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ORIGINAL ARTICLE

BONE DENSITY AND IMPLEMENTATION OF RECOMMENDATIONS FOR DAIRY PRODUCTS CONSUMPTION AND PHYSICAL ACTIVITY IN WOMEN: A PILOT STUDY

Ewa Niedźwiedzka[1], *Marta Jeruszka-Bielak*[2], *Magdalena Górnicka*[2]

[1]Department of Human Nutrition, University of Warmia and Mazury in Olsztyn, Poland
[2]Institute of Human Nutrition Sciences, Warsaw University of Life Sciences (SGGW-WULS), Poland

ABSTRACT

Background. Diet and lifestyle are key factors of osteoporosis prevention, and their synergistic interaction can significantly affect the condition of the skeletal system in women.

Objective. The aim of the study was to assess bone density and its relation with the implementation of recommendations regarding the consumption of dairy products and physical activity in young women.

Material and Methods. The study included 27 Caucasian women female participants aged 22-44 years (menstruate, non-menopausal). Dual energy X-ray beam absorptiometry (DEXA – Dual Energy X-Ray Absorptiometry; Lunar Prodigy camera) was used to assess bone density and indices as BMD (Bone Mineral Density), T-score and Z-score at the lumbar spine (L1-L4) and the femoral neck. Dairy intake was determined using the food frequency method for 4 subgroups: milk, fermented dairy drinks, rennet cheese and cottage cheese. The following criteria were used to assess compliance with the recommendations: for dairy intake at least 2 times per day, for physical activity at least 3 times per week.

Results. Recommendations for dairy intake or physical activity were followed by 33% and 74% of the women, respectively, both recommendations were followed by 26% of the women. Women meeting both recommendations had the highest median total BMD of 1.25 g/cm² (Q25-Q75: 1.20-1.34) and T-score of 1.70 (1.20-2.60). In women meeting only one recommendation, total BMD was 1.18 g/cm² (1.13-1.23) and T-score was 1.00 (0.50-1.50). The lowest values were found in women not meeting any of those recommendations, with total BMD of 1.14 g/cm² (1.07-1.19) and T-score of 0.60 (0.10-1.10).

Conclusions. Implementing both recommendations, namely for dairy intake and physical activity seems to be more effective for bone mineral density than following just one recommendation. In contrast, infrequent consumption of dairy products and low physical activity are associated with the risk of reduced bone mineral density in young women.

Keywords: *women, physical activity, osteoporosis, dairy products, bone*

INTRODUCTION

Osteoporosis is a systematic metabolic bone disease characterized by reduced bone density and abnormal bone structure, which leads to an increased risk of fractures [1, 2] Currently, about 32 million people worldwide suffer from osteoporosis, of which 25.5 million are women, who are more vulnerable to this problem due to bone loss after menopause [2]. In Poland in 2022, the number of patients was about 2.1 million, and cases of osteoporosis were more common in women - they accounted for 1.7 million of this group [3]. The increasing prevelance of this disease, especially in developed countries, where the average life expectancy is high, has the serious consequencies not only for affected individuals but also on the health system [2, 4]. In Europe, the annual costs of treatment of osteoporotic fractures are significant and depend on the level of development of national healthcare systems. The highest costs of osteoporotic fractures per person in 2019 were recorded in Switzerland (403 euros) and Denmark (251 euros), while the lowest were in Romania (13 euros) and Poland (18 euros) [2].

The standard method for measuring BMD (Bone Mineral Density) is the DXA (Dual Energy X-ray Absorptiometry) densitometry test. This test enables precise assessment of changes in bone density and identification of people at increased risk of fractures [2, 4]. DXA results enable not only precise diagnosis of the disease, but also an assessment of treatment effectiveness, which is particularly important in preventing further fractures [2, 5]. Currently, diagnostics

Corresponding authors: Ewa Niedźwiedzka, Department of Human Nutrition, University of Warmia and Mazury, Słoneczna 45 f, Olsztyn, Poland; email: ewa.niedzwiedzka@uwm.edu.pl; phone: + 48 502157710

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and therapy for osteoporosis treatment are focused on a detailed assessment of the individual risk of fractures, which also requires collecting information on dietary and non-dietary risk factors for bone fractures [2].

