doi:10.1017/S1368980020005224

Short Communication

Relationship between protein intake and bone architecture or bone mineral density among dynapenic-obese older adults

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Submitted 16 August 2020: Final revision received 17 November 2020: Accepted 16 December 2020

Abstract

Objective: The current study aimed to assess the relationship between protein intake and bone parameters among dynapenic-obese older adults.

Design: The current study is a secondary analysis with an *a posteriori* and exploratory design.

Setting: Subjects were recruited from the community via social communication (flyers and meetings in community centres) in the Great Montreal area.

Participants: Twenty-six subjects were divided *a posteriori* into two groups according to their usual protein intake: PROT−: < 1 g/kg per d (*n* 13; women: 53·8 %; 66·5 (SD 3·3) years) and PROT+: > 1·2 g/kg per d (*n* 13; women: 61·5 %; 67·2 (SD 2·7) years).

Results: Both groups were comparable for age (PROT−: 66·5 (SD 3·3) *v.* PROT+: 67·2 (SD 2·7) years, $P = 0·61$) and gender (women: PROT−: *n* 7; 53·8 % *v.* PROT+: *n* 8; 61·5 %, $P = 0·69$). The PROT− group had a higher marrow area ($P = 0·049$), a greater bone compressive strength ($P = 0·048$) and a larger total bone area ($P = 0·045$) than the PROT+ group. However, no significant difference between the two groups was observed regarding body composition (fat and lean masses) or muscle composition.

Conclusions: A lower protein intake seems to be associated with bone sizes, which influence bone strength, but do not influence bone density among dynapenic-obese older people.

Keywords
Bone density
Bone architecture
Dynapenia
Obesity
Ageing
Protein intake

Loss of bone mineral density (BMD) increases the risk for fractures, falls, limitation of mobility and disabilities[1]. Some authors suggest that bone architecture is a better predictor of fractures and falls than BMD[2]. There are also striking relationships between loss of muscle mass (sarcopenia) or strength (dynapenia) and osteoporosis, leading to similar health consequences (falls and fracture)[3]. However, the impact of obesity on bone parameters is still controversial[4]. Effectively, studies indicate that the positive effects of body weight on BMD cannot counteract the detrimental effects of obesity on bone parameters[4]. Nutrition and more specifically sufficient protein intake is also necessary for the growth, maintenance and proper functioning of the musculoskeletal system with age[5]. Therefore, we aimed to assess the influence of protein intake on BMD and bone architecture among dynapenic-obese older adults. Based on previous research conducted in other populations (e.g., people with/without chronic kidney disease[6]) we hypothesised that higher protein intake led to higher BMD and better bone architecture in this specific population.

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Methods

Study design and population

The current study is a secondary analysis from a double blinded randomised trial[7], with an *a posteriori* and exploratory design. A sample of twenty-six older adults (≥ 60 years), obese (fat (%): men > 25; women: > 35) and dynapenic (grip strength/body weight: men < 0·61; women < 0·44 kg/kg), with no cognitive impairment (MoCA > 26) were enrolled in the main study and divided *a posteriori* into two groups according to their initial protein intake: PROT−: < 1 g/kg per d (*n* 13) and PROT+: > 1·2 g/kg per d (*n* 13). Baseline data were used to perform this secondary analysis.

Measurements

The following measurements were performed and described in detail by Buckinx *et al.*[7].

Lifestyle habits data

Dietary intake (using the 3-d food dairy method)[8] and the number of steps (7 d; using the SenseWear® Mini Armband tri-axial accelerometer)[9] were recorded.

Body composition

BMI (body mass (kg)/height (m^2)), waist circumference (cm) and body composition (total, gynoid, android, legs and arms fat masses; total, legs, arms and appendicular lean masses; total, hip and spine bone density; *T*-score) using dual-energy X-ray absorptiometry (GE Prodigy Lunar) were measured.

Muscle composition and bone architecture composition

Muscle composition (area, fat content) and bone architecture (not only total, cortical, trabecular and marrow area or density but also bone compressive strength, torsion strength and bending strength) were assessed using a high resolution peripheral quantitative computed tomography (Stratec XCT3000). For muscle area, density and subcutaneous fat area, precision errors ranges are reported to be between 2·1 and 3·7, 0·7 and 1·9 %, and 2·4 and 6·4 %, respectively and for MAT area, the less accurate measure, varying from 3 to 42 %[10].

