

## Review Article

# Is Periodic Abstinence from Dairy Products for Half a Year, Detrimental to Bone Health of Children and Adolescents?

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The question of “What’s the best diet for children and adolescents which ensures their optimum bone health?” has triggered this review study of all nutritional habits including the Christian Orthodox Church’s diet with its particular periods of fasting. In order to evaluate the abstinence from dairy products in childhood and adolescence for more than 180 days per year, we assessed the relative knowledge on vegans and vegetarians in relation to calcium intake. We researched the world-wide published experience as well as studies focused on Christian Orthodox Church’s fasting and its contribution to bone health status in children and teenagers with at least one year follow-up randomized controlled trials. During the last 30 years, more than 120 published studies all over the world dispute the generalization that milk consumption during childhood and adolescence relates to “strong bones”. World-wide research experience on vegans and vegetarians reveals that non-dairy food resources of calcium fortify the bones, ensure their integrity and development and that calcium daily intake, essential for the bone health, and can be gained from foods other than dairy. Abstinence from dairy products in childhood and adolescence for about 180 days per year –as proposed by the Christian Orthodox Church- seems to act as a means to bone integrity and optimal development.

**Keywords:** Milk; Dairy; Children; Adolescents; Fast**Abbreviations**

AF: All Fasting Periods; BMC: Bone Mineral Content; BMD: Bone Mineral Density; CaD: Calcium Intake Diary; COC: Christian Orthodox Church; EAR: Estimated Average Requirement; IOM: Institute of Medicine; NF: Never Fasted; PF: Partially Fasted; RDI: Recommended Daily Intake; s-BAP: Alkaline Phosphatase; s-CTX: C-Terminal Telopeptides Of Type I Collagen; s-OC: Serum Osteocalcin; WHO: World Health Organization.

**Introduction**

Proper nutrition is important for the development and conservation of the bone mass. 80-90% of the Bone Mineral Content (BMC) is formed by calcium and phosphorus [1], along with other important molecules and elements (proteins, magnesium, copper, iron) and vitamins (A, C, D, K) [2].

Milk is broadly consumed because of its high nutritional value. It contains various elements such as bioactive peptides, calcium, and growth factors that interfere to the bone metabolism stages, namely bone turnover [3].

The Estimated Calcium Average Requirement (EAR) for the adolescent ranges between 800 to 1050 mg/day while the Recommended Daily Intake (RDI) is 1000-1300 mg/day; it’s also well understood that EAR as well RDI vary under certain conditions as in pregnancy, lactation, menopause and aging [4].

For more than two decades, USA recommends to children and

adults the intake of calcium for prevention of osteoporosis [1,5-8]. They suggest the dairy servings as the best way for that, depending on age, for 4-8 years old is 3 servings and 9-18 years old, 4 servings daily. Three servings of dairy provide 828 mg calcium and 4 servings 1104 mg Ca [9].

In the USA over 120 food products are calcium-fortified. Therefore taking the recommended portions of dairy daily plus the calcium from non dairy products far exceeds the RDI intake of calcium. It is also amazing that although the dietary intake of calcium ranks first around the world, representing the 72% of global dietary calcium intake [10], osteoporosis and bone fractures rates are high as they range between 700 and 1000 incidents per 100000 population annually [11,12]. Excessive calcium intake has been questioned on its efficacy in preventing osteoporosis and its potentially negative effects in health [13-17].

Recent epidemiological studies in women [18], children and adolescents [19-22], have questioned the efficacy of dairy products and other calcium-containing products for the good health of the bones [23].

World Health Organization (WHO) recommendations for the prevention of osteoporosis highlight the “calcium paradox” and suggest a minimum intake of 400-500 mg/day of calcium from all sources for individuals above 50 who live in countries with high rate of bone fractures [24]. Furthermore, WHO concludes that “there is no chance to globally approximate the calcium intake for the general population”. This statement also includes children and adolescents.

**Table 1:** Fasting of the Christian Orthodox Church (COC) [28-30].

FASTING	DAYS	PERIODS OF FASTING
LENT	41	From a Clean Monday to Saturday of Lazarus
EASTER WEEK	6	From Holy Monday to Saturday
CHRISTMAS	40	From November 15 through December 24
ASSUMPTION	14	From 1 to August 15
HOLY APOSTLES*	0 – 30**	On the next day Sunday of All Saints up to June 28, the eve of the feast of Saints Peter and Paul
DAILY	3	January 5 (Eve of Epiphany) August 29 (the decapitation of John the Baptist) September 14 (Exaltation of the Holy Cross)
EVERY WEDNESDAY AND FRIDAY	55 – 63	All Wednesdays and Fridays of the year, apart from those already in the periods of fasting and absolute or free periods
DAY TOTAL	159 – 197 SD:178 ± 19	

\* So named because it precedes the two apostolic feasts: the Apostles Peter and Paul, June 29 and “Synaxis (Bevy) of the 12 Apostles,” June 30.

