



**Question: What is the relationship between dietary patterns and bone health?**

**Table 3.** Summary of studies examining the relationship between dietary patterns and bone health

Author, Year Study Design; Location (Cohort) Risk of Bias*	Sample Size (Gender; Age) Number of cases; Duration of Follow-up	Dietary Patterns**	Results	Summary of Findings
<b>Benetou, 2013</b>  <b>Prospective Cohort Study (PCS); Europe (Germany; Greece; Italy; Netherlands; Norway; UK; Spain; Sweden) (EPIC)</b>  <b>Risk of Bias: 6/26</b>	N=188,795 (74% women; Age=47y)  802 cases of hip fracture; 9y	Modified Mediterranean diet score	<b>Hip fracture risk by modified Mediterranean Diet Score (continuous)</b>  <i>Full sample: HR=0.93 (95% CI=0.89-0.98), P&lt;0.05, and this relationship was stronger in men than women (P&lt;0.004)</i> <i>&gt;50 + postmenopausal women: HR=0.91 ((5% CI=0.86-0.96), P&lt;0.05</i>  <b>Hip fracture risk by modified Mediterranean Diet Score (categorical)</b>  <i>Higher adherence to the Mediterranean diet (score 6-9) was associated with reduced risk of hip fracture compared to lower adherence (score: 0-3): HR=0.76 (95% CI=0.60-0.97)</i>	Increased adherence to the Mediterranean diet was associated with decreased risk of hip fracture. This association was stronger among men and older individuals.
<b>Bullo, 2009</b>  <b>RCT; Spain (PREDIMED)</b>  <b>Risk of Bias: 5/28</b>	Initial N=271 Final N=202 Attrition 25.5% (49% women; Age=68y)  Cases N/A; 1y	<ul style="list-style-type: none"> <li>• MedDiet + Olive oil</li> <li>• MedDiet + Nuts</li> <li>• Low-fat diet - goal total fat &lt;35%</li> </ul>	<b>Bone Mineral Density:</b> There were no significant relationships between dietary pattern intervention group and bone mineral density (NS).	Consuming a Mediterranean diet (with either nuts or olive oil) or a low-fat diet was not associated with change in bone mineral density after 1 year.
<b>Dai, 2014</b>  <b>PCS; Singapore (Singapore Chinese Health Study)</b>  <b>Risk of Bias: 2/26</b>	N=63,154 (56% female; Age=57y)  1,630 cases of hip fracture; 17y	<ul style="list-style-type: none"> <li>• "Vegetable-fruit-soy"</li> <li>• "Meat-dim-sum" (Principal components analysis)</li> <li>• Alternate Healthy Eating Index (AHEI) 2010</li> </ul>	<b>Hip fracture risk:</b> <ul style="list-style-type: none"> <li>• "Vegetable-fruit-soy" pattern: Increased adherence was associated with lower hip fracture risk (HR=0.66 (95% CI=0.55-0.78); P for trend&lt;0.0001)</li> <li>• "Meat-dim-sum" (MDS) pattern: NS</li> <li>• AHEI-2010: Increased adherence was associated with lower hip fracture risk (HR=0.68 (95% CI=0.58-</li> </ul>	Consuming a "vegetable-fruit-soy" pattern and increased adherence to the Alternative Healthy Eating Index were associated with reduced risk of hip fracture. The "meat-dim-sum" pattern was not associated with hip fracture risk.



