

# The association between calcium consumption and students body composition

## *Zależność między spożyciem wapnia a składem ciała studentów*

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**Key words:** calcium consumption, body composition, body mass index.

**Słowa kluczowe:** spożycie wapnia, skład ciała, wskaźnik masy ciała.

### Abstract

**Introduction:** The consumption of calcium in the Polish population is insufficient, which may negatively influence the occurrence of osteoporosis, as well as cause overweight and obesity.

**Aim of the research:** To analyse the relationship between calcium consumption and body composition of the participants of this study.

**Material and methods:** The study was carried out on a sample group of 103 nursing students. The study group consisted of 91 (88.3%) women and 12 (11.7%) men, aged from 19 to 33 years. The participants of the study had their body composition analysed, the body mass index (BMI) was calculated, and the authors carried out a survey involving the Dairy Products Frequency Questionnaire (ADOS-Ca) as well as their own questionnaire to evaluate the socio-economic status of the subjects.

**Results:** The students who had the lowest calcium consumption also had the lowest BMI ( $p = 0.0015$ ) and the lowest amount of visceral fat ( $p = 0.0260$ ). Individuals who consumed the lowest amount of calcium also had the lowest muscle mass ( $p = 0.007$ ) and bone mass ( $p = 0.004$ ). However, the authors did not notice a significant statistical difference between the level of calcium consumption and the percentage of adipose tissue ( $p = 0.5000$ ) as well as body water percentage ( $p = 0.3200$ ).

**Conclusions:** The results of the research do not confirm the hypothesis that high calcium consumption is associated with a lower probability of the occurrence of excess body mass and adipose tissue.

### Streszczenie

**Wprowadzenie:** Spożycie wapnia w populacji polskiej jest niewystarczające, co może wpływać na zwiększoną częstość występowania nie tylko osteoporozy, lecz także nadwagi i otyłości.

**Cel pracy:** Analiza zależności między spożyciem wapnia a składem ciała studentów.

**Materiał i metody:** Badanie przeprowadzono wśród 103 studentów pielęgniarstwa. Grupę badaną stanowiło 91 (88,3%) kobiet i 12 (11,7%) mężczyzn w wieku 19–33 lat. Dokonano analizy składu ciała uczestników, wyliczono wskaźnik masy ciała (BMI) oraz przeprowadzono badanie ankietowe z wykorzystaniem *Ankiety diagnostycznej do oceny spożycia wapnia* (ADOS-Ca) i autorskiego kwestionariusza oceniającego warunki socjoekonomiczne badanych.

**Wyniki:** Studenci, u których odnotowano najmniejsze spożycie wapnia, mieli najmniejsze wartości BMI ( $p = 0,015$ ) i najmniejszą ilość tłuszczu trzewnego ( $p = 0,0260$ ). U osób spożywających najmniej wapnia wykazano najmniejszą masę mięśni ( $p = 0,007$ ) i masę kości ( $p = 0,004$ ). Nie stwierdzono natomiast istotnej statystycznie zależności pomiędzy poziomem spożycia wapnia ogółem przez badane osoby a procentem tkanki tłuszczowej ( $p = 0,5000$ ) oraz procentową zawartością wody ( $p = 0,3200$ ).

**Wnioski:** Wyniki przeprowadzonych badań nie potwierdziły hipotezy, że spożywanie większej ilości wapnia jest związane ze zmniejszeniem prawdopodobieństwa wystąpienia nadmiaru masy ciała i tkanki tłuszczowej.

## Introduction

Calcium is the main building material for bones, teeth, blood vessels, hair and nails, and it regulates many important life processes [1, 2]. Nearly 99% of this element in the body plays the role of building material in the form of hydroxyapatite. Biologically this form is practically inactive. The remaining part is present in the ionised form ( $\text{Ca}^{2+}$ ) in the intracellular fluid and extracellular fluid [1]. The average daily necessary intake of calcium for an adult (19 to 50 years old) is 800 mg, and the recommended daily consumption of this element is 1000 mg [3]. The best source of well assimilable calcium is milk and dairy products. Other excellent sources of calcium are fish consumed with their bones and wholemeal grain products [3].

