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DIETARY RESTRAINTS IN RELATION TO NUTRIENT INTAKE AND MORPHOROGICAL PARAMETERS IN YOUNG BALLET DANCERS

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Abstract

Background: Dietary restraints are very often in ballet dancers.

Objective: To investigate the prevalence of dietary restraints in ballet dancers and to examine the nutritional consequences of dietary restraints and its implications for the morphological and iron status.

Methods: The total of 29 female ballet dancers from a Poznań ballet school volunteered. The nutritional status was evaluated by analyzing the body composition using the BIA method (adipose tissue percentage (FM%, kg), fat-free mass (FFM%, kg). Morphological parameters, serum iron and ferritin levels were also measured. Nutritional values were estimated by examining dietary records for seven consecutive days. Moreover, the Three-Factor Eating Questionnaire (TFEQ) and Food Frequency Questionnaire (FFQ) were employed to describe eating behaviour. The energy balance and energy availability were also assessed.

Results: A diet of ballet dancers with higher dietary restraints was significantly lower in energy and nutrients. There were also significant differences with regard to how often they consumed foods that were a source of iron, especially its heme form. Moreover, in this group the incidence of patients with iron deficiency and anemia was higher. The hazard ratio indicated high likelihood of an increased number of patients with anemia.

Conclusion: Dietary restraints adopted by ballet dancers are associated with a reduced intake of energy and nutrients, and may significantly increase the risk of iron deficiency or anemia.

Key words: *dietary habits, body composition, serum iron, ferritin*

Introduction

Abnormal eating habits may be the result of a consciously applied dietary regimen that even includes self-provoked vomiting and taking laxatives and diuretics. Such practices are particularly dangerous as they may become a basis for clinical nutritional disorders that are also associated with problems assessing one's own body shape, emotional status and interpersonal relations (reference is needed). Anorexia nervosa belongs to the most extreme clinical forms of nutritional disorders. According to DSM IV (*Diagnostic and Statistical Manual of Mental Disorders* – standard classification of mental disorders used by mental health professionals in the United States), subjects suffering from this condition starve themselves even if their body weight is 15% below the ideal body mass. On the other hand, bulimic behaviours include alternate cycles of an extremely limited intake of foods and of compulsive eating, followed by "cleansing".

Nutritional disorders are also often diagnosed in physically active subjects, including elite female athletes. Athletes that train aesthetic disciplines such as artistic gymnastics, figure skating or even classical dancing are at the highest risk of such nutritional disorders because such athletes receive scores not only based on their technical performance, but also on their artistic expression that is associated with grace, movement elegance and a silhouette shape [1,2]. It has to be emphasized as well that with regard to these disciplines girls start physical training prior to the puberty, and therefore there is a risk of selecting a sports discipline that is inappropriate for their body shape at adulthood. Regarding gymnasts there has been a suggestion that starvation is a procedure used to delay sexual maturation that is associated with a body shape change that in future may disqualify a gymnast from continuing her sports career [3]. In their paper Thomas et al. [4] demonstrated that in order to control their body weight 9.6% in a group of 239 ballet dancers provoked vomiting, 29.3% starved themselves, whereas 4.2% abused laxatives. However, the restriction of a food intake in young girls is associated with physical and psychological changes including adverse influence of fitness-related parameters retardation of growth, development, metabolism, mental and menstrual cycle functioning and osteoporosis [5,6]. It has also been suggested that dieting, especially in adolescence, is associated with a lower iron intake. It has been reported that 23% of the females investigated who were attempting to lose weight were anemic compared with 7% of nondieting subjects; half of these anemic females had tried to lose weight [7]. These findings are of concern as a poor iron status has been associated with a reduced immune response, impaired cognitive function, and sport and technical performance.

Because there are no published data concern on relationship between dietary restraint and morphological and iron status in ballet dancers the purpose of this study was to investigate the prevalence of dietary restraints in ballet dancers and to examine the nutritional consequences of dietary restraints and their implications for morphological and iron status.

Methods

The total of 35 ballet dancers from the Poznań Secondary Ballet School volunteered. The inclusion criteria were: a training period of at least 3 years, training session > 5/wk, no serious medical conditions, no clinical diagnosis of eating disorders and a non-smoking status. 6 dancers were excluded from the study because they discontinued classes at a ballet school. Eventually, 29 dancers completed the study (Table 1). A written informed consent was obtained from all participants and their parents. The study was approved by the Poznań Medical Ethics Committee (no. 334/09).

