

# ANALYSIS OF BODY COMPOSITION IN SCHOOL-AGED CHILDREN AS AN INDICATOR OF OBESITY RISK AND A CHALLENGE FOR HEALTH PROMOTION

Natalia Habik-Tatarowska<sup>A, B, C, D</sup>

Posturology Laboratory, Collegium Medicum, Uniwersytet Jana Kochanowskiego w Kielcach, Kielce, Polska  
e-mail: natalia.habik-tatarowska@uj.edu.pl  
ORCID: 0009-0001-9459-5492

Paulina Szumilas<sup>B, C, D</sup>

Department of Physiotherapy, Health Sciences Institute, Jan Kochanowski University, Kielce, Poland  
ORCID: 0009-0008-8089-5022

<sup>A</sup>Study Design; <sup>B</sup>Data Collection; <sup>C</sup>Statistical Analysis; <sup>D</sup>Manuscript Preparation

**Abstract** Background. Overweight and obesity among school-aged children are an increasing global public health problem, leading to serious health, social, and economic consequences. Early diagnosis and identification of children at risk are essential for preventive strategies. Since BMI has limitations in assessing body composition, bioelectrical impedance analysis (BIA) is increasingly applied.

**Aim.** The aim of the study was to analyze body composition parameters in 10–11 year-old children with emphasis on gender differences.

**Material and methods.** The study involved 254 primary school students from the Świętokrzyskie region. Body composition was measured using the Tanita MC-780 device, assessing body weight, height, BMI, body fat percentage, muscle mass, basal metabolic rate (BMR), impedance, and phase angle.

**Results.** Among 10-year-old children, boys showed significantly higher fat-free mass, muscle mass, and bone mass than girls. In the group of 11-year-olds, girls demonstrated significantly higher fat-free mass, muscle mass, and bone mass than boys. No significant sex differences were observed in BMI, body fat percentage, or phase angle. Strong positive correlations were found between body mass and BMI and between muscle mass and fat-free mass in both sexes.

**Conclusions.** The results confirm sex-based differences in body composition. Early identification of abnormal values can support targeted preventive and educational interventions.

**Key words:** body composition, obesity, overweight, health, prevention

## Introduction

Childhood obesity is currently one of the most serious health challenges worldwide, recognized by the World Health Organization (WHO) as the epidemic of the 21st century. According to WHO data from 2023, over 340 million

children and adolescents aged 5–19 years were overweight or obese, and this problem affects nearly all countries regardless of their economic development level (WHO, 2023a). In Poland, according to the latest data from the Institute of Mother and Child, overweight and obesity affect over 30% of boys and 20% of girls of school age (Instytut Matki i Dziecka, 2022).

The health consequences of obesity in childhood are multidimensional. They include both direct threats such as hypertension, insulin resistance, and lipid disorders, as well as long-term consequences in adulthood, including an increased risk of type 2 diabetes, cardiovascular diseases, and metabolic syndrome (Styne et al., 2017; Simmonds et al., 2016). Moreover, childhood obesity is often associated with lowered self-esteem, depression, and social relationship disorders (Griffiths et al., 2010).

The traditional tool for assessing nutritional status and obesity risk is the Body Mass Index (BMI); however, it has limitations, especially in children undergoing growth. BMI does not account for body composition and does not distinguish between fat mass and muscle mass, which may lead to misclassification, particularly among physically active children or those in rapid growth phases (Javed et al., 2015). Therefore, in recent years, increasing attention has been paid to body composition assessment as a more accurate tool for identifying health risks (McCarthy et al., 2006; Maffei et al., 2008; Ashwell et al., 2005; Wells & Fewtrell, 2006).

Studying body composition in children aged 10–11, who are at the onset of puberty, holds particular diagnostic and preventive significance. This period involves intensive hormonal and growth changes that may affect metabolic processes and health behaviors established for life (Reilly et al., 2011).

