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Development of relative body mass (BMI) of students from Łódź, depending on the selected environmental, psychological and sociological factors

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Abstract: The human height-to-weight ratio is an important parameter of the body homeostasis. Currently, the most popular measurement determining the relationship between body mass and height is the Quetelet II indicator, called Body Mass Index (BMI). The aim of this study is an evaluation of the differences in the height-to-weight ratios, depending on selected environmental, psychological and sociological factors in people studying at higher education institutions in Łódź. The research was conducted among students of higher education institutions in Łódź, by electronic means or with the use of an anonymous survey. It consisted of 28 closed single or multiple choice questions. Statistical analysis was made of complete results of the research involving 135 people, both males and females, aged between 19–26. It was revealed that the factors related to higher BMI values in students are the following: the presence of a tendency in the students to gain weight themselves, and a tendency to gain weight present in their mothers, an evaluation of their own body mass as excessive, regularly smoking cigarettes and rarely undergoing medical check-ups. Among the factors connected with lower BMI values are: regular coffee consumption, perception of their own body mass as being too low, and also obtaining systolic pressure values below 110 mm Hg. Additionally, a positive correlation between taking up physical activity and higher values of systolic blood pressure ($p<0.05$) was shown. Among the subjects, it was found that 92% of the underweight women declared that their body mass and figure were normal. In the case of women with optimal BMI values, 40% stated that their body mass was excessive. In the case of men the problem was reverse: 50% of the subjects who were either overweight or obese claimed that their body mass was within the norm. The factors that significantly influence body proportion differences among students include the subject's and the subject's mother's tendency to put on weight, self-evaluation of their own body mass, the values of systolic blood pressure, coffee consumption and cigarette smoking, as well as the frequency of medical check-ups.

Key words: height-to-weight ratio, students' lifestyle, socio-economic status, stimulants, diets, eating disorders, physical activity, blood pressure

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Introduction

Currently, disorders of height-to-weight proportions constitute a worldwide problem. Globally, the percentage of overweight and obese people is increasing (James 2004; Wang and Beydoun 2007; Hattori andStrum 2013; WHO 2013), but also those underweight, resulting from insufficient material resources (Biernat and Wyka 2011), or being a consequence of anorexia or bulimia (Malara et al. 2010). The effects of environmental, sociological, genetic, paragenetic and epigenetic factors are thought to be the reasons for height-to-weight proportion disorders (Vaag et al. 2012; Sitek et al. 2013; Koszowska et al. 2013; Martínez et al. 2014). At present, several studies are being conducted on groups diversified in terms of age, sex, geographical region and socio-economic status, evaluating the influence of the selected determinants which affect the height-to-weight ratio (Taylor et al. 2005; Wang and Beydoun 2007). The majority of these studies involve children or adults (Sikorska-Wiśniewska 2007; Kuklińska-Szukalska and Chlebna-Sokół 2011; Żądzińska et al. 2012). Students are a group characterized by a lifestyle different than that of other young adults. Therefore, it seems interesting to select the factors significantly influencing differences in their height-to-weight ratio, as well as to determine the frequency of disorders of these index values (Poręba et al. 2008; Poínhos et al. 2013; Walentukiewicz et al. 2013).

The risk factors related to the development of excess body mass listed in literature can be classified in the group of environmental factors (i.a. physical activity, regularity of meals, time spent in front of a screen, using stimulants) (Poręba et al. 2008; Nowak-Zaleska et al. 2013), socio-economic (i.a. parents' education level, place of residence, number of siblings, family affluence) (Sanchez-Vaznaugh et al. 2008; Żądzińska et al. 2012) and psychological (i.a. the assessment of own body mass and figure, following weight reducing diets) (Strzelecki et al. 2007; Meule and Vogele 2013). It was also observed that together with the increase of the height-to-weight ratio, blood pressure rises (Wizner et al. 2002; Poręba et al. 2008; Kowalewski and Hebel 2013). Literature data indicate clearly that the value of the height-to-weight ratio correlates negatively with the physical activity of the subject individuals. It is observed that a decrease in physical activity favors an increase of these indicators and changes the body constitution, contributing to greater adipose tissue and a decrease of muscle and bone mass (Plewa and Markiewicz 2006).

Aim

The main purpose of this study is to identify the factors affecting the changeability of BMI in students of higher education institutions in Łódź. This selected group seems to be especially interesting because of a relatively homogenous lifestyle. The authors attempted at finding out whether the factors differentiating the physique of students are other than those affecting BMI in other adults and children.