The height and weight were measured using an anthropometer coupled with a WPT 200 OC verified medical scale (Rad Wag). The body mass index BMI (kg/m^2) was calculated as the body weight divided by the square of the body height. The participants were dressed in minimal clothing during the measurements, and the measurements were rounded to the nearest 0.5 kg and 0.5 cm. An analysis of the body fat mass (FM) and fat-free mass (FFM) was performed in the morning, following overnight fasting, with subjects lying in a supine position, using BODYSTAT 1500, as described by Heyward et al. [8]. Blood samples were collected between 6.00 a.m. and 9.00 a.m. following overnight fasting and rest. Subjects were instructed to abstain from caffeine and alcohol for 24 hours prior to the blood sampling, and to refrain from performing strenuous exercises on the day of sampling. The levels of blood morphotic elements were measured with a conductometric method (DC), combined with a photometric method to determine the SLS haemoglobin levels without cyanides, using SYSMEX K-4500. Reference ranges used in this laboratory were used to interpret blood test results. They were as follows: red blood cell RBC 3.70–5.10 M/μL, hemoglobin concentration HBG 12-16 g/dL, hematorcit HCT 37-47%, mean corpuscular volume MCV 80-99 fL, mean corpuscular hemoglobin MCH 27-35 pg, corpuscular hemoglobin concentration MCHC 32-37 g/dL, platelets PLT 140-440 K/μL, red-cell distribution width RDW-CV 12.0–15.0%, iron 25–156 μg/dL, ferritin 10–120 ng/mL. All parameters were determined in duplicates. Dietary records from seven consecutive days under the supervision of dieticians were obtained. Dancers regularly contacted a registered dietician who taught them how to control and record a nutrition intake. All meals (including recipes and item weights), non-meal foods, beverages, and fluids were recorded in a diary form using a photographic album of dishes [9]. The daily diets were analyzed with regard to their energy and nutrient levels (fat, protein, carbohydrate, vitamin C, B_{12}, iron, foliate) using the *Dietician* computer software package, based on Polish food composition tables [10]. Three-Factor Eating Questionnaire (TFEQ) was used to estimate dietary restrictions [11]. The questionnaire contained 36 items in a true-or-false response format and 15 questions where it was necessary to select one of the following descriptors: *never*, *seldom*, *often*, and *always*. All item responses were dichotomized and aggregated into three scales: cognitive restraint of 21 items, hunger of 14 items and disinhibition of 16 items. A dietary restraint was classified as a combined sum of scores for cognitive restraint and hunger. Subjects whose total score was below 16 were classified as a group with low dietary restraints (LDR), whereas subjects who scored higher than 16 were classified as a group with high dietary restraints (HDR). The Food Frequency Questionnaire (FFQ) was used for the assessment of consumption of selected products and meals.

For three days, each subject wore a heart-rate monitor (HR) (Polar Sport Tester, RS 400, Finland) in order to estimate the total energy expenditure (TEE). For each subject, the relationship between HR and VO_2 was established. The measurements were carried out two or more hours after meals, and after the subject had rested for 30 min. after they had arrived at the laboratory. Results were obtained by a simultaneous measurement of HR and VO_2 for the following activities carried out sequentially: lying in a supine position, sitting quietly, standing quietly, and continuous exercise on a cycle ergometer of a various intensity. After preliminary edition to remove spurious HR data was performed, the total energy expenditure (TEE) was calculated using the Flex-HR method. This method requires a definition of the Flex-HR for each subject; above this value there is a good correlation between HR and VO_2, but below this value there is a poor correspondence between these two parameters. The Flex-HR was calculated as the mean of the highest HR for activities at rest (supine position, sitting, and standing) and the lowest HR of exercise activities. At the end of a measurement session, researchers transferred minute-by-minute records of the last twenty-four hours from an instrument to a database. The 24-hour energy balance (EB) was calculated as a difference between the means for seven consecutive days of the 24-hour energy intake and the TEE as the mean for three days. The energy availability (EA) was calculated by subtracting the exercise energy expenditure (EEE) from the total daily energy intake, and was adjusted for the FFM kg [12].

Statistical analysis

The means and standard deviations of quantitative variables were calculated. The normality of the distribution was checked. Comparisons between data were carried out using an independent *t*-test. Additionally, a hazard ratio for anemia in the study group was calculated. Statistical analyses were performed using the *Statistica 8.0* software (StatSoft, 2008). *P*-values of less than 0.05 were considered statistically significant.