According to research, the Polish population does not consume enough calcium [4–7]. The consequences of a low intake of calcium are negative changes in the human body and chronic illnesses. In adults, the health problems related to a low intake are usually osteopaenia and osteoporosis, which cause unstable fractures, mainly of the ilium, femoral neck, and the vertebrae column. Eventually, movement is impaired and the quality of life is poorer [7–9].

The active form of calcium ( $\text{Ca}^{2+}$ ) regulates many processes that take place in the human body. It is responsible for the normal contraction of smooth muscles, striated muscles, and the cardiac muscle. It lowers the permeability of blood vessels, ensures the normal conduction of nerve impulses, and it plays a role in hormone balance [10].

The results of many studies have led to formulation of a hypothesis that low calcium intake and/or low consumption of dairy products is associated with a higher mass of adipose tissue, and a higher risk of overweight and obesity [11–15]. Many studies have also pointed to the influence of an incorrect calcium level on the occurrence of metabolic syndrome [16].

## Aim of the research

The aim of this work was the analysis of the relationship between calcium consumption, body mass index (BMI), and the body composition of students. It was also tested whether other factors, such as sex, socio-economic status, and selected healthy behaviours are connected with the value of BMI and the amount of adipose tissue in the participants of this study.

## Material and methods

A total of 103 students of nursing from the State Higher Vocational School in Tarnow took part in the study in July 2016. The research had been granted permission from the Bioethical Committee of the Faculty of Medicine and Health Sciences of the Jan Kochanowski University in Kielce (no. 24/2016). Body height was measured using a medical scales stadium-

eter. Body composition was measured using electro impedance method with a Body Composition Monitor Tanita BC-545N. The following results were further analysed:

- body mass index (BMI) – body mass divided by the square of the body height expressed in  $\text{kg}/\text{m}^2$ . The WHO classification was used to evaluate this indicator:  $< 18.5 \text{ kg}/\text{m}^2$  – underweight;  $18.5\text{--}24.99 \text{ kg}/\text{m}^2$  – healthy value;  $25.0\text{--}29.9 \text{ kg}/\text{m}^2$  – overweight;  $\geq 30 \text{ kg}/\text{m}^2$  – obesity [17].
- body fat percentage (%BF) – the amount of body fat as a proportion of body weight. It was assumed that excess body fat is the value of  $\geq 25\%$  in men and  $\geq 35\%$  in women [18].
- total body water percentage (%TBW) – the total amount of fluid in the body expressed as a percentage of total body weight.
- visceral fat rating (VFR) – indicates the rating of visceral fat in the body. The results are given as levels from 1 to 59.
- muscle mass (MM) – the weight of muscle in your body including the skeletal muscles, smooth muscles (digestive muscles and cardiac), and water contained in these muscles expressed in kilograms.
- bone mass (BM) – the amount of bone in the body (bone mineral level includes calcium and other minerals) expressed in kilograms.

The authors used their own questionnaire to evaluate socio-economic status (place of living, material status) and selected healthy behaviours (tobacco smoking, taking calcium supplements). To evaluate the consumption of calcium the Dairy Products Frequency Questionnaire (ADOS-Ca) was used. This is a validated, semi-quantitative questionnaire that evaluates the amount and frequency of intake of 11 dairy products that have been habitually consumed during the last 6 months. It also enables us to calculate the general amount of calcium intake from daily diet, involving regression equations compiled by Szymelfejnik *et al.* [19].

It was assumed that the optimal calcium intake was the level of the EAR norm (Estimated Average Requirement), i.e. 800 mg/day [3]. Taking into account the centile distribution of total calcium intake, three categories of calcium consumption were distinguished: low (T1), average (T2), and high (T3).