Materials and methods

The study was conducted by means of a survey method with a specially prepared electronic questionnaire containing 28 single and multiple choice questions. This questionnaire was addressed

and sent only to students studying at higher education institutions in Łódź. Respondents were given time to fill in the questionnaire from 24.11.2013 to 26.02.2014. In the case of questions related to anthropometric parameters and blood pressure, the subjects were informed how to take measurements correctly. 151 people participated in the survey (including 105 women and 46 men), all of whom are currently students of at least one institution of higher education in Łódź (University of Łódź, Łódź University of Technology, Medical University of Łódź). The statistical analysis involved complete surveys, filled in by 135 people (93 women and 42 men), aged between 19–26 (mostly women aged 22 – 33%, whereas men were mostly aged between 22–23 –71%). In the analysis, the following factors were included: the family's socio-economic status, mother's and father's education level, place of residence, the perception of the subject's own figure, the value of blood pressure, regularity of meals, mother's and father's tendency to gain weight, the subjects' lifestyle i.a. physical activity, using stimulants (alcohol, cigarettes, coffee) and the frequency of medical check-ups. The obtained data were collected with the use of a survey with the questions worded as shown in Table 1.

In order to assess the height-to-weight ratio, the Quetelet 2 indicator was used, i.e. BMI (Body Mass Index), which is a squared quotient of body mass (kg) and body height (m):

BMI = body mass [kg] / body height [m ^{2}].

Statistical analysis

Numerical distributions of women and men in separate BMI categories (according to the WHO classification, where individual categories were placed in the following BMI ranges: underweight <18,5; norm 18,5–24,99; overweight ≥25; obesity ≥30) were compared by means of a chi-squared test. In order to conduct further analyses, Box-Cox transformation was applied, which converts a continuous distribution of a random variable into a normal distribution and stabilizes its variance. With the use of a multiple regression, the influence of the factors included in the survey was tested on the variability of the transformed BMI values. By means of a T-student test for independent groups, it was assessed whether the value of blood pressure is significantly different in the group of subjects doing some sports and not doing any sports. Statistical analysis were performed using the program Statistica version 10 (statSoft 2010).

Results

Description of the study sample is shown in Table 1.

The comparison of the BMI values of the men and women showed statistically significant differences (t=–4.07; p<0.05). Upon the analysis of the disorders of the height-to-weight body ratio, it was found that the problem of being underweight more often applied to female students (25%), compared with male students (2%), whereas excess body mass was more frequently present in male students (jointly overweight and obesity 36%) compared with female students (6%) ($\chi 2$ = 23,99; p<0.0001) (Table 2). As far as age is concerned, this group was homogenous – the age of men and women was not statistically different.

Table 1. The number and frequency of individual variables used in the analysis by gender.

Variable	Males n=42	Females n=93	χ^2	*p*
	n (%)	n (%)		
Socio-economic status			1.21	NS
High	14 (33)	40 (43)		
Medium	25 (60)	48 (52)		
Low	3 (7)	5 (5)		
Smoking cigarettes			1.02	NS
Yes	14 (33)	23 (25)		
Coffee consumption			4.39	NS
Regularly	14 (33,3)	25 (27)		
Occasionally	14 (33,3)	48 (52)		
Never	14 (33,3)	20 (21)		
Alcohol consumption			2.56	NS
Regularly	9 (21)	10 (11)		
Occasionally	31 (74)	78 (83)		
Never	2 (5)	6 (6)		
Place of residence			12.5	***
Dormitory	8 (19)	7 (8)		
Flat/ Rented apartment	10 (24)	31 (33)		
Living with parents				
Urban areas	23 (55)	44 (47)		
Rural areas	1 (2)	11 (12)		
Subject's tendency to put on weight			0.28	NS
Yes	18 (48)	42 (45)		
Mother's tendency to put on weight			0.04	NS
Yes	12 (29)	25 (27)		
Father's tendency to put on weight			0.02	NS
Yes	10 (24)	21 (23)		
Body image perception			4.56	NS
Just right	24 (55)	55 (59)		
Too thin	7 (17)	5 (5)		
Too fat	11 (26)	33 (36)		

Therefore, the influence of the other variables on BMI was tested while controlling for the sex variable. With the use of a multiple regression, it was established which factors significantly affect the BMI value. In order to find the set of variables significantly differentiating BMI values, an analysis of a stepwise multiple regression was applied (Table 3). It was observed that the subjects who reported excessive body mass and their mother's tendency to put on weight, as well as regular tobacco smoking and infrequent medical check-ups (less frequently than once a year) were characterized by higher BMI values than the individuals who evaluated their body mass as normal, did not declare their own or their mother's tendency to put

Table 1. cont.