Results

Table 1 presents details of anthropometric parameters, body composition, information's about training/ballet carrier in two restraint groups (low dietary restraints, LDR and high dietary restraints, HDR). There were not any significant differences in these parameters in study subjects. The only differences were observed for dietary restraint assessment and it was a base to form these subgroups.

Table 1. *Baseline characteristics of two restraint groups M ± SD*

Parameters	LDR (*n* = 12)	HDR (*n* = 17)	*P* – value
Age (years)	17.7 ± 0.78	17.41 ± 0.94	NS
Height (cm)	168.3 ± 4.09	166.0 ± 4.95	NS
Body weight (kg)	55.15 ± 5.71	53.11 ± 5.63	NS
BMI (kg/m2)	19.38 ± 1.97	19.22 ± 1.71	NS
FM (%)	18.16 ± 3.84	20.18 ± 2.94	NS
FM (kg)	10.05 ± 2.48	10.78 ± 2.26	NS
FFM (%)	81.84 ±3.83	79.82 ± 2.94	NS
FFM (kg)	45.11 ± 4.79	42.34 ± 4.21	NS
Age at the beginning of training (years)	7.00 ± 0.74	6.74 ± 0.75	NS
Training period (years)	10.67 ± 1.15	10.65 ± 1.22	NS
Number of training session per week (n/d)	5.17 ± 0.39	5.29 ± 0.59	NS
Hours of training per day (hours/d)	4.42 ± 0.99	4.41 ± 0.16	NS
Hours of training per week (hours/week)	22.92 ± 5.82	23.35 ± 7.15	NS
TFEQ (pkt)	11.00 ± 3.20	24.33 ± 2.01	< 0.001

Table 2. *Daily intakes of nutrients, energy expenditure, energy balance and energy availability in ballet dancers classified by levels of dietary restraint M ± SD*

	LDR (*n* = 12)	HDR (*n* = 17)	*P* – value
Energy (kcal)	1955 ± 478	1533 ± 359	0.01
Fat (g)	73.06 ± 24.38	53.09 ± 16.78	0.01
Protein (g)	65.68 ± 15.09	57.29 ± 11.67	NS
Carbohydrate (g)	258.67 ± 52.37	206.73 ± 52.4	0.01
Sugar (g)	65.53 ± 14.99	51.74 ± 22.61	NS
Dietary fiber (g)	17.80 ± 3.66	15.78 ± 6.86	0.01
Calcium (mg)	610.8 ± 154.8	765.6 ± 276.5	NS
Iron (mg)	11.06 ± 3.65	9.03 ± 3.27	NS
Zinc (mg)	9.84 ± 3.00	8.83 ± 3.91	NS
Magnesium (mg)	218.3 ± 54.7	232.4 ± 88.3	NS
Vitamin A (mg)	680.3 ± 316.8	640.75 ± 172.1	NS
Vitamin D (mg)	2.47 ± 3.12	1.81 ± 1.29	NS
Vitamin E (mg)	8.21 ± 2.49	6.41 ± 2.65	NS
Thiamin (mg)	1.04 ± 0.32	0.84 ± 0.37	NS
Riboflavin (mg)	1.51 ± 0.48	1.43 ± 0.52	NS
Niacin (mg)	11.43 ± 3.95	10.41 ± 4.87	NS
Vitamin B6 (mg)	1.3 ± 0.50	1.62 ± 1.19	NS
Folate (mg)	198.18 ± 60.5	156.9 ± 52.7	NS
Vitamin B12 (mg)	2.43 ± 0.9	2.67 ± 0.80	NS
Vitamin C (mg)	60.1 ± 20.3	48.4 ± 22.9	NS
TEE (kcal/d)	2245 ± 276	2108 ± 348	NS
EB (kcal/d)	-290 ± 380	-563 ± 374	0.03
EEE (kcal/d)	819 ± 179	725 ± 213	NS
EA (kcal/kg FFM/d)	25.2 ± 8.0	19.6 ± 7.5	0.05

