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Research article

Protein intake, malnutrition, and its association with bone health after a hip fracture: A 3-month prospective study

Inge Groenendijk^{1,*}, Hugo H Wijnen², Diana G Taekema² and Lisette CPGM de Groot¹

- Division of Human Nutrition and Health, Wageningen University & Research, Wageningen, The Netherlands
- ² Department of Geriatrics, Rijnstate Hospital, Arnhem, The Netherlands
- * Correspondence: Email: inge.groenendijk@wur.nl.

Supplementary

Table S1. Explorative associations between protein intake and bone health outcomes in older hip fracture patients.

Exposure	Outcome	Model	Estimate	SE	95% CI	P value
-	Bone markers ^b					
ΔProtein intake, g/d ^a	Δ IGF-1, nmol/L	1	0.025	0.027	-0.030 - 0.079	0.37
		2	0.018	0.030	-0.041 - 0.077	0.55
		3	0.019	0.030	-0.041 - 0.079	0.53
	Δ PTH, pmol/L	1	-0.013	0.018	-0.048 - 0.023	0.48
		2	-0.016	0.020	-0.057 - 0.024	0.43
		3	-0.013	0.020	-0.052 - 0.027	0.53
	ΔPINP, μg/L	1	0.037	0.15	-0.26-0.33	0.80
	7.0	2	0.21	0.15	-0.094-0.51	0.17
		3	0.17	0.16	-0.15 - 0.49	0.29
	ΔCTX, μg/L	1	-0.001	0.002	-0.005 - 0.002	0.47
	7, 6	2	-0.001	0.002	-0.005 - 0.003	0.63
		3	-0.001	0.002	-0.005 - 0.002	0.46
	QUS parameters b					
ΔProtein intake, g/d	ΔBUA, dB/MHz	1	0.099	0.054	-0.009 - 0.21	0.072

		2	0.064	0.052	-0.040 - 0.17	0.22
		3	0.044	0.053	-0.061 - 0.15	0.40
	ΔSOS , m/s	1	-0.056	0.14	-0.34-0.23	0.70
		2	-0.075	0.16	-0.40-0.25	0.64
		3	-0.092	0.16	-0.40-0.22	0.56
	ΔSI	1	0.056	0.056	-0.055-0.17	0.32
		2	0.028	0.066	-0.10-0.16	0.68
		3	0.017	0.062	-0.11-0.14	0.78
	BMD^c					
Pre-fracture protein	Total body BMD at 3 mo,	1	0.001	0.001	-0.002 - 0.003	0.58
intake, g/d	g/cm ²	2	0.0004	0.001	0.001 - 0.002	0.64
, 8	8	3	-0.0003	0.001	-0.003 - 0.002	0.79
	Spine BMD at 3 mo, g/cm ²	1	0.002	0.002	-0.002 - 0.005	0.32
	1	2	0.002	0.002	-0.002 - 0.005	0.27
		2 3	0.003	0.002	-0.002 - 0.007	0.19
	L2L4 BMD at 3 mo, g/cm ²	1	0.003	0.002	-0.006 -0.001	0.15
		2	-0.002	0.002	-0.006 - 0.002	0.36
		3	-0.0004	0.002	-0.005 - 0.004	0.87
	Total hip BMD at 3 mo,	1	0.001	0.001	-0.001 - 0.003	0.43
	g/cm ²	2	0.001	0.001	-0.001 - 0.003	0.29
		3	0.002	0.001	-0.001 - 0.005	0.11
	Femoral neck BMD at 3 mo,	1	0.002	0.001	0.0002 - 0.004	0.036
	g/cm ²					
		2	0.002	0.001	-0.001 - 0.004	0.16
		3	0.003	0.002	-0.0005 - 0.006	0.092
	Ward's triangle BMD at 3	1	0.002	0.001	-0.0002 - 0.004	0.078
	mo, g/cm ²	2	0.001	0.001	-0.001 - 0.003	0.26
		3	0.002	0.001	-0.001 - 0.004	0.18
	Trochanter BMD at 3 mo,	1	0.001	0.001	-0.002 - 0.003	0.53
	g/cm ²	2	0.001	0.001	-0.001 - 0.003	0.30
		3	0.003	0.001	-0.0003 - 0.006	0.076
	Pelvis BMD at 3 mo, g/cm ²	1	-0.0003	0.001	-0.003 - 0.002	0.83
		2	0.0002	0.001	-0.003 - 0.003	0.91
		3	-0.002	0.002	-0.005 - 0.002	0.34