It has been shown that dietary factors for bone factors play an important role in preventing osteoporosis. Adequate dietary calcium intake contributes to increased bone mineral density, especially during periods of intensive growth, such as childhood and adolescence [5]. These periods are crucial for the development of peak bone mass (PBM), nevertheless PBM can be still achieved by the end of the third decade of. Achieving higher BMD is an important preventive factor in the development of osteoporosis later in life, as higher BMD correlates with a lower risk of fractures and bone loss in adulthood. In adulthood, after reaching PBM, the role of dietary factors such as dairy products is less important. Nevertheless, calcium intake is still important, as it contributes to slowing the rate of bone loss, especially in group of older adults and postmenopausal women, in whom the decline in estrogen levels accelerates the process of bone demineralization [5, 6]. Higher BMD values were shown to be associated with normal serum vitamin D levels, which highlights the importance of the synergistic effects of calcium and vitamin D in bone formation [7, 8]. These mechanisms include increased calcium absorption in the gastrointestinal tract, stimulation of bone matrix mineralization, and regulation of bone resorption processes by osteoclasts. Furthermore, vitamin D deficiencies in populations with different levels of dairy product consumption may lead to reduced efficacy of these products in maintaining optimal bone health [9, 10]. In addition, vitamin K_2 plays a crucial role in proper calcium metabolism, osteoblast activation, and prevention of vascular calcification, and thus should also be considered as an important factor in maintaining bone health [11].

Physical activity is an important non-dietary factor in prevention of osteoporosis. According to the World Health Organization (WHO) guidelines, it should include strength and resistance exercises, especially in adults [12]. WHO recommends a minimum of 150 minutes of moderate-intensity physical activity per week, which strengthens the skeletal structure by increasing the mechanical forces acting on bones and stimulating osteogenesis. This mechanism is well explained by Frost's mechanostat theory, which posits that bone tissue adapts its mass and structure to habitual mechanical loading, increasing bone formation in response to higher strains and reducing bone mass when loads are insufficient [13, 14]. Regular physical activity in children, adolescents, and premenopausal women has been shown to improve BMD, particularly at weight-bearing skeletal sites such as the lumbar spine and hip [15]. Evidence consistently indicates that weight-bearing, high-impact, and resistance exercises are the most effective types of activity for maintaining and improving bone health, while sedentary behavior and insufficient activity are major risk factors for bone loss and osteoporosis development [15].

Diet and lifestyle are key factors of osteoporosis prevention, and their synergistic interaction can significantly affect the condition of the skeletal system. It is particular important in the female population, among whom the incidence of osteoporosis is higher than in men. The aim of the study was to assess bone density and its relation with the implementation of recommendations regarding the consumption of dairy products and physical activity in adult females.

MATERIAL AND METHODS

Study participants

Volunteers were recruited from July-August 2023 at the Warsaw University of Life Sciences, Poland. The participants were 27 apparently healthy Caucasian females aged 22-44 years who menstruate before menopause living in a big city. The inclusion criteria were: (1) age 20-50 y; (2) intake of dairy products; (3) no contraindications to DXA testing (recently administered gastrointestinal contrast or radionuclides; pregnancy; scoliosis, which may affect spine measurements; severe degenerative changes or fracture deformity in the measurement area; implants, hardware, devices, or other foreign material in the measurement area; the inability to attain the correct position or remain motionless for the measurement) [16]; (4) menstruating regularly; (5) normal body weight (BMI 18.5-24.99); (6) the lack of endocrine disorders and other disorders that could decrease BMD (e.g.: chronic renal failure, rheumatoid arthritis and other inflammatory arthritides. gastrointestinal malabsorption); (6) consent to participate in the study. The exclusion criteria included: (1) current vitamin D supplementation lasting at least 1 month; (2) using multivitamin preparations; (3) using hormone therapy; (4) using oral glucocorticoids; (5) smoking; (6) regular alcohol consumption (several times a week or every day). This study complied with the ethical guidelines of the Declaration of Helsinki. The study was approved by the Ethics Committee of the Institute of Human Nutrition Sciences, Warsaw University of Life Sciences, Poland (Resolution No. 39/2021), and informed consent was obtained from all participants.

