



POSITIVE IMPACT OF FREQUENT MILK AND DAIRY PRODUCTS CONSUMPTION ON BONE MINERAL DENSITY OF OVER 50-AGED MACEDONIAN WOMEN

*Zora UZUNOSKA¹, Tanja KALEVSKA¹, Viktorija STAMATOVSKA¹, Daniela
NIKOLOVSKA NEDELKOSKA¹, Natalija TRAJCESKA¹, Daniela BELICHOVSKA², Katerina
BELICHOVSKA³

¹"St. Kliment Ohridski" University in Bitola, Faculty of Technology and Technical Sciences - Nutrition, Dimitar
Vlahov bb, 1400 Veles, Republic of Macedonia

²MIT University, Faculty of Environmental Resources Management, blvd. Treta Makedonska Brigada bb, 1000
Skopje, Republic of Macedonia

³" St. Cyril and Methodius University in Skopje, Faculty of Agricultural Sciences and Food, blvd. Aleksandar
Makedonski bb, 1000 Skopje, Republic of Macedonia

zora_51@hotmail.com

*Corresponding author

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Abstract: A segment of our research was focused on examining the impact of the frequency of milk and dairy products' (MDP) consumption on bone mineral density (BMD) of Macedonian female population. BMD was measured by DEXA-densitometer in 210 females at the Public Institution "Borka Taleski" in Prilep and a Questionnaire about their dietary habits was performed. Females were categorized into 3 groups according to MDP consumption: those who consume MDP on a daily base; 3 - 5 times/week; or 1 - 2 times/ week, and those who did not consume MDP were a reference category. Data analysis was performed by multiple regression analysis (R), while the significance was determined by $p < 0.05$. The results indicated that daily consumption of milk and dairy products was most beneficial for BMD of the females, then 3 - 5 times/ week, and the worst impact on BMD was present in females of 1 - 2 times/ week MDP consumption. Females on a daily MDP consumption had in average 0.17 g/cm^2 significantly higher BMD as compared to non consumers. Females of 3 - 5 times / week MDP consumption had an average 0.08 g/cm^2 significantly higher BMD as compared to non consumers. Females of 1 - 2 times/ week MDP consumption had 0.02 g/cm^2 insignificantly lower BMD as compared to non consumers. The results strongly suggest that daily and/or 3 - 5 times/ week MDP consumption had a significant positive effect on BMD of females and can be considered as a natural benefactor in osteoporosis prevention.

Keywords: bone mineral density, milk and dairy products, osteoporosis, female population

1. Introduction

The mode of nutrition is a significant factor of bone mineral density preservation and bone health in humans. Optimal early growth is supported by adequate nutrition which has positive and lasting effects on bone mineralization, such as breast milk in the diet has a vital importance for the child. BMD reflects bone strength through the content of calcium, which is

particularly present in milk and dairy products. Densitometry is a sensitive and specific method by which a healthy bone, osteopenia (mild bone loss, which occurs asymptomatic) or osteoporosis (expressed bone loss, which can cause symptoms and fracture diathesis) can be determined [1-5]. Osteoporosis is defined as a progressive systemic-skeletal disease, characterized by

a disorder of bone mineral microanatomy, low bone mass and mineral density, causing brittle bone fragility and increasing susceptibility to fracture. This disease of today's civilization, with greater incidence in developed western countries occurs more frequently in women after menopause (postmenopausal osteoporosis) and in elderly (senile osteoporosis), but may result in significant morbidity and mortality in men as well [6]. It is estimated that osteoporosis affects over 100 million people worldwide, and 22 million women and 5.5 million men suffer from osteoporosis in the European Union [7].

An individual reaches the peak - maximum of the bone mass (density) about 30 years of age. Furthermore, the rate of bone loss is slowly increasing, while the bone buildup rate decreases. Whether a person will develop reduction of BMD to osteopenia or osteoporosis depends on thickness of the bones in early life, peak BMD, gender, age, lifestyle, nutrition, climatic conditions, etc. [8].