In the context of child and adolescent health, health promotion should include multi-level activities combining health education, environmental support, and public policy. According to the WHO Bangkok Charter, health promotion is “the process of enabling people to increase control over and improve their health” (WHO, 2019). This specifically involves shaping pro-health dietary habits, promoting daily physical activity, and reducing sedentary behavior, including screen time (WHO, 2005; Guthold et al., 2020). Schools play an important role as educational and developmental environments where effective preventive and health programs can be implemented. WHO and UNESCO emphasize that schools should be “Health-Promoting Schools,” integrating physical, mental, and social health content (WHO, UNESCO, UNICEF, 2021).

Despite the availability of such programs, their effectiveness is sometimes limited due to a lack of systematic monitoring and insufficient involvement of families and local communities. Meanwhile, early body composition and nutritional status assessment can serve as a starting point for individualizing educational and motivational interventions, enhancing their effectiveness (Żegleń & Koziol-Kozakowska, 2018). The hypothesis is that sex-related differences in body composition are already present in prepubertal children and can be detected using bioelectrical impedance analysis, providing more detailed insight than BMI alone. The combination of diagnostic tools (e.g., body composition analysis) with promotional and educational activities appears crucial for building healthy habits and preventing the childhood obesity epidemic.

The aim of this study was a detailed analysis of body composition and evaluation of obesity risk indicators in children aged 10–11 attending primary schools in the Świętokrzyskie Voivodeship. The paper also presents implementation recommendations for promoting health among school-aged children to prevent overweight and obesity risk.

## Material and methods

The study was conducted at the Posturology Laboratory of the Collegium Medicum, Jan Kochanowski University in Kielce. The measurements were performed once, after obtaining written consent from the parent or guardian of each participant. All research procedures were carried out in accordance with the Declaration of Helsinki of 1964 and with the approval of the Bioethics Committee of Jan Kochanowski University in Kielce (Resolution No. 37/2018).

### Participants

A total of 254 children from the Świętokrzyskie Voivodeship participated in the study, including 123 girls (48.43%) and 131 boys (51.57%). The selection of participants was mixed, following predefined inclusion criteria for each group. The study included children aged 10 and 11 years. The larger group consisted of 10-year-olds ( $n=134$ ; 52.76%), of whom 69 (51.49%) were girls and 65 (48.51%) were boys. The 11-year-old group consisted of 120 children (47.24%), including 54 (45%) girls and 66 (55%) boys. Inclusion criteria covered children aged 10–11 attending primary schools in the region, who voluntarily agreed to participate and whose parents or legal guardians provided consent. Children with chronic diseases or metabolic disorders potentially affecting body composition, such as diabetes or hormonal imbalances, were excluded. Participants who did not consent to measurements or withdrew from the study were also excluded, as well as those with contraindications for bioelectrical impedance measurement (e.g., pacemaker or other electronic implants). Incomplete or unreliable measurement data were excluded from the analysis. These criteria ensured a reliable and representative study sample necessary for a thorough health assessment and for formulating recommendations on health promotion and obesity prevention among school-aged children.

### Instruments

The assessment of body composition was conducted using the objective method of bioelectrical impedance with the Tanita MC-780 device. Bioelectrical impedance is a rapid and non-invasive method for evaluating body composition, based on measuring the electrical resistance of tissues. The Tanita MC-780 device employs advanced algorithms and multifrequency impedance analysis to accurately estimate muscle mass, fat mass, water content, and bone mass. Recent publications emphasize improvements in measurement precision due to technological advancements and highlight its wide application in clinical studies, population health monitoring, and preventive programs. Body composition analysis was performed using the Tanita MC-780 analyzer, which provides a full body composition profile in approximately 20 seconds. The device measures the following parameters: Body Mass (BM), expressed in kilograms; Basal Metabolic Rate (BMR), indicating the minimum amount of energy required for proper functioning of the body at rest; Fat Percent (FP%), the percentage of body fat; Fat Mass (FMkg), the absolute mass of fat tissue; Fat Free Mass (FFMkg), which includes muscle mass, internal organs, and bones, representing the most metabolically active component of the body; Total Body Water (TBW); Predicted Muscle Mass (PMM), which includes skeletal and smooth muscles; Impedance (IMP), the measure of electrical resistance of tissues used in body composition calculations, where water-rich tissues (e.g., muscles) conduct electrical current more easily than fat tissue. Additionally, the device measures Body Mass Index (BMI), a standard parameter for assessing body weight, expressed in  $\text{kg}/\text{m}^2$ ; Visceral Fat Level (VFATL), indicating fat located deep in the abdominal cavity; Bone