Variable	Males n=42 n (%)	Females n=93 n (%)	χ^2	*p*
Regular meals consumption			5.55	*
Yes	23 (55)	31 (33)		
Period starting physical activity			3.21	NS
Primary/lower junior school	10 (24)	11 (12)		
Higher junior school	5 (12)	8 (9)		
High school	5 (12)	8 (9)		
No physical activity	22 (52)	56 (70)		
Mother education			2.90	NS
Primary/Vocational	4 (10)	18 (19)		
Secondary/Technical	19 (45)	35 (38)		
Tertiary/ university degree	19 (45)	40 (43)		
Father education			1.13	NS
Primary/Vocational	12 (28)	18 (19)		
Secondary/Technical	15 (36)	40 (43)		
Tertiary/ university degree	15 (36)	25 (27)		
The frequency of preventive visit			7.06	*
<once a year	38 (67)	42 (45)		
once a year	10 (24)	41 (44)		
>once a year	3 (9)	10 (11)		
Systolic blood pressure mmHg			41.8	***
<110	1 (2)	17 (18)		
110–125	21 (50)	66 (71)		
>125	20 (48)	10 (11)		
Diastolic blood pressure mmHg				
<110	3 (9)	18 (19)		
110–125	24 (55)	63 (68)		
>125	15 (36)	12 (13)		

NS – statistically non-significant, statistically significant at *$p<0.05$ **$p<0.01$ ***$p<0.001$.

on weight, did not smoke cigarettes and had a basic check-up at least once a year. The students who declared themselves as being underweight, with regular coffee consumption and low blood pressure (below 110 mm Hg), on average had a lower BMI than the subjects who assessed their body weight as normal, drank coffee occasionally or did not drink any coffee and had systolic blood pressure equal or higher than 110 mm Hg. The listed variables allowed for al-

Table 2. The number of students in the categories of the BMI indicator (according to WHO 2013).

BMI (kg/m^2) Weight status	Females n=93	Males n=42
	n	n
< 18,5 kg/m^2 Underweight	23 (25)	1 (2)
18,5–24,99 kg/m^2 Normal weight	64 (69)	26 (62)
≥25,0 kg/m^2 Overweight and obesity	6 (6)	15 (36)

Females vs Males $\chi^2=23.99$; $p<0.0001$.

Table 3. Stepwise multiple regression explaining the variability of the BMI indicator (after Box-Cox transformation) depending on the tested factors (adjusted model includes the sex variable).

R= 0.787 R^2=0.619; Adjusted R^2= 0.591; $F(9, 125)=22.54$; $p<0.0000$; S.E.=0.0005				
n=135	BETA	SE	$t(125)$	p
Constant			6080.53	<0.0001
I am overweight/ obese[1]	0.405	0.060	6.73	<0.0001
I am underweight	–0.245	0.058	–4.19	0.0001
I have tendency to put on weight[2]	0.244	0.062	3.92	0.0001
I regularly drink coffee [3]	–0.189	0.058	–3.27	0.0014
I regularly smoke cigarettes[4]	0.118	0.058	2.03	0.0444
My mother has tendency to put on weight[5]	0.138	0.058	2.39	0.0184
I have check-ups less frequently than once a year[6]	0.125	0.058	2.15	0.0336
My systolic blood pressure <110[7]	–0.114	0.0569	–2.00	0.0480

1 vs. my body mass is normal.
2 vs.. a lack of tendency to put on weight in a subject.
3 qvs. I drink coffee occasionally or I do not drink coffee.
4 vs. I smoke cigarettes occasionally or I do not like cigarettes.
5 vs. a lack of tendency to gain weight in a mother.
6 vs. I have a check-up at least once a year (basic prophylactic tests).
7 vs. systolic blood pressure ≥ 110.

most 62% BMI variability in the subject group.

A stepwise regression analysis revealed that the determined variables are correlated in 79%. Moreover, a dependent variable was explained by the model in 61%. The factors correlating with the BMI decrease include: declaration of being underweight, regular coffee consumption and also systolic blood pressure below 110 mm Hg. Whereas the factors increasing BMI values are: a tendency to gain weight present in the subject's and their mother, declaration of being overweight, regular cigarette smoking and undergoing medical check-ups less frequently than once a year.

Physical activity

A lack of statistical significance was shown between physical activity and BMI. According to the results of this study, about 12% of women and 24% of men had been doing some sports regularly since primary or grammar school, 9% of women and 12% of men since they started their studies, whereas as many as 70% of female students and 52% of male students do not do any sports or play them on a regular basis. A significant correlation was found between a declared physical activity with higher systolic blood pressure values (t=2,09; $p<0.05$), but within the normal range.

