

# The interaction between stress and metabolic disruption in student population – preliminary study

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## Abstract

**Introduction:** Approximately 26% of individuals between 18 and 24 years old are overweight or obese, and the number of persons with excessive body mass index (BMI) is growing. Obesity increases the risk of metabolic disruptions, which is well connected with mental health problems. Stressful situations, including entering adulthood and starting university education, affect food choices negatively. The aim of the study was to examine the relationship between psychological stress and body composition in the student population.

**Materials and methods:** The study group consisted of 80 students (76% of women and 24% of men) between 19 and 28 years old from universities in Lublin. To determine anthropometric measurement (fat-free mass (FFM), fat mass (FM), total body water (TBW), intracellular (ICF) and extracellular (ECF) fluids), bioelectrical impedance analysis (BIA) method was applied. The severity of stress symptoms was measured using Perceived Stress Scale (PSS-10).

**Results:** When it comes to 41.25% of participants, they used relaxation techniques, mainly meditation, yoga practice and walking. Most students had optimal body weight. While 60% of individuals had high stress levels. The perceived stress was not related to using the relaxation methods. Individuals with the high stress severity were characterized by lower: TBW, ECF and ICF expressed in liters, and lower FFM represented in kilograms. The inverse relationship between the severity of stress and the aforementioned parameters was also detected ( $p < 0.05$ ).

**Conclusions:** Implementing appropriate health education programs to prevent negative changes in anthropometric measurements, psychological stress, and their health-related consequences in the student population should be considered.

**Keywords:** Bioelectrical Impedance Analysis, Obesity, Students, Mental health, Stress

## Streszczenie

**Wstęp:** Około 26% osób pomiędzy 18 a 24 rokiem życia cierpi na nadwagę lub otyłość, a ilość osób z nadmiernym wskaźnikiem masy ciała (BMI) rośnie. Otyłość zwiększa ryzyko zaburzeń metabolicznych, które mogą pociągać za sobą konsekwencje pogorszenia zdrowia psychicznego. Stresujące sytuacje takie jak wkraczanie w dorosłość i rozpoczynanie edukacji na uczelni wyższej, negatywnie wpływają na wybory żywieniowe. Celem badania była ocena związku pomiędzy stresem psychologicznym i kompozycją składu ciała w populacji studentów.

**Materiały i metody:** Populacja badana liczyła 80 studentów (76% kobiet i 24% mężczyzn) między 19 i 28 rokiem życia, uczelni wyższych w Lublinie. Do oceny parametrów antropometrycznych (beztłuszczowej masy ciała (FFM), masy tkanki tłuszczowej (FM), całkowitej zawartości wody w organizmie (TBW), wewnątrz- (ICF) i zewnątrzkomórkowych (ECF) płynów) zastosowano metodę impedancji bioelektrycznej (BIA). Nasilenie objawów stresu zostało zmierzone przy użyciu Skali Odczuwanego Stresu (PSS-10).

**Wyniki:** 41.25% uczestników stosowało techniki relaksacyjne, głównie medytację, jogę oraz spacer. Większość studentów miało optymalną masę ciała. 60% respondentów doświadczało wysokiego stresu psychologicznego. Odczuwany stres nie był związany ze stosowanymi technikami relaksacyjnymi. Osoby z wyższym nasileniem objawów stresu charakteryzowały się niższymi wartościami: TBW, ECF and ICF wyrażonymi w litrach i niższą FFM podawaną w kilogramach. Zaobserwowano odwrotną zależność pomiędzy nasileniem objawów stresu a wyżej wymienionymi zmiennymi antropometrycznymi ( $p < 0.05$ ).

**Wnioski:** Wyniki badania sugerują konieczność rozważenia wdrożenia programów zdrowotnych w profilaktyce niekorzystnych zmian antropometrycznym, stresu psychicznego oraz ich konsekwencjom zdrowotnym w populacji studentów.