Data

Dairy products intake

A Dietary Habits and Nutrition Beliefs Questionnaire (KomPAN®) [17] was used to assess the frequency of consumption of four dairy subcategories: milk, fermented milk products, cottage cheese, and

other types of cheese. All participants were asked to record their habitual frequency of consumption for each subgroups within the last twelve months according to the following categories: '1 – never or almost never', '2 – 1-3 times per month', '3 – once a week', '4 – several times a week', '5 – once a day', '6 – a few times a day'. According to KomPAN® [17], the consumption frequency of each subcategory was recoded into daily frequency: 0, 0.06, 0.14, 0.5, 1, and 2, respectively for 1., 2., 3., 4., 5., and 6. category. Then, all four daily frequencies were summed up and compared with Polish Food Based Dietary Guidelines [18]. A daily frequency of dairy products consumption equaled 2 or more was considered as meeting the dietary guidelines.

Physical activity

All participants were asked the question: 'How often do you engage in physical activity during the week?', and could choose one out of seven categories: '1 – never or almost never', '2 – once a week', '3 – twice a week', '4 – three times a week', '5 – four times a week', '6 – five times a week', '7 – 6-7 times a week'. The question description indicates that it refers to activity lasting at least 60 minutes of moderate or vigorous intensity. The physical activity undertaken at least 3 times a week was considered as meeting the WHO recommendations for adults [12].

Anthropometrics and bone density

Height (H) was measured with a portable stadiometer with the head in the horizontal Frankfurt plane and recorded with a precision of 0.1 cm (SECA 220, Hamburg, Germany), and weight to the nearest 0.1 kg using electronic scales. Body mass index (BMI) was calculated as weight/height^2 (kg/m^2) and was interpreted according to WHO recommendations [19]. Using dual energy X-ray absorptiometry (DXA) method (a densitometer: GE Lunar Prodigy, software version 1.31), fat content (% and centiles), Visceral Adipose Tissue (VAT), Subcutaneous Adipose Tissue (SAT), and Bone Mineral Density (BMD) at the lumbar spine (L2-4), femoral necks, whole body were measured. The densitometer was calibrated daily, and effective radiation dose for total body scan was 0.5 μSv, for lumbar spine – 0.7, and dual femur – 1.35 μSv [20]. Study participants were instructed not to take calcium supplements for 24 hours before the test, to fast for at least 12 hours, and to wear comfortable, loose-fitting clothing, avoiding metal elements such as zippers. Each woman was asked if there was a possibility of pregnancy. During the measurement of the lumbar spine, it was checked whether it was correctly positioned – the 12th rib and the iliac crest were visible on the image and whether the L4-L5 intervertebral disc was in line with the iliac crest. During the measurement of the femurs, the leg angle was adjusted so that the femoral shaft was in line with the vertical central axis of the image. Among the DXA results, the whole body, hips and lumbar spine BMD were used for further analysis. According to official position of International Society for Clinical Densitometry [21], to determine the occurrence of low bone density in adults younger than age 50, a Z-score of -2.0 or lower is defined as 'below the expected range for age' and a Z-score above -2.0 is 'within the expected range for age.' We also used T-score results, taking into account the WHO international reference standard. The WHO defines T-scores as follows: greater than or equal to -1.0: normal; between -1.0 and -2.5: low bone mass; less than or equal to -2.5: osteoporosis; less than or equal to -2.5 plus fragility fracture: severe osteoporosis [16].

All measurements were performed under strictly standardized conditions (room temperature 22°C, air humidity 45%) by one well-trained researcher (dietitian), using the same device in order to avoid inter-observer and inter-device variability.

Statistical analysis

By combining two classifications, namely meeting the dairy products recommendations (yes/no) and meeting the physical activity recommendations (yes/no), the subjects were finally classified into 3 groups: meeting the both recommendations for dairy products AND physical activity (Dairy AND PA), meeting either dairy OR physically activity recommendations (Dairy OR PA), meeting neither dairy NOR physical activity recommendations (Neither Dairy NOR PA). Categorical data are presented as *n* and percentage (%), while quantitative data are presented as median, lower and upper quartile as well as arithmetic mean and standard deviation. As all quantitative variables were not normally distributed according to the Shapiro-Wilk test, the Kruskal-Wallis test was applied to compare the three groups of women. We also calculated the effect size for the Kruskal-Wallis test (Eta Squared, η^2). For all analysis, the significance level was set at 0.05. The statistical analyses were performed using STATISTICA software (version 13.0 PL; StatSoft Inc., Tulsa, OK, USA; StatSoft, Krakow, Poland).

