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Selected blood biochemical parameters and energy intake in physically active women and men in the context of body shape satisfaction or dissatisfaction

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ABSTRACT

Introduction: To evaluate selected blood biochemical parameters, energy intake and energy expenditure in physically active women and men in the context of body shape satisfaction or dissatisfaction.

Material and methods: A total of 187 female and male students from the Faculty of Physical Education volunteered to participate in the study. The selected anthropometric and blood biochemical parameters were measured. Participants were asked to provide a positive or negative response to the question of whether they were satisfied with their body shape.

Results: A higher percentage of women, compared to men, express dissatisfaction with their body shape. However, within both groups, the quantity is significant. Individuals dissatisfied with their body shape perceived themselves as more overweight than they actually were. In both groups, especially among women, cortisol concentrations were close to the upper limit of the norm, indicating a higher level of stress in this group.

Conclusions: Even people with normal body weight and regular physical activity, regardless of gender, often declared dissatisfaction with their body shape. It is important because disturbances in the perception of body shape may contribute to physical and mental health disorders.

Keywords: college students; perception of their body shape; hormones; lipid profile

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Introduction

In the era of obesity, excessive interest in one's appearance and slim figure affects an increasing number of young women and men [1, 2]. Nowadays, as confirmed by numerous literature data, in connection with the fashion for a slim figure, many people, mainly women, as a result of dissatisfaction with the appearance of their own figure, excessively limit their energy consumption [3–5]. Recent findings implicate body shape dissatisfaction in the development and maintenance of eating pathology. It is worth noting that about 43% of teenagers are sometimes or often afraid of being overweight. Half of teens are afraid of weight gain [6]. It is known that disrupting the balance between calorie intake and metabolic demand results in a state of energy deficiency. In conjunction with physical activity, low energy availability leads to multisystem deregulation favouring essential bodily functions, which in turn causes irregular menstrual cycles and deterioration in bone health [7, 8]. It is worth emphasizing that energy consumption disorders and their consequences are well documented in women and men who practice sports where a slim figure is necessary (e.g. marathon, artistic gymnastics, synchronous swimming). They are referred to as the metabolic triad (currently RED — relative energy deficiency) [9, 10]. The consequences of this low-energy condition can alter many physiological systems, including metabolism, menstrual function, bone health, immunity, protein synthesis, and cardiovascular and psychological health [11]. It has also been demonstrated that women dissatisfied with their body shape exhibit excessive activation of the hypothalamus-pituitary-adrenal (HPA) axis. However, no data was found regarding possible metabolic disorders in men dissatisfied with their body shape. This axis constitutes a hormonal system comprising numerous structural and functional connections between the hypothalamus, pituitary gland, and adrenal gland, playing a significant role in the body's response to stress [12]. The stimulation of this axis, associated with elevated cortisol levels in the blood, reflects an increased level of stress. The regulatory functions of the HPA axis govern the cardiovascular and metabolic systems, immune functions, behaviour, and reproduction. Excessive activity on the hypothalamus-pituitary-adrenal axis results in hormonal imbalance, reduced immunity, and disruptions in sleep and circadian rhythm. It can be a cause of adrenal exhaustion and thyroid hyperactivity. Elevated cortisol levels impact TSH, T3, and T4. In addition, its long-term excessive activity can lead to chronic inflammation, uncontrolled blood pressure spikes, increased blood glucose, diabetes, obesity, autoimmune disorders and even cancer [13, 14]. Research results also indicate the role of cortisol and the autonomic nervous system in controlling all three body composition compartments, suggesting that stress can have an adverse impact on body composition, even in young, seemingly healthy individuals [15, 16]. Therefore, the purpose of this research was to evaluate selected blood biochemical parameters and energy intake in physically active women and men in the context of body shape satisfaction or dissatisfaction.

Materials and methods

Subjects

A total of 187 female and male students of the Faculty of Physical Education volunteered to participate in the study. The participants were recruited based on word-of-mouth and advertisements in student dormitories. All volunteers declared no health problems, did not smoke and were not taking supplements regularly. All participants were engaged in different types of regular physical activity due to the study program (martial arts, swimming, games). Before the study, all subjects provided written consent to participate in all procedures. The study protocol was approved by the local ethics commission at the University of Physical Education.