\*\* The duration of this fasting period is undefined, because the launch depends on the moveable feast of Easter.

On the other hand, European and UK reports suggest dietary reference intake of calcium through dairy products between 800 and 1300 mg/day for all individuals –USA included- for their whole life [25].

Skeletal health indexes such those of bone growth as well of biological maturity of bony structures can be determined through correlation between Bone Mineral Density (BMD) and/or Bone Mineral Content (BMC) outcomes and calcium intake from milk and dairy products [25]. The Institute of Medicine (IOM) in order to assess the importance of calcium and vitamin D intake determined the optimum Dietary Reference Intake (DRI) [26].

According to Recommended Dietary Allowances (RDA) recommendations, 700 mg of calcium is the optimum daily dosage for children between 1 and 3 years old, whereas 1000mg for those of 4-8 years old. Adolescents need higher calcium levels, no less than 1300mg per day [27].

However, prospective epidemiological studies have raised questions about the effectiveness of the use of dairy products in the promotion of bone health [28]. Over the past two decades an increasing number of studies it has been carried out on religious fasts and their impact on human health [27]. The Christian Orthodox Church (COC) diet proposes entirely different dietary habits that are worth to be mentioned because through alternating time-fixed fasting periods they achieve the optimal balance in an admittedly healthy nutritional pattern: the Mediterranean diet.

COC recommends abstaining from dairy, meat, and eggs for about 180 days per year (159-197, SD: 178±19) and instead of 155 days/year from fish for adults and children (Table 1).

For that reason, it may be considered as periodic vegetarianism although seafood allowed in all fasting periods [31-35].

Low consumption of dairy, meat and egg products leads to reduced intake of saturated fats, while the use of olive oil in large quantities has shown positive effects on the prevention of chronic diseases [36]. In addition, COC fasts as nutritional health-promotive habits [37,38], are still the main characteristics of Mediterranean diet in Greece [39-41]. The objective of this study is to review the existing literature on the effects of consumption of dairy products and total dietary calcium intake on bone integrity in children and adolescents,

primarily to assess whether the evidence supports the following:

(1) Which one of the two nutritional habits promotes the optimum bone growth during childhood and adolescence: a daily consumption of 3-4 servings of dairy products, or a periodic fasting that includes calcium from non-dairy foods?

(2) Does the statement “the recommended servings of dairy products is the optimal choice for promoting bone health and integrity in contrast to other sources of food or supplements containing calcium” seem to be valid?

(3) Has the 180-day abstinence from dairy products per year, as suggested by the COC, negative effects on bone growth in children and adolescents?

## Methods

The MEDLINE, COCHRANE, EMBASE and PUBMED databases were searched. Articles not included in those databases and studies on vegetarian diets as well as studies from the Christian Orthodox Church on fasting were also searched.

Keywords used were: dairy, dairies, dairy products, vegan, fast, fasting, plus bones, Bone Mineral Density (BMD), Bone Mineral Content (BMC), osteoporosis, osteopenia, including only studies and reports to humans, children and teenagers, aging above 3 years-old, published in English language, from 1990 to January 2017.

The research focused on age, sex, and race of the participants and also on the activity level and the pubertal status. Other factors such as socioeconomic status, exposure to the sun or caffeine consumption didn't be taken into consideration.

As changes in BMD develop slowly [42] we focused on trials and studies having at least one-year follow-up.

Finally, our search yielded to 12 cross-sectional studies; 7 longitudinal prospective studies, 3 randomized and one case-control study.

## Results

We studied 22 selected randomized controlled trials of milk and calcium intake for children and adolescents (Table 2).

Kardinaal et al. in cross-sectional study investigated the

**Table 2:** Characteristics of the 22 selected randomized controlled trials of milk and calcium intake for children and adolescents.