Muscle strength and muscle power

Maximum voluntary upper limb muscle strength using a Lafayette© hand dynamometer[9], maximal isometric lower limb muscle strength using a strain gauge system attached to a chair[11] and lower limb muscle power (N) using the Nottingham Leg Extensor Power rig© were measured[12]. Muscle strength was expressed in absolute (kg) and relative (/body weight).

Functional and aerobic capacities

The 3-m Timed Up & Go (walking speed; m/s)[13], unipedal balance test (60 s; s)[14], chair stand[15] and step tests[16] (lower-body function) were used to capture the functional capacities. Mobility and aerobic capacities were assessed using the 6-min walking test[17].

Statistical analysis

Data were presented as median and percentiles (P25–P75). An independent *t* test or non-parametric Mann–Whitney test was used, when appropriate, to identify between-group baseline differences. The χ^2 test or Fisher test was used to compare frequency of observations between groups. All statistical analyses were performed using SPSS 25.0 ($P < 0·05$: significant).

Results

Participants

Both groups were comparable for age (PROT−: 67 (66–68) *v.* PROT+: 67 (66–68) years, $P = 0·61$), gender (women: PROT−: *n* 7; 53·8 % *v.* PROT+: *n* 8; 61·5 %, $P = 0·69$) and MoCA score (PROT−: 28 (27–29) *v.* PROT−: 28 (28–29), $P = 0·79$).

By design, protein intake was significantly lower in the PROT− group than in the PROT+ group (0·78 (0·76–0·86) *v.* 1·42 (1·31–1·53) g/kg per d; $P < 0·001$) but also lipids (57·2 (49·0–77·9) *v.* 90·5 (77·2–95·1) g/d; $P < 0·003$). Carbohydrates, Ca and vitamin D were similar between groups. Physical activity level was comparable and both groups were sedentary (number of steps < 7500).

Body composition and muscle composition

No significant difference between the two groups was observed regarding body composition (fat and lean masses) or muscle composition (Table 1).

Bone architecture and density

As shown in Fig. 1, marrow area was greater in PROT− than in PROT+ (155 (114–159) *v.* 100 (65·3–119) mm^2; $P = 0·049$). Bone compressive strength was significantly stronger in the PROT− group than in the PROT+ group (3090 (2709–3496) *v.* 2666 (2207–2936) mm^2; $P = 0·048$). The PROT− group displayed a higher total bone area compared with the PROT+ group (626 (574–688) *v.* 568 (501–615) mm^2; $P = 0·045$). No other difference in bone architecture or bone density was found.

Muscle strength and power

Absolute and relative muscle strength and muscle power were comparable between the two groups (Table 1).

Functional and aerobic capacities

No difference between groups was found for functional and aerobic capacities (Table 1).

Table 1 Body profile, body composition, bone parameters (assessed by DXA), muscle composition (assessed by pQCT), bone architecture (assessed by pQCT) and muscle strength and power of the participants, according to the groups*,†

