1±2.9
BMI [kg/m^2]	17.1±1.6 **	19.3±1.3 **
Mean of skinfolds [mm]	7±1 *	8±1 *

* – significant differences p<0.001; ** – significant differences p<0.05

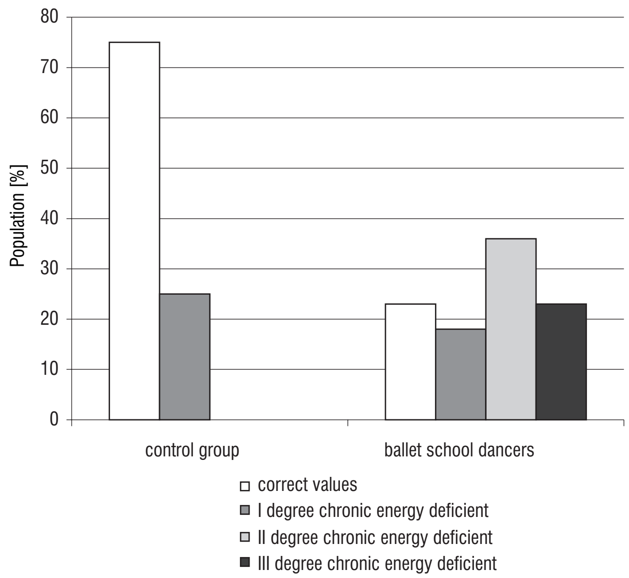

FIGURE 2. Distribution of BIA variables in young female dancers and controls.

Small energy deficiencies (I degree) were characteristic for 25% of controls and 18% of ballet dancers. The BMI--based nutritional status evaluation for the rest of the ballet dancers classified almost 36% of them as characterized by the second degree and 23% by the third degree of the energy deficiencies.

These results corresponded with the results of the body composition analysis and the measurements of the schoolgirls' skinfolds. The young ballet dancers had significantly less adipose tissue (14.5%±4.1) as compared with the controls (28%±2.9) (p<0.001), as well as smaller skinfold thickness (7.0 mm±1.3 *vs.* 8.0 mm±1.1 respectively, p<0.001).

It should be emphasized that the correlations between the energy balance values and % of fat mass in the body as well as skinfold thickness of the ballet dancers and the controls were statistically significant (Table 4).

TABLE 4. Correlation coefficients between energy balance and parameters of nutritional status in young ballet dancers and controls.

Parameter	Energy balance	
	Ballet school dancers	Control group
% FM	r=0.83 p<0.001	r=0.72 p<0.001
BMI	r=0.61 p<0.001	r=0.74 p<0.001
Mean of skinfolds	r=0.71 p<0.001	r=0.64 p<0.001

DISCUSSION

There is limited literature on the relationship between energy balance and body composition in ballet dancers. This is surprising, since the necessity to maintain a lean figure combined with intensive physical exercise may often involve poor nutritional habits. Special attention should be paid to ballet school dancers, since the enrollment to such schools involves young children aged 8-9 years, who are in a high growth velocity phase.

The findings described in this paper clearly indicate the need to systematically monitor the nutrient and energy intakes and nutritional status parameters of children trained to be professional ballet dancers. Results show that the ballet school dancers were statistically significantly shorter and lighter than their peers attending "regular" primary schools. These observations correspond with the results obtained by Warren *et al.* [1986], Karlsson & Johnell [1993] as well as Lichtenbenbelt *et al.* [1995], who found that young dancers aged 12–14 years were shorter than the non-dance population. It was suggested by these authors that the body composition in the dancers might be related to the amount of energy intake, while the low percentage of adipose tissue in their bodies prolongs the stage of sexual immaturity. Lichtenbenbelt *et al.* [1995] also showed that the dance-trained girls' low body mass and delayed menstruation have a negative impact on the bone mineral density and that the first menstruation occurs later (mean age 14) than in the non-dance population.

Twenty-four-hour heart rate monitoring of ballet school dancers allowed us to estimate our population's energy expenditures and to determine the physical load related to practice in such a school. The young dancers had relatively high daily energy expenditure expressed both in absolute values and per body mass unit values. Daily food intakes should, therefore, compensate for such intensified expenditure. Unfortunately, the 24-h nutrition interview discovered a surprisingly low energy supply in the young dancers' food rations, which did not compensate for the energy expenditure and entailed a significantly negative energy balance (- 2.35±2.14 MJ/24 h). Such a significantly uneven balance may raise a suspicion as to the credibility of the nutrition interview results. However, low energy intake may seem to be quite common among ballet dancers. The authors of the research observed that the ballet dancers were put under a lot of psychological pressure at school, which was aimed at motivating them to maintain lean figures and low body mass (substantially small increase in the body mass could even trigger an expulsion of a girl from the school). Other authors also claim that the energetic values of the dancers' diets are low and substantially depart from the recommended values [Andersen *et al.*, 1995; Beals & Manore 1998; Calabrese *et al.*, 1983; Hamilton *et al.*, 1986; Kersting *et al.*, 1998]. Lopez-Varela *et al.* [2000] examined a group of 14 ballet dancers and 23 controls. They proved that the ballet dancers used hypocalorific diets (approx. 6.5 MJ/24 h). The energy intake in their food rations was substantially lower than that of the controls and did not compensate for the high energy expenditures of the dancers. Similarly, Calabrese *et al.* [1983] found that the energy intake for 46% of the examined ballet dancers did not even reach 66% of the energy intake specified by the RDA. Many researchers suggest that dietary limits imposed by the dancers verge on anorectic and bulimic behaviours [Calabrese *et al.*, 1983; Frusztajer *et al.*, 1990].

