Supplementary Materials

Sex Differences in Dietary Protein Sources, Preferences, and Body Composition: A Cross-Sectional Substitution Analysis

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Table S1. Behavioral concordance between harmonized habitual food preference categories on the self-developed questionnaire and observed 7-day food record consumption frequencies (servings/week, N = 1694).

Questionnaire Item → 7-Day Diary Variable	No / Unfamiliar Mean ± SD (n)	Reluctantly Mean ± SD (n)	Yes Mean ± SD (n)	Kruskal–Wallis p
Fish preference → Fish diary	0.80 ± 1.21 (n = 94)	1.92 ± 1.52 (n = 180)	2.49 ± 1.53 (n = 1,420)	<0.0001
Eggs preference → Eggs diary	0.14 ± 0.39 (n = 64)	0.33 ± 0.56 (n = 149)	0.70 ± 0.80 (n = 1,481)	<0.0001
Legumes preference → Legumes diary	0.61 ± 0.98 (n = 57)	1.14 ± 1.34 (n = 138)	1.80 ± 1.67 (n = 1,499)	<0.0001
Tofu preference → Soy diary	0.06 ± 0.31 (n = 937)	0.12 ± 0.50 (n = 430)	0.75 ± 1.50 (n = 327)	<0.0001
Processed meat preference → Processed meat diary	0.12 ± 0.47 (n = 113)	0.45 ± 1.13 (n = 85)	0.77 ± 1.04 (n = 1,496)	<0.0001

Bilingual questionnaire responses were harmonized into 'No/Unfamiliar' ('No', 'NO', 'Don't know', 'Non so cosa sia'), 'Reluctantly' ('Reluctantly', 'Se proprio devo...'), and 'Yes' ('Yes', 'SI'). Values represent mean ± SD weekly servings recorded in the 7-day food diary across preference categories. Kruskal–Wallis tests evaluate differences in observed weekly intake distributions across preference groups. Table S1 presents the five protein groups with a direct 1:1 questionnaire-to-diary pairing across the full adult cohort (N = 1,694); dairy items (assessed across three separate questionnaire items) and fresh meat subtypes (white vs. red meat, available in n = 1,021) were evaluated in dedicated multivariable models.

Table S2. Hierarchical multivariable linear regression models (Models 1–3) examining associations between weekly protein exposures and Fat Mass Index (FMI), Fat-Free Mass Index (FFMI), and Abdominal Circumference (AC) (N = 1694).