Note: BMD = bone mineral density, BUA = broadband ultrasound attenuation, CTX = C-terminal telopeptide of type I collagen, IGF-1 = insulin like growth factor, PINP = procollagen type 1 N propeptide, SI = Stiffness Index, SOS = speed of sound, QUS = quantitative ultrasound. ^a Delta (Δ) refers to the change from baseline till 3 months. ^b Model 1: adjusted for time. Model 2: additionally adjusted for age, sex, BMI, CFS, history of fractures, vitamin D status, and calcium supplementation. Model 3: additionally adjusted for number of drugs, smoking, and alcohol. ^c Model 1: crude. Model 2: adjusted for pre-fracture age, sex, BMI, CFS, history of fractures, vitamin D status, and calcium supplementation. Model 3: additionally adjusted for pre-fracture number of drugs, smoking, and alcohol.

Table S2. Explorative associations between MNA-SF with QUS and BMD in older hip fracture patients.

Exposure	Outcome	Model	Estimate	SE	95% CI	P
_						value
	QUS parameters b					
Δ MNA-SF, score $(0-14)^a$	ΔBUA, dB/MHz	1	0.33	0.34	-0.35-1.01	0.34
		2	0.45	0.37	-0.28-1.18	0.22
		3	0.26	0.37	-0.48-1.00	0.48
	ΔSOS , m/s	1	-0.48	0.87	-2.22-1.25	0.58