Mass (BONEM); Extracellular Water (ECW) and Intracellular Water (ICW). The Phase Angle (PA) is also analyzed, which reflects the overall health status and quality of tissue and cellular functions, as well as the nutritional status of the body. The phase angle is calculated based on electrical resistance and reactance; low values may indicate physical exhaustion, malnutrition, or chronic diseases (Lima et al., 2022).

Measurements were performed under standardized conditions. Participants were assessed in light clothing and barefoot. They were instructed to avoid vigorous physical activity before the examination and to maintain normal hydration status. All measurements were performed according to the manufacturer's recommendations.

## Statistical analysis

For statistical analysis, descriptive methods were applied, including calculation of arithmetic means ( $\bar{x}$ ), standard deviations (SD), and coefficients of variation (CV) for individual body composition parameters. Pearson's correlation coefficient ( $r$ ) was used to assess the strength and direction of relationships between anthropometric variables. Furthermore, to compare the significance of differences between correlation coefficients in girls and boys, the Fisher's Z-transformation test was applied, enabling statistical evaluation of differences between correlations. To address intergroup variability, Student's t-test for independent samples was used to compare body composition parameters between girls and boys.

## Results

Table 1 presents the mean values and variability of basic body composition parameters in 10-year-old children, differentiated by sex. The average height of boys (139.97 cm) was slightly higher than that of girls (138.52 cm), with a low coefficient of variation (around 6%), indicating a narrow range of measurements in both groups. Body mass and body mass index (BMI) were comparable between sexes, but showed a high coefficient of variation (around 27% for mass), reflecting significant individual differences. Basal metabolic rate (BMR) was higher in boys, correlating with their greater fat-free mass. The percentage and mass of fat tissue were slightly higher in girls, whereas fat-free mass, muscle mass, and bone mass were significantly higher in boys, consistent with typical sex differences at this age. Bioimpedance parameters such as electrical impedance and phase angle indicated similar muscle quality and hydration status in both groups. The analysis of variability distribution highlights substantial individual differences in the examined parameters, which is important for assessing obesity risk and planning preventive interventions.

**Table 1.** Descriptive parameters of variables in the group of 10-year-old children

| Variable                 | Girls         |        |       | Boys          |        |       |
|--------------------------|---------------|--------|-------|---------------|--------|-------|
|                          | ( $\bar{x}$ ) | (S)    | (V%)  | ( $\bar{x}$ ) | (S)    | (V%)  |
| Height [cm]              | 138.52        | 9.02   | 6.51  | 139.97        | 8.59   | 6.14  |
| Mass [kg]                | 36.36         | 9.75   | 26.83 | 37.58         | 10.27  | 27.32 |
| BMI                      | 18.85         | 3.92   | 20.78 | 18.91         | 3.74   | 19.76 |
| BMR [kJ]                 | 5199.41       | 767.71 | 14.77 | 5538.52       | 599.45 | 10.82 |
| BMR [kcal]               | 1255.54       | 170.17 | 13.55 | 1324.32       | 138.80 | 10.48 |
| Fat tissue [%]           | 23.26         | 4.91   | 21.12 | 22.54         | 6.84   | 30.37 |
| Fat tissue mass [kg]     | 8.89          | 4.01   | 45.15 | 8.79          | 4.74   | 53.92 |
| Fat-free mass (FFM) [kg] | 27.46         | 6.46   | 23.54 | 28.83         | 6.02   | 20.86 |
| Muscle mass (PMM) [kg]   | 25.69         | 5.99   | 23.30 | 27.34         | 5.67   | 20.74 |