Analysis of psychological factors

The analysis of psychological factors concerning self-evaluation of the subjects' body mass indicates a worrying phenomenon in the female group (Table 4). In fact, 92% of the underweight subjects declared that their body mass was within the norm. In the case of women with normal BMI values, a frequent statement about excessive body mass was observed (40%). In the case of men with normal BMI, only 16% think that their body mass was excessive, whereas 19% de-

Table 4. BMI placing the subjects in a given weight status and body image perception among the subjects.

BMI kg/m² Weight status	A correct evaluation of own figure		An incorrect evaluation of own figure	
	Males	Females	Males	Females
Underweight	2 (100)	2 of 8	–	22 (92) – think that their body mass is normal
Normal weight	21 (65) 38 (60)	5 (16) – think that their body mass is excessive	6 (19) - think that their body mass is too low	25 (40) – think that their body mass is excess
Overweight and obesity	5 (50)	6 (100)	5 (50) – think that their body mass is normal	–
People assessing their body weight correctly	28 (67)	46 (49)		

clared that it was even too low. What is more, men can self-evaluate their body mass better (67%) than women (49%). The achieved results suggest that women have a tendency to overestimate their body mass, while in men an underestimation of body mass is observed.

Discussion

The literature confirms that one's studies is a specific time in a person's life (Romanowska-Tołłoczko 2011). Students are young people who are mature enough to realize how their lifestyle affects their health and height-to-weight parameters. On the other hand, this group, apart from being relatively mature, is comparatively not very self-reliant and still dependent on their parents to a large extent. Therefore, they are under a considerable influence of a family environment even in a situation, when starting studies is related to living on their own. Moreover, although students show biological and intellectual maturity and are potentially aware of the lifestyle's effect on biological parameters, they are also subject to cultural pressure. Even though economic independence of students is limited, the study period is associated with "leaving the nest" and the autonomy in shaping your own lifestyle. Taking into consideration the relatively young age of students, their tendency to do various experiments with stimulants, a dangerous lifestyle, following fads and being influenced by an entire student community, which is directed at being carefree and not a really regulated way of life should be highlighted. The period of tertiary studies is usually connected with an intensification of social life. Learning is often put off until an examination session or just before tests. All this makes it clear that students' lifestyle is often related to a little amount of sleep. A student's social life creates favorable conditions for using stimulants such as alcohol, whereas an unregulated sleep-wake rhythm and temporary insufficient amount of sleep contribute to using stimulants such as coffee. Research shows that a student's lifestyle is more anti- than health promoting (Romanowska-Tołłoczko 2011). Some authors indicating a relatively high alcohol consumption among students did not observe its correlation with the BMI values of the subjects (Chodkiewicz 2006; Kurpas et al. 2012), which is also confirmed by the results of our own analyses. Frequent coffee consumption is ob-

served among students. One can even say that drinking coffee has become popular in this group. In a way, drinking coffee and the whole ritual related to it (brewing, using coffee machines, meeting in cafes) can be recognized as a cultural phenomenon. Studies by some authors indicate that frequent coffee consumption statistically correlates with lower BMI values (Kostenecka 2007), because it reduces hunger and also accelerates metabolism (Bakuradze et al. 2014).

Another factor that can affect the value of the height-to-weight proportion is cigarette smoking. This study has revealed the significant influence of nicotinism on BMI: regular cigarette smoking was related to higher BMI values. The applied questionnaire did not include detailed questions concerning smoking, which would allow us to take into consideration the subjects' length of this addiction. Maybe such questions would enable us to determine the relationship between cigarette smoking and a BMI value more precisely. Literature data indicate that smokers have a lower BMI (Nicklas et al. 1999, Flegal et al. 2007). At the same time, it is highlighted that a BMI value is determined by multiple factors and lower values of this proportion among smokers may result from other factors than nicotinism. However, as study results show, nicotine accelerates metabolism, so a lower BMI value among smokers is justified (Audrain-McGovern and Benowitz 2011). Therefore, there is a problem how to interpret the results achieved in this study. The subject group has a specific lifestyle, an important aspect of which involves social contact. Currently, a growing number of people declare occasional smoking (Maćkowiak et al. 2012), while it should be stressed that this addiction has a significant social context, e.g. "cigarette breaks". It seems that this social context of smoking, very characteristic for this addiction, can cause discrepancies between the results concerning the BMI relationship with nicotinism. Students are a group of people for whom social aspects are an important factor that affect the choices made. Therefore, a pure biological correlation between BMI and smoking can be modified by cultural aspects (social) specific for a subject group. In the studies by Piotrowska et al. (2009), conducted on a group of 16–18 year old girls, cigarette smoking was a phenomenon more frequent among people characterized by a higher BMI, which is explained by the authors with a general scheme of their unhealthy lifestyle. A lack of healthy diet and physical activity, which is often accompanied by cigarette smoking, leading consequently to a bigger body mass, which can also explain the effect observed in our own research. Moreover, we have shown that the frequency of medical check-ups also significantly influences the values of the height-to-weight ratio, which is connected with the hypothesis of an integrated influence of a lifestyle on BMI.