ASI							
ASI			2	-0.25	1.05	-2.34-1.84	0.82
Pre-fracture score (0-14) MNA-SF, Total body BMD at 3 mo, g/cm² Control of the score (0-14) Pre-fracture score (0-14) MNA-SF, Total body BMD at 3 mo, g/cm² Control of the score (0-14) Pre-fracture score (0-14			3	-0.96	1.02	-3.00-1.09	0.35
Pre-fracture score (0-14) MNA-SF, Total body BMD at 3 mo, 1 g/cm² 0.001 0.013 -0.25-0.027 0.94 Score (0-14) 9/cm² 2 0.031 0.014 0.002-0.060 0.035 0.035 0.00		ΔSI	1	-0.064	0.33	-0.73 - 0.60	0.85
Pre-fracture score (0-14) MNA-SF, Total body BMD at 3 mo, 1 g/cm² 0.001 0.013 -0.25-0.027 0.94 Score (0-14) 9/cm² 2 0.031 0.014 0.002-0.060 0.035 0.035 0.00			2	0.17	0.44	-0.71 - 1.04	0.70
Pre-fracture score (0−14) MNA-SF, core (0−14) Total body BMD at 3 mo, g/cm² 1 0.001 0.013 −0.25−0.027 0.94 score (0−14) 2 0.031 0.014 0.002−0.060 0.035 3 0.048 0.016 0.015−0.080 0.005 4 0.06 0.015−0.080 0.005 5 5pine BMD at 3 mo, g/cm² 1 0.022 0.019 −0.016−0.059 0.25 6 0.025 0.006−0.107 0.029 0.025−0.014 0.006 6 0.025 0.006−0.107 0.029 0.025−0.021 0.38 7 0.004 0.026 −0.048−0.057 0.87 8 0.035 0.029 −0.024−0.055 0.24 9 0.026 0.0044 0.015 −0.025−0.034 0.77 9 2 0.044 0.019 0.066−0.082 0.025 9 2 0.044 0.019 0.006−0.082 0.025 9 2 0.023 0.018			3	-0.29	0.41	-1.12 - 0.53	0.48
score (0–14) g/cm² 2		BMD^c					
Spine BMD at 3 mo, g/cm ² 1 0.022 0.019 -0.016-0.080 0.005 Spine BMD at 3 mo, g/cm ² 1 0.022 0.019 -0.016-0.059 0.25 2 0.056 0.025 0.006-0.107 0.029 3 0.085 0.029 0.025-0.144 0.006 L2L4 BMD at 3 mo, g/cm ² 1 -0.017 0.019 -0.055-0.021 0.38 2 0.004 0.026 -0.048-0.057 0.87 3 0.035 0.029 -0.024-0.095 0.24 Total hip BMD at 3 mo, 1 0.004 0.015 -0.025-0.034 0.77 g/cm ² 2 0.044 0.019 0.006-0.082 0.025 3 0.055 0.018 0.018-0.093 0.005 Femoral neck BMD at 3 mo, 1 -0.005 0.014 -0.032-0.023 0.73 g/cm ² 2 0.023 0.018 -0.014-0.060 0.22 3 0.029 0.020 -0.013-0.070 0.17 Ward's triangle BMD at 3 1 -0.003 0.012 -0.027-0.021 0.79 mo, g/cm ² 2 0.022 0.016 -0.009-0.054 0.16 3 0.028 0.016 -0.009-0.054 0.16 3 0.028 0.016 -0.005-0.060 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013-0.047 0.26 g/cm ² 2 0.044 0.019 0.005-0.082 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013-0.047 0.26 g/cm ² 2 0.044 0.019 0.005-0.080 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013-0.047 0.26 g/cm ² 2 0.044 0.019 0.005-0.080 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013-0.047 0.26 g/cm ² 2 0.044 0.019 0.005-0.080 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013-0.047 0.26 g/cm ² 2 0.044 0.019 0.005-0.080 0.092 Trochanter BMD at 3 mo, 1 0.0017 0.015 -0.013-0.047 0.26	MNA-SF,		1	0.001	0.013	-0.25-0.027	0.94
Spine BMD at 3 mo, g/cm ² 1 0.022 0.016 0.015-0.080 0.005 0.25			2	0.031	0.014	0.002 - 0.060	0.035
Spine BMD at 3 mo, g/cm ² 1 0.022 0.019 -0.016-0.059 0.25 2 0.056 0.025 0.006-0.107 0.029 3 0.085 0.029 0.025-0.144 0.006 L2L4 BMD at 3 mo, g/cm ² 1 -0.017 0.019 -0.055-0.021 0.38 2 0.004 0.026 -0.048-0.057 0.87 3 0.035 0.029 -0.024-0.095 0.24 Total hip BMD at 3 mo, 1 0.004 0.015 -0.025-0.034 0.77 g/cm ² 2 0.044 0.019 0.006-0.082 0.025 3 0.055 0.018 0.018-0.093 0.005 Femoral neck BMD at 3 mo, 1 -0.005 0.014 -0.032-0.023 0.73 g/cm ² 2 0.023 0.018 -0.014-0.060 0.22 3 0.029 0.020 -0.013-0.070 0.17 Ward's triangle BMD at 3 1 -0.003 0.012 -0.027-0.021 0.79 mo, g/cm ² 2 0.022 0.016 -0.009-0.054 0.16 3 0.028 0.016 -0.009-0.054 0.16 3 0.028 0.016 -0.009-0.054 0.16 7 0.005 0.006 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013-0.047 0.26 g/cm ² 2 0.044 0.019 0.005-0.080 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013-0.047 0.26 g/cm ² 2 0.044 0.019 0.005-0.082 0.029 Pelvis BMD at 3 mo, g/cm ² 1 0.001 0.015 -0.029-0.031 0.92 0.026 0.021 -0.017-0.069 0.22				0.048	0.016	0.015 - 0.080	0.005