Author / year (Study)	No of patients	Ages (years)	Duration	Calcium Intake, mg/day	Milk and Dairy, g/day	Groups	Type of Research	Indices
Kardinaal 1999 [15]	1116 girls and young women / 6 Europe countries	11-15	-	609±282 (Italy) 831±363 (Poland) 881±335 (France) 1134±462 (Netherlands) 1258±594 (Denmark) 1267±550 (Finland)	Not representative for the respective countries.	750 girls (11-15 years of age) 375 young women (20-23 years of age) from Finland, Italy, Denmark, Poland, Netherlands, France	Cross-sectional study	BMC, BMD
Kroger 1993 [19]	65 children and adolescents / Finland	7-20	1 year	<800 - >1200	-	-	Prospective study	BMD
Lloyd 2000 [20]	81 white teenager girls / US	12-18	6 years	500-1500	-	Sports-exercise No sports	Longitudinal study	BMD
Lloyd 2002 [22]	75 white female adolescents / US	12-20	8 years	486 - 1958	-	Exercise, fitness	Longitudinal study	BMD
Kohlenderg-Mueller 2003 [43]	16 young adults / Germany	19-24	10 days	843±140 1322±302	Milk 32%	8 Vegan 8 Lacto vegetarian	Cross-sectional study	Urinary calcium excretion
Ho-Pham 2009 [44]	210 women / Vietnam	50-85	10-72 years vegan diet	375 (330±205) 683 omnivores	-	105 Vegans Buddhist nuns 105 omnivores women	Cross-sectional study	BMD
Budek 2007 [45]	24 boys / Denmark	8	7 days	1000±300 2900±200	1.5 L/day skimmed milk	12 boys, milk group 12 boys, meat group	Cross-sectional study	Bone turnover markers (s-Osteocalcin, s-CTX, s-BAP)
Volek 2003 [46]	28 boys / US	13-17	3 months	1723±274 979±286	236 mL/ serving/d of 1% fluid milk (3 daily servings)	14 boys, milk group 14 boys, juice group	Cross-sectional study	BMC, BMD
Jones 2001 [47]	330 children (215 boys, 115 girls/ Tasmania, Australia)	8	5 years	1336±541	590 mL/d	215 boys 115 girls	Cross-sectional study	BMD, Urinary Potassium and Sodium
Uusi-Rasi 1997 [48]	176 girls / Finland	8-20	7 days	1018±361 (T1) 1059±460 (T2 & T3) 1231±565 (T4 & T5)	7d calcium intake diary (CaD)	Tanner stage 1(T1) pre-pubertal: 9.2±1.1 age Tanner stage 2 & 3 (T2 & T3) per pubertal: 11.8±1.3 age Tanner stage 4 & 5 (T4 & T5) post-pubertal: 15.9±1.8 age	Cross-sectional study	BMC, BMD, BMAD
Yoshii 2007 [49]	4761 children / Japan	15-18	3 years	-	Dairy (milk, cheese, yogurt, cream): daily, 4-5 times, 2-3 times, ≤ 1 time a week	2651 high school girls 2110 high school boys 1252 women	Cross-sectional study	Bone status (Z-score)
VandenBergh 1995 [50]	1359 children / Netherlands	7-11	28 months	-	Boys: 1.3±0.44 Girls: 1.2±0.43	653 boys 706 girls	Cross-sectional study	BMC
Young 1995 [51]	215 female twin pairs / Australia	10-26	-	60% of total dietary calcium is derived from dairy produce and fish.	Premenarchial: 1178±701 Postmenarchial: 1041±674	122 monozygotic (MZ) 93 dizygotic (DZ)	Cross-sectional twin study	BMD, BMC
Cheng 1999 [52]	179 children / China	12-16	3 years	Boys: 722 (beginning of the study)-700.8 (at the last visit) Girls: 560-608.8	-	87 girls 92 boys	Longitudinal study	BMC, BMD
Kristinsson 1994 [53]	162 girls / Iceland	13 and 15	-	1000 - 1200	13 years: 1293±452 15 years: 1082±382	80 girls, 13 years 82 girls, 15 years	Cross-sectional study	BMD, BMC
Petridou 1997 [54]	100 children / Greece	7-14	2 years	-	Assess consumption of the calcium rich dairy products	74 boys 26 girls	Case control study	Fracture
Felily 1992 [55]	581 children / United Kingdom	7-9	2 years (assessed 14 years later)	Men: 1297±397 1323±319 (Control) Women: 933±278 940±317 (Control)	190 ml milk on each school day for 6 terms	197 boys and girls 174 controls	Randomized, controlled trial (RCT)	BMC, BMD
Lehtonen-Veromaa 2002 [56]	171 girls / Finland	9-15	3 years	1575±637	Supplement 10 µg Vit. D <sub>2</sub> + 500 mg Ca per day	66 gymnasts 65 runners 60 nonathletic	Longitudinal study	BMD or BMAD