The period of puberty and early adulthood is a time of special interest in your own body, in particular in terms of beauty ideals. Susceptibility to cultural and social influence is characteristic for this age. It concerns mainly girls, but not exclusively. Students are willing to take activities aimed at modifying their appearance. Taking physical activity and experimenting with various diets is motivated, to a large extent, by esthetic reasons and the trend to be fit and slim. Female students are relatively critical about their appearance. They usually evaluated their figure as too fat, despite the fact that their body mass was normal – such

results were also obtained by other authors (Kołoło and Woynarowska 2004; Piotrowska et al. 2009). Also in literature the opposite tendency is observed in men, i.e. they do not perceive the problem of an excess body mass and their BMI is too high (Aoki et al. 2014)

The conducted research shows that a lower BMI is correlated with lower values of systolic blood pressure. This result is difficult to interpret, because it is in contradiction with the literature data, which indicate an increased risk of higher values of blood pressure in the case of overweight or obese people (Ewing et al. 2003; Małecka-Tendera et al. 2005; Zachurzok-Buczyńska and Małecka-Tendera 2005; Czyżewski 2008). The study also revealed a significant statistical dependency between a higher systolic blood pressure among subjects who declared that they do physical activity. Available literature does not contain similar study results. Generally, authors indicate that higher blood pressure is found in people who do not show higher than average physical activity (Church et al. 2007). However, it should be highlighted that physical activity can be taken up by people with excess body mass in order to achieve a slim figure. Therefore, the relationship of higher blood pressure values in people doing physical activity can be explained by their increased height-to-weight body ratio.

In the subject group of students, a correlation between subjects' BMI and a tendency to put on weight present in their mothers turned out to be statistically significant. However, no correlation was found between fathers' tendency to put on weight and BMI values of the respondents. Research indicates that a genetic predisposition to gain weight is inherited by children, from 40–70% (Morandi et al. 2012; Zhao and Grant 2011). Several authors stress that the influence of the parents' lifestyle on children's eating habits and lifestyle (Osiecka-Chojnacka 2012). If the level of physical activity is not right and a diet is not healthy, parents usually represent higher BMI values, and children following those habits are also characterized by a tendency to gain excess body mass. If in a family genetic factors coexist with the above mentioned environmental factors related to improper lifestyle and unhealthy diet, the effect of the relationship of parents' and children's BMI is even more explicit (Waalen 2014). A lack of correlation of students' BMI and their fathers' tendency to put on weight observed in this study, can be explained by the fact that despite the cultural changes which we have witnessed, in Poland the dominant model of a family is still the one in which the mother is responsible for the organization of family life, including diet. This regularity has been confirmed by other authors (Zaworski 2005; Cameron 2011). Moreover, biological interactions between a mother and a child are increased by the entire prenatal period, when a woman, through her diet and lifestyle, among others, affects the developing child's body, influencing its genome through epigenetic modifications (Vaag et al. 2012).

Students are a specific group of young people, biologically mature, whereas still, in some life aspects, dependent on their parents to a large extent. What is more, the student community has several habits typical for this group, which significantly influence body proportion differentiation. Too critical an assessment of their figure and body mass by female students is disturbing, as well as the large percentage of students having excess body mass.

As literature shows, 21st century brings the problem of the height-to-weight ratio disorders. On the one hand, a higher frequency of underweight is observed, while on the other hand, the number of overweight people is on the increase (Zegan 2010). The height-to-weight ratio studies are necessary, especially among young people, because a right change of lifestyle in this period may decrease the risk of complications related to the BMI disorders, contributing to the improvement of the population's health and reducing the costs related to the treatment of diseases connected with insufficient or excessive body weight.

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Authors' Contributions

PP-P was the originator of the studies, main author of the paper and the executor of statistical analysis; KS and PS were co-authors of a working version of this paper. All authors were engaged in carrying out this research project.

Conflict of interest

The Authors declare that there is no conflict of interests.

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