In the wide spectrum of risk factors for osteoporosis, nutritional factors play a significant role and at the same time provide an opportunity for intervention in preventive purposes and / or slowing down the process of bone loss [9 - 11]. Numerous studies have suggested that the consumption of milk and dairy products (cheese, yogurt, and other fermented dairy products) have a significantly positive impact on BMD of adolescents [12], females and males, on BMD of postmenopausal women [13 - 14] and older women [15]. Some studies confirm the positive correlation of calcium intake through MDP consumption and BMD [16 - 17]. Conversely, some studies have not established a correlation between calcium intake through MDP consumption and

bone health [18 - 20].

Osteoporosis, which can lead to disability and fracture diathesis over human's lifetime and to life quality impairment of elderly is in the focus of the scientific interest, in order to identify all possible risk factors for occurrence of osteoporosis and to recommend an adequate preventive measures, especially in the field of nutrition as a variable category, which may have a dual role, to represent a potential risk factor or benefactor.

There are no data investigating the influence of certain type of nutrition on BMD of females in Republic of Macedonia. Therefore, the aim of this study was to investigate the impact of MDP frequency consumption on BMD of the female Macedonian population, i.e. to determine whether the frequent MDP consumption can have a beneficial effect on BMD of females and can be suggested as a nutritional natural factor in osteoporosis prevention and/or in slow down the bone loss.

2. Materials and methods

The investigation was conducted on 210 women who came for examination in Public Health Institution "Borka Taleski" in Prilep. BMD was measured with a densitometer (DEXA), and a Questionnaire about dietary habits was used. Females were categorized into 4 groups by age (40 - 49; 50 - 59; 60 - 69 and over 69 years); and in 4 subgroups according to the manner of consumption of MDP: those who consume daily; 3 - 5 times / week; and 1 - 2 times/ week. Referent category was the group of respondents who did not consume MDP. During the processing of the obtained data, both types of expression of the values of bone mineral density were used, i.e. g/cm^2 and "t-score", statistic analysis and graphic display.

Data analysis was performed by statistical program "Statistica 7.1 for Windows" and "SPSS Statistics 17.0". In the series with numerical marks (age), descriptive statistics was produced (Mean; Std. Deviation; \pm 95.00% CI; Minimum; Maximum). The distribution of data was tested with: Kolmogorov-Smirnov test; Lilliefors test; and Shapiro - Wilks test (p). The relationship between bone mineral density as dependent phenomena and age and the frequency of MDP consumption as independent phenomena has been investigated with multiple regression analysis (R). The significance was determined by $p < 0.05$.

3. Results and discussion

Bone mineral density levels in terms of the frequency of MDP consumption are shown in Table 1. The results show that the percentage of the normal BMD level is higher in females of daily MDP consumption, and of 3 - 5 times/week

consumption as compared to those who consume 1 - 2 times/week or do not consume MDP at all (33.3%; 25% v. 17%; 10%). In addition to the favorable effect of the daily consumption of milk and dairy products, the percentages of severe form of osteoporosis was much lower in everyday MDP consumers as compared to non consumers (6.8% v. 30%).

There are studies suggesting that dairy products, especially those with low fat, did not increase the risk of cardiovascular disease. Rozenberg *et al.* [20], claim that the intake of dairy products, 3 times a day, was solely beneficial for bone health. Another study [21] suggested that consumption of milk and dairy products had a beneficial effect on bone, cardio, metabolic, cognitive and digestive health of the individual. Due to the nutritional profile and the current awareness of MDP benefits, the guidelines of several countries recommend 1 - 3 cups of dairy products per day.

Table 1

BMD levels in terms of frequency of MDP consumption

Frequency of MDP consumption	Bone mineral density									
	Normal level		Osteopenia		Osteoporosis		Severe form of osteoporosis		Total	
Daily	14	33.3%	14	33.3%	12	26.6%	3	6.8%	43	100%
3-5 times/week	14	25%	20	35%	12	20%	12	20%	58	100%
1-2 times/week	14	17%	39	47.6%	14	17.1%	15	18.3%	82	100%
No consumers	3	10%	5	20%	11	40%	8	30%	27	100%

The study of Wadolowska *et al.* [13] suggested that consumption of dairy products in elder women did not lead to significant difference of BMD ($p > 0.05$) when compared to those who did not consume. However, in pre-school girls and adolescents a significantly positive

difference ($p < 0.05$) was obtained.