**Słowa kluczowe:** Impedancja Bioelektryczna, Otyłość, Studenci, Zdrowie Psychiczne, Stres

## 1. Introduction

According to National Polish Health Test, approximately 26% of individuals between 18 and 24 years old are overweight or obese and the number of persons with excessive body mass index (BMI) is growing linearly with age [1]. The transition from high school to university is a critical period for establishing health-related behaviours that in further life lead to various chronic diseases. The mean index of health according to data from 2021 indicates that individuals between 18 and 24 years old care less about their health than another group of age [1]. Obesity increases the risk of metabolic disruptions, which is known to be well connected with depression and other mental health problems [2]. On the other hand, stressful situations, including entering adulthood and starting university education, affect food choices negatively. Persons who leave home change eating behaviours and usually eat more fast-food and easy-to-cook, packaged meals. Studies time is also related to stressful situations like exams, which affect food choices. This interconnectedness could negatively affect mental health [3]. The mental health self-assessment in young adults indicates that 7% less than in 2020 reported it as good or very good, and 6% more than the year earlier assessed it as bad or very bad [1].

Stress is also linked to the hyperactivity of the hypothalamic-pituitary-adrenal (HPA) axis, which contributes to excessive glucocorticoids and primarily cortisol secretion. Abdominal obesity is related to stress-related cortisol secretion and vice versa – cortisol affects the accumulation of abdominal fat [4]. Release of cortisol stimuli overeating via disruption of neuropeptide Y and leptin systems homeostasis. Psychological stress is a trigger in both overweight and depression. Fat mass is hormonally activated and leads to cytokine production, including inflammatory interleukins (ILs). Higher level of peripheral and central ILs, which is linked with poor mental health, is an independent risk factor of major depression [4,5].

Considering the interconnectedness and interplay between stress and obesity as an important risk factor for worsened mental health, the study aimed to examine the relationship between psychological stress and body composition in the student population.

## 2. Materials and methods

### 2.1. Examined population

The study group consisted of 80 students of both genders between 18 and 30 years old from universities in Lublin. The exclusion criteria were as follows: the presence of psychiatric (except personality disorder, nicotine abuse), autoimmune, cardiovascular, inflammatory bowel diseases, diabetes mellitus or other diseases that highly affect metabolism or pro/anti-inflammatory homeostasis. Individuals taking anti-inflammatory medications or drugs that affect glucose and lipids metabolism, non-steroidal anti-inflammatory drugs for one week, and antibiotics: one month before examination and with infection during entry to the study were also excluded. In the case of women, only non-pregnancy and no-breast-feeding individuals were included. The study was conducted with the ethical principles of the Declaration of Helsinki [6]. The protocol was approved by the Ethics Committee of the Medical University of Lublin, Poland (project identification code: KE-0254/163/2021).

### 2.2. Sociodemographic and clinical data

Information about participants was obtained using a self-prepared questionnaire. The questionnaire consists of sociodemographic, lifestyle- and health-related parts, including questions about gender, age, year and type of study, chronic diseases, medication and dietary supplements, implement relaxation techniques, and stimulants (especially tobacco). All of the students were asked to fulfill them by themselves.

### 2.3. Stress severity

The severity of stress symptoms was measured using Perceived Stress Scale (PSS-10) [7]. The PSS-10 is a self-reported questionnaire that allows measuring perception of psychological stress. The tool has 10-items concerning thoughts and feelings during the last month. Higher results indicate higher severity of symptoms.

### 2.4. Bioelectrical impedance analysis (BIA)

All anthropometric measurements were performed following the recommendations of the International Society for the Advancement of Kinanthropometry [8]. Tanita BC601 InnerScan Segmental Body Composition

Monitor (Tanita, Japan) was used to determine participants' body weight. Bioelectrical impedance analysis (BIA) was conducted using ImpediMed SFB7 BioImp v1.55 (PinkenbaQld 4008, Australia). The participants were asked to lie supine with no touching legs and arms to the torso during the examination. Two tetrapolar electrodes were put between the left wrist and the left ankle. The measurement was carried out triplicate in 2-second time intervals, and the obtained results were averaged. BIA enables the determination of parameters such as lean (fat-free) mass (FFM), fat mass (FM), total body water (TBW), intracellular (ICF) and extracellular (ECF) fluids. The examination was carried out between 8 and 10 am, after overnight fasting with an empty bladder to ensure consistency of measurement for all examined students.