Anthropometric measurements

In all participants, after all outer clothing and shoes were removed body mass and height were measured using standard medical equipment. Body mass was measured to the nearest 0.1 kg and body height to the nearest 0.5 cm. Body mass index (BMI) was calculated as body mass (kg) divided by height (m) squared. The percentage of body fat was determined from the sum of the thickness of four skinfolds (biceps, triceps, suprailiac and subscapular), measured using a Harpenden Skinfold Caliper (British Indicators, Burgess Hill, UK) and calculated according to Durnin and Womersley [17]. Each measurement was repeated twice and in case of discrepancy was repeated for a third time.

Biochemical analyses

The participants were instructed to eat the last meal at least 8 hours before blood sampling. Blood was withdrawn between 7:30 and 9:00 a.m. from the antecubital vein under aseptic conditions into plastic tubes with anticoagulant and centrifuged 15 min/4000 rpm at 40°C to obtain plasma. Plasma was stored at –70° C until analysis. Plasma glucose was determined using the GOD-PAP method. Triacylglycerols (TG), total cholesterol (TC) and HDL-cholesterol (HDL-C) were assayed using colourimetric methods and commercial kits (Randox Laboratories, UK). Coefficients of variation for all parameters did not exceed 5 The plasma concentration of LDL — cholesterol (LDL-C) was calculated according to the Friedewald formula [18]. Plasma insulin was measured using a standard radioimmunoassay (RIA) with human monoclonal. Plasma levels of thyrotropin (TSH), triiodothyronine (T3), thyroxine (T4), cortisol and insulin were determined by standard radioimmunoassay methods using BioSource commercial kits (Belgium). Inter- and intra-assay coefficients of variation for hormones did not exceed 7%. All measurements were done in duplicate.

Energy expenditure

Physical activity was assessed by an experienced interviewer using the Seven-Day Physical Activity Recall Questionnaire (SDPAR) [19]. The SDPAR is a questionnaire which was found to be reliable for the assessment of different dimensions of physical activity and to be a useful tool in lifestyle-dependent disease preventive screening [20].

Data concerning the duration, frequency, and intensity of various activities (occupational and leisure, sports participation, active transportation) within a week were collected. Light, moderate, hard, and very hard physical activity was defined as MET 1.5, 4, 6, and 10, respectively, and finally expressed in kcal/day. The SDPAR takes into account also energy expenditure during sleep, that's why it was possible to estimate the total daily energy expenditure (DEE, kcal/day) of the participants.

Energy intake

In all subjects, the intake of energy (EI) was briefly assessed from 24-hour food records taken over 4 days (2 weekdays and weekend) and analysed using Photo Album of Products and Dishes [21] and computer program Dieta 5.0 purchased from the Institute of Food and Nutrition in Warsaw (Poland). A set of pictures of meals and foods were shown to the subjects by an experienced interviewer and household measures of food were converted into gram weights. Subsequently, an interviewer assigned codes to the food reported by the participants and performed computer analysis.

Participants in the study were also asked to provide a positive or negative response to the question of whether they were satisfied with their body shape.

The Stunkard figure assessment scale was used to assess one's own perception of body size (Fig. 1). The Stunkard scale consists of nine shapes ranging from 1 (very slim) to 9 (very obese) [22]. Research participants chose a figure number in response to the question "Choose the figure that reflects what you think you look like".

Statistical analysis

All data were tested for normality using the Shapiro-Wilk test. Statistical significance was tested using the Mann-Whitney test. The Pearson Chi-square test was used to analyse the frequency distribution of responses regarding satisfaction with their body shape and with perception of one's own silhouette. The Spearman rank correlation coefficients between circulating cortisol and satisfaction or dissatisfaction with one's appearance were calculated. Data are presented as mean ± SD. The value of $p < 0.05$ was accepted as significant. All calculations were carried out using the Statistica v.12 (Statsoft, Illinois, USA).