The results shown on Table 2 relate to the investigated relationship between BMD mg/cm^2 as a dependent phenomena and the frequency of MDP intake (daily & 3 - 5 times/ week & 1 - 2 times/week & non consumers) as independent phenomena.

Table 2

Bone mineral density & frequency of MDP consumption

Frequency of MDP consumption	Beta*	Std. Err. of Beta	B**	Std. Err. of B	t (206)	p- level
Intercept			0.88	0.03	29.08	0.000
Daily	0.40	0.09	0.17	0.04	4.44	0.000
3-5 times/ week	0.20	0.10	0.08	0.04	2.09	0.04
1-2 times /week	-0.05	0.10	-0.02	0.03	-0.47	0.64

Beta*- The correlation between BMD in gr/cm² and MDF consumption

B** - BMD in gr/cm²

In the investigated ratio for $R = 0.42$ and $p < 0.001$ ($p = 0.000$), a medium strong significant correlation was determined. No consumers group was a reference category. The highest influence was present in daily MDP consumers (Beta = 0.40), then 3 - 5 time/ week (Beta = 0.20, while the weakest impact was noted in 1 - 2 times/week consumers (Beta = -0.05). Females on daily MDP consumption had an average of 0.17 g/cm² (B = 0.17) higher BMD compared to no consumers, which was statistically significant $p < 0.001$ ($p = 0.000$). Females on 3 - 5 times/week MDP consumption have an average of 0.08 g/cm² (B = 0.08) significantly higher BMD compared to no consumers, for $p < 0.05$ ($p = 0.04$). However, females on 1 - 2 times/week MDP consumption had an average of 0.02 g/cm² (B = -0.02) insignificantly lower BMD compared to no consumers, for $p > 0.05$ ($p = 0.64$).

These results are in line with the findings of Sato *et al.* [22] suggesting that more frequent milk consumption was associated with lower bone turnover, higher BMD and higher bone micro architecture index in the population of older men with relatively low calcium intake in Japan. Sahni *et al.* [23] proved that the consumption of milk and yoghurt was associated with higher BMD, but not with fractures of the hips.

The tables below show the correlation of

frequency of MDP consumption and BMD of the four age groups of females (aged 40 - 49 50 - 59, 60 - 69 and over 69).

3.1. 40 – 49- aged females

There was no significant difference for $p > 0.05$ ($p = 0.62$) in BMD values in females aged 40 - 49 years in terms of daily MDP consumption, 3 - 5 times/ week, 1 - 2 times/week basis and non consumers (1.14 g/cm² v. 0.97 g/cm² v. 1.07 g/cm² v. 0.97 g/cm²) –Figure 1.

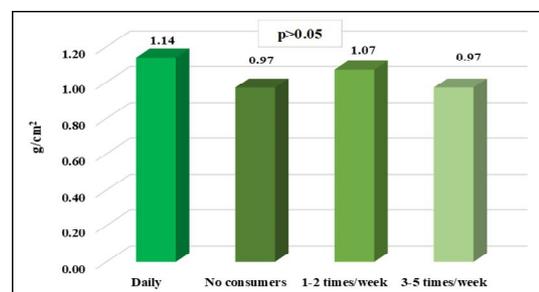


Fig. 1. Consumption of MDP and BMD

In a multiple comparison of p values in respect of BMD of females who consumed MDP on a daily base, 3 - 5 times /week, 1 - 2 times/ week, and non consumers there was no significant difference for $p > 0.05$. The results shown in Table 3 relate to the examined relationship between BMD (g/cm²) as a dependent phenomenon and MDP consumption (daily & 3 - 5 times/

week & 1 - 2 times/week & non consumers) & the age of women as independent phenomenon. In the investigated ratio for $R = 0.81$ and $p > 0.05$ ($p = 0.08$) a strong non-significant correlation was found.