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			0.79); P for trend<0.0001).	
<b>Feart, 2013</b> <b>PCS; France</b> <b>(Three-City</b> <b>Study)</b>  <b>Risk of Bias: 2/26</b>	N=1,482 (63% female; Age=76y)  155 cases of fracture (57 hip, 43 vertebra, 73 wrist); 8y	Mediterranean Diet (MeDi) score	<b>Hip fracture risk:</b> There were no significant relationships between Mediterranean diet score and risk of hip fracture (NS).	Adherence to a Mediterranean diet was not associated with hip fracture risk.
<b>Langsetmo, 2010</b> <b>PCS; Canada</b> <b>(Canadian</b> <b>Multicentre</b> <b>Osteoporosis</b> <b>Study)</b>  <b>Risk of Bias: 2/26</b>	N=6,539 (71% female; Age=61y)  Cases: N/A; 3y	<ul style="list-style-type: none"> <li>• “Nutrient-dense”</li> <li>• “Energy-dense”</li> </ul> (Factor analysis)	<b>Bone Mineral Density:</b>  <b>“Nutrient-dense”:</b> <ul style="list-style-type: none"> <li>• <i>Men (25-49 y):</i> Consuming a “Nutrient-dense” pattern was associated with increased BMD (P=0.028)</li> <li>• <i>Men (&gt;50 y), Pre- and postmenopausal women:</i> NS.</li> </ul> <b>“Energy-dense”:</b> <ul style="list-style-type: none"> <li>• Consuming an “Energy-dense” pattern was associated with decreased BMD in men (&gt;50 y) (P=0.007) and postmenopausal women (P=0.032)</li> <li>• <i>Men (25-49y), premenopausal women:</i> NS.</li> </ul>	A “Nutrient-dense” dietary pattern was associated with increased BMD in younger men, but not older men or women.  An “Energy-dense” dietary pattern was associated with reduced BMD in older men and postmenopausal women, but not younger men or premenopausal women.
<b>Langsetmo, 2011</b> <b>PCS; Canada</b> <b>(Canadian</b> <b>Multicentre</b> <b>Osteoporosis</b>	N=5,188 (68% female; Age=67y)  442 cases of fracture; 8y	<ul style="list-style-type: none"> <li>• “Nutrient-dense”</li> <li>• “Energy-dense”</li> </ul> (Factor analysis)	<b>Fracture risk:</b> <ul style="list-style-type: none"> <li>• <i>“Nutrient-dense”:</i> Associated with decreased risk of fracture in women (HR=0.86 (95% CI=0.76-0.98), P=0.05), but not in men (NS)</li> <li>• <i>“Energy-dense”:</i> Not significantly associated with</li> </ul>	A “Nutrient-dense” dietary pattern was associated with decreased risk of fracture in women, but not men.  An “Energy-dense” dietary pattern was not associated with risk of fracture.



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<b>Study)</b> <b>Risk of Bias: 6/26</b>			fracture risk in men or women (NS).	
<b>McTiernan, 2009</b> <b>RCT; US</b> <b>(Women’s Health Initiative)</b>  <b>Risk of Bias: 3/28</b>	Initial N=56,139 Final N=48,835 Attrition=13% (100% women; Age=62y)  6,095 cases of fracture (500 hip, 552 vertebral, 1,602 arm/wrist); 8y	<ul style="list-style-type: none"> <li>• <b>Dietary modification intervention group:</b> Reduce total fat to 20% of energy, increase vegetables and fruit to at least 5 and grains to at least 6 servings/d</li> <li>• Control (no changes)</li> </ul>	<p><b>Fracture risk:</b> Risk of fracture did not differ between groups (NS).</p> <p><b>Bone Mineral Density:</b></p> <ul style="list-style-type: none"> <li>• Percent change in hip BMD was lower by ~0.4-0.5% in the intervention group vs. comparison group (P for trend=0.003)</li> <li>• Spine BMD and total body BMD did not differ between groups (NS).</li> </ul>	A low-fat and increased fruit, vegetable, and grain diet intervention slightly lowered change in hip BMD, but did not change the risk of osteoporotic fractures.
<b>Monjardino, 2012</b> <b>PCS; Portugal</b> <b>(EPITeen Study)</b>  <b>Risk of Bias: 4/26</b>	N=1,023 (54% female; Age=13y)  Cases N/A; 4y	<ul style="list-style-type: none"> <li>• Mediterranean diet Index for Kids (KIDMED) score</li> <li>• DASH diet index</li> <li>• Oslo Health Study dietary index</li> </ul>	<b>Bone Mineral Density:</b> There were no significant relationships between any of the dietary patterns and bone mineral density (NS).	Adherence to the Mediterranean diet, DASH diet, and Oslo Health Study dietary index was not associated with bone mineral density in adolescents.
<b>Monma, 2010</b> <b>PCS; Japan</b>  <b>Risk of Bias: 4/26</b>	N=877 (56% female; Age=79y)  28 cases of fracture; 4y	<ul style="list-style-type: none"> <li>• "Vegetable pattern"</li> <li>• "Meat pattern"</li> <li>• "Traditional Japanese pattern"</li> </ul> <p>(Factor analysis)</p>	<p><b>Fracture risk:</b></p> <ul style="list-style-type: none"> <li>• <i>“Vegetable pattern”</i>: Higher adherence was associated with significantly greater risk of fall-related fracture (T3 vs. T1) (HR=2.62 (95% CI 0.93-7.41; P for trend=0.044)).</li> <li>• <i>“Meat pattern” and “Japanese pattern”</i>: No significant associations with fracture risk (NS).</li> </ul>	Consuming a "Vegetable pattern" was associated with greater risk of fall-related fractures in an elderly population. However, consuming a "Meat pattern" or a "Japanese pattern" was not associated with fracture risk.
<b>Noh, 2011</b>	N=198	• "Egg and Rice"	<b>Bone Mineral Content (BMC):</b>	High adherence to the "Fruit, Nuts, Milk