The assessment of the nutritional status of young dancers was adequate to the uneven dietary balance since the dancers obtained very low BMI values (proving 3rd degree of chronic energy deficiencies for 23%, and 2nd degree for 36% of the dancers), as well as low percentage of adipose tissue in the body. Sustained nutrition deficiencies may further lead to anaemia, osteoporosis and fertility disorders [Calabrese *et al.*, 1983; Eichner, 1992; Warren *et al.*, 1986].

CONCLUSIONS

We may conclude that the youth from the ballet school, exposed to relatively intensive physical performance, are prone to losing health due to negative energy balance and low nutritional value of food rations. The issue of ballet school dancers requires further research, especially as the studies devoted to the nutritional patterns and nutritional status of dancers are not numerous, and these related to ballet school dancers are very scarce. It seems necessary to perform systematic controls of the nutritional value of meals served to students of ballet schools, as well as to undertake activities to raise the awareness among school teachers and parents about potential health hazards.

REFERENCES

1. Andersen L.F., Nes M., Sandstad B., Bjorneboe G.E., Drevon C.A., Dietary intake among Norwegian adolescents. Eur. J. Clin. Nutr., 1995, 49 (8), 555–564.
2. Beals K.A., Manore M.M., Nutritional status of female athletes with subclinical eating disorders. J. Am. Diet. Assoc., 1998, 98 (4), 19–25.
3. Benardot D., Schwarz M., Heller D.W., Nutrient intake in young, highly competitive gymnastic. J. Am. Diet. Assoc., 1989, 89, 401–403.
4. Calabrese L.H., Kirkendall D.T., Floyd M., Menstrual abnormalities, nutritional patterns and body composition in female classical ballet dancers. Phys. Sports Med., 1983, 11 (2), 86–102.
5. Ceesay S.M., Prentice A.M., Day K.C., Murgatroyd P.R., Goldberg G.R., Scott W., Spurr G.B., The use of heart rate monitoring in the estimation of energy expenditure: a validation study using indirect whole-body calorimetry, Br. J. Nutr., 1989, 61, 175–186.
6. Christensen C.C., Frey H.M.M., Foenstelien E., Aadland E., Refsum H.E., A critical evaluation of energy expenditure based on individual O_2 consumption/ /heart rate curves and average daily heart rate. Am. J. Clin. Nutr., 1983, 37, 468–472.
7. Eichner E.R., Medical issues in the eating disorders, 1992, *In*: Eating, body weight and performance in athletes (ed. Brownell K.D., Rodin J., Wilmore J.H. *et al.*) Lea and Febiger, Philadelphia, pp. 191–201.
8. Eliakim A., Scheett T.P., Newcomb R., Mohan S., Cooper D.M., Fitness, training and growth hormon →insulin-like growth factor I axis in prepubertal girls. J. Clin. Endocrinol. Metal., 2001, 86 (6), 2797–2802.
9. Ferro-Luzzi A., Sette S., Franklin S., James W.P.T., A simplified approach of assessing adult chronic energy deficiency. Eur. J. Clin. Nutr., 1992, 46, 173–186.
10. Frusztajer N.T., Dhuper S., Warren M.P., Brooks G.J., Fox R.P., Nutrition and the incidence of stress fractures in ballet dancers. Am. J. Clin. Nutr., 1990, 51, 779–783.
11. Hamilton L.H., Brooks-Gunn J., Warren M.P., Sociocultural influences on eating disorders in professional female ballet dancers. Int. J. Eat. Disord., 1986, 4 (4), 465–477.
12. Higet R., Athletic amenorrhoea: an update on etiology, complications and management. Sports Med., 1989, 7, 127–136.
13. Karlsson M., Johnell O., Bone mineral density in professional ballet dancers. Bone and Mineral, 1993, 21, 163–169.
14. Kersting M., Sichert-Hellert W., Lausen B., Alexy U., Manz F., Schoch G., Energy intake of 1 to 18 year old German children and adolescents. Forschungsinstitut fur Kinderernahrung, 1998, 37 (1), 47–55.
15. Lichtenbenbelt M., Fogelholm M., Ottenheijm R., Westerterp K.R., Physical activity, body composition and bone density in ballet dancers. Brit. J. Nutr., 1995, 74, 439–451.
16. Livingstone M.B., Simultaneous measurment of free--living energy expenditure by the doubly labelled water method and heart-rate monitoring. Am. J. Clin. Nutr., 1990, 52, 59–65.
17. Livingstone M.B., Coward W.A., Prentice A.M., Davies P.S.W., Strain J.J., McKenna P.G., Mahoney C.A., White J.A., Stewart C.M., Kerr M.J.J., Daily energy expenditure in free-living children: comparison of heart-rate monitoring with the doubly labelled water ($^2H_2{}^{18}O$) method. Am. J. Clin. Nutr., 1992, 56, 343–352.
18. Lopez-Varela S., Montero A., Chandra R.K., Marcos A., Nutritional status of young female elite gymnasts. Int. J. Vitam. Nutr. Res., 2000, 70 (4), 185–190.
19. Lukaski H.C., Johnson P.E., Bolonchuk W.W., Lykken G.I., Assessment of fat-free mass using bioelectrical impedance measurements of the human body. Am. J. Clin. Nutr., 1985, 41, 810–817.
20. Railly J.J., Wilson J., Durnin J.V.G.A., Determination of body composition from skinfold thickness: a validation study. Arch. Dis. Child., 1995, 73, 305–310.