Women who did not consume milk and dairy products were taken as the reference category. A more significant influence on the investigated ratio had the age (Beta = -0.94), than the daily MDP consumption (Beta = 0.76), 1 - 2 times/week consumption (Beta = 0.20), and the worst impact had 3 - 5 times/week MDP consumption (Beta = -0.08). With each increase in the age by one year, BMD decreased for 0.08 g/cm^2 ($B = -0.08$) significantly for $p < 0.05$ ($p = 0.01$) /at constant values of the other parameters.

In this age group, no statistically significant difference of BMD between the subgroups of the examinees in the context of the consumption of MDP, i.e. between the daily consumers, 3 - 5 times/week, 1 - 2times/week consumers, and non consumers was found at constant values of other parameters.

Namely, females who regularly consume MDP had an average of 0.35 g/cm^2 ($B = 0.35$) which was slightly higher BMD for $p > 0.05$ ($p=0.06$) as compared to non consumers. Females of 3 - 5 times/week MDP consumption had an average of 0.04 g/cm^2 ($B = -0.04$) insignificantly lower BMD than no consumers for $p > 0.05$ ($p = 0.78$). Females of 1 - 2 times/week MDP consumption had for 0.11 g/cm^2 ($B = 0.11$) insignificantly higher BMD compared to no consumers, for $p > 0.05$ ($p = 0.48$).

Females 40 - 49 years old are still protected by estrogens, despite of estrogens fluctuations, which have a positive impact on their BMD. These results suggest that other factors, such as

genetics, peak bone mass, physical activity, and climatic conditions have a greater impact on BMD of this age group. Soroko *et al.* [24] suggested that MDP daily consumption of milk in youth and adulthood is associated with improved BMD in older women.

Table 3
BMD/Age & Frequency of MDP consumption

	Beta	Std.Err. of Beta	B	Std. Er r. of B	t (206)	p-level
Intercept			4.40	0.99	4.40	0.003
Age	-0.94	0.29	-0.08	0.02	-3.30	0.01
Daily	0.76	0.35	0.35	0.16	2.19	0.06
3-5 times/week	-0.08	0.29	-0.04	0.12	-0.29	0.78
1-2 times/week	0.20	0.27	0,11	0.15	0.74	0.48

3.2. 50-59-aged females

There was a significant difference for $p < 0.001$ ($p = 0.0002$) in BMD values in this age group of 50 - 59 according to MDP consumption subgroups: on daily basis, 3 - 5 times/week, 1 - 2 times/week and non consumers (1.08 g/cm^2 v. 1.00 g/cm^2 v. 0.88 g/cm^2 v. 0.86 g/cm^2) - Figure 2.

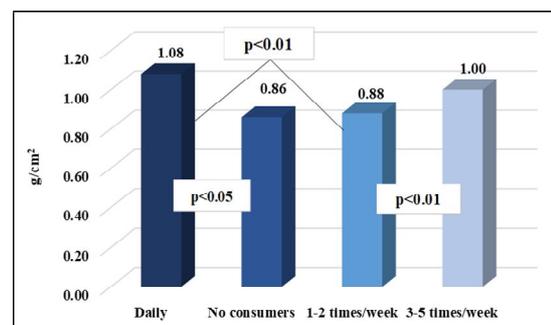


Fig. 2. Consumption of MDP and BMD

Females who regularly consume MDP (Figure 2) had a significantly higher BMD as compared to females of 1 - 2 times/week consumption for $p < 0.01$ ($p = 0.006$); and compared to non consumers for $p < 0.05$ ($p = 0.04$). In addition, women who consume MDP 3 - 5 times/week had a significantly higher BMD than those of 1 - 2 times/week