	PROT– (*n* 13)		PROT+ (*n* 13)		
Variables	Median	Percentiles (P25–P75)	Median	Percentiles (P25–P75)	*P*
Body profile and body composition					
BMI (kg/m)	32·5	29·2 to 32·9	29·2	27·6 to 31·2	0·13
Waist circumference (cm)	108	101·5 to 114·5	102	95·7 to 108·5	0·09
Total fat mass (%)	40·8	39·4 to 45·1	39·9	36·5 to 40·8	0·25
Legs fat mass (%)	39·7	31·5 to 47·2	40·4	33·3 to 43·6	0·96
Android fat mass (%)	50·9	48·3 to 54·5	49·2	42·7 to 23·1	0·17
Total lean mass (kg)	45·9	40·9 to 52·7	43·7	36·2 to 50·6	0·43
Legs lean mass (kg)	16·1	14·5 to 18·7	15·2	13·3 to 18·1	0·52
Appendicular lean mass (kg)	21·3	16·9 to 25·3	20·3	18·8 to 25·1	0·63
Bone parameters					
Total BMD (g/cm)	1·15	1·11 to 1·29	1·16	1·03 to 1·28	0·72
T-score total (%)	–0·1	0·8 to 1·4	–0·15	–1·2 to 0·7	0·72
Non-osteopenic prevalence					1·00
%	85		85		
n	11		11		
Hip bone density (g/cm)	1·07	0·93 to 1·15	0·94	0·79 to 1·11	0·15
T-score hip (%)	0	–0·6 to 0·5	–0·4	–1·9 to –0·1	0·18
Non-osteopenic prevalence					0·66
%	77		69		
n	10		9		
Spine bone density (g/cm)	1·16	0·98 to 1·28	1	0·89 to 1·19	0·33
T-score spine (%)	–0·2	–1·4 to 0·9	–1·7	–2·5 to 0·2	0·29
Non-osteopenic prevalence					0·69
%	69		54		
n	9		7		
Muscle composition					
Total muscle area (cm^2)	105·9	90·6 to 120·6	94·5	71·4 to 114·4	0·52
Total fat area (cm^2)	101·7	69·9 to 120·2	90·2	64·9 to 104·2	0·70
Subcutaneous fat area (cm^2)	75·3	63·7 to 110·6	84·6	58·9 to 98·8	0·94
Intra-muscular fat area (cm^2)	5·55	3·48 to 7·74	5·24	4·02 to 6·78	0·94
Bone architecture					
Cortical area (mm^2)	383	363 to 439	370	344 to 400	0·46
Trabecular area (mm^2)	242	171 to 288	165	159 to 236	0·10
Bone marrow density (mg/cm)	27·2	21·8 to 33·7	27·3	26·3 to 38·2	0·46
Cortical density (mg/cm)	1093	1081 to 1108	1090	1058 to 1099	0·70
Total bone density (mg/cm)	690	624 to 745	743	703 to 763	0·21
Torsion strength (mm^4)	53 316	46 274 to 64722	50 073	39 697 to 53 469	0·19
Bone strength index (g^2/cm)	3·07	2·76 to 3·6	3·34	2·67 to 3·43	0·96
Muscle strength and power					
Relative upper limb muscle strength (kg/kg BW)	0·34	0·31 to 0·39	0·38	0·35 to 0·48	0·15
Relative lower limb muscle strength (kg/kg BW)	4·56	3·7 to 4·79	4·16	3·31 to 4·58	0·61
Muscle power (*n*)	122	109 to 166	133	101 to 179	0·11

PROT–: protein intake < 1 g/kg per d; PROT+: protein intake > 1·2 g/kg per d; BMD, bone mineral density; DXA, dual-energy X-ray absorptiometry; pQCT, peripheral quantitative computed tomography.
**P*-values obtained using Mann–Whitney test.
†$P \leq 0{\cdot}05$: significant differences.

Discussion

Despite the low statistical power of the current study, the results suggest that a lower protein intake, but higher than RDA, protects more bone architecture but does not influence bone density among dynapenic-obese older people. The heterogeneity of the population (i.e., very older adults aged 85 years or older[18] *v.* young older adults in the present study), as well as the type of population (malnourished, frail or osteoporotic[2] *v.* healthy adult in the present study) and the difference in study design (i.e., position paper[5], longitudinal study[18] *v.* cross-sectional analysis in the present study) can explain the discrepancies between our conclusion and those from others. Another explanation is that our sample included men and women, whereas Scott *et al.* showed that only dynapenic-obese men and not women presented more risk of bone deterioration than others[19]. Nevertheless, we cannot investigate these hypotheses since our sample is too small. Finally, the bone health status of our population (without osteoporosis) could have influenced the results of this research. Some limitations are to be emphasised and can explain our conclusion. First, there is a risk of false positive because of the large number of bivariable comparisons performed. Then, the design of the study (i.e., cross-sectional study) does not allow us to establish causal links and the sample size also limits the external validation of the results. Others limitations are the lack of accuracy of the 3-d food diary