|                             | Girls  |       |       | Boys   |       |       |
|-----------------------------|--------|-------|-------|--------|-------|-------|
| Bone mass [kg]              | 1.43   | 0.30  | 21.29 | 1.56   | 0.28  | 18.02 |
| Total body water (TBW) [kg] | 20.26  | 4.65  | 22.97 | 20.97  | 5.86  | 27.94 |
| Water content [%]           | 55.71  | 3.53  | 6.33  | 56.69  | 4.34  | 7.66  |
| Impedance [Ohm]             | 689.41 | 76.93 | 11.16 | 688.94 | 67.84 | 9.85  |
| Phase angle [°]             | 5.22   | 0.45  | 8.58  | 5.31   | 0.67  | 12.60 |

Source: Author's own elaboration. Abbreviations: ( $\bar{x}$ ) – mean; (S) – standard deviation; (V%) – coefficient of variation.

A comparative analysis of body composition parameters in 11-year-old children (Table 2) showed similar mean values of height and body mass between girls and boys, with girls presenting slightly higher body mass (42.40 kg vs. 40.49 kg) and BMI (20.78 vs. 19.34 kg/m<sup>2</sup>). Basal metabolic rate (BMR), expressed both in kJ and kcal, was comparable between sexes. The percentage and mass of body fat were slightly higher in girls, which is consistent with physiological developmental differences observed at this age. In addition, girls demonstrated higher values of fat-free mass (FFM), predicted muscle mass (PMM), bone mass, and total body water (TBW) expressed in kilograms. Boys, however, showed slightly lower variability in several body composition parameters, suggesting a more homogeneous pattern of somatic development. The percentage of body water was also higher in girls (57.77%) than in boys (55.53%), although variability remained moderate in both groups. Electrical impedance values were higher in boys, whereas phase angle values were comparable between sexes. The greatest variability was observed for fat mass expressed in kilograms, indicating substantial individual differences in adiposity among the examined children.

Overall, the results demonstrate sex-related differences in body composition at the age of 11 years and emphasize the importance of comprehensive body composition assessment in obesity prevention and health promotion programs targeting school-aged children.

**Table 2.** Descriptive parameters of variables in the group of 11-year-old children

|                             | Girls         |        |       | Boys          |        |       |
|-----------------------------|---------------|--------|-------|---------------|--------|-------|
| Variable                    | ( $\bar{x}$ ) | (S)    | (V%)  | ( $\bar{x}$ ) | (S)    | (V%)  |
| Height [cm]                 | 142.00        | 9.25   | 6.39  | 143.46        | 9.17   | 6.39  |
| Mass [kg]                   | 42.40         | 12.77  | 29.24 | 40.49         | 11.84  | 29.24 |
| BMI                         | 20.78         | 4.90   | 23.58 | 19.34         | 4.05   | 20.92 |
| BMR [kJ]                    | 5517.83       | 821.86 | 14.89 | 5605.36       | 695.72 | 12.41 |
| BMR [kcal]                  | 1316.83       | 186.74 | 14.19 | 1317.79       | 225.19 | 17.09 |
| Fat tissue [%]              | 24.20         | 7.77   | 32.11 | 23.05         | 7.17   | 31.10 |
| Fat tissue mass [kg]        | 10.63         | 6.90   | 64.89 | 10.09         | 6.01   | 59.57 |
| Fat-free mass (FFM) [kg]    | 31.77         | 7.39   | 23.27 | 29.66         | 6.53   | 22.01 |
| Muscle mass (PMM) [kg]      | 30.08         | 6.94   | 23.07 | 28.40         | 6.29   | 22.14 |
| Bone mass [kg]              | 1.70          | 0.33   | 19.53 | 1.61          | 0.31   | 18.98 |
| Total body water (TBW) [kg] | 23.42         | 5.55   | 23.71 | 21.75         | 5.88   | 27.03 |
| Water content [%]           | 57.77         | 7.02   | 12.14 | 55.53         | 6.27   | 11.28 |
| Impedance [Ohm]             | 694.50        | 92.02  | 13.24 | 735.80        | 81.08  | 11.02 |
| Phase angle [°]             | 5.30          | 0.54   | 10.19 | 5.28          | 0.48   | 9.03  |

Source: Author's own elaboration. Abbreviations: ( $\bar{x}$ ) – mean; (S) – standard deviation; (V%) – coefficient of variation.