consumption for $p < 0.01$ ($p=0.005$); but the difference in BMD between 1 - 2 times/week MDP consumers and non consumers was not significant for $p > 0.05$ ($p = 0.08$). This result may be explained by the assumption that non-dairy respondents have a better BMD peak, or a compensated calcium intake through other types of food such as fruits, vegetables and/or a better lifestyle, which suggest further research. There was no significant difference in BMD among women who daily consume MDP and those with 3 - 5 times/week consumption for $p > 0.05$ ($p = 1.00$); between those who consume MDP 3 - 5 times/week and non consumers for $p > 0.05$ ($p = 0.08$); and between subgroups of those who consume MDP products 1 - 2 times/week and non consumers for $p > 0.05$ ($p = 1.00$). The results shown in Table 4 relate to the examined relationship between BMD (g/cm^2) as a dependent phenomenon and MDP consumption (daily & 3 - 5 times/week & 1 - 2 time/week & no consumers) & the age of women as independent occurrences. In the investigated ratio for $R = 0.52$ and $p < 0.001$ ($p = 0.0009$), a mean strong significant correlation was determined. Female non consumers were taken as the reference category. The strongest influence on this ratio had a daily MDP consumption (Beta = 0.48), then 3 - 5 times/week (Beta = 0.41), then 1 - 2 times/week consumption (Beta = 0.06) and the lowest influence had the age (Beta = -0.03).

In the case of unchanged values of other parameters, the following results were obtained. Females of daily MDP consumption had an average of 0.23 g/cm^2 ($B = 0.23$), i.e. significantly higher BMD for $p < 0.01$ ($p = 0.002$) as compared to non consumers. Similar results were obtained in females who consumed MDP 3 - 5 times/week, on average they had 0.14 g/cm^2 ($B = 0.14$) significantly higher BMD

for $p < 0.05$ ($p = 0.02$) compared to non consumers. However, BMD difference was insignificant for $p > 0.05$ ($p = 0.72$) in females who consume 1 - 2 times/week compared to non consumers, they had 0.02 g/cm^2 ($B = 0.02$) higher BMD than non consumers. With each increase in age for a year BMD decreased by approximately 0.002 g/cm^2 ($B = -0.002$), which is insignificant for $p > 0.05$ ($p = 0.7$).

Table 4
BMD / Age & MDP Consumption

	Beta	Std.Err. of Beta	B	Std.Err. of B	t (206)	p-level
Intercept			0.95	0.35	2.71	0.009
Age	-0.03	0,11	-0.002	0.01	-0.27	0.79
Daily	0.48	0.15	0.23	0.07	3.28	0.002
3-5 times/week	0.41	0.17	0.14	0.06	2.42	0.02
1-2 times/week	0.06	0.18	0.02	0.05	0.37	0.72

The results suggest that in postmenopausal period, the frequent MDP consumption has a positive impact on BMD of those females. These results correspond to the research of Young *at al.* [25] and their study of the prevalence of osteoporosis over the level of intake of certain food in postmenopausal Koreans which indicated the beneficial effect of food containing sufficient amounts of calcium such as dairy products, algae, fish, fruits, which support calcium absorption and might prevent osteoporosis later in life.

3.3. 60-69-aged females

There was a significant difference for $p < 0.01$ ($p = 0.004$) of BMD in females aged 60 - 69 years in terms of MDP consumption on daily basis, 3 - 5 times/week, 1 - 2 times/week and non

consumers (1.14 g/cm² v. 0.93 g/cm² v. 0.86 g/cm² v. 0.97 g/cm² respectively). The results are shown in Figure 3.

The results of Figure 3 showed that only women who consumed MDP on a daily basis had significantly higher BMD for $p < 0.05$ ($p = 0.02$) compared to 3 - 5 times/week MDP consumers; and to 1 - 2/week MDP consumers for $p < 0.01$ ($p = 0.007$).

It is interesting to note that females who daily consume MDP did not have a significantly higher BMD for $p > 0.05$ ($p = 0.87$) compared to non consumers. Perhaps the reason for this result is the fact that women who do not consume milk and dairy products meet the needs for calcium through the consumption of fruits, fish and vegetables. Consumption of MDP 3 - 5 times/week, was not associated with a significantly higher BMD, compared to females of 1 - 2 times/week consumption; and to no consumers for $p > 0.05$ ($p = 1.00$). Also, non consumers had insignificantly higher BMD for $p > 0.05$ ($p = 1.00$) compared to those of 1 - 2 times/week.