## Statistical analysis

The results were statistically analysed using the Statistica PL 9.0 program. A  $\chi^2$  test was used to evaluate the association between selected factors, body mass indicators, and the amount of body fat. The following tests were utilised to evaluate the correlation between calcium consumption from daily diet as well as from rennet and cream cheeses, and body composition: a non-parametric Kruskal-Wallis test, a one-way ANOVA test, and a post-hoc test. The level of statistical significance was set at  $p = 0.05$ .

**Table 1.** Characteristics of the study group

Variable		N	%
Gender	Female	91	88.3
	Male	12	11.7
Place of living	City	45	43.7
	Village	58	56.3
Economic status	Good and very good	74	71.8
	Average	28	27.3
	Poor and very poor	1	0.9
Cigarette smoking	Yes	9	8.7
	No	96	91.3
BMI [kg/m <sup>2</sup> ]	< 18.5	7	6.8
	≥ 18.5 < 25	74	71.8
	≥ 25	22	21.4
%BF	< 25% male < 35% female	93	90.3
	≥ 25% male ≥ 35% female	10	9.7
Calcium supplementation	Yes	11	10.7
EAR	≥ 800 mg	20	19.4

BMI – body mass index, %BF – body fat percentage, EAR – estimated average.

## Results

The study group consisted of 91 (88.3%) women and 12 (11.7%) men from 19 to 33 years old (21.7

±2.9 years) (Table 1). The percentage of participants from rural areas was 56.3%, the remaining 43.7% were from urban areas. The significant majority of the participants stated that their material status was high or very high (71.8%). 27.3% declared that their material status was average, and 0.9% that it was low or very low. 8.7% of the participants smoked cigarettes; the others never smoked. The BMI showed that 6.8% of the students were underweight and 21.4% of students were overweight or obese. Participants with a normal level of adipose tissue (%BF) constituted 90.3% of the value of this indicator; the rest exceeded the norm.

## Requirement

Excess body mass appeared more often in men (58.3%) than in women (16.5%) ( $p = 0.0008$ ) (Table 2). Among individuals who had a BMI ≥ 25 kg/m<sup>2</sup>, the percentage of those who consumed calcium in the amount that was equal or exceeded the EAR norm was higher (36.4%) than in the group with a lower BMI (14.8%) ( $p = 0.0234$ ). In the case of the other variables, the authors did not notice any significant correlations with BMI. The authors did not find any significant associations between the variables analysed and the percentage of adipose tissue.

The research results demonstrated significant statistical differences between the levels of total calcium intake by the students, the amount of visceral fat ( $p = 0.0260$ ), the amount of muscle mass ( $p = 0.0070$ ), bone mass ( $p = 0.0040$ ), and the value of BMI ( $p = 0.015$ ) (Table 3). Individuals who consumed more calcium had more visceral fat in comparison to those

**Table 2.** The associations between selected factors, body mass index, and adipose tissue indicators

Variable		BMI < 25 kg/m <sup>2</sup>	BMI ≥ 25 kg/m <sup>2</sup>	P-value	%BF < 25 male, < 35 female	%BF ≥ 25 male, ≥ 35 female	P-value
Sex	Male	5 (41.6%)	7 (58.3%)	<b>0.0008</b>	10 (10.8%)	2 (20%)	0.3864
	Female	76 (83.5%)	15 (16.5%)		83 (89.3%)	8 (80%)	
Place of living	City	36 (44.4%)	9 (40.9%)	0.7668	40 (43.0%)	5 (50%)	0.6719
	Village	45 (55.6%)	13 (59.1%)		53 (57.0%)	5 (50%)	
Economic status	Average	23 (28.4%)	6 (27.3%)	0.9173	26 (28.0%)	3 (30%)	0.8914
	Good and very good	58 (71.6%)	16 (72.7%)		67 (72.0%)	7 (70%)	
Cigarette smoking	No	74 (91.4%)	20 (90.9%)	0.9472	86 (92.5%)	8 (80%)	0.1844
	Yes	7 (8.6%)	2 (9.1%)		7 (7.5%)	2 (20%)	
Calcium supplementation	Yes	10 (12.4%)	1 (4.5%)	0.2935	11 (11.8%)	0 (0%)	0.2498
	No	71 (87.7%)	21 (95.5%)		82 (88.2%)	10 (100%)	
Total calcium intake	≥ EAR	12 (14.8%)	8 (36.4%)	<b>0.0234</b>	19 (20.4%)	1 (10%)	0.4281
	< EAR	69 (85.2%)	14 (63.6%)		74 (79.6%)	9 (90%)	

BMI – body mass index, %BF – body fat percentage, EAR – estimated average requirement,  $p$  – level of significance.