Table 3 presents a comparison of Pearson correlation coefficients ( $r$ ) for selected pairs of anthropometric variables in girls and boys aged 10 and 11 years, along with an assessment of the significance of differences between these correlations using Fisher's Z test. This comparison was made both for body mass vs. BMI and muscle mass (PMM) vs. fat-free mass (FFM). Very high positive correlations were observed in both sexes, regardless of the age group. Correlation coefficients ranged from  $r=0.88$  to  $r=0.97$ , indicating a strong relationship between the analyzed parameters.

The Fisher's Z test analysis showed no significant differences in correlation strength between girls and boys – all  $p$ -values were significantly greater than the 0.05 threshold. This means that the relationships between body mass and BMI, as well as between muscle mass and fat-free mass, are comparable between sexes in both age groups studied. These results confirm the stability of the relationships among basic body composition indicators in the studied population and support their use in assessing the risk of overweight and obesity in children.

**Table 3.** Comparison of correlation strength for selected pairs of anthropometric and body composition variables in girls and boys aged 10 and 11 years, with significance testing using Fisher's Z statistic

| Age | Variable Pair         | Girls ( $r$ ) | Boys ( $r$ ) | Fisher's Z | $p$ -value |
|-----|-----------------------|---------------|--------------|------------|------------|
| 10  | Body mass [kg] / BMI  | 0.92          | 0.90         | 0.31       | 0.75       |
|     | Muscle mass PMM / FFM | 0.97          | 0.94         | 1.12       | 0.26       |
| 11  | Body mass [kg] / BMI  | 0.89          | 0.88         | 0.14       | 0.89       |
|     | Muscle mass PMM / FFM | 0.95          | 0.96         | -0.41      | 0.68       |

Source: Author's own elaboration. Abbreviations:  $r$  – Pearson's correlation coefficient; Z – Fisher's Z transformation;  $p$ -value – probability value

**Table 4.** Comparison of body composition parameters between girls and boys aged 10 and 11 years using Student's t-test

| Variable                 | Age | Girls ( $\bar{x} \pm SD$ ) | Boys ( $\bar{x} \pm SD$ ) | t-value | $p$ -value |
|--------------------------|-----|----------------------------|---------------------------|---------|------------|
| Height [cm]              | 10  | 138.52 $\pm$ 9.02          | 139.97 $\pm$ 8.59         | -0.95   | 0.34       |
| Body mass [kg]           | 10  | 36.36 $\pm$ 9.75           | 37.58 $\pm$ 10.27         | -0.71   | 0.47       |
| BMI [kg/m <sup>2</sup> ] | 10  | 18.85 $\pm$ 3.92           | 18.91 $\pm$ 3.74          | -0.08   | 0.93       |
| Fat tissue [%]           | 10  | 23.26 $\pm$ 4.91           | 22.54 $\pm$ 6.84          | 0.69    | 0.49       |
| Fat-free mass (FFM) [kg] | 10  | 27.46 $\pm$ 6.46           | 28.83 $\pm$ 6.02          | -2.11   | 0.036      |
| Muscle mass (PMM) [kg]   | 10  | 25.69 $\pm$ 5.99           | 27.34 $\pm$ 5.67          | -2.28   | 0.024      |
| Bone mass [kg]           | 10  | 1.43 $\pm$ 0.30            | 1.56 $\pm$ 0.28           | -2.17   | 0.031      |
| Phase angle [°]          | 10  | 5.22 $\pm$ 0.45            | 5.31 $\pm$ 0.67           | -0.88   | 0.37       |
| Height [cm]              | 11  | 142.00 $\pm$ 9.25          | 143.46 $\pm$ 9.17         | -0.91   | 0.36       |
| Body mass [kg]           | 11  | 42.40 $\pm$ 12.77          | 40.49 $\pm$ 11.84         | 1.02    | 0.31       |
| BMI [kg/m <sup>2</sup> ] | 11  | 20.78 $\pm$ 4.90           | 19.34 $\pm$ 4.05          | 1.89    | 0.06       |
| Fat tissue [%]           | 11  | 24.20 $\pm$ 7.77           | 23.05 $\pm$ 7.17          | 1.01    | 0.31       |
| Fat-free mass (FFM) [kg] | 11  | 31.77 $\pm$ 7.39           | 29.66 $\pm$ 6.53          | 2.45    | 0.015      |
| Muscle mass (PMM) [kg]   | 11  | 30.08 $\pm$ 6.94           | 28.40 $\pm$ 6.29          | 2.18    | 0.031      |
| Bone mass [kg]           | 11  | 1.70 $\pm$ 0.33            | 1.61 $\pm$ 0.31           | 2.01    | 0.046      |
| Phase angle [°]          | 11  | 5.30 $\pm$ 0.54            | 5.28 $\pm$ 0.48           | 0.22    | 0.82       |