Welten 1994 [57]	182 children / Netherlands	13	15 years	Boys: 1100-1435 Girls: 941.4-1204	80% of the calcium intake is supplied by dairy products	84 boys 98 girls	Longitudinal study	BMD
Chan GM 1995 [58]	48 white girls / US	11	1 year	Control: 728±321 Dairy: 1437±366	Dairy products weekly (1200 mg Ca)	24 Control group 24 Dairy group	Randomized, controlled trial (RCT)	BMC, BMD
Cadogan 1997 [59]	82 white girls / United Kingdom	12.2	18 months	Control: 703 Milk: 1125	Milk group: 568 mL/d	38 Control 44 Milk	Open Randomized intervention trial	BMD, BMC
Chrysoschoou 2010 [60]	323 boys and 286 girls / Greece	5-15 ½	3 ½ years	1134±28 (TF) 1040±28 (PF) 1090±59 (NF)	451±14 (TF) 383±14 (PF) 427±30 (NF)	Total fastening (TF) 12,1% Partial fastening (PF) 43,3% No fastening (NF)	Cross-sectional study	Growth rate

association between dietary calcium intake and radial bone density among 1116 Caucasian girls (aged 11-15 years) at different levels of calcium intake in six European countries. There was no evidence of a relation between calcium intake and BMD at different levels of intake; although there was a positive association at calcium intake levels <600 mg/day (6.28,  $p=0.02$ ). Nevertheless, the interaction was not significant and there was no consistent trend over intake categories. These results do not support the hypothesis that dietary calcium acts as a determinant of peak BMD in European young women, for a wide range of intake [15].

Kröger et al. studied the effect of puberty and genetic factors on the development of bone mass and density in a prospective study 65 children and adolescents (aged 7-20 years old). They didn't find any significant relationship between the increment rate of bone density and physical activity or calcium intake (<800 - >1200) [19].

Lloyd et al. studied in two longitudinal studies the relation of exercise and BMD on teenage. The first, one (year 2000) was conducted in 81 girls [20] Cumulative sports-exercise scores between ages 12 and 18 years were associated with hip BMD at age of 18 years ( $r = .42$ ) but not related to the total body bone mineral gain. Time-averaged daily calcium intake ranged from 500 to 1500 mg/day in this cohort, was not associated with hip BMD at age 18 years or with total body bone mineral gain at age 12 through 18 years.

The second study (2002) included 75 healthy white female adolescents (aged 12-18 years) sports-exercise scores were correlated with BMD at the femoral neck and shaft. Average total daily calcium intake at age 12-20 years old ranged from 486 to 1958 mg/day and no associations ( $p < 0.05$ ) were observed between bone measurements and calcium intake [22].

Kohlenberg-Mueller et al. in a cross-sectional study focused on the vegan diet in seven women and one man 19 to 24 years old indicating that neither calcium balance nor a single bone turnover biomarker has been significantly affected. Calcium intake levels (843±140 mg,  $p<0.01$ ) were adequate despite the significant difference in calcium intake levels between plant foods and dairy [43].

Ho-Pham's et al. cross-sectional study compared bone health in 105 postmenopausal vegan Mahayana Buddhist nuns and 105 omnivorous postmenopausal women 50-85 years old. Nuns, which had been engaged the vegan diet at mean 33 years (range: 10-72 years), demonstrated on average very low ( $330 \pm 205$  vs.  $682 \pm 417$  mg/day,  $p < 0.001$ ) calcium daily intake. Lumbar Spine BMD was identical in both groups ( $0.74 \pm 0.14$  vs.  $0.77 \pm 0.14$  g/cm<sup>2</sup>; mean  $\pm$  SD;

$p=0.18$ ). Same results in Femoral Neck BMD ( $0.62 \pm 0.11$  vs.  $0.63 \pm 0.11$  g/cm<sup>2</sup>;  $p=0.35$ ) as well as in Body BMD results were  $0.88 \pm 0.11$  vs.  $0.90 \pm 0.12$  g/cm<sup>2</sup>; ( $p=0.31$ ). Prevalence of osteoporosis (T scores  $\leq -2.5$ ) at the femoral neck in vegans and omnivores was 17.1% and 14.3% ( $p=0.57$ ), respectively. Therefore, veganism has no adverse effect on BMD [44].

In a randomized case-control study, milk intake of 1.5 L/day for 7 days was associated with higher calcium intake ( $p<0.0001$ ) but decreased bone turnover in prepubertal 24 boys. Serum osteocalcin (s-OC) and C-terminal telopeptides of type I collagen (s-CTX) were significantly decreased in the milk group (-30.9%; -18.7%, respectively,  $p \leq 0.04$ ) as well as bone-specific alkaline phosphatase (s-BAP) ( $p=0.06$ ) [45].

Another randomized case-control prospective study examined the effects of increased milk consumption on bone (and body) composition in boys engaged with resistance training. Twenty-eight boys (13 to 17 years of age) were randomly assigned to consume, in addition to their habitual diet, 3 servings/day of 1% milk ( $n=14$ ) or fruit juice not fortified with calcium ( $n=14$ ) while followed a 12-week resistance training program. Only the "whole-body BMD" was been affected. The milk group showed two-fold greater increase than the juice group ( $0.028$  vs  $0.014$  g/cm<sup>2</sup>, respectively). Nevertheless, the juice group showed a greater increase at "whole-body BMC", after 12 weeks ( $2,667$ g vs  $2,591$ g respectively,  $p<0.001$ ). BMD and BMC were increased in both groups after six weeks, and there was a further increase at 12<sup>th</sup> week [46].