Protein Exposure & Outcome	Model 1 (Age + Sex) β (95% CI); p	Model 2 (+ SES, Smoking, Sport) β (95% CI); p	Model 3 (+ Background Diet) β (95% CI); p
Fresh meat (+1 serv./wk) — FMI (kg/m²)	+0.176 (+0.077, +0.275) p = 0.0005	+0.184 (+0.088, +0.280) p = 0.0002	+0.182 (+0.085, +0.278) p = 0.0002
Fresh meat (+1 serv./wk) — FFMI (kg/m²)	+0.088 (+0.034, +0.142) p = 0.0015	+0.093 (+0.039, +0.148) p = 0.0008	+0.089 (+0.035, +0.143) p = 0.0014
Fresh meat (+1 serv./wk) — AC (cm)	+0.706 (+0.350, +1.062) p = 0.0001	+0.738 (+0.397, +1.079) p < 0.0001	+0.737 (+0.395, +1.079) p < 0.0001
Processed meat (+1 serv./wk) — FMI (kg/m²)	+0.115 (−0.051, +0.281) p = 0.1734	+0.125 (−0.036, +0.286) p = 0.1290	+0.124 (−0.037, +0.284) p = 0.1319
Processed meat (+1 serv./wk) — FFMI (kg/m²)	−0.020 (−0.111, +0.071) p = 0.6671	−0.014 (−0.105, +0.077) p = 0.7702	−0.014 (−0.105, +0.077) p = 0.7645
Processed meat (+1 serv./wk) — AC (cm)	+0.208 (−0.389, +0.806) p = 0.4943	+0.253 (−0.320, +0.827) p = 0.3864	+0.215 (−0.357, +0.788) p = 0.4606
Fish (+1 serv./wk) — FMI (kg/m²)	−0.016 (−0.126, +0.093) p = 0.7738	+0.012 (−0.094, +0.119) p = 0.8223	−0.002 (−0.108, +0.104) p = 0.9723
Fish (+1 serv./wk) — FFMI (kg/m²)	−0.005 (−0.065, +0.056) p = 0.8793	+0.005 (−0.055, +0.065) p = 0.8656	−0.007 (−0.067, +0.053) p = 0.8248
Fish (+1 serv./wk) — AC (cm)	−0.162 (−0.556, +0.232) p = 0.4196	−0.038 (−0.416, +0.341) p = 0.8456	−0.104 (−0.481, +0.273) p = 0.5885
Eggs (+1 serv./wk) — FMI (kg/m²)	−0.239 (−0.455, −0.023) p = 0.0303	−0.211 (−0.421, −0.001) p = 0.0487	−0.208 (−0.418, +0.001) p = 0.0509
Eggs (+1 serv./wk) — FFMI (kg/m²)	−0.151 (−0.269, −0.032) p = 0.0128	−0.133 (−0.251, −0.014) p = 0.0281	−0.141 (−0.259, −0.023) p = 0.0192
Eggs (+1 serv./wk) — AC (cm)	−0.835 (−1.613, −0.057) p = 0.0355	−0.709 (−1.454, +0.037) p = 0.0624	−0.726 (−1.470, +0.018) p = 0.0559
Dairy (+1 serv./wk) — FMI (kg/m²)	+0.148 (+0.022, +0.274) p = 0.0213	+0.171 (+0.049, +0.293) p = 0.0059	+0.176 (+0.055, +0.298) p = 0.0044
Dairy (+1 serv./wk) — FFMI (kg/m²)	+0.051 (−0.018, +0.120) p = 0.1495	+0.059 (−0.010, +0.128) p = 0.0918	+0.065 (−0.003, +0.134) p = 0.0618
Dairy (+1 serv./wk) — AC (cm)	+0.388 (−0.066, +0.841) p = 0.0937	+0.494 (+0.060, +0.927) p = 0.0257	+0.520 (+0.089, +0.952) p = 0.0181
Legumes (+1 serv./wk) — FMI (kg/m²)	−0.088 (−0.190, +0.015) p = 0.0943	−0.056 (−0.156, +0.044) p = 0.2742	−0.045 (−0.145, +0.055) p = 0.3803
Legumes (+1 serv./wk) — FFMI (kg/m²)	−0.024 (−0.081, +0.032) p = 0.3962	−0.019 (−0.076, +0.037) p = 0.5038	−0.013 (−0.069, +0.044) p = 0.6642
Legumes (+1 serv./wk) — AC (cm)	−0.424 (−0.794, −0.055) p = 0.0243	−0.309 (−0.664, +0.045) p = 0.0873	−0.272 (−0.628, +0.083) p = 0.1334
Soy (+1 serv./wk) — FMI (kg/m²)	−0.369 (−0.583, −0.155) p = 0.0007	−0.283 (−0.492, −0.074) p = 0.0080	−0.274 (−0.482, −0.065) p = 0.0103
Soy (+1 serv./wk) — FFMI (kg/m²)	−0.106 (−0.223, +0.011) p = 0.0768	−0.086 (−0.204, +0.032) p = 0.1542	−0.091 (−0.209, +0.027) p = 0.1298
Soy (+1 serv./wk) — AC (cm)	−1.043 (−1.815, −0.271) p = 0.0081	−0.664 (−1.408, +0.079) p = 0.0799	−0.656 (−1.400, +0.087) p = 0.0836
Protein diversity (+1 source) — FMI (kg/m²)	+0.038 (−0.126, +0.201) p = 0.6507	+0.101 (−0.057, +0.260) p = 0.2107	+0.112 (−0.046, +0.270) p = 0.1635
Protein diversity (+1 source) — FFMI (kg/m²)	+0.012 (−0.078, +0.102) p = 0.7955	+0.035 (−0.055, +0.125) p = 0.4423	+0.043 (−0.046, +0.132) p = 0.3443
Protein diversity (+1 source) — AC (cm)	+0.048 (−0.540, +0.637) p = 0.8724	+0.311 (−0.253, +0.876) p = 0.2797	+0.331 (−0.231, +0.894) p = 0.2484
Plant protein share (+10%) — FMI (kg/m²)	−0.137 (−0.230, −0.045) p = 0.0037	−0.116 (−0.207, −0.026) p = 0.0114	−0.107 (−0.197, −0.016) p = 0.0212