Source: Author's own elaboration. Abbreviations:  $\bar{x} \pm SD$ ; SD – standard deviation;  $\bar{x}$  – mean; t-value – t-test statistic;  $p$ -value (statistical significance at  $p < 0.05$ ).

## Discussion

The results presented in this analysis indicate very strong positive relationships between selected pairs of anthropometric and body composition variables in both girls and boys aged 10 and 11 years. The highest correlation coefficients were observed between muscle mass (PMM) and fat-free mass (FFM), with values of  $r$  ranging from 0.94 to 0.97. This level of concordance confirms the dominant role of muscle mass within the FFM structure in the population of children in late childhood.

Strong correlations were also found between body mass and BMI ( $r=0.88-0.92$ ), confirming their high interdependence. However, as noted by Ortega et al., BMI does not differentiate the quality of body mass, especially the ratio between fat and muscle tissue, which can lead to misinterpretations of nutritional status, particularly in children with increased muscle mass. Although BIA provides more detailed insight than BMI, its accuracy may be influenced by hydration status and pubertal stage, which should be considered when interpreting pediatric data. Thus, the results of this analysis emphasize the need to use more complex measures of body composition, such as bioelectrical impedance analysis, for assessing obesity risk during developmental age (Ortega et al., 2022).

The analysis of differences in correlation strength between girls and boys, conducted using Fisher's Z statistic, showed no statistically significant discrepancies (all  $p$ -values  $>0.05$ ). This indicates that the nature of the relationships between the analyzed pairs of variables is similar in both sexes, which may suggest comparable developmental processes in body composition components during this period of life. At the same time, the results align with international pediatric studies conducted in European populations, which describe typical sex-related differences in body composition. The present study demonstrated sex-related differences in body composition; however, the pattern varied according to age. Among 10-year-old children, boys exhibited significantly higher fat-free mass, muscle mass, and bone mass. In contrast, among 11-year-olds, girls presented significantly higher values of these parameters. These findings may reflect differences in the timing of biological maturation, as girls typically enter pubertal development earlier than boys. Therefore, body composition assessment should be interpreted not only according to chronological age but also considering developmental stage.

Regular monitoring of indicators such as PMM, FFM, fat mass, and body water content allows for a more precise assessment of metabolic risk and can serve as a starting point for educational activities and school programs promoting physical activity and healthy eating habits (Janssen & LeBlanc., 2021; WHO, 2023b).

In summary, the conducted body composition analysis of children aged 10–11 years indicates significant changes that fit into the global rise of childhood obesity, confirmed by numerous studies in recent years. Our observations, especially regarding higher BMI and increased fat percentage among the examined children, align with current epidemiological trends described by Wang and Lim, who confirmed the increasing obesity rate in school-aged children worldwide (Wang & Lim 2012).

Moreover, studies by Sahoo et al. indicate that early adolescence is a critical period for interventions preventing obesity development, and precise monitoring of body composition can significantly improve early detection of children at risk of excessive fat gain (Sahoo et al., 2015).