A cross-sectional study of 330 boys and girls aged 8 years no association was found between children's current calcium intake (1336 mg per day deriving from milk, fruit and vegetable consumption) and BMD. Only potassium and vegetable intakes, were negatively associated with total-body BMD (-0.14 and -0.15, respectively,  $p < 0.05$ ) [47].

A cross-sectional study of 176 Finnish girls aged 8-20 years-old had a seven-day Calcium intake Diary (CaD). Subjects were classified into three groups according to Tanner stage: prepubertal (Tanner 1;  $n=41$ ), peripubertal (Tanner 2 and 3;  $n=54$ ), and postpubertal (Tanner 4 and 5;  $n=81$ ). No association was found between calcium intake and bone activity variables (BMD, BMC, and BMD femoral neck), but the high level of calcium intake in all age groups of the study T1=1018±361mg/d, T3 and T4=1059±460mg/d and T4 and T5=1231±565mg/d was likely to explain the lack of association. Namely, the fact that calcium intake that exceeds a certain level does not further contribute to bone mineralization [48].

A cross-sectional study in Central Japan's community (Mie) study the effects of dairy intake on bone health in a representative population sample of Japanese adult women ( $n = 1252$ , 19-80 years-old), high-school adolescent girls ( $n = 2651$ , 15-18 years-old) and boys ( $n = 2110$ , 15-18 years-old). These groups were examined according to the frequency of weekly milk consumption which was set at 4-5 times, 2-3 times and  $\leq 1$  time a week. Z-score dropped as the frequency of milk intake increased in all women. Specifically, it was 103.4% for once a week intake or less, 102.3% for 2 or 3 times a week, 102.8% for 4 to 5 times a week, and 101.2% for the daily intake. Bone density of the subjects was noticeably lower in the daily intake subgroup than that of the once a week or less, although not statistically significant ( $p < 0.1$ ). This suggests that the bone density of adult women decreases as the frequency of milk intake is increasing. Also, the intake of milk did not affect the bone density of high school girls who avoided physical exercise (Z-score daily 95.3%,  $\leq 1$  time 95.2%, ( $p < 0.1$ )) [49].

The same study included 2110 Japanese boys, study the effect of milk intake on bone density on those abstained from physical activities in comparison to those systematically exercised was similar ( $p < 0.1$ ). For no-exercise boys, Z-score showed a rise proportionally to the milk consumption, although the alteration was not significant (for daily milk intake was 95.9% and for  $\leq 1$  time was 93.3%,  $p < 0.1$ ). In those Japanese boys cheese intake showed that Z-score was lowest in the daily intake group (systematic-exercise boys: daily 99.5% and  $\leq 1$  time 100.4%, no-exercise boys: daily 93.6% and  $\leq 1$  time 94.4%, ( $p < 0.1$ )). Same results for yoghurt in no-exercise high school girls (daily 93.8% and  $\leq 1$  time 95.1%, ( $p < 0.1$ )). Lastly, the cream seems to be beneficial for the bone health of girls without physical activity ( $p = 0.05$ ) [49].

In a cross-sectional study in Netherlands examined the relation between physical activity, calcium intake from dairy products and BMC in 1359 children aged 7 to 11 years. No significant differences (in adjusted mean levels) in bone mineral content were found when "high" and "low" calcium intake groups were compared ("high" and "low" being defined by the upper and lowest decile of calcium intake). No evidence was found for any association between daily calcium intake and BMC in childhood, concluding that increased BMC was only detected in children with a high level of physical activity [50].

The study of 215 female twin pairs (122 monozygotic and 93 dizygotic) aged 10-26 years demonstrated the roles of constitutional and lifestyle factors on bone mass. 60% of total dietary calcium was derived from dairy products. In post-menarchial pairs, the detected difference in daily calcium intake level of intake ( $1041 \pm 674$ g/day) was associated with a univariate fashion with a relevant difference in total body BMC, although the robust estimation was considerably smaller. Across all pairs and after adjusting for menarchial status, height, lean mass, and fat mass, the coefficient for calcium intake became  $0.04 -/+ 0.09\%/100$  mg. There were also found no associations within-pair relatively calcium intake and BMD at the lumbar or femoral sites [51].