### 2.5. Statistical analysis

Statistical analyses were conducted using Statistica software (TIBCO Software Inc., Palo Alto, CA, USA). Descriptive statistics were depicted by mean value and median for quantitative variables and percentages for categorical variables. We applied Shapiro-Test Wilk to assess the distribution of variables. Based on the PSS-10 scale results, we divided the group into populations with and without the high severity of stress. U-Mann-Whitney test was applied to determine differences between the mentioned subgroups in anthropometrical measurements. Spearman's rho correlation test was used to find the relationship between the severity of stress and body composition. The value of  $p < 0.05$  was considered statistically significant.

## 3. Results

### 3.1. Characteristic of examined population

We examined 80 students ( $n=61$ ; 76% of women and  $n=19$ ; 24% of men) between 19 and 28 years old (median=23). Most of the group participants were students of V (30%), IV (23.75%) and VI (22.5%) year of the studies. The vast majority studied medicine (55%). Thirty-one students (38.75%) had chronic diseases (mainly bowel disease, endocrinologic disruption or asthma, and allergy). When it comes to 32.5% of the examined population (26 students), they received medication, mostly birth control pills. While 40% of respondents supplemented some nutrients, especially vitamin D (27.5%). Thirty-three individuals (41.25%) used relaxation techniques, mainly meditation, yoga practice and walking. The sociodemographic characteristic of examined population was shown in Table 1.

Table 1. Sociodemographic and clinical characteristic of examined group

Variable	Results
Gender (n, % males)	19; 24
Age (M)	23
Year of study (n, %)	I – 2; 2.50 II – 7; 8.75 III – 10; 12.50 IV – 19; 23.75 V – 24; 30 VI – 18; 22.5
Chronic diseases (n, %)	Gastrointestinal – 7; 8.75 Endocrine – 4; 5 Allergy/asthma/AZS – 12; 15
Tobacco smoking (n, %)	Yes – 17; 21.25
Use of relaxation techniques (n, %)	Yes – 33; 41.25

M – median; n – number of participants

### 3.2. Differences in anthropometric measurements between students exposed and not exposed to stress

The anthropometric measures and other examined variables are depicted in Table 2. The median BMI index value was 22.43 kg/m<sup>2</sup>, and most students had optimal body weight. When it comes to 60% of individuals, they had high perceived stress according to the PSS-10 scale. The psychological stress was not related to relaxation methods and most anthropometric measurements. However, individuals with the increased severity of stress were characterized by lower TBW expressed in liters ( $p<0.05$ ), lower ECF and ICF expressed in liters and lower FFM represented in kilograms ( $p<0.05$ ).

### 3.3. Relationship between stress and body composition

What is more, there was an inverse relationship between severity of stress symptoms (PSS-10 scale) and TBW ( $R=-0.33$ ,  $p<0.05$ ), ECF ( $R=-0.29$ ,  $p<0.05$ ), ICF ( $R=-0.34$ ,  $p<0.05$ ), and FFM ( $R=-0.33$ ,  $p<0.05$ ). The anthropometric measurements were not different between individuals with and without any chronic condition. However, students with endocrinological disruptions had less TBW expressed in per cent, more FM in kilograms and in per cent, and less FFM in per cent. Gender highly affected the FM to FFM ratio ( $p<0.05$ ). However, there was no effect of gender on obtained results (the results remained significant after excluding men from analysis).