RESULTS

The mean age of participants was 33.5 ± 6.4 years. On average women consumed dairy products 1.2 times/day, more often as milk and fermented products like yogurts and kefirs, while less often as cottage cheese and other types of cheese (Table 1). On average, they spent 3 hours a week on physical activity lasting at least 60 minutes of moderate or vigorous intenssity.

Both, median and mean values of BMI were in the range of normal weight body, nevertheless the fat content equaled 33% in the whole population, exceeding the reference values for women (Table 2). According to BMI, only 50% of women had normal weight, while 33% had excessive body weight, mostly overweight (Table 3).

Only 33% of women met the recommendations for consuming the dairy products at least twice a day and almost 74% met the recommendations for being physically active for at least 180 minutes a week (Table 3). Meeting both recommendations was found only among 26% of women.

Nutritional status and bone density parameters according to meeting the recommendations for dairy products consumption and/or physical activity are presented in Table 4 and Table 5. For all analyzed variables related to body composition and fat content no significant differences were found among three groups of women (Table 4). None of the woman was at risk of osteoporosis. On the contrary, total BMD and T-score differed significantly in the population (Table 5). Women meeting both recommendations had the highest median total BMD of 1.25 g/cm² (Q25-Q75: 1.20-1.34) and T-score of 1.70 (1.20-2.60). In women meeting only one recommendation, total BMD was 1.18 g/cm² (1.13-1.23) and T-score was 1.00 (0.50-1.50). The lowest values were found in women not meeting any of those recommendations, with total BMD of 1.14 g/cm² (1.07-1.19) and T-score of 0.60 (0.10-1.10). Although for Z-score such significant differences were not detected, a similar tendency as for total BMD and T-score can be observed. Calculated η^2 indicated a large effect size for total BMD (0.31) and T-score (0.31), while medium effect size for Z-score (0.08).

Three women had low bone mass and two of them did not meet any of the recommendations, while the third woman met the recommendations for physical activity but not for dairy products consumption.

Table 1. Characteristic of women according to dairy products consumption [daily frequency] and physical activity [hours/week]

Variable	Me (Q25; Q75)*	X ± SD**
Dairy products in total:	1.20 (0.78; 2.14)	1.52 ± 0.99
Milk	0.50 (0.00; 1.00)	0.48 ± 0.57
Fermented dairy	0.50 (0.14; 0.50)	0.46 ± 0.35
Cottage cheese	0.14 (0.06; 0.50)	0.32 ± 0.41
Other types of cheese	0.14 (0.14; 0.50)	0.26 ± 0.20
Physical activity	3.00 (3.00; 4.00)	3.15 ± 1.75

*Me (Q25; Q75) – median, lower and upper quartile;

**X ± SD – mean and standard deviation.

Table 2. Characteristics of nutritional status of women

Variable	Me (Q25; Q75)*	X ± SD**
BMI [kg/m²]	20.9 (19.3; 26.0)	23.0 ± 4.6
Fat %	33.5 (24.2; 38.6)	32.7 ± 8.3
Fat %, centile	65.0 (28.0; 78.0)	58.0 ± 28.9
VAT	18.0 (6.0; 62.0)	39.8 ± 43.9
SAT	120.0 (57.0; 226.0)	140.2 ± 105.7
BMD Total [g/cm²]	1.19 (1.13; 1.24)	1.19 ± 0.08
T-score	1.10 (0.50; 1.60)	1.11 ± 0.81
Z-score	1.00 (0.60; 1.70)	1.16 ± 0.81

*Me (Q25; Q75) – median, lower and upper quartile;
**X ± SD – arithmetic mean and standard deviation;
VAT – Visceral Adipose Tissue;
SAT – Subcutaneous Adipose Tissue;
BMD – Bone Mineral Density.