**Table 3.** The association between calcium consumption from daily diet and body composition ( $\bar{x} \pm \text{SD}$ ; Me (95% CI))

Body composition	Total calcium consumption			P-value
	Low (T1) 338.21–510.49 mg/day n = 34	Average (T2) 510.50–671.06 mg/day n = 35	High (T3) 671.06–1905.63 mg/day n = 34	
%BF	24.8 $\pm$ 5.5 24.25 (22.9–26.7)	25.8 $\pm$ 8.4 25.1 (22.9–28.7)	26.7 $\pm$ 5.7 25.65 (24.7–28.7)	0.5000
VFR (level)	1.42 $\pm$ 0.76 <sup>c</sup> 1.0 (1.16–1.69)	2.50 $\pm$ 2.54 1.5 (1.63–3.37)	2.50 $\pm$ 2.03 <sup>c</sup> 1.5 (1.79–3.21)	<b>0.0260</b>
%TBW	55.6 $\pm$ 4.0 55.9 (54.2–56.9)	54.7 $\pm$ 5.7 55.2 (52.8–56.7)	53.9 $\pm$ 3.7 54.85 (52.6–55.2)	0.3200
MM [kg]	39.7 $\pm$ 2.8 <sup>a,c</sup> 39.7 (38.7–40.7)	45.4 $\pm$ 9.1 <sup>a</sup> 43.3 (42.3–48.5)	45.0 $\pm$ 9.7 <sup>c</sup> 41.8 (41.6–48.4)	<b>0.0070</b>
BM [kg]	2.13 $\pm$ 0.15 <sup>a,c</sup> 2.10 (2.08–2.18)	2.42 $\pm$ 0.45 <sup>a</sup> 2.30 (2.27–2.58)	2.40 $\pm$ 0.49 <sup>c</sup> 2.20 (2.23–2.57)	<b>0.0040</b>
BMI [kg/m <sup>2</sup> ]	21.2 $\pm$ 2.6 <sup>a</sup> 21.19 (20.30–22.08)	23.8 $\pm$ 4.6 <sup>a</sup> 22.27 (22.18–25.38)	23.1 $\pm$ 3.7 22.77 (21.86–24.42)	<b>0.0150</b>

%BF – body fat percentage, VFR – visceral fat rating, %TBW – total body water percentage, MM – muscle mass, BM – bone mass, T – tertile, Me – median, CI – confidence interval, BMI – body mass index, <sup>a,b,c</sup>post hoc test results: <sup>a</sup>statistically significant difference between T1 a T2, <sup>b</sup>statistically significant difference between T2 a T3, <sup>c</sup>statistically significant difference between T1 a T3.

with low calcium consumption. The lowest calcium consumption was associated with the lowest muscle mass and bone mass in comparison to persons with average and high calcium consumption. Individuals who demonstrated the lowest calcium consumption had the lowest BMI in comparison to persons with average calcium consumption. The authors did not notice a significant statistical difference between the levels of calcium consumption and the percentage of adipose tissue ( $p = 0.5000$ ), as well as the percentage of body water ( $p = 0.3200$ ).

The analysis carried out did not show a significant statistical difference between the percentage of adipose tissue ( $p = 0.0960$ ), the amount of visceral fat ( $p = 0.3500$ ), the percentage of body water ( $p = 0.1100$ ), muscle mass ( $p = 0.4100$ ), bone mass ( $p = 0.3200$ ), and the value of BMI ( $p = 0.3500$ ), in association with the level of calcium consumption from rennet and cream cheeses in the participants of this study (Table 4). However, it was observed that the individuals with the lowest calcium intake (T1 group) had notably lower adipose tissue in comparison to the other participants of this study.