Protein Exposure & Outcome	Model 1 (Age + Sex) β (95% CI); p	Model 2 (+ SES, Smoking, Sport) β (95% CI); p	Model 3 (+ Background Diet) β (95% CI); p
Plant protein share (+10%) — FFMI (kg/m²)	−0.044 (−0.095, +0.007) p = 0.0881	−0.043 (−0.094, +0.008) p = 0.1003	−0.038 (−0.089, +0.013) p = 0.1483
Plant protein share (+10%) — AC (cm)	−0.497 (−0.831, −0.164) p = 0.0035	−0.421 (−0.741, −0.100) p = 0.0101	−0.389 (−0.712, −0.067) p = 0.0179
Processed meat share (+10%) — FMI (kg/m²)	+0.107 (−0.055, +0.269) p = 0.1942	+0.091 (−0.067, +0.248) p = 0.2601	+0.088 (−0.069, +0.245) p = 0.2727
Processed meat share (+10%) — FFMI (kg/m²)	−0.011 (−0.100, +0.078) p = 0.8046	−0.012 (−0.101, +0.077) p = 0.7951	−0.010 (−0.099, +0.079) p = 0.8242
Processed meat share (+10%) — AC (cm)	+0.237 (−0.347, +0.820) p = 0.4269	+0.179 (−0.381, +0.739) p = 0.5310	+0.151 (−0.408, +0.710) p = 0.5962

Model 1 adjusts for age and sex. Model 2 additionally adjusts for annual household income, employment status, current smoking, sport modality, and weekly sport training hours. Model 3 additionally adjusts for habitual preference/intake of cooked and raw vegetables, fruits, whole grains, and nuts, daily water intake, weekly alcohol consumption, and daily sugary beverages. Two-compartment fat-free mass index (FFMI) was calculated as (Body Weight − Fat Mass) / Height².

Table S3. Sex-stratified fully adjusted associations (Model 3) and protein-by-sex interaction p-values across weekly protein exposures in females (n = 972) and males (n = 722).