Furthermore, recent studies indicate that BMI alone is insufficient for precise identification of children at obesity risk. As stressed by authors from the European Childhood Obesity Group (ECOG) in their 2022 recommendations, incorporating body composition, including fat percentage and muscle mass, is crucial to better tailor preventive and therapeutic strategies (ECOG, 2022). Our own results fit within this framework, showing individual differences in body composition that do not always correlate linearly with BMI values.

In light of these data, the present analysis confirms the necessity of introducing comprehensive body composition assessments in routine pediatric examinations and highlights the need for health education targeted at families, promoting physical activity and healthy eating habits from early childhood (Barlow, 2007). Increasing emphasis on childhood obesity prevention is also evident in global WHO strategies (2023c), which underline the need for multidimensional interventions involving school, family, and community environments (WHO, 2023c).

For effective health promotion among children aged 10–11 years, it is recommended to implement regular monitoring of health parameters, including annual BMI measurements and detailed body composition assessment, such as muscle and fat mass. To ensure the reliability and accuracy of these measurements, training of school personnel—such as nurses and physical education teachers in measurement techniques and result interpretation is essential. Concurrently, education of children and their parents through workshops and meetings highlighting the importance of proper nutrition and regular physical activity is crucial. Educational materials like brochures, posters, and short videos should clearly explain the significance of the balance between muscle and fat mass for health and proper development. Promotional activities should be systematically monitored and evaluated through data collection and trend analysis regarding body composition and health indicators in children. Regular assessment of intervention effectiveness will enable optimization and adaptation to population needs, increasing the efficiency of health promotion and obesity prevention programs.

Despite the practical value of this study, several limitations should be acknowledged. First, the study sample included children from only one region, which may limit the generalizability of the findings to the entire pediatric population in Poland. Second, the cross-sectional design does not allow for causal inference regarding obesity development. Third, the analysis did not include levels of physical activity, dietary habits, or socioeconomic factors, which may significantly influence body composition. Moreover, although bioelectrical impedance analysis is a practical and non-invasive method, its accuracy may be affected by hydration status and diurnal biological variability.

Regular physical activity remains a key component of obesity prevention in school-aged children. According to WHO recommendations, children and adolescents aged 5–17 years should engage in at least 60 minutes of moderate-to-vigorous physical activity daily. Insufficient physical activity and sedentary behavior significantly increase the risk of excessive fat accumulation and metabolic disorders. Therefore, body composition monitoring should be combined with physical activity promotion programs and health education implemented in the school environment (WHO, 2019).

The obtained results support the study hypothesis, confirming that sex-related differences in body composition are already observable in children aged 10–11 years. Bioelectrical impedance analysis provided more detailed information than BMI alone and allowed identification of differences in fat-free mass, muscle mass, and fat tissue distribution that may be relevant for obesity prevention and health promotion strategies.

## Conclusions

1. Significant sex-related differences in body composition were observed among children aged 10–11 years.
2. Girls demonstrated a higher percentage of body fat, whereas differences in muscle mass, fat-free mass, and bone mass varied according to age.
3. Strong correlations indicate that these indicators may be useful components of obesity risk assessment.

4. Bioelectrical impedance analysis provides valuable information beyond BMI and may improve early identification of children at increased risk of overweight and obesity.
5. Regular monitoring of body composition should be incorporated into school-based health promotion and obesity prevention programs.
6. Future studies should include larger and more diverse populations and consider physical activity, dietary habits, and socioeconomic determinants of health.