## Discussion

The aim of the study was to assess the relationship between stress and body composition in the population of students from Lublin. In previous studies, it was well

Table 2. Anthropometric measurements in examined population

Variable	Students with high levels of stress (mean, median)	Students without high levels of stress (mean, median)	Differences
BMI (kg/m <sup>2</sup> )	21.81 21.05	23.35 23.03	NS
FM (%)	24.16 23.38	23.42 23.42	NS
FM (kg)	15.11 13.46	16.50 14.17	NS
FFM (%)	75.39 76.62	76.58 76.58	NS
FFM (kg)	46.10 43.80	53.70 49.73	p=0.02
TBW (%)	55.19 56.08	56.06 56.06	NS
TBW (l)	33.75 32.06	39.30 36.45	p=0.02
ECF (%)	42.06 42.05	42.22 42.08	NS
ECF (l)	14.38 13.85	16.81 14.88	p=0.03
ICF (%)	57.16 57.82	57.86 57.92	NS
ICF (l)	19.46 18.55	22.76 21.57	p=0.01

BMI – body mass index; FFM – fat free mass; FM – fat mass; TBW – total body water; ECF – extracellular fluids; ICF – intracellular fluids; kg – kilograms; l – liters; NS – nonsignificant

established that the severity of psychological stress affects metabolic changes dynamically [9,10].

In our study, despite the optimal body weight of most examined studies, approximately 60% experienced a high level of stress. The perceived stress was related to anthropometric measurements. Students with higher severity of stress were characterized by lower total body water expressed, lower extra and intracellular fluids and lower fat-free mass.

In the human body, water flows according to changes in extracellular osmolarity and between compartments (intra- and extracellular) via pressure (osmotic, hydrostatic). Intracellular fluids are engaged in the proper muscle functioning, and their content is the suggested marker of functional capacity and performance. FFM content is strongly related to TBW counts, containing approximately 70% of FFM. ICF corresponds to body cell mass (BCM), an essential nutritional status parameter [11]. The swelling theory assumes that cell volume is a metabolic signal responsible for regulating cellular function. Fluid imbalance reflected by the extracellular fluid to TBW ratio is associated with many clinical conditions and is a suggested indicator of cognitive deficits. ICF imbalance impedes nutrient availability and contributes to intracellular catabolism [12]. Activated by

stress sympathetic nervous system (SNS) and HPA axis are responsible for water and sodium retention facilitating compensatory mechanisms via fluid loss. Alternations in organism hydrations affect the functioning of internal organs, including the central nervous system, and could have the impact on overall health and well-being [13].

The study conducted in Terengganu did not find any association between stress and anthropometric parameters in a population between 20 and 59 years old. It should be noted that the authors determined BMI and did not include more precise indicators of body composition (as body fat, muscles mass, fluids) [14]. In an Indian study, body fat expressed in percentage was positively related to women's stress levels. The development of adiposity could be mediated by psychological stress and vice versa: higher body weight contributes to a more robust response to psychological stress. Fat tissue accumulation could be more significant in stress conditions due to leptin resistance, also observed in overweight individuals. Stress and leptin are well-known activators of SNS [15].

Psychological stress and obesity are emerging public health issues, especially in students. According to the meta-analysis results, body weight increased approximately 1.55 kg, especially in fat tissue (1.17% of weight) during the college period. These changes

are positively related to the duration of education and do not depend on gender or baseline body weight [16]. Approximately 70% of students reported dissatisfaction with their body image [17].

Bodyweight increases and hormonal changes lead to excessive fat accumulation in response to negative stimuli. Obesity is a growing public health concern worldwide. According to Centre for Public Opinion Research (CBOS) data, the number of individuals with excessive body weight raises to half of Poles [18]. This negative trend increases the risk of metabolic disruptions, which are well-documented factors linked with depression and mood symptoms [2]. Psychological stress could aggravate these disruptions. Education time is critical for shaping lifestyle habits (diet, physical activity, relaxation techniques). College students experience a lot of stress linked with educational demands and university-related hassles [19].

Appropriate prevention programs and health education should be implemented for the students population to prevent adverse changes in anthropometric measurements and health-related consequences.

