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Abstract:	Osteoarthritis is a debilitating joint disease impacting millions of people around the world, but for which few effective treatments exist. It is influenced by both mechanical and systemic factors, each of which may be mitigated by appropriate dietary interventions. Unfortunately, few patients are given advice beyond, "lose some weight." The effect of weight loss on pain and function are recognized, but less known is the evidence that diet quality may impact pain and function. In this article we discuss evidence-based weight-loss strategies and the additional role of an anti-inflammatory diet on both the progression and severity of osteoarthritis. We present a case from our family medicine practice to demonstrate how evidence-based medical nutrition therapy can be used to help patients with osteoarthritis achieve symptom relief.

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Diet and Osteoarthritis: Sharing strategies for reduced pain and improved function when the evidence is limited

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Short title: Diet and Osteoarthritis

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ABSTRACT

Osteoarthritis is a debilitating joint disease impacting millions of people around the world, but for which few effective treatments exist. It is influenced by both mechanical and systemic factors, each of which may be mitigated by appropriate dietary interventions. Unfortunately, few patients are given advice beyond, "lose some weight." The effect of weight loss on pain and function are recognized, but less known is the evidence that diet quality may impact pain and function. In this article we discuss evidence-based weight-loss strategies and the additional role of an anti-inflammatory diet on both the progression and severity of osteoarthritis. We present a case from our family medicine practice to demonstrate how evidence-based medical nutrition therapy can be used to help patients with osteoarthritis achieve symptom relief.

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4 24 Guidelines for the Management of OA

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7 25 There is no cure for OA, and recommendations for its management include only strategies for symptom
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10 26 relief. Therapies recommended by the American College of Rheumatology and the Arthritis Foundation
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12 27 include nonsteroidal anti-inflammatory drugs (NSAIDs), glucocorticoid injections, biomechanical
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14 28 supports, joint replacement surgeries, physical activity with muscle strengthening, and weight loss, and
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17 29 they discourage the use of dietary supplements. They do not discuss evidence-based strategies for
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19 30 healthy weight loss, nor the impact of inflammatory components in the diet (1). *The Nutrition Care*
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21 31 *Manual*, published by The Academy of Nutrition and Dietetics (Academy), also offers little specific
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24 32 recommendations for the management of OA beyond weight loss to reduce joint-load. The Academy
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26 33 does emphasize that patients should follow a diet consistent with the US Dietary Guidelines (17).

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30 34 We review the case of an elderly woman with OA referred to East Carolina University's Family Medicine
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32 35 Center for weight management, and discuss the dietary options for managing her condition.

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35 36 **CASE INTRODUCTION**

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38 37 Ms. MC is a 70-year-old woman, 61 in. tall and 265 lbs. (BMI 50.2 kg/m²) with a waist circumference of
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41 38 57 in. when first seen by a Registered Dietitian Nutritionist (RDN) three years ago. She has a past
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43 39 medical history of hypertension, hyperlipidemia, metabolic syndrome (MetS), vitamin D deficiency,
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45 40 gastroesophageal reflux disease, osteoporosis, stage III chronic kidney disease (CKD3), and OA of the
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48 41 hands, knees, and spine. At that time, she reported taking daily aspirin, lisinopril, metoprolol XL
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50 42 succinate, cholecalciferol, hydrochlorothiazide, pantoprazole EC, simvastatin, sodium bicarbonate, a
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53 43 1,000 mg omega-3 fatty acid supplement, and a Centrum silver multivitamin. Her blood pressure and
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55 44 lipids were well-controlled.

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58 45 At a meeting with her physician regarding her OA, Ms. MC reported increasing OA pain, rating it a 9 out
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69 is suggested and results in improvements of both symptomatic and serum biomarkers of OA (2,6).

70 However, adherence is difficult and may have detrimental impacts on lean body mass (LBM) if the diet is
71 not nutritionally adequate (3,9). Adequate protein intake is important to promote the maintenance of
72 LBM, and there is evidence that a higher protein intake may be associated with added functional
73 improvements in patients with OA (18).

74 Meal-Replacements. Meal replacements (MR) refer to any food or drink product eaten in place of a
75 meal, usually with the goal of managing total daily caloric intake, and the Academy lists them as an
76 option for individuals who need extra support with weight loss (20,21). The evidence also suggests that
77 some dieters using a MR may achieve both significant and faster weight loss compared with other diet
78 approaches (20). In one RCT, older adults on a low-calorie diet including up to 2 MR/day achieved
79 significant weight loss and improvements in joint-load, inflammatory biomarkers, pain, and function (6).
80 MRs are well-accepted, convenient products that can be easily incorporated into various lifestyles and
81 may be an effective weight management strategy for some patients. Some researchers report that some
82 dieters choose to continue using MRs to aid in weight maintenance even after the completion of a
83 weight loss program (22).