21. Scofield W.N., Scofield C., James W.P.T., Basal metabolic rate. Hum. Nutr. Clin. Nutr., 1985, 39 C (Suppl. 1), 1–96.
22. Steen Nelson S., Brownell K.D., Patterns of weight loss and regain in wrestlers: has the tradition changed? Med. Sci. Sports Exerc., 1990, 22, 762-768.
23. Spurr G.B., Prentice A.M., Murgatroyd G.R., Goldberg G.R., Reina J.C., Christman N.T., Energy expenditure from minute-by-minute heart rate recording: comparison with indirect calorimetry. Am. J. Clin. Nutr., 1988, 48, 552–559.
24. Warren M.P., Brooks G.J., Hamilton L.H., Warren L.F., Hamilton W.G., Scoliosis and fractures in young ballet dancers. Relation to delayed menarche and secondary amenorrhoea. New Engl. J. Med., 1986, 314, 1348–1353.
25. Young N., Formica C., Szmulker G., Seeman E., Bone density at weight-bearing and non-weight-bearing sites in ballet dancers: the effects of exercise, hypogonadism and body weight. J. Clin. Endocrinol. Metab., 1994, 78, 449–454.
26. Ziemlański Ś., Bułhak-Jachymczyk B., Budzyńska-Topolowska J., Panczenko-Kresowska B., Wartanowicz M., 1995, Normy Żywienia dla ludności w Polsce, Nowa Medycyna, 5 (in Polish).

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BILANS ENERGETYCZNY I SKŁAD CIAŁA UCZENNIC SZKOŁY BALETOWEJ

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Celem niniejszych badań była ocena jaki wpływ ma nauka w szkole baletowej na wielkość wydatków energetycznych, bilans energetyczny i stan odżywienia uczennic tej szkoły. W badaniach uczestniczyły dwie grupy dziewcząt w wieku 13–14 lat: a/ 44 uczennice ze szkoły baletowej (BSD); b/ 29 dziewcząt ze szkoły podstawowej, stanowiących grupę kontrolną (CG). Wartość energetyczną całodobowych racji pokarmowych (DEI) oszacowano na podstawie wywiadu z ostatnich 24 godzin, wydatki energetyczne (TEE) metodą 24-godzinnego monitorowania częstości tętna. Ponadto, oceniono komponenty składu ciała metodą impedancji bioelektrycznej, podstawowe wskaźniki antropometryczne oraz wielkość otłuszczenia podskórnego (metodą kaliperową).

Rezultaty dowiodły, że wydatki energetyczne BSD były wyższe niż CG (11,04±1,3 MJ/24 godz. *vs.* 9,47±1,3 MJ/24 godz., $p<0{,}001$), przy czym wartość energetyczna ich racji była znamiennie niższa (8,68±2,25 MJ/24 godz. *vs.* 9,52±1,38 MJ/24 godz., $p<0{,}001$). W konsekwencji bilans energetyczny młodych tancerek był wyraźnie ujemny (-2,35±2,14 MJ/24 godz.), co znalazło odzwierciedlenie w parametrach stanu odżywienia (tab. 2). Bilans energetyczny młodych tancerek korelował ze wskaźnikiem BMI, średnim fałdem skórno-tłuszczowym oraz komponentami składu ciała. W grupie BSD wszystkie te parametry były znamiennie niższe w porównaniu z CG (BMI: 17,1±1,6 *vs.* 19,3±1,3; $p<0{,}001$, body fat: 14,5%±4,1 *vs.* 28%±2,9; $p<0{,}001$, skinfold thickness 7,0 mm±1,3 *vs.* 8,0 mm±1,1; $p<0{,}001$), (tab. 3).

Reasumując, dziewczęta ze szkoły baletowej cechowały wysokie całodobowe wydatki energetyczne, których nie bilansowała wartość energetyczna racji pokarmowych. Uczennice tej szkoły mogą być więc narażone, z tytułu utrzymującego się ujemnego bilansu energetycznego, na poważne ryzyko utraty zdrowia.