## Discussion

A well-balanced diet is very important for the functioning of the human body. Limited consumption of dairy products that contain calcium may lead to many complications, including malnutrition or decalcification of bones [20]. A lower level of calcium is also associated with the occurrence of overweight and obesity. Eagan *et al.* demonstrated

in their research that increased calcium intake from dairy products may prevent the build-up of adipose tissue in young, healthy women with normal body mass [21]. Also, Jacqmain *et al.* claim that, among adults, the potential influence of calcium on body mass and the amount of adipose tissue is visible, especially in women [22].

The research carried out by Zemel *et al.* confirmed that body mass, BMI and the amount of body fat were significantly higher in women who consumed less calcium [11]. Research carried out by Heiss *et al.* among post-menopausal women also shows that increased calcium consumption was associated with a low percentage of body fat [23]. There was not an association, however, between calcium consumption and BMI. A similar correlation between increased calcium consumption and lower body mass was presented in the work by Hlavata [24].

The authors found an opposite tendency in their own research. Higher calcium consumption in the students was associated with a higher amount of visceral fat and the value of BMI. It was observed that there were significantly more persons among overweight individuals who consumed the recommended (EAR norm) amount of calcium in comparison to individuals who had a low BMI. A significant statistical correlation between calcium intake and the percentage of body fat was not found. Moreover, the authors found in their own research that low calcium consumption was associated with low bone mass and muscle mass. Similar results of research were presented by Correa-Rodríguez *et al.* [25]. An examination of Spanish men and women demonstrated that a diet low in calcium

**Table 4.** The association between calcium consumption from rennet, cream cheeses, and body composition ( $x \pm SD$ ; Me (95% CI))

Body composition	Calcium consumption from rennet and cream cheese			P-value
	Low (T1) 0.00–23.87 mg/day n = 35	Average (T2) 23.88–81.77 mg/day n = 34	High (T3) 81.78–971.46 mg/day n = 34	
%BF	23.9 $\pm$ 6.0 24.4 (21.8–25.9)	27.3 $\pm$ 7.6 27.15 (24.7–30.0)	26.1 $\pm$ 6.2 24.75 (24.0–28.3)	0.0960
VFR (level)	2.16 $\pm$ 2.39 1.0 (1.34–2.98)	2.04 $\pm$ 1.90 1.0 (1.38–2.71)	2.23 $\pm$ 1.62 1.5 (1.67–2.80)	0.3500
%TBW	56.0 $\pm$ 4.1 56.0 (54.6–57.4)	53.8 $\pm$ 5.2 53.75 (51.9–55.6)	54.4 $\pm$ 4.1 55.1 (52.9–55.8)	0.1100
MM [kg]	43.7 $\pm$ 8.9 41.3 (40.6–46.7)	41.8 $\pm$ 5.6 39.7 (39.8–43.7)	44.7 $\pm$ 9.4 42.2 (41.4–48.0)	0.4100
BM [kg]	2.33 $\pm$ 0.44 2.20 (2.17–2.48)	2.24 $\pm$ 0.29 2.10 (2.13–2.34)	2.39 $\pm$ 0.47 2.30 (2.23–2.56)	0.3200
BMI [kg/m <sup>2</sup> ]	22.5 $\pm$ 4.1 21.64 (21.11–23.90)	22.7 $\pm$ 4.2 21.24 (21.21–24.16)	23.0 $\pm$ 3.3 22.44 (21.79–24.12)	0.5400

%BF – body fat percentage, VFR – visceral fat rating, %TBW – total body water percentage, MM – muscle mass, BM – bone mass, T – tertile, Me – median, CI – confidence interval, BMI – body mass index.

in early adulthood may have a negative influence on bone mass and muscle mass. A positive association between the consumption of dairy products and fat-free mass in men was confirmed by Nezami *et al.* [26]. One may suppose that a higher BMI in individuals who consume more calcium can be associated more with their higher bone mass and muscle mass, not the amount of body fat.