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<b>PCS; South Korea</b>  <b>Risk of Bias: 4/26</b>	(100% female; Age=9-11y)  Cases N/A; 22 mo	<ul style="list-style-type: none"> <li>• "Fruit, Nuts, Milk</li> </ul> (Reduced rank regression; Response variables: change in BMI, body fat, and calcaneus BMD and BMC)	<ul style="list-style-type: none"> <li>• Higher adherence to the "Egg and Rice" pattern was associated with less increase in BMC (P for trend=0.04).</li> <li>• Higher adherence to the "Fruit, Nuts, Milk Beverage, Egg, Grain" was associated with higher increase in BMC (P for trend&lt;0.01).</li> </ul> <b>Bone Mineral Density (BMD):</b> Neither dietary pattern was associated with change in BMD (NS).	Beverage, Egg, Grain" pattern was associated with greater increases in BMC during follow-up.  High adherence to the "Egg and Rice" pattern was associated with smaller increases in BMC during follow-up.  Bone mineral density was not significantly correlated with adherence to either dietary pattern.
<b>Park, 2012</b>  <b>PCS; South Korea (Korean Genome and Epidemiology Study)</b>  <b>Risk of Bias: 4/26</b>	N=1,464 (100% female; Age=60 y)  324 osteoporosis cases; 4y	<ul style="list-style-type: none"> <li>• "Traditional" pattern</li> <li>• "Western" pattern</li> <li>• "Dairy" pattern</li> </ul> (Factor analysis)	<b>Osteoporosis risk:</b> (All Q5 vs. Q1)  <b>"Traditional":</b> <ul style="list-style-type: none"> <li>• <i>Radius:</i> NS</li> <li>• <i>Tibia:</i> Associated with increased risk of osteoporosis (R=1.82 (95% CI=1.12-2.96); P for trend=0.0095)</li> </ul> <b>"Dairy":</b> <ul style="list-style-type: none"> <li>• <i>Radius:</i> NS</li> <li>• <i>Tibia:</i> Associated with decreased risk of osteoporosis (RR=0.56 (95% CI=0.35-0.90); P for trend=0.0483)</li> </ul> <b>"Western":</b> <ul style="list-style-type: none"> <li>• <i>Radius:</i> Associated with increased risk of osteoporosis (RR=1.46 (95%CI=1.02-2.10); P for trend=0.0428)</li> </ul>	The risk for osteoporosis (tibia) decreased with higher adherence to the "Dairy" pattern.  The risk for osteoporosis increased with higher adherence to the "Traditional" pattern (tibia), and the "Western" pattern (radius).