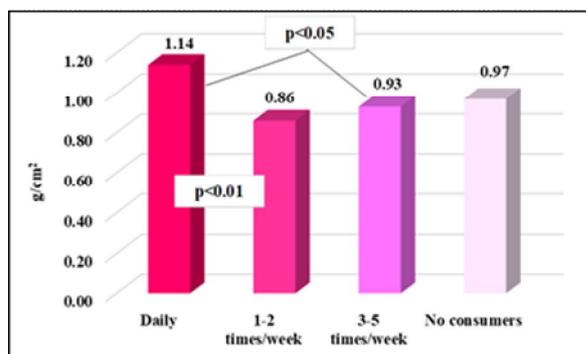


Fig.3. Consumption of MDP and BMD

The results presented in Table 5 refer to the examined relationship between BMD in g/cm² as a dependent phenomenon and frequency of MDP consumption (daily & 3 - 5 times/week & 1 - 2 times/week & no consumers) & the age of women as independent phenomena. The examined

ratio for $R = 0.50$ and $p < 0.01$ ($p = 0.009$) showed a medium strong significant correlation. As a reference category, non consumers were taken into consideration. The highest influence on the ratio had a daily MDP consumption (Beta = 0.39), than 1 - 2 times/week MDP consumption (Beta = -0.19), than 3 - 5 times/week MDP consumption (Beta = -0.07) and the weakest influence had the age of female (Beta = 0.06). At unchanged values of other parameters, females of a daily MDP consumption had an average of 0.18 g/cm² (B = 0.18) higher BMD compared to no consumers, which was insignificant for $p > 0.05$ ($p = 0.12$). 1 - 2 times/week MDP consumers had an average 0.10 g/cm² (B = -0.10) insignificantly lower BMD compared to non consumers for $p > 0.05$ ($p = 0.39$) as well as 3 - 5 times/week MDP consumers had an average of 0.03 g/cm² (B = -0.03) insignificantly lower BMD compared to non consumers for $p > 0.05$ ($p = 0.80$). With each age increase in a year, BMD increased insignificantly by a mean of 0.004 g/cm² ($p = 0.004$), for $p > 0.05$ ($p = 0.68$) / under unchanged values of other parameters.

Table 5.
BMD / Age & MDP consumption

	Beta	Std.Err. of Beta	B	Std.Err. of B	t (206)	p-level
Intercept			0.70	0.66	1.06	0.29
Age	0.06	0.14	0.004	0.010	0.41	0.68
Daily	0.39	0.24	0.18	0.11	1.60	0.12
3-5 times/week	-0.07	0.26	-0.03	0.11	-0.26	0.60
1-2 times/week	-0.19	0.22	-0.10	0.12	-0.86	0.39

3.4. Females over 69 years

There was a significant difference for $p < 0.01$ ($p = 0.004$) of BMD in patients

over 69 years in terms of MDP consumption, daily 3 - 5 times/week, 1 - 2 times/week and non consumers (0.95 g/cm² v. 0.94 g/cm² v. 0.84 g/cm² v. 0.80 g/cm²) - Figure 4. Women over age of 69, who daily consume MDP had significantly higher BMD for $p < 0.05$ ($p = 0.03$) than female non consumers. There was no significant difference in BMD between women of daily MDP consumption and those who consume 3 - 5 times a week – $p > 0.05$ ($p = 1.00$), or 1 - 2 times a week for $p > 0.05$ ($p = 0.06$). Also, there was no significant difference in BMD among women who consume MDP 3 - 5 times/week compared to those who consume 1 - 2 times/week for $p > 0.05$ ($p = 0.17$); and in relation to non consumers for $p > 0.05$ ($p = 0.07$). In addition, no difference was found in BMD between two subgroups of consumers: 1 - 2 /weeks and non consumers for $p > 0.05$ ($p = 1.00$)

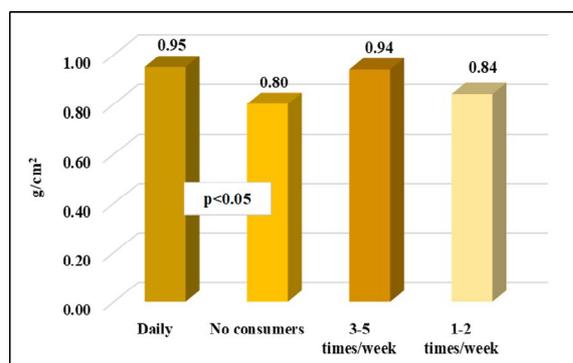


Fig. 4. Consumption of MDP and BMD

The results shown in Table 6 refer to the examined relationship between BMD g/cm² as a dependent phenomenon and frequency of MDP consumption (daily & 3 - 5 times/week & 1 - 2 times/week & non consumers) & the age of women as independent phenomena. In the

investigated ratio for $R = 0.44$ and $p < 0.01$ ($p = 0.002$), a moderately strong correlation was found. As the reference category, female non consumers were taken into account.