Table 3. *Differences in frequency intake of products*

	LDR (*n* = 12)	HDR (*n* = 17)	*P* – value
Whole milk	14.7 ± 13.1	5.6 ± 3.7	0.04
Low fat	20.4 ± 12.9	22.91 ± 12.5	NS
Veal	3.5 ± 3.2	1.6 ± 2.6	0.04
Poultry	18.1 ± 18.8	11.1 ± 8.4	NS
Pork	7.3 ± 3.7	3.2 ± 2.6	0.031
Fish and see fruits	4.3 ± 5.6	3.9 ± 6.9	NS
Eggs	12.8 ± 20.3	5.4 ± 5.8	NS
Podroby	13.3 ± 12.5	5.5 ± 3.6	0.008
Plant Fats	12.3 ± 13.3	6.1 ± 7.0	NS
Fats	42.8 ± 30.0	22.2 ± 27.4	0.046
Legumes and nuts	1.7 ± 1.6	3.0 ± 2.5	NS
Products with whole grain	14.8 ± 11.8	13.6 ± 7.2	NS
Cereal product with purified flour	65.8 ± 42.3	19.5 ± 9.8	0.003
Products with high energy value	1.5 ± 0.7	1.9 ± 1.5	NS
Fast foods	1.6 ± 1.6	1.6 ± 2.1	NS
Fruits	14.3 ± 11.8	10.0 ± 7.3	NS
Vegetable	32.1 ± 29.9	33.9 ± 34.1	NS
Sweets	13.0 ± 10.1	14.0 ± 13.5	NS
Mineral water	80.6 ± 59.7	112.1 ± 38.7	NS
Juice	26.2 ± 35.8	14.8 ± 18.6	NS
Sweet drinks	13.8 ± 12.3	5.1 ± 18.1	0.05
Energetic drinks	0.3 ± 0.5	0.4 ± 0.7	NS
Isotonic drink	3.1 ± 8.5	1.0 ± 2.4	NS

Table 4. *Mean values of blond components (iron status) of subjects M ± SD*

	LDR (*n* = 12)	HDR (*n* = 17)	*P* – value
RBC (3.7 – 5.1 mln/μl)	4.56 ± 0.24	4.52 ± 0.30	NS
HBG (12.0 -16.0 g/dl)	13.04 ± 0.65	12.83 ± 0.76	NS
HCT (37 - 47%)	39.00 ± 1.58	39.00 ± 1.93	NS
MCV (80 - 99 fl)	85.82 ± 2.38	86.15 ± 3.73	NS
MCH (27 - 35 fl)	27.99 ± 1.30	28.62 ± 1.55	NS
MCHC (32 - 37g/dl)	33.54 ± 0.95	33.16 ± 1.26	NS
PLT (140 - 440 tys/μl)	237.75 ± 55.11	259.5 ± 46.45	NS
RDW (12.0 – 15.0%)	14.10 ± 1.29	13.69 ± 1.09	NS
Serum Iron (25 - 156 μg/l)	60.15 ± 24.81	52.33 ± 29.52	NS
Serum Ferritin (10–120 ng/dl)	19.27 ± 20.54	16.64 ± 20.17	NS
Norma % (n)	41.7 (5)	11.8 (2)	
Depleted iron stores % (n)	50 (6)	35.3 (6)	
Iron deficient % (n)	0	17.6 (3)	
Anemia % (n)	8.3 (1)	35.3 (6)	
Odds ratio	22.5		0.021
95% Cl	1.609 to 314.5789		

Nutrient intake data for the current subjects are presented in Table 2. There were significant differences with regard to energy, fat, carbohydrate and dietary fiber intake (P<0.01). Energy and these macronutrients were inversely related to dietary restraints. Many subjects were found to have a very low intake of iron nearly a quarter of the group had an iron intake below the Lower Reference Nutrient Intake. Statistically significant differences were also recorded with regard to the energy balance and energy availability, and ballet dancers with HDR had a more negative energy balance and lower energy availability.

A degree of dietary restraints was also associated with differences in frequency intake of specific food products. In a group with lower dietary restraints non-skimmed milk, veal, pork, variety meats, animal fat, white flour products and sweet beverages were consumed more often (Table 3).

Table 4 shows that there were no significant differences in the mean values of blood components to determine the iron status between dietary restraint groups. However, in a subjects with high dietary restraints the rate of subjects diagnosed with iron deficiency and anemia was higher. At the same time, the percentage of subjects with normal blood parameters was higher in a group with lower dietary restraints. The odds ratio calculated using these data indicates that there is a statistically significantly (p = 0.002) higher odds ratio for anemia development or iron deficiency in a group with high dietary restraints.

Discussion

In order to be a ballet dancer one has to maintain low body weight and a lean silhouette. Appropriate aesthetic appearance of ballet dancers is as important as their technical preparation. Due to such requirements in this group there is a tendency for inappropriate eating habits. Dietary restraints applied by dancers result in serious energy and nutritional deficiencies in their diet that may lead to serious negative health consequences. Castelo–Branco et al. [13] confirmed that 87% of the studied ballet dancers demonstrate restrictive eating behaviours including, first of all, a reduced number of meals, reduced energy intake and consuming only low-fat products.