Results

Women and men did not differ concerning age. However, significant differences were noted in height, weight, Fat % and BMI ($p < 0.001$) (Table 1).

Biochemical characteristics revealed that circulating TC and HDL-C were significantly higher in women vs. men ($p < 0.03$ for TC; $p < 0.001$ for HDL-C). However, circulating TG and LDL-C did not differ between the two groups (Table 2).

Plasma levels of selected hormones indicated that circulating TSH and T3 did not differ between the two groups. On the contrary, circulating T4, insulin and cortisol were significantly higher and glucose was significantly lower in women vs. men ($p < 0.01$ for T4 and insulin; $p < 0.001$ for glucose; $p < 0.02$ for cortisol) (Table 3).

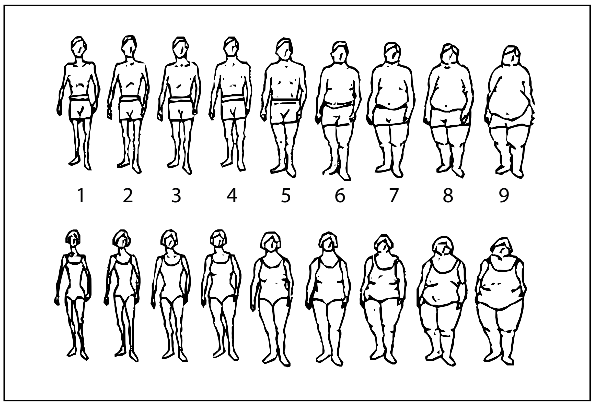

Figure 1. Stunkard figure rating scale

Table 1. Characteristics of participants in the study (means ± SD)

	Women (n = 94)	Men (n = 93)	p-value
Age [years]	20.5 ± 1.5	20.6 ± 1.4	NS
Height [cm]	168.5 ± 6.0	181.9 ± 6.6	0.001
Weight [kg]	61.9 ± 8.3	77.9 ± 8.7	0.001
Fat [%]	23.6 ± 5.2	10.8 ± 3.8	0.001
BMI [kg/m^2]	21.7 ± 2.3	23.5 ± 2.3	0.001

BMI — body mass index; Fat (%) — body fat percentage

The number of women dissatisfied with their body shape was significantly higher compared to the group of men, accounting for 41.5% and 26.9%, respectively (Table 4).

The analysis of response frequencies regarding the Stunkard figure rating scale revealed that satisfaction and dissatisfaction with body shape had a significant impact on self-perception in both studied groups (Table 5).

Circulating cortisol and Fat (%) in the women's group were significantly higher, while daily energy expenditure and energy intake were significantly lower vs. the men's group ($p < 0.01$ for cortisol; $p < 0.001$ for Fat (%), EI and DEE). Furthermore, both women and men satisfied with their body shape exhibited significantly lower Fat (%) vs. their respective groups of women

Table 2. Serum lipids profile of study participants (means ± SD)

	Women (n = 94)	Men (n = 93)	p-value
TG [mg/dL]	69.6 ± 24.8	74.7 ± 28.7	NS
TC [mg/dL]	163.7 ± 27.7	155.8 ± 23.6	0.03
HDL-C [mg/dL]	72.5 ± 13.5	57.2 ± 11.1	0.01
LDL-C [mg/dL]	77.2 ± 23.9	83.6 ± 19.7	NS

TG — triacylglycerols; TC — total cholesterol; HDL-C — HDL cholesterol; LDL-C — LDL cholesterol

Table 3. Plasma levels of selected hormones of study participants (means ± SD)

	Women (n = 94)	Men (n = 93)	p-value
TSH [μIU/mL]	2.4 ± 1.1	2.5 ± 1.1	NS
T3 [ng/dL]	116.1 ± 27.7	116.5 ± 18.6	NS
T4 [μg/dL]	7.3 ± 1.5	6.8 ± 0.9	0.01
Glucose [mg/dL]	81.0 ± 5.4	84.7 ± 5.8	0.001
Insulin [μIU/mL]	6.0 ± 2.7	5.1 ± 2.0	0.01
Cortisol [μg/dL]	18.0 ± 8.5	15.7 ± 3.3	0.02