### Limitations

This study has some limitations. Firstly, small group size could highly affect obtained results. Nevertheless, the presented examination is a part of a deeper analysis, including more specific biological and psychological factors related to somatic and mental health. Gender is a factor that highly affects body composition, and most of the groups in our study were women. However, we conducted appropriate analysis and confirmed that gender did not affect the obtained results. It should also be noted that we did not examine the menstrual cycle period in the women subgroup, which is another confounder [20]. Participants applied for the analysis voluntarily. More interest in individual results could have students focusing on a healthy lifestyle. It is possible that an insufficient number of people with a less healthy pattern of lifestyle were assessed.

### Conclusions

1. Most of the examined students had optimal body weight and high stress levels.
2. The students with the high severity of stress were characterized by lower total body water, lower extra- and intracellular fluids and lower fat-free mass.
3. The higher the stress, the lower the extracellular, intracellular, and fat-free mass were.
4. The Government and other public health organizations should consider implementing appropriate health education programs to prevent adverse changes in anthropometric measurements, psychological stress, and their health-related consequences in the student

population.

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### Conflict of interest

The authors have declared no conflict of interest.

### References

1. Narodowy Test Zdrowia Polaków - Medonet.PL Available online: <https://www.medonet.pl/narodowy-test-zdrowia-polakow,kategoria.html> (accessed on 25 January 2022).
2. Oddy, W.H.; Allen, K.L.; Trapp, G.S.A.; Ambrosini, G.L.; Black, L.J.; Huang, R.-C.; Rzehak, P.; Runions, K.C.; Pan, F.; Beilin, L.J.; et al. Dietary Patterns, Body Mass Index and Inflammation: Pathways to Depression and Mental Health Problems in Adolescents. *Brain, Behavior, and Immunity* 2018, 69, 428–439, doi:10.1016/j.bbi.2018.01.002.
3. Relationships between Food Consumption and Living Arrangements among University Students in Four European Countries - A Cross-Sectional Study | *Nutrition Journal* | Full Text Available online: <https://nutritionj.biomedcentral.com/articles/10.1186/1475-2891-11-28> (accessed on 25 January 2022).
4. Ceccato, F.; Lizzul, L.; Barbot, M.; Scaroni, C. Pituitary-Adrenal Axis and Peripheral Cortisol Metabolism in Obese Patients. *Endocrine* 2020, 69, 386–392, doi:10.1007/s12020-020-02392-4.
5. Misiak, B.; Łoniewski, I.; Marlicz, W.; Frydecka, D.; Szulc, A.; Rudzki, L.; Samochowiec, J. The HPA Axis Dysregulation in Severe Mental Illness: Can We Shift the Blame to Gut Microbiota? *Progress in Neuro-Psychopharmacology and Biological Psychiatry* 2020, 102, 109951, doi:10.1016/j.pnpbp.2020.109951.
6. World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. *Jama* 2013, 310, 2191.
7. Cohen, S.; Kamarck, T.; Mermelstein, R. A Global Measure of Perceived Stress. *Journal of health and social behavior* 1983, 385–396.
8. International Standards for Anthropometric Assessment. Available online: <https://repository.openpolytechnic.ac.nz/handle/11072/1510> (accessed on 25 January 2022).
9. Perceived Stress Correlates with Visceral Obesity and Lipid Parameters of the Metabolic Syndrome: A Systematic Review and Meta-Analysis - ScienceDirect Available online: [https://www.sciencedirect.com/science/article/pii/S030645301731586X?casa\\_token=sz2p\\_BJ\\_kXcAAAAA:2kzuyW4MXzp6y0B3YP54htGdqcPwxwzHLQEMqKulFzfx\\_G1R4dJZajz7pQANfiVQXs5C-FHBww](https://www.sciencedirect.com/science/article/pii/S030645301731586X?casa_token=sz2p_BJ_kXcAAAAA:2kzuyW4MXzp6y0B3YP54htGdqcPwxwzHLQEMqKulFzfx_G1R4dJZajz7pQANfiVQXs5C-FHBww) (accessed on 25 January 2022).
10. Karakula-Juchnowicz, H.; Rog, J.; Juchnowicz, D.; Łoniewski, I.; Skonieczna-Żydecka, K.; Krukow, P.; Futyma-Jedrzejewska, M.; Kaczmarczyk, M. The Study Evaluating the Effect of Probiotic Supplementation on the Mental Status, Inflammation, and Intestinal Barrier in Major Depressive Disorder Patients Using Gluten-Free or Gluten-Containing Diet (SANGUT Study): A 12-Week, Randomized, Double-Blind, and Placebo-Controlled Clinical Study Protocol. *Nutr J* 2019, 18, 50, doi:10.1186/s12937-019-0475-x.