Anthropometric parameters of the study population were similar to results obtained by other authors [14]. A low adipose tissue content that is especially noticeable in a group with higher dietary restraints may indicate that restraints applied by the study subjects may have been in place for a long time, and therefore their consequences are visible. The results of an assessment of energy and nutritional values of meals consumed by the studied population also confirm that dancers practice dietary restraints on almost daily basis. In both groups, a negative energy balance and too low energy availability were observed in line with previously available data (reference is needed). Noticeably, differences between girls belonging to groups with low or high dietary restraints turned out to be statistically significant. These results are rather disturbing because when the energy availability is reduced below a critical value of 30 kcal/kgFFM/d it may have a negative effect on the bone formation, and not only on the functions of the hypothalamic-pituitary-ovarian axis [12]. It is especially dangerous for individuals who are in the period where their peak skeletal mass is formed. Additionally, a diet used by dancers had deficiencies with regard to the supply of the majority of vitamins and minerals. Moreover, Ziegler et al. [15] and Doyle-Lucas et al. [16] demonstrated that a diet of dancers and female athletes who practice sports disciplines similar to classical dancing, such as figure skating dancing, does not cover their energy or nutritional requirements.

Differences in the energy and nutritional values of daily meals in the studied dancers were also associated with visible differences in the frequency of consuming analysed products and different foodstuff groups. A diet of ballet dancers belonging to a high dietary restraint groups was associated with lower consumption of whole milk, varied meats, animal fat, white flour products or sweetened beverages, and it may prove that they tried to eliminate products of high energy values and low nutritional values from their diet. On the other hand, consumption of meat and meat-derivative products was also lower, therefore the supply of heme iron was limited, and this form of iron has significantly better bioavailability than non-heme iron. Therefore, in line with published data [17], in the group with high dietary restraints the rate of iron deficiency and anemia was significantly higher. Unfortunately, a calculated odds ratio indicates that there is high likelihood that the number of subjects with anemia will increase - based on current results of anthropometric measurements and the iron and ferritin levels. Ryan et al. [18] noticed that the proportion of females who `wanted to be slimmer' was higher among `reduced meat eaters' compared with `meat eaters' and more of the `reduced meat eaters' compared with `meat eaters' reported that they had tried to lose weight. There is also a hypothesis that vegetarianism, as it is an alternative diet eliminating some groups of products, may be a way to mask nutritional disorders that are already present [18]. A higher rate of subjects with iron deficiency or anemia in the HDR group might have been a result of a lower number of meals containing heme iron as well as the fact that daily meals had in general lower nutritional values. With regard to prevention and treatment of iron-deficiency anemia it is important not only to increase the iron amount and bioavailability, but the role of other nutrients with hematopoietic properties is also extremely important. A published report revealed a positive correlation between an increased intake of vitamin C and a significant increase in the erythrocyte count, hemoglobin levels and hematocrit levels in female athletes with iron deficiency and iron-deficiency anemia [19].

Moreover, an inappropriately balanced diet as well as the use of restrictive dietary restraints may result not only from an attempt to reduce food consumption purposely but also from lack of knowledge on how to prepare a diet for individuals with increased physical activity by providing an appropriate energy balance [20]. Doyle–Lucas et al. [21] demonstrated that educational programs conducted in an appropriate way among young ballet dancers may lead to significant improvement in their dietary habits and to increased energy and nutrient consumption in a population that is at a special risk of triad development. Iron deficiency and iron-deficiency anemia in subjects associated with dancing and professional sport is extremely undesirable as even the smallest decrease in the levels of blood morphotic elements may have a significant negative effect on physical performance [22] that should be maintained as high as possible in ballet dancers as well in order to maintain appropriate technical performance in dancing.

This study has several limitations. Firstly, the body composition was determined using the electrical bioimpedance method, which potentially raises some controversies. However, DEXA method was not used due to young age of study participants, tests frequency, and potential adverse (UV) effects. Secondly, questionnaire methods are always be underestimated.

In conclusion, and within the limitations of this study, the present data revealed that dietary restraints applied by ballet dancers and associated with a reduced intake of energy and nutrients in a diet may significantly affect the levels of blood cell parameters, leading to an increased risk of iron deficiency or anemia.

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Declaration of interest

The authors report no conflicts of interest.

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