TSH — thyrotropin; T3 — triiodothyronine; T4 — thyroxine

Table 4. Frequency distribution of responses regarding dissatisfaction with your body shape

	Women (n=94)	Men (n = 93)	Chi 2 (p) 4.4313 (0.0517)
Number of dissatisfied individuals	39.0	25.0	
Percentage of the group	41.5	26.9	

Table 5. Frequency distribution of responses regarding the Stunkard figure rating scale

	Women	(n = 94)	Chi 2 (p)	Men	(n = 93)	Chi 2 (p)
Figure number	**S (n = 55)**	**D (n = 39)**	**28.70 (0.0001)**	**S (n = 68)**	**D (n =25)**	**24.08 (0.0002)**
1	–	–		1 (1)	4 (1)	
2	9* (5)	2 (1)		18 (12)	20 (5)	
3	35 (19)	16 (6)		38 (26)	24 (6)	
4	49 (27)	49 (19)		40 (27)	28 (7)	
5	5 (3)	23 (9)		3 (2)	16 (4)	
6	2 (1)	8 (3)		–	8 (2)	
7	–	–		–	–	
8	–	2 (1)		–	–	
9	–		–	–	–	

S — individuals satisfied with their body shape; D — individuals dissatisfied with their body shape; *percent of participants; in brackets — number of subjects

Table 6. Plasma levels of cortisol, body fat content, energy intake and daily energy expenditure of men and women satisfied and dissatisfied with their body shape

	Cortisol [μg/dL]	Fat (%)	EI [kcal/day]	DEE [kcal/day]
		Women (n=94)		
S* (n = 55)	18.2 ± 7.9	22.5 ± 4.8	2000.4 ± 669.4	2140 ± 178.8
D (n = 39)	18.2 ± 9.5	25.3 ± 5.4	1868.3 ± 478.4	1918 ± 289.5
p-value	NS	0.004	0.01	0.01
		Men (n = 93)		
S (n = 68)	15.7 ± 3.1	10.3 ± 3.4	2947.7 ± 768.8	2934 ± 256.5
D (n = 25)	15.7 ± 3.4	12.4 ± 4.5	2983.0 ± 997.4	2960 ± 690.1
p-value	NS 0.01*	0.01 0.001*	NS 0.001*	NS 0.001*

S — individuals satisfied with their body shape; D — individuals dissatisfied with their body shape; DEE — daily energy expenditure; EI — energy intake; *significantly different vs. appropriate group of women

and men dissatisfied with their body shape ($p < 0.004$ in women, $p < 0.01$ in men) (Table 6).

Discussion

In the present study, selected biochemical parameters were assessed concerning body shape satisfaction and dissatisfaction among physically active young women and men. As previously mentioned, distorted body image perception due to commonly portrayed standards is becoming more prevalent not only among women, as confirmed by the results obtained in these studies [23–25]. Literature data on this issue mainly focuses on individuals who are overweight, obese or have eating disorders such as anorexia or bulimia [26–28]. However, there is a lack of studies addressing individuals with normal body weight engaging in regular physical activity and not exhibiting the aforementioned disorders. In the presented studies, 41.5% of women and 26.9% of men declared dissatisfaction with their body shape, consistent with the findings of other authors, as women tend to be less satisfied with their physique [29, 30]. Despite participants' anthropometric indicators falling within the reference range, these results are still concerning. In both groups, regardless of gender, individuals dissatisfied with their body shape perceived themselves as more overweight than they actually were. Similar observations were made by other authors [31, 32]. Literature data also indicate that body shape dissatisfaction increases with age regardless of gender and is associated with education level, as individuals with lower education levels tend to have a poorer self-perception [33]. As previously mentioned, improper body image perception and the associated stress can influence the occurrence of metabolic disorders that contribute to the development of various diseases [34, 35].