Table 3. Characteristics of women according to BMI categories and meeting the recommendations for dairy consumption and physical activity (PA)

Variable	n	%
BMI [kg/m²]		
Underweight (< 18.5)	4	14.8
Normal weight (18.5-24.9)	14	51.8
Overweight (25.0-29.9)	7	25.9
Obesity (≥ 30.0)	2	7.4
Meeting the recommendations for dairy products (yes)	9	33.3
Meeting the recommendations for PA (yes)	20	74.1
Meeting the recommendations for both dairy products and PA (yes)	7	25.9

DISCUSSION

Our study showed that bone mineral density (BMD) was dependent on the combined effect of regular consumption of dairy products (at least twice daily) and compliance with the recommended time of physical activity, which was at least 180 minutes per week. Women meeting only one of these recommendations (regarding dairy consumption or physical activity) were characterized by lower BMD and T-score values. These results are consistent with other studies, which confirmed that higher BMD values depend on several coexisting factors, including physical activity and consumption of milk and dairy products, especially as a good source of highly bioavailable calcium and protein [8, 10, 22, 23, 24].

Adequate intake of calcium, vitamin D and dairy products may contribute to improving peak bone mass in adolescents, counteract bone loss in postmenopausal

Table 4. BMI and body fat according to meeting recommendations for dairy products and physical activity (PA) in women

Variable		Meeting the recommendations			Kruskal-Wallis test p-value
		Yes Dairy AND PA n = 7 (26%)	Yes/No Dairy OR PA n = 16 (59%)	No Neither Dairy NOR PA n = 4 (15%)	
BMI [kg/m^2]	Me (Q25; Q75)*	23.4 (19.7; 29.8)	20.3 (19.1; 25.0)	25.0 (21.6; 27.7)	0.3583
	X ± SD**	24.7 ± 5.4	22.1 ± 4.2	24.7 ± 4.5	
Fat %	Me (Q25; Q75)	36.2 (24.2; 41.3)	31.7 (27.8; 38.2)	35.9 (27.9; 43.4)	0.5776
	X ± SD	34.6 ± 8.7	32.0 ± 7.3	35.7 ± 10.2	
Fat %, centile	Me (Q25; Q75)	77.0 (28.0; 88.0)	63.0 (35.0; 76.0)	75.5 (44.5; 89.5)	0.4291
	X ± SD	65.9 ± 28.2	55.4 ± 26.7	67.0 ± 34.0	
VAT	Me (Q25; Q75)	41.0 (5.0; 47.0)	14.0 (5.0; 62.0)	57.0 (8.5; 117.5)	0.5426
	X ± SD	42.6 ± 46.4	33.7 ± 39.5	63.0 ± 63.9	
SAT	Me (Q25; Q75)	157.0 (57.0; 275.0)	91.0 (58.0; 222.0)	145.0 (89.5; 237.5)	0.5139
	X ± SD	182.6 ± 133.1	182.6 ± 133.1	163.5 ± 120.3	

*Me (Q25; Q75) – median, lower and upper quartile; **X ± SD – mean and standard deviation; VAT – Visceral Adipose Tissue; SAT – Subcutaneous Adipose Tissue.

Table 5. Bone density parameters according to meeting recommendations for dairy products and physical activity in women

Variable		Meeting the recommendations			Kruskal-Wallis test p-value
		Yes Dairy AND PA n = 7	Yes/No Dairy OR PA n = 16	No Neither Dairy NOR PA n = 4	
BMD Total [g/cm^2]	Me (Q25; Q75)*	1.25 (1.20; 1.34)^a	1.18 (1.13; 1.23)^b	1.14 (1.07; 1.19)^b	0.0074
	X ± SD**	1.27 ± 0.07	1.18 ± 0.07	1.13 ± 0.07	
T-score	Me (Q25; Q75)	1.70 (1.20; 2.60)^a	1.00 (0.50; 1.50)^b	0.60 (-0.10; 1.10)^b	0.0073
	X ± SD	1.87 ± 0.66	0.95 ± 0.68	0.50 ± 0.71	
Z-score	Me (Q25; Q75)	1.90 (0.80; 2.20)	1.00 (0.60; 1.60)	0.85 (-0.10; 0.90)	0.1337
	X ± SD	1.67 ± 0.79	1.11 ± 0.67	0.40 ± 0.93	