84 High-Quality Diet. Advancing age is a strong risk factor for OA (2,4,5), with its prevalence significantly
85 increasing with each decade of life (12). Diet quality, or the nutritional adequacy and interaction of
86 whole foods within a diet, is important in the prevention of chronic disease, the preservation of LBM,
87 and the maintenance of QOL in older adults (9). The DASH and Mediterranean eating approaches are
88 two of the most well-studied eating patterns, and both emphasize high intakes of fruits, vegetables,
89 whole grains, legumes, olive oil, fish and seafood, and limits the intake of saturated fats, sodium and
90 added sugars. Each have been associated with decreased morbidity, improved cognitive health,
91 increased longevity, and lower rates of overweight and obesity (11-13). Overweight and obese
92 individuals starting a high-quality diet may also achieve weight loss comparable to other diet strategies,

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116 A high-quality diet is theorized to be effective in OA management due to its inclusion of foods high in
117 anti-inflammatory factors and antioxidants. These mechanisms have been demonstrated to positively
118 impact MetS, DM, and obesity, which suggests their potential role in attenuating the systemic
119 inflammation and oxidative stress contributing to the progression of OA (11,12). Most of the research on
120 diet and OA is limited and observational, so we cannot state causality between the two. However, the
121 following discussion will describe what emerging research is finding about the relationship between
122 dietary characteristics and OA.

123 Total Dietary Fat. A high-fat diet has been associated with worsened symptoms and structural
124 characteristics of OA, though the research has been, thus far, limited to in vitro, animal, and
125 observational studies (10,14). There is also a significant positive relationship between total fat intake
126 and both total caloric intake and BMI, suggesting its potential to modify OA through its impact on body
127 weight. However, one study found that the association remained significant after weight was controlled
128 for, suggesting its possible influence on the metabolic and inflammatory factors impacting OA. Fatty
129 acids may contribute to OA through their role as precursors for inflammatory factors, thus both the
130 quantity and type of fatty acid consumed may impact levels of systemic inflammation and subsequently,
131 OA characteristics (14).

132 Saturated and Unsaturated Fat. Diets high in saturated fat are positively associated with worsened
133 symptomatic and clinical characteristics of OA (9,10,14). The inverse has also been demonstrated (3,9).
134 On the other hand, one study among overweight and obese older adults with knee OA, demonstrated a
135 protective relationship between unsaturated fat intake and knee OA structural damage, causing
136 researchers to conclude that unsaturated fatty acids may potentially reduce the radiographic
137 progression of the disease (14). Both monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids,
138 have independently been associated with clinical and symptomatic OA improvements in laboratory,
139 animal, and observational studies. The two PUFAs, omega-3's and omega-6's, impact OA in different

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163 study, for example, found that consuming at least two servings of fruit each day was associated with
164 fewer reports of severe knee pain in normal weight adults (16). Small RCTs have also demonstrated the
165 specific benefit of strawberries (50g freeze-dried strawberry powder per day, equivalent to 500g fresh
166 strawberries) (24) and pomegranate juice (200mL of 100% juice per day) (26) on OA symptoms.

167 The quality of evidence to support vegetable intake for OA management is not as strong. While some
168 research has demonstrated a protective relationship, specifically on pain, depression, and QOL (13,16),
169 others have not found a significant association (7,25). It is important to note, however, that the method
170 of preparation of vegetables can impact its efficacy. For example, one study, which found no significant
171 association, classified french-fries as vegetables (7).

172 Dietary Fiber. High quality diets are generally associated with higher dietary fiber intake given the
173 inclusion of whole grains, fruits, vegetables, nuts, seeds, and legumes. Fiber intake has been associated
174 with fewer OA symptoms and pain in a dose response manner (2-4,8,12). In one large prospective
175 cohort study among US adults with or at risk of OA, participants with the highest fiber intake had a 61%
176 lower risk of symptomatic OA (8). Additionally, fiber from cereal grains has been independently shown
177 to have a significant benefit on OA symptoms in observational studies (8,11).

