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REVIEW ARTICLE

Effects of omega-3 supplementation on lean body mass in cancer patients: a systematic review and meta-analysis

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Omega-3 fatty acids are bioactive nutrients with the potential to preserve lean body mass in individuals with cancer. This study aimed to review the literature on randomized clinical trials that evaluated the effects of omega-3 supplementation on lean body mass in cancer patients. As secondary objectives, we evaluated the effects of omega-3 supplementation on body mass index (BMI) and body weight. We conducted a systematic review and meta-analysis in the following databases: Pubmed, LILACS, Scielo, Scopus, Web of Science, Cochrane, and Embase. It included randomized clinical trials that investigated the effects of omega-3 supplementation on lean body mass in cancer patients. Observational studies, animal experiments, studies carried out with healthy humans, and non-randomized clinical trials were excluded. We utilized the Cochrane scale to assess the quality of the studies. A meta-analysis was carried out to evaluate the effect of omega-3 on lean body mass, BMI, and body weight. Fourteen studies were included, of which four showed significant results from omega-3 supplementation for lean body mass. In the meta-analysis, omega-3 fatty acids increased lean body mass by 0.17 kg compared to placebo, but without significant differences between the groups [SMD: 0.17; CI 95%: −0.01, 0.35; $I^2 = 41\%$]. For body weight, omega-3 showed a statistically significant effect [SMD: 0.26; CI 95%: 0.06, 0.45; $I^2 = 46\%$], whereas for BMI the results were not significant. This systematic review and meta-analysis showed no statistically significant effect from omega-3 on lean body mass and BMI. On the other hand, there was a statistical significance for body weight.

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INTRODUCTION

Cancer is a condition that worsens the individual's quality of life. Among the health-related worsening, cachexia is a metabolic condition that affects individuals with cancer, especially those at the end-stage of the disease. Cachexia is a complex metabolic syndrome associated with an underlying illness characterized by muscle loss, with or without adipose tissue loss [1]. The maintenance of lean body mass is essential in patients with cancer because it reduces chemotherapy toxicity and improves overall survival [2, 3]. The main predictors of muscle loss in patients with cancer are age, sex, tumor type, and inflammation [4]. In a study, authors identified that 46% of individuals who underwent curative gastrectomy for gastric cancer lost >5% of their lean body mass [5]. It was also identified that individuals with head and neck cancer demonstrate lower lean body mass levels after radiotherapy than healthy individuals [6].

Intervention for lean body mass involves increased resistance training, hormonal and nutrition interventions [7]. However, not all cancer patients can perform resistance training since many are in weakened situations for exercising. Dietary supplements or formulas containing nutrients may be easier to administer to these individuals since they have many calories or nutrients in small capsules or portions.

Omega-3 fatty acids are bioactive nutrients that appear as a substance with potential benefits for cancer patients. Omega-3 is a polyunsaturated fatty acid present in marine origin foods and plant oils. The eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are part of the family of omega-3 from marine origin, while alpha-linolenic acid (ALA) is found mainly in plant oils. Omega-3 is widely used to treat or prevent different pathologies, such as diabetes [8], depression [9], and anxiety [10]. A recent study found some preclinical evidence about omega-3 and its metabolites in modulating underlying pathways related to complications secondary to cancer. The authors recommend further investigation to assess the potential effects of omega-3 associated with cancer [11]. Omega-3 supplementation may be an effective therapy in cachexia treatment for patients with cancer, especially if administered at the beginning of treatment [12]. A recent review showed that omega-3 fatty acids, especially EPA, might reduce cancer cachexia when administered at doses of 1 g/day and increased to 6 g/day over four weeks [13]. Moreover, a study with sixty pancreatic cancer patients found that low doses of omega-3 supplementation may preserve weight and appetite [14]. In a study with 53 individuals with advanced cancer, those who supplemented with EPA maintained their lean body mass compared to the control group [15].

Considering the importance of maintaining lean body mass in cancer and the potential that omega-3 has in this situation, this study aimed to review the literature on randomized clinical trials that evaluated the effects of omega-3 supplementation on lean

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body mass in cancer patients. As secondary objectives, we assessed the effects of omega-3 supplementation on body mass index (BMI) and body weight.

METHODS

We conducted a systematic review and meta-analysis with randomized controlled trials about the effects of omega-3 supplementation (or one of its family members, such as EPA or DHA) in cancer patients' lean body mass, BMI, and body weight. We followed the recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA) [16]. Moreover, it was prospectively registered on the International Prospective Registry for Systematic Reviews (PROSPERO) under the following protocol number: CRD42021232610.

Inclusion criteria

We included randomized clinical trials with cancer patients, under treatment or not, that evaluated the effects of omega-3 supplementation compared to placebo on lean body mass, BMI, and body weight. We also included studies in which only EPA or DHA was supplemented.

Exclusion criteria

Observational studies, studies not carried out with humans, studies carried with healthy humans, non-randomized clinical trials, and studies with post-surgical patients were excluded.