*Me (Q25; Q75) – median, lower and upper quartile; **X ± SD – arithmetic mean and standard deviation; BMD – Bone Mineral Density; ^{ab} – values not sharing the same superscript are significantly different, $p < 0.05$.

women and reduce the risk of developing osteoporosis in old age [8, 25]. Dairy products, consumed at least twice a day, provide essential nutrients such as calcium, vitamin D and protein, which support the building and regeneration of bone tissue [7, 9, 24, 25]. In addition, dairy products, particularly cheese, also provide vitamin K_2, which plays an important role in calcium metabolism, osteoblast activation, and prevention of vascular calcification, complementing the effects of calcium and vitamin D on bone health [11]. Consumption of dairy products during childhood and adolescence has the most beneficial effect on skeletal health and development [8], while their consumption in adulthood brings moderate benefits [8, 24]. The relationship between a high-protein diet (HPD) and bone health remains a topic of debate. Studies conducted on rats subjected to diets with varying protein content for three weeks have shown that HPD has only a marginal effect on indicators related to bone metabolism. In contrast, other analyses suggest that diets with moderate to high protein content, combined with an appropriate exercise regimen, may lead to an increase in bone mineral density (BMD) and influence cortical bone structure; however, they do not cause significant changes in bone turnover markers in obese rats [26].

In our own studies, it was shown that women most often consumed milk and fermented products, such as natural yogurt and kefir, once a day. The least frequently declared consumption of cottage cheese and other cheeses. Similar results were obtained in studies conducted among Polish women with an average age of 34, living in urban areas [27]. In this group, 30% of women declared daily consumption of milk, 18% of yogurts, 17% of cheeses, and only 7% of buttermilk

and kefir. Fermented milk products are particularly important due to the content of probiotic strains, which can affect bone metabolism regardless of the energy, protein or calcium supplied [23]. Many studies have shown that fermented milk products contributed to a increase in BMD and decreased bone turnover in women of different ages [8, 9]. However, it is worth noting that the level of dairy consumption among Polish women remains lower than recommended in the context of osteoporosis prevention. Studies in Western and Northern European populations report daily dairy consumption among 30-50% of women, with the highest rates in Scandinavian countries and the lowest in Mediterranean regions [8]. Autors of this review also highlighted that regular intake of yogurt and kefir is associated with significantly higher BMD at the lumbar spine and femoral neck and with lower bone resorption markers. Similarly, Rizzoli [9] noted that consuming at least three servings of fermented dairy products per day can reduce the risk of osteoporotic fractures by 20-30% compared to consuming less than one serving per day. In the context of the Polish population, however, the situation appears less favorable. Ratajczak et al. [23] emphasized that the average intake of milk and dairy products among adult Polish women remains below recommended levels for osteoporosis prevention, particularly in postmenopausal women. Kalkwarf et al. [28] also demonstrated in an American cohort that high milk consumption during childhood and adolescence was associated with higher BMD and a lower risk of osteoporotic fractures in adulthood, although intake declined substantially with age, with only about one-third of adult women reporting regular dairy consumption.

Our findings align with this trend of insufficient intake. In our study group, only 33% of women reported consuming dairy products at least twice daily, while in Kozirok's study [27] approximately 42% of Polish women aged 20-49 reported drinking at least one glass of milk daily. These results highlight a significant gap between evidence-based recommendations and actual dietary behaviors, underlining the need for public health efforts to promote regular consumption of fermented dairy products in this population.

Another important aspect is the type of diet used by the study participants and supplementation of the diet with calcium or consumption of products enriched with this ingredient. In recent years, there has been a significant change in lifestyle and diet structure towards a high-sugar, high-fat or high protein diet [25]. A high-sugar diet negatively affects bone mineral balance, which has been confirmed in many studies. In turn, the impact on bones of a vegetarian diet, intermittent fasting or a calorie-restricted diet as a weight loss strategy has not yet been thoroughly studied or is controversial [29]. Promoting a balanced diet can significantly contribute to reducing the occurrence of osteoporosis. A well-balanced diet, healthy eating habits, effective nutrition strategies, and regular physical activity are the foundations of maintaining human health [25], which was also confirmed in a meta-analysis [8]. In adults, no significant differences in BMD were observed between those using calcium-rich foods and those taking calcium-containing dietary supplements. However, dairy products appear to be more beneficial for maintaining or building bone mass than fortified beverages such as sweetened drinks or soy drinks [8]. This superiority of dairy products over supplementation or fortification may be explained by the complex nutrient matrix of dairy, which provides not only calcium but also high-quality protein, phosphorus, bioactive peptides, and fat-soluble vitamins such as vitamin D and K_2, resulting in synergistic effects that cannot be achieved with isolated calcium supplementation alone [8, 11, 25, 29]. Furthermore, calcium from dairy products is better absorbed, and regular dairy intake is associated with improved overall diet quality and adherence to healthy dietary patterns, both of which are beneficial for bone health [25]. A narrative review also highlighted that individuals relying solely on calcium supplementation might not achieve the same reduction in fracture risk as those consuming dairy as part of a balanced diet [29]. These findings underscore the importance of encouraging the consumption of dairy products as part of a comprehensive nutritional strategy for osteoporosis prevention.