In a 3-year prospective study of 179 Hong Kong boys and girls aged 12-13 years at baseline - reported that there was no influence of calcium intake ( $711.8$  mg/day for boys and  $580.8$  mg/day for the girls) on BMD, BMC and bone mineral accretion. During the study period, mean BMC of the dominant forearm increased from 0.61 to 0.75 ( $p$

$< 0.001$ ) in the boys (25%) and from 0.64 to 0.73 ( $p < 0.001$ ) in the girls (12.3%). Similarly, mean BMD of L2-L4 vertebrae was increased for both sexes from 0.63 to 0.77 ( $p < 0.001$ ) in boys (24.2%) and from 0.75 to 0.87 ( $p < 0.001$ ) in girls (14.5%). For girls, a higher age and an advanced pubertal stage at the beginning of the study resulted in a significantly ( $p=0.03$ ) slower rate of increase in BMC of the forearm and BMD of the lumbar spine when compared with those girls with a less advanced pubertal stage at the beginning of the study. Comparing BMC of the forearm and BMD of the lumbar spine among boys and girls, rates of change in boys were significantly higher than those in girls ( $p < 0.01$ ) [52].

In a study of 162 Icelandic Caucasian girls aged 13 and 15, reported a threshold effect intake on BMD of calcium intake  $1293 \pm 452$  mg/d in 13 year age group and  $1082 \pm 382$  mg/d calcium in 15 year age group (the intake of calcium from dairy products was 16.3% higher in younger girls as compared to older); above this, no further effect has been noticed. Univariate analysis showed no significant correlation between calcium intakes from milk and other dairy products and BMD or BMC in either age group [53].

A case-control study investigated for 2 years the relationship between dairy intake and the risk of fractures in 100 children (74 boys and 26 girls, aging 7-14 years old). They concluded that high consumption of cola sodas and noncarbonated beverages (including fruit juices) are positively and significantly associated with the probability of a fracture. On the other hand, consumption of either non-cola carbonated beverages or dairy products is unrelated. The latter is possibly due to misclassification of dairy intake or/and the fact that consumption of dairy products is generally high in adolescence and early adulthood [54].

A cohort of 581 pupils from Wales aged 7-9 investigated for the effect of milk supplement in childhood during growth on adult forearm Bone Mineral Content (BMC) and Bone Mineral Density (BMD) in a 14 years follow-up. They were randomized half of them to receive 190 ml of milk daily (or 228 mg of calcium) at their free school meal, regardless of that at home, on each school day for six terms in comparison to a control group given no milk. The total calcium intake in the two groups was for the Men:  $1297 \pm 397$ ,  $1323 \pm 319$  (Control) and for the Women:  $933 \pm 278$ ,  $940 \pm 317$  (Control). They found that BMD was positively associated with body weight ( $p < 0.01$ ) current intakes of calcium ( $P$  less than 0.05), vitamin D ( $P$  less than 0.01) and sports activity during adolescence; inversely associated with alcohol consumption ( $p < 0.05$ ). In multiple linear regression analysis, body weight and sports activity during adolescence were stronger determinants of female BMD than was diet [55].

In a 3-year prospective study 171 Finnish girls aged 9-15 years were investigated for calcium intake ( $1575 \pm 637$  g/day) and BMD measured every 6 months for 3 years. There's no significant correlation between mean dietary calcium & vitamin D intake and BMD or BMAD at the lumbar spine or femoral neck regarding the overall study population. However, lumbar spine BMD was at 27% ( $0.030$ g/cm<sup>2</sup>) greater in the highest than in the lowest vitamin D intake tertile in the girls with advanced sexual maturation (95% CI: 0.004, 0.056 g/cm<sup>2</sup> -  $p$  for trend for all tertiles = 0.016) [56].

Another 15-year longitudinal study (the "Amsterdam Growth

and Health Study”), examined 84 males and 98 females (aged between 13 and 28). Multiple-regression analyses incorporating Calcium Intake By Body Height (CAIH), Weight-Bearing Activities (WBA), Body Weight (WT) and BMD indicated that calcium intake during adolescence and young adulthood was not a significant predictor of lumbar BMD at the age of 27 years for both sexes (males  $p < 0.01$ , females  $p < 0.001$ ) [57].

The effects of calcium supplementation and dairy products consumption on bone and body composition were studied in 48 of pubertal girls from USA (aged 9 to 13). In this randomized intervention study, the control group consumed their usual diet ( $728 \pm 321$  mg/day calcium) and the dairy group’s diet was supplemented weekly with dairy products to at least 1200 mg calcium daily ( $1437 \pm 366$  mg/day) over a period of 1 year. There were no differences between the two groups during the study as showed by bone mineral values (control group:  $1508 \pm 167$ , dairy group:  $1490 \pm 291$  gm) and lumbar spine bone density data (control:  $0.665 \pm 0.077$ , dairy:  $0.663 \pm 0.096$  gm/cm<sup>2</sup>). At the end of the year, either average lumbar spine bone density (control group:  $0.748 \pm 0.084$ , dairy group:  $0.772 \pm 0.086$ ) or total body bone mineral content (control:  $1617 \pm 152$ , dairy:  $1695 \pm 317$ ) did not differ significantly between groups [58].

