The relationship between dairy intake, body composition, physical activity, and bone health among pre-pubertal children

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ABSTRACT

Objective: To examine the effects of dairy intake, body composition parameters, and physical activity on the bone mineral status of pre-pubertal children.

Study design: This was a cross-sectional study of 45 healthy pre-pubertal children aged 5-10 years. Total headless bone mineral content (tBMC), total headless bone mineral density (tBMD), lumbar spine bone mineral content (LS-BMC), and lumbar spine bone mineral density (LS-BMD) were measured with dual energy x-ray absorptiometry (DEXA). Dietary calcium intake was assessed using a food frequency questionnaire (FFQ) and a 3-day estimated food record. Anthropometric data was collected and a previous day physical activity recall (PDPAR) was used to measure the physical activity as metabolic equivalents of task (METs) and energy expenditure (EE). The FFQ was also validated against the 3-day estimated food record.

Results: The average daily serves of dairy consumed by children were above the recommended levels. Similarly the FFQ analysis also showed mean calcium intake of the sample to be higher than the recommended dietary intake (RDI) level. Boys had significantly higher lean body mass (LBM) than girls ($p < 0.02$). Girls on the other hand had significantly higher percent body fat (%BF) compared to boys ($p<0.0005$). Multiple linear regression analyses for the population sample showed no significant association was present between calcium or dairy intake and any bone parameters. Furthermore, calcium/dairy intake was also not significantly related to body composition, physical activity, and anthropometric variables. tBMC and tBMD did show a positive significant relationship with LBM and TFM but an inverse significant association with %BF. Average EE showed a significantly positive relationship with tBMD only. Whereas, METs were a negative significant predictor of only %BF. Validation of the FFQ showed that it overestimated daily calcium intake.

Conclusions: Calcium or dairy intakes were not significantly associated with bone health status. LBM, TFM, and %BF are important significant predictors of children's bone health. And finally, physical activity has beneficial effects upon the bone health and body fat.

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List of Abbreviations used:

%BF	Percent body fat
$1,25(OH)_2D_3$	1α,25- dihydroxyvitamin D_3
AI	Adequate intake
BMC	Bone mineral content
BMD	Bone mineral density
BMDC	Bone mineral density childhood study
BMI	Body mass index
BMP	Bone morphogenic protein
BMU	Bone multicellular unit
BRC	Bone remodelling cycle
cAMP	cyclic adenosine monophosphate
CB	Calbindin
CDC	Centres for Disease Control and Prevention
CLA	Conjugated linoleic acid
cm	Centimetre
CMPA	Cow's milk protein allergy
CT	Calcitonin
CTR	Calcitonin receptor
DEXA	Dual energy x-ray absorptiometry
DLX5	Distal-less homeobox 5
EAR	Estimated average requirement
EE	Energy expenditure
EGF	Epidermal growth factor
EPG	Epiphyseal growth plate
F	Females
FAO	Food and agriculture organization
FFQ	Food frequency questionnaire
FFSS	Fluid flow sheer stress
FGF	Fibroblast growth factor
FGFR-3	Fibroblast growth factor receptor-3
FSANZ	Food standards Australia & New Zealand
GC	Glucocorticoid
GF	Growth Factor
GH	Growth hormone
GHD	Growth hormone deficiency
GHRH	Growth hormone releasing hormone
HCl	Hydrochloric acid
IFN	Interferon
Ig-E	Immunoglobulin E
IGF-1	Insulin like growth factor-1
IL	Interleukin
IQR	Interquartile range
IU	International unit
kg	Kilogram
LBM	Lean body mass

LI	Lactose intolerance
LS-BMC	Lumbar spine bone mineral content
LS-BMD	Lumbar spine bone mineral density
M	Males
M-CSF	Macrophage colony stimulating factor
MET	Metabolic equivalent of task
mg	Milligram
MOH	Ministry of health
MRI	Magnetic resonance imaging
MSC	Mesenchymal stem cell
MSX2	msh homeobox homologue 2
MT1-MMP	molecule membrane type-1 matrix metalloproteinase
N	Number
NCN survey	National children's nutrition survey
NCP	Non collagenous protein
NCX	Na^{+}-Ca^{2+} pump
NHMRC	National health and medical research council
NO	Nitric oxide
NRV	Nutrient reference value
NZEO	New Zealand European origin
OPG	Osteoprotegerin
OSx	Osterix
PAL	Physical activity level
PAQ	Physical activity questionnaire
PBM	Peak bone mass
PDGF	Platelet derived growth factor
PDPAR	Previous day physical activity recall
PEM	Protein energy malnutrition
PGE2	Prostaglandin E-2
PMCA	Ca-ATPase pump
pQCT	Peripheral computed tomography
PTH	Parathyroid hormone
PTHrP	Parathyroid hormone receptor protein
QUS	Quantitative ultrasound
RANK	Receptor activator of nuclear factor-kB
RANK-L	Receptor activator of nuclear factor-kB ligand
RCT	Randomised controlled trial
RDA	Recommended dietary allowance
RDI	Recommended dietary intake
Runx2	Runt-related transcription factor 2
S1P	sphingolipid 1-phosphate
SAS	Statistical analysis system
SD	Standard deviation
SOST	Seclerostin
Spns2	Spinster Homologue 2
SPSS	Statistical package for social sciences
T_3	3,5,3'-L-triiodothyronine
T_4	Thyroxine

TFM	Total fat mass
TGF-β	Transforming growth factor β
TH	Thyroid hormone
TNF-α	Tumour necrosis factor α
TNF-β	Tumour necrosis factor β
TSH	Thyroid stimulating hormone
ug	Microgram
UK	United kingdom
UL	Upper level of intake
US	United states
VDR	Vitamin D receptor
VDRE	Vitamin D responsive element
VIF	Variation inflation factor
WBPA	Weight bearing physical activity
WC	Waist circumference
WHO	World health organization