Protein Exposure & Outcome	Females (n = 972) β (95% CI); p	Males (n = 722) β (95% CI); p	p Interaction (Protein × Sex)
Fresh meat (+1 serv./wk) — FMI (kg/m²)	+0.239 (+0.095, +0.384) p = 0.0012	+0.140 (+0.013, +0.267) p = 0.0313	0.2539
Fresh meat (+1 serv./wk) — FFMI (kg/m²)	+0.134 (+0.060, +0.207) p = 0.0004	+0.080 (−0.002, +0.162) p = 0.0543	0.1513
Fresh meat (+1 serv./wk) — AC (cm)	+0.908 (+0.431, +1.384) p = 0.0002	+0.692 (+0.192, +1.193) p = 0.0068	0.2987
Processed meat (+1 serv./wk) — FMI (kg/m²)	+0.183 (−0.087, +0.453) p = 0.1829	+0.080 (−0.114, +0.273) p = 0.4190	0.5898
Processed meat (+1 serv./wk) — FFMI (kg/m²)	+0.103 (−0.035, +0.240) p = 0.1423	−0.093 (−0.217, +0.031) p = 0.1404	0.0603
Processed meat (+1 serv./wk) — AC (cm)	+0.562 (−0.330, +1.454) p = 0.2162	+0.019 (−0.742, +0.780) p = 0.9611	0.3668
Fish (+1 serv./wk) — FMI (kg/m²)	+0.009 (−0.148, +0.165) p = 0.9143	+0.008 (−0.133, +0.150) p = 0.9082	0.9055
Fish (+1 serv./wk) — FFMI (kg/m²)	+0.042 (−0.037, +0.122) p = 0.2984	−0.050 (−0.141, +0.042) p = 0.2868	0.2706
Fish (+1 serv./wk) — AC (cm)	+0.059 (−0.458, +0.577) p = 0.8218	−0.143 (−0.700, +0.413) p = 0.6135	0.7315
Eggs (+1 serv./wk) — FMI (kg/m²)	−0.358 (−0.676, −0.040) p = 0.0275	−0.103 (−0.374, +0.168) p = 0.4572	0.1126
Eggs (+1 serv./wk) — FFMI (kg/m²)	−0.187 (−0.349, −0.025) p = 0.0238	−0.128 (−0.302, +0.047) p = 0.1508	0.4169
Eggs (+1 serv./wk) — AC (cm)	−1.130 (−2.183, −0.077) p = 0.0355	−0.520 (−1.588, +0.548) p = 0.3393	0.1967
Dairy (+1 serv./wk) — FMI (kg/m²)	+0.209 (+0.032, +0.386) p = 0.0207	+0.123 (−0.040, +0.286) p = 0.1392	0.4214
Dairy (+1 serv./wk) — FFMI (kg/m²)	+0.087 (−0.004, +0.177) p = 0.0604	+0.034 (−0.071, +0.140) p = 0.5226	0.6087
Dairy (+1 serv./wk) — AC (cm)	+0.448 (−0.139, +1.035) p = 0.1345	+0.527 (−0.116, +1.170) p = 0.1078	0.8250
Legumes (+1 serv./wk) — FMI (kg/m²)	−0.044 (−0.191, +0.102) p = 0.5521	−0.061 (−0.195, +0.073) p = 0.3740	0.7439
Legumes (+1 serv./wk) — FFMI (kg/m²)	−0.051 (−0.126, +0.023) p = 0.1790	+0.015 (−0.072, +0.101) p = 0.7409	0.1481
Legumes (+1 serv./wk) — AC (cm)	−0.400 (−0.883, +0.083) p = 0.1048	−0.195 (−0.723, +0.333) p = 0.4691	0.3098
Soy (+1 serv./wk) — FMI (kg/m²)	−0.164 (−0.461, +0.133) p = 0.2794	−0.397 (−0.686, −0.108) p = 0.0072	0.4450
Soy (+1 serv./wk) — FFMI (kg/m²)	−0.091 (−0.242, +0.060) p = 0.2368	−0.095 (−0.282, +0.092) p = 0.3186	0.9264
Soy (+1 serv./wk) — AC (cm)	−0.582 (−1.565, +0.400) p = 0.2452	−0.732 (−1.876, +0.412) p = 0.2094	0.9961
Protein diversity (+1 source) — FMI (kg/m²)	+0.048 (−0.171, +0.268) p = 0.6659	+0.183 (−0.042, +0.409) p = 0.1110	0.3164
Protein diversity (+1 source) — FFMI (kg/m²)	+0.012 (−0.100, +0.124) p = 0.8350	+0.049 (−0.097, +0.194) p = 0.5094	0.4228
Protein diversity (+1 source) — AC (cm)	−0.021 (−0.748, +0.706) p = 0.9552	+0.688 (−0.201, +1.576) p = 0.1290	0.1285
Plant protein share (+10%) — FMI (kg/m²)	−0.087 (−0.214, +0.040) p = 0.1772	−0.144 (−0.272, −0.016) p = 0.0277	0.9115
Plant protein share (+10%) — FFMI (kg/m²)	−0.071 (−0.135, −0.006) p = 0.0315	−0.011 (−0.093, +0.072) p = 0.7981	0.1575

Protein Exposure & Outcome	Females (n = 972) β (95% CI); p	Males (n = 722) β (95% CI); p	p Interaction (Protein × Sex)
Plant protein share (+10%) — AC (cm)	−0.442 (−0.861, −0.023) p = 0.0386	−0.383 (−0.889, +0.122) p = 0.1370	0.5308
Processed meat share (+10%) — FMI (kg/m²)	+0.096 (−0.135, +0.326) p = 0.4153	+0.088 (−0.122, +0.298) p = 0.4094	0.8845
Processed meat share (+10%) — FFMI (kg/m²)	+0.057 (−0.060, +0.175) p = 0.3359	−0.083 (−0.219, +0.052) p = 0.2277	0.1171
Processed meat share (+10%) — AC (cm)	+0.318 (−0.443, +1.079) p = 0.4128	+0.051 (−0.777, +0.878) p = 0.9041	0.5175

All sex-stratified models adjust for age, income, employment status, smoking, sport modality, weekly sport volume, cooked and raw vegetables, fruits, whole grains, nuts, daily water, weekly alcohol, and daily sugary beverages. Two-compartment fat-free mass index (FFMI) was calculated as (Body Weight − Fat Mass) / Height². Interaction p-values derive from cross-product terms in the pooled sample (N = 1,694).