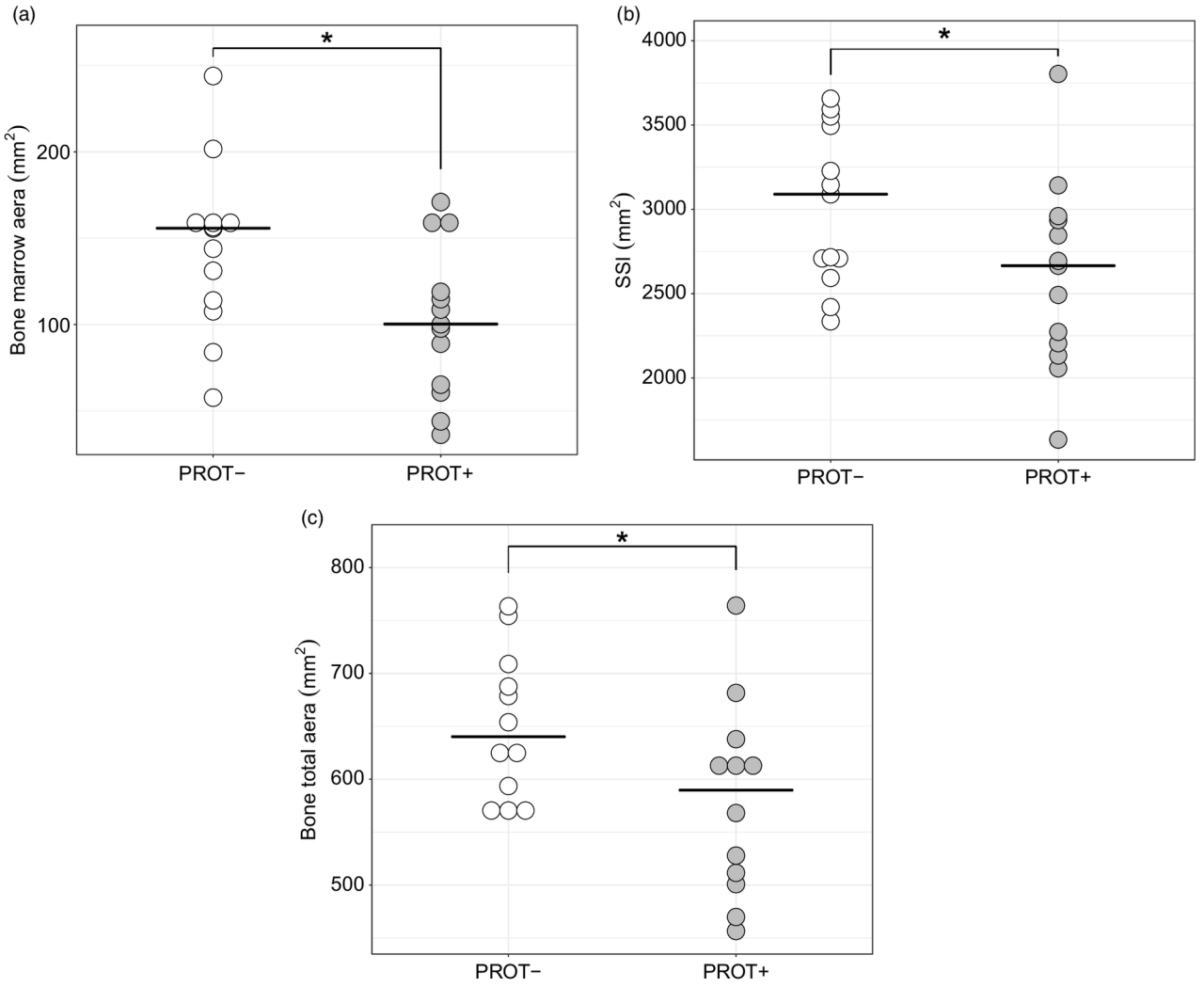

Fig. 1 (a) Bone marrow area (mm^2), (b) bone compressive strength (SSI, mm^2) and (c) bone total area (mm^2), according to protein intake (PROT−: < 1 g/kg per d *v.* PROT+: > 1·2 g/kg per d) among dynapenic-obese older people. **P*-value < 0·05

method, and the fact that confounding variables could not be adjusted. Finally, confounding factors were not taken into account in the analysis, such as age, sex, and in the case of women, time elapsed since menopause and hormonal replacement.

In conclusion, in non-osteoporotic dynapenic-obese young older adults, a lower protein intake seems to be associated with bone sizes, which influence bone strength, but do not influence bone density.

Acknowledgements

Acknowledgements: The authors would like to thank all study participants. *Financial support:* F.B. is funded by IRSC and FRQS post-doctoral fellowships, A.B. is funded by IRSC and FRQS master fellowships. M.A.-L. is recipient of Chercheur Boursier salary awards from the FRQS. This work was supported by grants from the FRQS, the Réseau Québécois de Recherche sur le Vieillissement, a thematic network funded by FRQS and the Groupe de Recherche en Activité Physique Adaptée – Université du Québec à Montréal. *Conflict of interest:* The authors declare that they have no conflict of interest. *Authorship:* M.A.L. and P.N. conceived the original idea. E.P. and A.B. collected the data. F.B. and P.N. performed the statistical analyses. F.B. wrote the manuscript. M.A.L., P.N., E.V. and A.B. revised the manuscript. M.A.L. and P.N. supervised the project. *Ethics of human subject participation:* The current study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Ethics Committee of the Université du Québec à Montréal. Written informed consent was obtained from all subjects/patients.

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