The greatest impact on the examined ratio had everyday MDP consumption (Beta = 0.45), than 3 - 5 times week consumption (Beta=0.39), than 1 - 2 times/week MDP consumption (Beta = 0.14) and the weakest impact had the age (Beta = 0.07).

Table 6.
BMD / Age & MDP consumption

	Beta	Std.Err. of Beta	B	Std.Err. of B	t (206)	P-level
Intercept			0.62	0.25	2.44	0.02
Age	0.07	0.10	0.002	0.003	0.70	0.49
Daily	0.45	0.14	0.15	0.05	3.12	0.003
3-5 times/week	0.39	0.14	0.14	0.09	2.86	0.005
1-2 times/week	0.14	0.15	0.04	0.04	0.90	0.37

In the case of unchanged values of other parameters, the following results were obtained: Females who daily consumed MDP had an average of 0.15 g/cm² (B = 0.15) significantly higher BMD for $p < 0.01$ ($p = 0.003$) compared to non consumers. Females who consumed MDP 3 - 5 times/week had an average of 0.14 g/cm² (B = 0.14) significantly higher BMD compared to non consumers for $p < 0.01$ ($p = 0.005$). Females of 1 - 2 times/week MDP consumption had an average of 0.04 g/cm² (B = 0.04) insignificantly higher BMD for $p > 0.05$ ($p = 0.37$), compared to no consumers. With each increase in age for a year, BMD increased insignificantly by an average of 0.002 g/cm² (B = 0.002) for $p > 0.05$ ($p = 0.49$) / under unchanged values of other parameters.

The results from this age group of females over 69, suggested that daily and 3 - 5 times/week MDP consumption had a favorable effect on BMD and can be treated as natural factor in prevention of osteoporosis and in the fight against the dramatic decline of BMD to the fracture threshold.

These results correspond with the epidemiological study of Nguyen *et al.* [26] where 1075 women and 696 men, with an average age of 69 +/- 6 years were studied in order to investigate the relationship of osteoporosis (body mass index) with calcium intake through food and physical activity. The authors concluded that an adequate intake of calcium through food and a physically active lifestyle in the late decades of life can reduce the the risk of osteoporosis and thereby improve the quality and, perhaps, the quantity of life in the elder population. The meta-analysis of 11 studies of measuring BMD, bone mineral content and bone metabolism markers performed by Ma *et al.* [27] suggested that intake of milk, significantly reduced bone loss by inhibiting bone metabolism. Conflicting results were obtained by Tai *et al.* [28] who concluded that increased calcium intake through food, or by calcium supplements can cause a slight non-progressive increase of BMD, which can prevent a significant bone reduction and the risk of fractures.

4. Conclusion

Daily consumption of milk and dairy products has a significant positive impact on the bone mineral density of the female population. However, when the females were categorized into 4 age groups, the results were different. Namely, in women aged 40 - 49 years, BMD values did not associate with the frequency of

consumption of milk and dairy products. At this age, physiological mechanisms are probably able to prevent the occurrence of osteoporosis or other factors than the consumption of milk and dairy products are involved. A particularly beneficial effect on BMD has everyday MDP consumption and 3 - 5 times/week MDP consumption in age groups of women of 50 - 59 and over 69 years, which suggests that the frequent consumption of dairy products is a natural nutrition protective factor which can play a significant role in the prevention of osteoporosis and consequent dramatic loss of BMD to fracture threshold in older women over 50 years of age. Also, the results suggest that women who do not consume milk and dairy products might regulate the intake of calcium by other types of food. Further research is needed to confirm these findings.

5. References

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