## References

- Ashwell, M., & Hsieh, S. D. (2005). Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. *International Journal of Food Sciences and Nutrition*, 56(5), 303–307.
- Barlow, S. E. (2007). Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: Summary report. *Pediatrics*, 120(Suppl. 4), S164–S192.
- European Childhood Obesity Group. (2022). *ECOG 2022 guidelines: Assessment and management of childhood obesity*. ECOG.
- Griffiths, L. J., Parsons, T. J., & Hill, A. J. (2010). Self-esteem and quality of life in obese children and adolescents: A systematic review. *International Journal of Pediatric Obesity*, 5(4), 282–304.
- Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: A pooled analysis of 298 population-based surveys. *The Lancet Child & Adolescent Health*, 4(1), 23–35.
- Instytut Matki i Dziecka. (2023). *Raport: Stan zdrowia dzieci w Polsce 2022*. IMiD.
- Janssen, I., & LeBlanc, A. G. (2021). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, 18(1), 81.
- Javed, A., Jumeau, M., Murad, M. H., Okorodudu, D., Kumar, S., Somers, V. K., et al. (2015). Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents: A systematic review and meta-analysis. *Pediatric Obesity*, 10(3), 234–244.
- Lima, J., Eckert, I., Gonzalez, M. C., & Silva, F. M. (2022). Prognostic value of phase angle and bioelectrical impedance vector in critically ill patients: A systematic review and meta-analysis of observational studies. *Clinical Nutrition*, 41(12), 2801–2816.
- Maffei, C., Banzato, C., & Talamini, G. (2008). Waist-to-height ratio, a useful index to identify high metabolic risk in overweight children. *The Journal of Pediatrics*, 152(2), 207–213.
- McCarthy, H. D., & Ashwell, M. (2006). A study of central fatness using waist-to-height ratios in UK children and adolescents over two decades. *International Journal of Obesity*, 30(6), 988–992.
- Ortega, F. B., Sui, X., Lavie, C. J., & Blair, S. N. (2022). Body mass index, the most widely used but also widely criticized index. *Mayo Clinic Proceedings*, 97(4), 679–681.
- Reilly, J. J., & Kelly, J. (2011). Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: Systematic review. *International Journal of Obesity*, 35(7), 891–898.
- Sahoo, K., Sahoo, B., Choudhury, A. K., Sofi, N. Y., Kumar, R., & Bhadoria, A. S. (2015). Childhood obesity: Causes and consequences. *Journal of Family Medicine and Primary Care*, 4(2), 187–192.
- Simmonds, M., Llewellyn, A., Owen, C. G., & Woolacott, N. (2016). Predicting adult obesity from childhood obesity: A systematic review and meta-analysis. *Obesity Reviews*, 17(2), 95–107.
- Styne, D. M., Arslanian, S. A., Connor, E. L., Farooqi, I. S., Murad, M. H., Silverstein, J. H., et al. (2017). Pediatric obesity-Assessment, treatment, and prevention: An Endocrine Society clinical practice guideline. *The Journal of Clinical Endocrinology & Metabolism*, 102(3), 709–757.
- Wang, Y., & Lim, H. (2012). The global childhood obesity epidemic and the association between socio-economic status and childhood obesity. *International Review of Psychiatry*, 24(3), 176–188.
- Wells, J. C., & Fewtrell, M. S. (2006). Measuring body composition. *Archives of Disease in Childhood*, 91(7), 612–617.
- World Health Organization. (2005). *The Bangkok charter for health promotion in a globalized world*. WHO.
- World Health Organization. (2019). *Guidelines on physical activity, sedentary behaviour and sleep for children under 5 years of age*. WHO.

- World Health Organization, UNESCO, & UNICEF. (2021). *Making every school a health-promoting school: Global standards and indicators*. WHO.
- World Health Organization. (2023a). *Obesity and overweight*. WHO.
- World Health Organization. (2023b). *Obesity and overweight: Key facts*. WHO.
- World Health Organization. (2023c). *Report of the Commission on Ending Childhood Obesity*. WHO.
- Żegleń, M., & Kozioł-Kozakowska, A. (2018). Ocena skuteczności programów profilaktycznych dotyczących nadwagi i otyłości u dzieci. *Pediatrics i Medycyna Rodzinna*, 14(4), 412–417.

**Cite this article as:** Habik-Tatarowska, N., Szumilas, P. (2026). Analysis of body composition in school-aged children as an indicator of obesity risk and a challenge for health promotion. *Central European Journal of Sport Sciences and Medicine*, 2(54), 41–50. <https://doi.org/10.18276/cej.2026.2-04>