Physical activity exceeding 180 minutes per week contributes to improving trabecular microstructure and increasing overall bone density in the hip and other body regions. Regular physical exercise increases BMD and reduces the frequency of falls by increasing muscle mass [30]. In addition, physically active young people have higher levels of lean body mass, which is a strong predictor of bone mass [31]. In turn, BMI affects the mechanical load on bones, which can stimulate their adaptation and strengthening, which is responsible for biomechanical factors. Our own studies have shown that women who met both recommendations regarding physical activity and dairy product consumption had higher BMD values. Study results clearly indicate that the type of physical activity is crucial for bone mass/bone density, and bone mass gains can be optimized through mechanical loading using high-impact exercises such as walking, stair climbing, jogging, Tai Chi, and multi-component exercises that combine different methods (aerobics, strengthening, progressive resistance, balance, and dance) [14]. According to Kopiczko et al. [14] physical activity, especially sports training, specifically exercises such as throwing, is essential for proper bone mineralization in women, and

athletic training after the age of 40 can help eliminate the risk of developing osteoporosis.

Health policy should include comprehensive strategies for the prevention and treatment of osteoporosis in people of all ages. Deepening knowledge about the connections and molecular mechanisms between dietary patterns and bone health may provide a basis for developing more effective dietary strategies that will contribute to improving the health of the skeletal system. Moreover, healthy dietary patterns promoted by parents, guardians, and the school environment, along with encouragement of regular physical activity, play an important role in consolidating the habit of daily consumption of dairy products and an active lifestyle, thus supporting the development of proper health behaviors from an early age.

Strengths and weaknesses of the study

Strengths of the study:

The study demonstrates significant methodological advantages, such as the use of a food frequency questionnaire (FFQ), with particular emphasis on the consumption of milk and dairy products. Additionally, declared physical activity, use of dietary supplements, bone mineral density (BMD) and anthropometric tests were taken into account, which allows for a comprehensive assessment of the relationships between the variables studied. Conducting preliminary pilot studies and detailed analysis of the results allowed for the identification of key areas requiring refinement within the main studies. An advantage is also the age of the women studied, which is the premenopausal period, as there is a lack of studies in this group and the literature data is fragmentary.

Weaknesses of the study:

One of the main weaknesses of the study is the insufficient sample size, which limits the possibility of generalizing the results to a wider population. To increase the homogeneity of the group, prematurity, low birth weight, and childhood rickets should also be added as exclusion criteria in future studies. In addition, the lack of detailed data on the amount and type of dairy products consumer is a significant limitation in the precise analysis of their impact on bone health. There was also a lack of information regarding baseline calcium intake and vitamin D status in the body. In addition, there were no questions regarding the type of diet used, as well as the consumption of dairy products during childhood and adolescence, which are crucial for shaping peak bone mass.

Moreover, in future study, more recommended tools should be used to assess physical activity, as IPAQ, and information on type of physical activity should be collected.

However, as this was a pilot study, the obtained results provided valuable indications as to which elements should be considered and refined in the design of the proper studies.

CONCLUSIONS

Implementing both recommendations, namely for dairy intake and physical activity seems to be more effective for bone mineral density than following just one recommendation. In contrast, infrequent consumption of dairy products and low physical activity are associated with the risk of reduced bone mineral density in young women.

Conflicts of interest

The authors declare no conflict of interest.

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