The results of studies of many other researchers also do not confirm the hypothesis that a higher consumption of dairy products is correlated with a lower probability of the occurrence of overweight in adolescents. The results of the meta-analysis carried out by Schwingshackl *et al.* [27] demonstrated that the consumption of dairy products was not positively correlated with the changes in body mass. The only product from that group whose higher intake resulted in a lower risk of obesity and positive changes in body mass or waist circumference was yoghurt. Jones *et al.* carried out research on people who they divided into two groups [28]. The first group consumed products that contained a high amount of dairy and calcium; the second group consumed foods with a low amount of those elements. Results of this study also confirm that a diet rich in calcium was not associated with a higher loss of body mass. Nezami *et al.* [26] actually stated that the consumption of dairy products seems to play a role in developing abdominal obesity, especially in boys. The results of the authors' own research that show a positive correlation between calcium consumption and the amount of visceral fat are in accordance with those observations.

Although the authors did not observe a significant statistical association between the consumption of calcium from rennet and cream cheeses, which are dairy products with the highest amount of fat, and the percentage value of body fat and BMI, it was observed that body fat tends to increase with a higher intake of calcium from these products. It may suggest that among the sources of calcium only low-fat dairy products have a positive influence on body mass and body composition. Similarly, Salehi-Abargouei *et al.* stated that increased dairy consumption without an energy restriction might not lead to a favourable change in weight or body composition [29]. Some products consumed by the researched students may have also contained the addition of sugar and/or high-fructose corn syrup. These ingredients may have been responsible for fat accumulation and elimination of the positive influence of calcium as well. However, the questionnaire applied by us did not allow for a more accurate determination of their content in the analysed products.

While many studies suggest a strong association between calcium consumption, body mass, and the amount of body fat, other researchers point to an inverse correlation between calcium supplementation and the reduction of body mass or adipose tissue [30–32]. The authors did not observe in their own research a significant difference between consuming calcium supplements and BMI or body composition, including the amount of adipose tissue. Similar results were presented by Boon *et al.* [33]. The research carried out on the Dutch population demonstrated a lack of influence of calcium supplementation on body mass or body

composition. The results of the study by Reid *et al.* [34] are no different. The study in which post-menopausal women consumed calcium supplements did not show any significant changes in their body mass. Another randomised, controlled study by Jensen *et al.* noted that 1 g/day of calcium supplementation does not cause changes in body mass [35]. Also, Bowen *et al.* noted in their randomised parallel study of 50 overweight and obese people that an increase of calcium-rich product consumption does not influence the loss of body mass or change in body composition [36]. Phillips *et al.* also showed a lack of association between calcium intake and body composition in non-obese adolescents [37]. Nevertheless, if the supplement was taken in the company of sugary, high-calorie dairy products, it may have impaired the positive impact of calcium. In addition, calcium supplements taken in the company of dairy products are less well absorbed, which may also affect the outcome of the study [38–40].

Socio-economic factors and selected healthy behaviours did not show an association with the BMI value and the amount of body fat in the study group. A higher frequency of the occurrence of excess body mass in men than in women was observed.

## Conclusions

The results of this study do not support the hypothesis that a higher consumption of dairy products is associated with a lower probability of occurrence of excess body mass and adipose tissue. A higher consumption of calcium by the students was connected with a higher amount of visceral fat and a higher BMI, but also with higher muscle mass and bone mass. The tendency to have a lower amount of visceral fat by persons that consume fewer dairy products high in fat may suggest that only low-fat dairy products have a positive influence on body mass and body composition. This issue requires further research.

Excess body mass was more frequently found in men in comparison to women. Socio-economic factors and selected healthy behaviours did not seem to be associated with the value of BMI and the amount of body fat.

The authors recommend promoting healthy dietary patterns among students, including a higher consumption of dairy products, especially low-fat products.

## Conflict of interest

The authors declare no conflict of interest.

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