Another randomized intervention study, 82 girls of United Kingdom 12 year old girls treated with daily consumption of 568 ml milk for 18 months follow-up. The control group received an average baseline of 150 ml of daily milk. Both groups demonstrated 9.6% increase for total body BMD of milk group (SD 1.9%; 95% confidence interval 9.0% to 10.2%) and control group 8.5% (2.7%; 7.6% to 9.4%);  $p = 0.017$  and total body BMC 27.0% (5.8%; 25.2% to 28.8%) v 24.1% (6.3%; 22.0% to 26.1%);  $p = 0.009$ . Expressed in absolute terms, the respective increases were 0.090 (0.020; 0.084 to 0.096) v 0.081 (0.025; 0.072 to 0.089) g/cm<sup>2</sup> for total body BMD ( $p = 0.021$ ) and 428 (88; 398 to 452) v 391 (107; 358 to 430) g for total body BMC ( $p = 0.035$ ). Short term increases in calcium or dairy food intake in children or adolescents may not be sufficient to sustain an increase in bone mass over several decades [59].

At last, Chrysochoou et al. in a cross-sectional study investigated the relationships between Christian Orthodox Church’s fasting and overall nutrition, growth and physical activity in children and adolescents from northern Greece. Among 609 children between 5 and 15.5 years old, 12.1% of them followed All Fasting periods (AF) without consuming dairy products ( $p = 0.056$ ) during the last 3.5 years and they didn’t demonstrate any significant difference in their height ( $144.0 \pm 1.2$  cm) in comparison to those that Partially Fasted (PF) ( $145.0 \pm 0.6$  cm) or to the Never Fasted (NF) ( $145.1 \pm 0.6$ ) ( $p = 0.730$ ). These children (NF) were found to have significantly higher calcium intake than full-fasted ones (1.151 versus 1.037 mg, respectively,  $p = 0.017$ ) [60].

## Discussion

This study summarizes the published data on calcium balance regarding different types of dietary patterns. On the other hand, it presents the current knowledge on Orthodox Christian Church’s diet as she combines features of other diets in proper timing as well as in a balanced combination of food ingredients.

Benefits from Calcium consumption are well-established

regardless the source. Calcium intake - as the apparent rate of calcium absorption - doesn’t significantly differ between vegan (26%) and lactovegetarian (24%) diet [43]. These rates are consistent with other studies on calcium balance that carried out with different kinds of non-vegetarian diet: 15% -36% [61], 27% [62], 16% -21% [63], 23%-31% [64] and 16% -24% [65].

The controversy about calcium’s impact on musculoskeletal metabolism and more specifically on bone density shows significant interest. Studies on dairy-free vegetarian diets showed no (statistically significant) difference in BMD or in the degree of bone loss [66].

On the other side, the “Rotterdam study” points that fruit, vegetable, and dairy pattern with 135gr more milk as well as 29gr more yogurt, is responsible for high BMD, bending strength and more stable bones and hence for reduced osteoporotic fracture risk [HR (95% CI): 0.92 (0.89 - 0.96)] and hip fracture [HR (95% CI): 0.81 (0.70 - 0.93)] in women at the age of 55 [67].

Finally, others support that bone density and risk of bone fractures were found to be similar in omnivores and lacto-vegetarians [68,69].

The amount of calcium uptake is inversely related to the risk of fractures. Indeed sub-Saharan people with around 200 mg calcium daily consumption, they present lower bone fragility than those with double intake levels (i.e. Hong Kong, Singapore and Papua New Guinea) and even more than people who exceed 1000 mg (Norway, Sweden, Denmark, USA, UK, Ireland, New Zealand, Finland, etc.). Reasons for the wide geographic variation of fracture incidence still remain unknown [70] while causality can be found in high animal-derived protein intake, low vegetable and fruit intake, and low physical activity. The negative effect of menopause onto the musculoskeletal metabolism logically it should be accompanied by corresponding changes in bone density, though this has not yet been confirmed in populations where the daily calcium intake is significantly limited about 375 mg on average per day [44].

Even calcium and vitamin D3 daily intake for vegans is 55% and 63% respectively of those of omnivores; this doesn’t adversely affect bone density or the frequency of fractures. In contrast, the higher intake of animal protein and lipids is associated with more bone loss than that of vegans [66].