In the current study, the analysis included the serum lipid profile. Literature data suggest that lipid profile disorders may appear even in young, lean, physically active women and men [36]. Women in the presented studies had significantly higher HDL cholesterol concentrations compared to men, consistent with the findings of other authors [37, 38]. Interestingly, women also had significantly higher total cholesterol concentrations than men, and it is known that only after menopause does total cholesterol tend to increase. It cannot be ruled out that higher stress levels, associated with higher cortisol levels, could have influenced these differences [39]. Despite these differences, lipid concentrations in both groups were within the reference range. A detailed analysis of the serum lipid profile concerning body satisfaction was not presented in the study, but a tendency toward higher TG concentrations and lower HDL-C concentrations in the serum was observed in men dissatisfied with their body shape.

Furthermore, the study included the analysis of selected hormones in the serum. Women exhibited significantly higher concentrations of T4, insulin, cortisol, and lower glucose concentrations compared to men. Higher T4 concentrations in women may be a consequence of increased cortisol levels, which are responsible for reducing the conversion of T4 to T3, or the observed energy deficit in both groups of women. The results suggest that the decrease in T4 to T3 conversion may result from a disrupted energy balance in the body [40]. Higher insulin concentrations in this group of women may result from increased cortisol levels in the serum, as cortisol can affect insulin secretion by the pancreas, increasing its production [41]. Cortisol also influences an increase in blood glucose levels. On the other hand, lower glucose concentrations in women in this study may be influenced by sex hormones, as some studies suggest that oestrogens may have a beneficial effect on blood glucose control [42]. However, further analysis of the mentioned biochemical parameters did not show significant differences in relation to participants satisfied or dissatisfied with their body image within each gender group and was not presented in the study. In this study, the average cortisol concentrations in the group of women were significantly higher compared to men but did not differ within groups based on body shape satisfaction. It is worth noting that in both groups, especially among women, cortisol concentrations were close to the upper limit of the norm, indicating a higher level of stress in this group. Similarly, higher cortisol concentrations in women compared to men were observed in the studies by Larsson et al. [43]. It has been documented that even mildly elevated cortisol levels can have harmful effects on pancreatic insulin production, significantly increase fat accumulation, decrease skeletal muscle mass, and affect carbohydrate and lipid metabolism [44, 45]. Additionally, it has been shown that both women and men dissatisfied with their body shape had significantly higher body fat content compared to the respective satisfied groups. It was also observed that energy intake in the diet and energy expenditure in women satisfied with their body shape were significantly higher compared to women dissatisfied. It is noteworthy that only in the groups of women was energy expenditure greater than energy intake, and as mentioned earlier, disturbances in energy balance can affect cortisol secretion [46, 47].

The most significant finding of this study is that even participants with normal body weight and regular physical activity, regardless of gender, often declared dissatisfaction with their body shape. It's worth emphasizing that a high percentage of patients who are dissatisfied with their figure and who try to limit the calorie-intake, still have poorer physical activity and consume more energy. Furthermore, both groups of women exhibited an energy deficit, which may account for significantly higher cortisol concentrations. This discovery is crucial because elevated cortisol levels can contribute to various metabolic disorders, as mentioned earlier, and can also lead to psychological and social problems, as well as issues with self-esteem and well-being [48].

Must be mentioned that this study has limitations concerning not precise registration of physical activity and relatively low number of participants. Moreover, it is a cross-sectional study.

Conclusions

Even people with normal body weight and regular physical activity, regardless of gender, often declared dissatisfaction with their body shape. This finding is important because disturbances in body shape perception through the mechanisms mentioned earlier contribute to both physical and mental health disorders.

Article information

Data availability statement: *The author agrees to share the data.*

Ethics statement: *Ethical clearance was obtained from the Bioethical Commission of the University of Physical Education in Warsaw. Also, informed written consent was obtained from all participants after explaining the purpose of the study, the importance of their contribution as well as the right to refuse participation. All the information gathered was kept confidential.*

Author contributions: *Marzena Malara — conception, design, execution and interpretation of the data being published, wrote the paper.*

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Conflict of interest: *None.*

Supplementary material: *None.*

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