178 **CASE REVISITED**

179 Ms. MC decided to begin the Intensive Behavioral Therapy for Obesity (IBTO) program, involving a year
180 of regularly scheduled appointments focused on weight management (27). During her initial encounter,
181 she reported that she had struggled with her weight for years and had tried Weight Watchers and Slim
182 Fast diets without success. She was very discouraged, stated that she did not think she could lose
183 weight, did not anticipate changing her current eating habits, and did not expect to gain any significant
184 benefit from the meetings.

185 Ms. MC came to her appointment with her daughter-in-law, and reported that she lives alone, uses a

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209 gradually over her first year with the RDN.

210 Reduce Fat. Total- and saturated-fat, respectively, made up over 48 and 17% of Ms. MC's total caloric
211 intake, and primarily came from fast-foods and sandwiches. Overtime, Ms. MC was able to reduce her

212 total- and saturated-fat intake by more than half. Changes she made included exchanging her daily

213 Bojangles' biscuit for a homemade breakfast sandwich, switching to a reduced-fat cheese, substituting

214 sliced turkey for salami, and limiting mayonnaise on her sandwiches. She was able to increase her

215 unsaturated fat intake by snacking on nuts more often than prepackaged snacks.

216 Increase Dietary Fiber. The RDN encouraged Ms. MC to increase her fiber intake to assist with both

217 weight loss and OA symptom management. Small changes that she made included switching from white

218 to 100% whole wheat bread and shifting some of her snacks to higher-fiber foods. Despite these

219 changes, however, her daily fiber intake remained inadequate. Thus, the RDN recommended Ms. MC try

220 a high-fiber meal replacement bar to replace her midday meal. She chose a bar which also provided

221 additional protein, and its inclusion in her diet significantly improved both her daily protein and fiber

222 intake to amounts that would meet her needs and help to support the management of her OA.

223 Fruits and Vegetables. Despite frequent encouragement from the RDN to consume more fruits and

224 vegetables, Ms. MC was not ready to make this change, but was beginning to contemplate how this

225 could fit into her eating pattern. In the meantime, she took a daily multivitamin-mineral supplement.

226 Physical Activity. Ms. MC initially expressed no intent to exercise, noting pain, stiffness, and limited

227 mobility. Towards the end of her IBTO program, however, Ms. MC expressed an increased interest in

228 adding chair exercises to her routine.

229 The Results

230 Each of the changes listed above supported Ms. MC's weight loss goals and were consistent with an anti-

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254 supporting the role of diet quality on OA is less conclusive, as few large randomized controlled trials
255 have been performed. However, the preliminary observational studies are promising, and high-quality
256 diets have been strongly associated with overall health, weight management, and are consistent with US
257 dietary guidelines. Therefore, a high-quality, anti-inflammatory diet may support an appropriate weight
258 loss intervention in the successful management of OA. These efforts are best made with the guidance of
259 an RDN who can tailor a plan that supports weight loss goals, ensures nutritional adequacy, and
260 promotes long-term maintenance. These plans could utilize strategies like restricting calories, using
261 MRs, and encouraging a high-quality, anti-inflammatory diet. Encouraging physical activity, as
262 appropriate, can further increase the efficacy of dietary interventions.

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353 **Table 1: Pre-Intervention 24-hr Recall and Nutrition Analysis**
354 **Table 2: Post-Intervention 24-hr Recall and Nutrition Analysis**

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Table 1

Table 1: Pre-Intervention 24-hr Recall and Nutrition Analysis

	Food	Calories	Carbohydrate	Protein	Total Fat	Saturated Fat	Fiber
Meal 1	1 - Bojangles' sausage, egg, cheese biscuit	625 kcal	41 g	16 g	41.5 g	16 g	3 g
Meal 2	1 - Pack peanut butter filled cheese crackers	210 kcal	25 g	5 g	10 g	2 g	2 g
Snack 1	4 - Snickers 'fun-size' candies	320 kcal	44 g	4 g	14 g	6 g	0 g
Meal 3	1 - Sandwich with salami, full-fat cheese, and mayonnaise on white bread	400 kcal	24 g	13 g	27.5 g	9 g	0 g
Snack 2	1 - Fudgesicle	70 kcal	13.5 g	2 g	1 g	0.5 g	0 g
Beverages	½ - 20 oz. bottle Dr. Pepper	125 kcal	33 g	0 g	0 g	0 g	0 g
Total		1750 kcals	180.5 g	40 g	93.8 g	33.5 g	5 g
	(% of Total Calories)		(41.26%)	(9.14%)	(48.24%)	(17.23%)	