On the daily milk consumption or calcium supplements during childhood and adolescence, some studies support that dietary or supplementary calcium does not affect spine & hip bone density [15,17-19,21,22,25,44,45,48,50,52,53,55,56,71-92] or bone turnover [45], even when the daily consumption of calcium exceeds 1000 mg [48,53,90].

Others studies advocate the opposite; total body BMC/BMD increase range from small [93] to significant [46,59,76,85,94-97], also they lack sufficient information about that beneficial effect.

Having on mind that the ideal vitamin D intake levels for the children and adolescents are 400-600 IU/day, alterations on its quantity as well as on that of other nutrients (such retinol) along with exercise habits could alter the effects of milk on BMD [18,87,89,98,99].

High intakes of calcium (>1400 mg/day) in women are associated with higher death rates from all causes and cardiovascular disease

[100]. Indeed, higher milk intake was associated with higher mortality as disclosed by cohort studies in both sexes with higher fracture incidence in women [101]. Moreover, there's a link between habitual consumption of milk & dairy products with increasing risk for prostate cancer [102-104].

Apart from all the above reported on calcium equilibrium and its interactions, non-animal sources of calcium such beverages from soy or rice, cereals, and fruit juices are of great biological and nutritional importance [105].

The content of oxalates or fibers (phytate/dietary) seems to be associated with low calcium intake [106-109]. Indeed, high oxalates in spinach and rhubarb show 5% [110] and 9% [111] absorption rates respectively, while other plant foods demonstrate higher: 41% for cabbage [112], 22% for beans [113] or 52% for Chinese cabbage and 48% for broccoli [114].

Regardless of vegan or lactovegetarian diet, calcium equilibrium isn't affected despite foods with high oxalates (spinach, beets), fiber-rich (whole grain bread, oats) or the calcium-rich mineral water [43]. Nevertheless, adequate calcium amounts in humans can be also achieved at intake levels far below the recommended [115-118].

Over and above, calcium bioavailability is of importance. In mineral water and milk is almost the same no matter the content [119-120] as a single dose of 172mg/l mineral water's calcium inhibits PTH secretion and bone resorption [121]. Higher bioavailability was observed in low-oxalate vegetables as broccoli, kale, cabbage and collards unlike in nuts, dried beans, and spinach [122,123].

Regular weight-bearing exercise and at least a normal age-related body weight in adolescence and young adulthood are of key importance in reaching the highest lumbar peak bone mass at the age of 27 years, regardless calcium intake [57], protein consumption or vitamin D levels [58].

Alternative nutritional lifestyles such as vegetarianism are popular the trend for any age group. An increasing rate of 2-5% of European adult population adopts a vegetarian eating pattern [124]. Concerns about global warming and sustainable food production as well as economic concerns are important incentives for someone to become vegetarian [105,125,126]. Most of them are young parents who introduce their children to vegan diet [105]. Moreover, vegan teenagers live in an otherwise omnivorous family [127]; published data (even limited) report no significant effect of vegan or vegetarian diet in growth during adolescence [128].

Among these various diets and under the general acceptance of the healthy eating habits that they introduce, Christian Orthodox Church (COC) diet introduces the "rationale of measure" instead of a complete abstinence from certain kind of foods. Fish is less frequently recommended while dairy and meat products are not allowed.

These fasting periods are well-defined and applied every year. Before long periods of fasting, such the 48-day long Lent, free consumption of all kind of food for three weeks is allowed. At the third week, only dairy products and fish (except meat) are allowed. During the week that follows the end of Lent (Easter Week) and the first 12 days after the Christmas fasting (The Twelve days) any kind of food is allowed to be consummated (Table 1) [28-30].

Papadaki et al. studied data on calcium intake alterations during one week of Lent. A double portion of all foods and drinks were chemically analyzed. Mean daily calcium intake was 533mg all from non-dairy products. Same chemical analysis for the non-fasting week after Easter reported 966mg/day [129].

A study conducted in children who fast, show a lower than the recommended daily intake of vitamin E and magnesium, but not for calcium and other minerals or trace elements which did not differ significantly between fasters (partially or completely) and non-fasters. These latter are ranked higher in daily energy intake, as they consume larger amounts of animal proteins and/or saturated fatty acids [6].

## Conclusion

Overall balance and bioavailability of calcium are not significantly affected by the type of diet followed by children and adolescents. Christian Orthodox Church diet with its fasting may have a favorable effect on health as it provides adequate nutrition coverage as well as protection against numerous chronic diseases. In fact, periodic abstinence since childhood from dairy products meat and eggs tends to reduce the risk for future osteoporosis as it positively affects the bone mass density.

Far away from permanent food deprivations, which are not secondary to medical directives, one can argue that COC fasting is an integrated nutritional opportunity for a healthy lifestyle.

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