11. Jaffrin, M.Y.; Morel, H. Body Fluid Volumes Measurements by Impedance: A Review of Bioimpedance Spectroscopy (BIS) and Bioimpedance Analysis (BIA) Methods. *Med Eng Phys* 2008, 30, 1257–1269, doi:10.1016/j.medengphy.2008.06.009.
12. Total Body Water and Intracellular Water Relationships with Muscle Strength, Frailty and Functional Performance in an Elderly Population. A Cross-Sectional Study | SpringerLink Available online: <https://link.springer.com/article/10.1007/s12603-018-1129-y> (accessed on 25 January 2022).
13. Increased Extracellular Water Measured by Bioimpedance Analysis and Increased Serum Levels of Atrial Natriuretic Peptide in Polymyalgia Rheumatica Patients | SpringerLink Available online: <https://link.springer.com/article/10.1007/s00393-020-00845-9> (accessed on 25 January 2022).
14. Wee, B.S.; Aryati, A.; Karimah Fakhriah, I. Association between Stress, Physical Activity and Body Composition among Adults in Terengganu.; Kuala Lumpur, 2018.
15. Full Article: Association of Body Fat with Stress Levels and Dietary Intakes in Indian Women Available online: <https://www.tandfonline.com/doi/full/10.1080/03630242.2018.1539429> (accessed on 25 January 2022).
16. Change in Weight and Adiposity in College Students: A Systematic Review and Meta-Analysis - ScienceDirect Available online: [https://www.sciencedirect.com/science/article/pii/S0749379714004024?casa\\_token=IAWtyEA5mVgAAAAA:65cdfSF6NakS8UZZ7QahuVgq-T2Wfj6QRtkGCwhnpM2FaTB4zyS0jwm3vbdmONzj2\\_rSwE6ZHg](https://www.sciencedirect.com/science/article/pii/S0749379714004024?casa_token=IAWtyEA5mVgAAAAA:65cdfSF6NakS8UZZ7QahuVgq-T2Wfj6QRtkGCwhnpM2FaTB4zyS0jwm3vbdmONzj2_rSwE6ZHg) (accessed on 25 January 2022).
17. Legey, S.; Lamego, M.K.; Lattari, E.; Campos, C.; Paes, F.; Sancassiani, F.; Mura, G.; Carta, M.G.; Rocha, N.B.F.; Nardi, A.E.; et al. Relationship Among Body Image, Anthropometric Parameters and Mental Health in Physical Education Students. *Clin Pract Epidemiol Ment Health* 2016, 12, 177–187, doi:10.2174/1745017901612010177.
18. Jakubowska, L.; Grabowska, B.; Seń, M. PHYSICAL ACTIVITY, HEALTH CONDITION AND LIFESTYLE OF ACADEMIC YOUTH. *Journal of Education Culture and Society* 2019, 10, 201–215, doi:10.15503/jecs20192.201.215.
19. Borghi, F.; Rocha-Teles, C.M.; McFadden, S.K.; da Silva, P.C.; Souza, A.L.; Grassi-Kassisse, D.M. The Influence of the Academic Exams Routine on the Perceived Stress, Resilience and Salivary Cortisol in Brazilian Pharmacy Undergraduate Students. *Personality and Individual Differences* 2021, 179, 110928, doi:10.1016/j.paid.2021.110928.
20. The Effect of the Menstrual Cycle on Body Composition Determined by Contact-Electrode Bioelectrical Impedance Analyzers Available online: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5841670/> (accessed on 25 January 2022).

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