2 0.056 0.025 0.006-0.107 0.029 3 0.085 0.029 0.025-0.144 0.006 L2L4 BMD at 3 mo, g/cm² 1 -0.017 0.019 -0.055-0.021 0.38 2 0.004 0.026 -0.048-0.057 0.87 3 0.035 0.029 -0.024-0.095 0.24 Total hip BMD at 3 mo, 1 0.004 0.015 -0.025-0.034 0.77 g/cm² 2 0.044 0.019 0.006-0.082 0.025 3 0.055 0.018 0.018-0.093 0.005 Femoral neck BMD at 3 mo, 1 -0.005 0.014 -0.032-0.023 0.73 g/cm² 2 0.023 0.018 -0.014-0.060 0.22 3 0.029 0.020 -0.013-0.070 0.17 Ward's triangle BMD at 3 1 -0.003 0.012 -0.027-0.021 0.79 mo, g/cm² 2 0.022 0.016 -0.009-0.054 0.16 3 0.028 0.016 -0.009-0.054 0.16 3 0.028 0.016 -0.005-0.060 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013-0.047 0.26 g/cm² 2 0.044 0.019 0.005-0.082 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013-0.047 0.26 g/cm² 2 0.044 0.019 0.005-0.082 0.029 3 0.057 0.019 0.018-0.096 0.006 Pelvis BMD at 3 mo, g/cm² 1 0.001 0.015 -0.029-0.031 0.92 2 0.026 0.021 -0.017-0.069 0.22		Spine BMD at 3 mo, g/cm ²		0.022	0.019	-0.016 - 0.059	0.25
L2L4 BMD at 3 mo, g/cm ² 1				0.056	0.025	0.006 - 0.107	0.029
2 0.004 0.026 -0.048-0.057 0.87 3 0.035 0.029 -0.024-0.095 0.24 Total hip BMD at 3 mo, 1 0.004 0.015 -0.025-0.034 0.77 g/cm² 2 0.044 0.019 0.006-0.082 0.025 3 0.055 0.018 0.018-0.093 0.005 Femoral neck BMD at 3 mo, 1 -0.005 0.014 -0.032-0.023 0.73 g/cm² 2 0.023 0.018 -0.014-0.060 0.22 3 0.029 0.020 -0.013-0.070 0.17 Ward's triangle BMD at 3 1 -0.003 0.012 -0.027-0.021 0.79 mo, g/cm² 2 0.022 0.016 -0.009-0.054 0.16 3 0.028 0.016 -0.009-0.054 0.16 3 0.028 0.016 -0.005-0.060 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013-0.047 0.26 g/cm² 2 0.044 0.019 0.005-0.082 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013-0.047 0.26 g/cm² 2 0.044 0.019 0.005-0.082 0.029 3 0.057 0.019 0.018-0.096 0.006 Pelvis BMD at 3 mo, g/cm² 1 0.001 0.015 -0.029-0.031 0.92 2 0.026 0.021 -0.017-0.069 0.22			3	0.085	0.029	0.025 - 0.144	0.006
Total hip BMD at 3 mo, 1		L2L4 BMD at 3 mo, g/cm ²	1	-0.017	0.019	-0.055 - 0.021	0.38
Total hip BMD at 3 mo, 1			2	0.004	0.026	-0.048 - 0.057	0.87
g/cm ² 2 0.044 0.019 0.006–0.082 0.025 3 0.055 0.018 0.018–0.093 0.005 Femoral neck BMD at 3 mo, 1 -0.005 0.014 -0.032–0.023 0.73 g/cm ² 2 0.023 0.018 -0.014–0.060 0.22 3 0.029 0.020 -0.013–0.070 0.17 Ward's triangle BMD at 3 1 -0.003 0.012 -0.027–0.021 0.79 mo, g/cm ² 2 0.022 0.016 -0.009–0.054 0.16 3 0.028 0.016 -0.005–0.060 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013–0.047 0.26 g/cm ² 2 0.044 0.019 0.005–0.082 0.029 3 0.057 0.019 0.018–0.096 0.006 Pelvis BMD at 3 mo, g/cm ² 1 0.001 0.015 -0.029–0.031 0.92 2 0.026 0.021 -0.017–0.069 0.22			3	0.035	0.029	-0.024 -0.095	0.24