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<p><b>Samieri, 2013</b> <b>PCS; France</b> <b>(Three-City Study)</b>  <b>Risk of Bias: 4/26</b></p>	<p>N=1,482 (63% female; Age=76y)  155 cases of fracture (57 hip, 43 vertebra, 73 wrist); 8y</p>	<ul style="list-style-type: none"> <li>• "Nutrient dense pattern"</li> <li>• "Pattern 2"</li> <li>• "South-western-France pattern"</li> </ul> <p>(Principal components analysis)</p>	<p>• <i>Tibia</i>: NS</p> <p><b>Hip Fracture Risk:</b></p> <ul style="list-style-type: none"> <li>• "<i>South-western-France pattern</i>": Associated with lower risk of hip fracture (HR=0.78 (95%CI= 0.61-0.99); P=0.04)</li> <li>• "<i>Nutrient dense pattern</i>," "<i>Pattern 2</i>": No associations with risk of hip fracture (NS)</li> </ul> <p><b>Risk of Vertebral Fracture:</b> No associations with any of the dietary patterns identified (NS).</p> <p><b>Risk of Wrist Fracture:</b></p> <ul style="list-style-type: none"> <li>• "<i>Nutrient dense pattern</i>": Associated with lower risk of wrist fracture (HR=0.82 (95%CI=0.67-1.00); P=0.05)</li> <li>• "<i>Pattern 2</i>," "<i>South-western-France pattern</i>": No associations with risk of wrist fracture (NS).</li> </ul> <p><b>Total Fracture Risk:</b></p> <ul style="list-style-type: none"> <li>• "<i>Nutrient dense pattern</i>": Associated with lower total fracture risk (HR=0.87 (95% CI=0.76-0.99); P=0.04)</li> <li>• "<i>Pattern 2</i>," "<i>South-western-France pattern</i>": No associations with total fracture risk (NS).</li> </ul>	<p>A "Nutrient dense pattern" was associated with reduced risk of total fractures and wrist fractures, but not vertebral or hip fractures.</p> <p>A "South-western-France pattern" was associated with reduced risk of hip fractures, but not total, wrist, or vertebral fractures.</p> <p>A dietary pattern ("Dietary Pattern 2") higher in retinol, vitamin B<sub>12</sub>, folate, and iron, and lower in Ca, P, Mg, and K, and lower in proteins, carbohydrates, cooked vegetables, legumes, pasta, poultry, sweets, and dairy products was not associated with risk of fracture.</p>
<p><b>Wosje, 2010</b> <b>PCS; US</b></p>	<p>N=308 (48% female; Age=4y)</p>	<ul style="list-style-type: none"> <li>• "Diet pattern 1"</li> <li>• "Diet pattern 2"</li> </ul> <p>(Reduced rank</p>	<p><b>Bone Mass:</b></p> <p>"<i>Dietary Pattern 1</i>": Higher scores associated with higher bone mass at all years (1-4) (P&lt;0.0001,</p>	<p>Higher adherence to both of the dietary patterns examined was associated with higher bone mass in young children ("<i>Diet pattern 1 (DP1)</i>"): Non-whole grains, cheese, processed</p>



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<b>Risk of Bias: 0/26</b>	Cases N/A; 4y	regression; Response variables: fat mass, bone mass)	P=0.04, P<0.01, P<0.01) "Dietary Pattern 2": Higher scores associated with higher bone mass at years 1, 3, and 4 (P=0.03, P<0.01, P=0.01), but not year 2 (NS).	meats, eggs, fried potatoes, discretionary fats, artificially sweetened beverages; "Diet pattern 2 (DP2)": Dark-green vegetables, deep-yellow vegetables, processed meats).

\*Risk of Bias as determined using the Nutrition Evidence Library Bias Assessment Tool