Femoral neck BMD at 3 mo, 1 -0.005 0.018 0.018-0.093 0.005 g/cm^2 2 0.023 0.018 $-0.014-0.060$ 0.22 3 0.029 0.020 $-0.013-0.070$ 0.17 Ward's triangle BMD at 3 1 -0.003 0.012 $-0.027-0.021$ 0.79 mo, g/cm^2 2 0.022 0.016 $-0.009-0.054$ 0.16 3 0.028 0.016 $-0.009-0.054$ 0.16 3 0.028 0.016 $-0.005-0.060$ 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 $-0.013-0.047$ 0.26 g/cm^2 2 0.044 0.019 0.005-0.082 0.029 3 0.057 0.019 0.018-0.096 0.006 Pelvis BMD at 3 mo, g/cm^2 1 0.001 0.015 $-0.029-0.031$ 0.92 0.026 0.021 $-0.017-0.069$ 0.22			1	0.004	0.015	-0.025-0.034	0.77
Femoral neck BMD at 3 mo, 1			2	0.044	0.019	0.006 - 0.082	0.025
$\begin{array}{cccccccccccccccccccccccccccccccccccc$				0.055	0.018	0.018 - 0.093	0.005
2 0.023 0.018 -0.014-0.060 0.22 3 0.029 0.020 -0.013-0.070 0.17 Ward's triangle BMD at 3 1 -0.003 0.012 -0.027-0.021 0.79 mo, g/cm² 2 0.022 0.016 -0.009-0.054 0.16 3 0.028 0.016 -0.005-0.060 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013-0.047 0.26 g/cm² 2 0.044 0.019 0.005-0.082 0.029 3 0.057 0.019 0.018-0.096 0.006 Pelvis BMD at 3 mo, g/cm² 1 0.001 0.015 -0.029-0.031 0.92 2 0.026 0.021 -0.017-0.069 0.22			1	-0.005	0.014	-0.032-0.023	0.73
Ward's triangle BMD at 3 $\begin{array}{cccccccccccccccccccccccccccccccccccc$			2	0.023	0.018	-0.014 - 0.060	0.22
mo, g/cm ² 2 0.022 0.016 -0.009-0.054 0.16 3 0.028 0.016 -0.005-0.060 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013-0.047 0.26 g/cm ² 2 0.044 0.019 0.005-0.082 0.029 3 0.057 0.019 0.018-0.096 0.006 Pelvis BMD at 3 mo, g/cm ² 1 0.001 0.015 -0.029-0.031 0.92 2 0.026 0.021 -0.017-0.069 0.22				0.029	0.020	-0.013 - 0.070	0.17
2 0.022 0.016 -0.009-0.054 0.16 3 0.028 0.016 -0.005-0.060 0.092 Trochanter BMD at 3 mo, 1 0.017 0.015 -0.013-0.047 0.26 g/cm ² 2 0.044 0.019 0.005-0.082 0.029 3 0.057 0.019 0.018-0.096 0.006 Pelvis BMD at 3 mo, g/cm ² 1 0.001 0.015 -0.029-0.031 0.92 2 0.026 0.021 -0.017-0.069 0.22			1	-0.003	0.012	-0.027-0.021	0.79
Trochanter BMD at 3 mo, 1 0.028 0.016 -0.005-0.060 0.092 g/cm² 2 0.044 0.019 0.005-0.082 0.029 3 0.057 0.019 0.018-0.096 0.006 Pelvis BMD at 3 mo, g/cm² 1 0.001 0.015 -0.029-0.031 0.92 2 0.026 0.021 -0.017-0.069 0.22		, 8	2	0.022	0.016	-0.009 - 0.054	0.16
Trochanter BMD at 3 mo, 1 0.017 0.015 $-0.013-0.047$ 0.26 g/cm^2 $ \begin{array}{ccccccccccccccccccccccccccccccccccc$							
2 0.044 0.019 0.005-0.082 0.029 3 0.057 0.019 0.018-0.096 0.006 Pelvis BMD at 3 mo, g/cm ² 1 0.001 0.015 -0.029-0.031 0.92 2 0.026 0.021 -0.017-0.069 0.22			1				0.26
Pelvis BMD at 3 mo, g/cm ² 1 0.001 0.015 -0.029-0.031 0.92 2 0.026 0.021 -0.017-0.069 0.22		B. 4.111	2	0.044	0.019	0.005-0.082	0.029
Pelvis BMD at 3 mo, g/cm ² 1 0.001 0.015 -0.029-0.031 0.92 2 0.026 0.021 -0.017-0.069 0.22			3				
2 0.026 0.021 -0.017-0.069 0.22		Pelvis BMD at 3 mo g/cm ²					
		1 11 12 13 11 11 W 2 11 10, B, OH					

Note: BMD = bone mineral density, BUA = broadband ultrasound attenuation, MNA-SF = Mini Nutritional Assessment Short Form, SI = Stiffness Index, SOS = speed of sound, QUS = quantitative ultrasound. ^a Delta (Δ) refers to the change from baseline till 3 months. ^b Model 1: adjusted for time. Model 2: additionally adjusted for age, sex, CFS, history of fractures, vitamin D status, and calcium supplementation. Model 3: additionally adjusted for number of drugs, smoking, and alcohol. ^c Model 1: crude. Model 2: adjusted for pre-fracture age, sex, CFS, history of fractures, vitamin D status, and calcium supplementation. Model 3: additionally adjusted for pre-fracture number of drugs, smoking, and alcohol.



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