Search strategy

To determine the article's eligibility, we utilized the PICOS strategy (Population, Intervention, Comparison, Outcomes, Study design) (Supplementary Table 1). The searches included the following databases: Pubmed, LILACS, Scielo, Scopus, Web of Science, Cochrane, and Embase, and were performed until February 2021. Date or language restrictions were not applied. Three groups of keywords were used to find the articles selected using the Medical Subject Headings (MeSH). In the first one used to search for omega-3, we used: "ômega-3", "omega 3", "w-3", "n-3 Fatty Acids", "fish oil", and "n 3 Fatty Acids". In the second, terms for type lean body mass were used: "lean mass", "lean body mass", "muscle mass", "cachexia", and "body composition". The third group included the terms: "cancer", and "neoplasms". We utilized the Boolean operators "OR" and "AND" within or between groups, respectively.

Study selection

According to the inclusion and exclusion criteria established, two reviewers (FMD and LMF) independently conducted screenings of titles, abstracts, and full texts. The disagreements between reviewers were solved by consensus. Finally, the references of the included studies were reviewed for possible additional articles.

Risk of bias

We utilized the Cochrane tool to assess the risk of bias across the studies (21). Two reviewers independently assessed the risk of bias (FMD and LMF), and disagreements were solved by consensus. The scale items refer to questions about 1- random sequence generation (selection bias); 2- allocation concealment (selection bias); 3- blinding of patients and personnel (performance bias); 4- blinding of outcome assessment (detection bias); 5- incomplete outcome data (attrition bias); 6- selective reporting (reporting bias); 7- other bias, (other potential bias, not included in the domains described above). For the last, we decided to evaluate the supplementation of other substances in addition to omega-3. Thus, studies that administered a combined supplementation using omega-3 were classified as high risk when it was impossible to detect specific results from omega-3. We utilized the Review Manager 5.4 software to perform the Cochrane scale. We also performed Egger's regression tests and funnel plots to determine publication bias for analyses with more than ten studies.

Meta-analysis

We included studies that provided mean with standard deviation (SD), before and after the intervention, on lean body mass, BMI, and body weight. We also included studies that reported data as fat-free mass, lean tissue mass, or another measure that has mainly evaluated lean body mass. Based on this, the results are presented as lean body mass, as it is the measure that covers the others. For studies with no information, we assessed the mean change using the equation: SD change = square root [(SD baseline^2 + SD final^2) − (2 × R × $SD_{baseline}$ x SD_{final})] [17]. In this equation, we utilized a correlation coefficient (R) of 0.5, considering it a conservative measure for a predictable range of 0-1 [17]. For studies that reported data as standard error (SEM), we converted it to standard deviation (SD) through the following formula: SD = SEM x square root (n), where n is the number of subjects in each group [18]. For studies that reported data as confidence interval (CI), we converted to standard deviation (SD) utilizing the formula: [SD = square root (n) x upper limit − lower limit / 3.92]. In this formula, n represent the sample size, and 3.92 means 95% confidence interval [18]. Values from Interquartile ranges were converted to SD using the following formula: SD = Interquartile range / 1.35 [19]. We attributed the same SD from the intervention group for studies that did not report data to calculate SD from the control group [19].

Results are presented as the standardized mean difference (SMD) and 95% confidence intervals (95% CI). The Higgins I^2 statistic was calculated to estimate the heterogeneity between studies. Heterogeneity was statistically significant if $I^2 > 50\%$ and $p < 0.05$ [20]. We applied DerSimonian and Laird random-effects model to pool the SMDs. Meta-analysis was performed using the program RStudio, through the package Meta. The level of significance was set at 5%. Lean body mass and body weight were assessed in kilograms (kg), whereas BMI was kg/m^2.

RESULTS

Studies characteristics

Figure 1 presents the study selection flowchart. After excluding duplicates, 1152 were included. Reading the abstracts resulted in 63 studies for a complete reading. Of these, 12 met the inclusion criteria and were included in the review. The main reasons for exclusion at last stage were: did not evaluate the outcome studied ($n = 27$), it was not randomized trial ($n = 12$), animal study ($n = 1$), repeated study ($n = 3$), conference abstract ($n = 5$), and full text not found ($n = 2$). The process of reading the references resulted in two additional studies, totaling 14 manuscripts included in the present review.

Table 1 shows the main characteristics and results of the included studies. Of the 14 studies, eight were published between 2013 and 2020 [21–28]. Six studies were carried out in Europe [15, 28–32], seven in America [21–24, 26, 27, 33], and one in Asia 25 [25]. The smallest sample size was 21 individuals [21], while the highest was 518 [31]. Two studies were conducted only with women [24, 27], and the others 12 with both sexes. The omega-3 doses ranged from 2 grams of EPA [31] or omega-3 [24] to 18 capsules of omega-3 (3.24 g of EPA and 2.16 g of DHA) [33]. Five studies combined omega-3 with other substances. Seven studies utilized only EPA, while the other seven utilized omega-3 (EPA and DHA). Most studies were conducted with individuals aged between 50 and 70 years. Intervention time ranged from two [21, 33] to 12 weeks [27].

Main findings and meta-analysis

In general, four studies (29%) found some potential benefits from omega-3, or any of its isolated components, on lean body mass

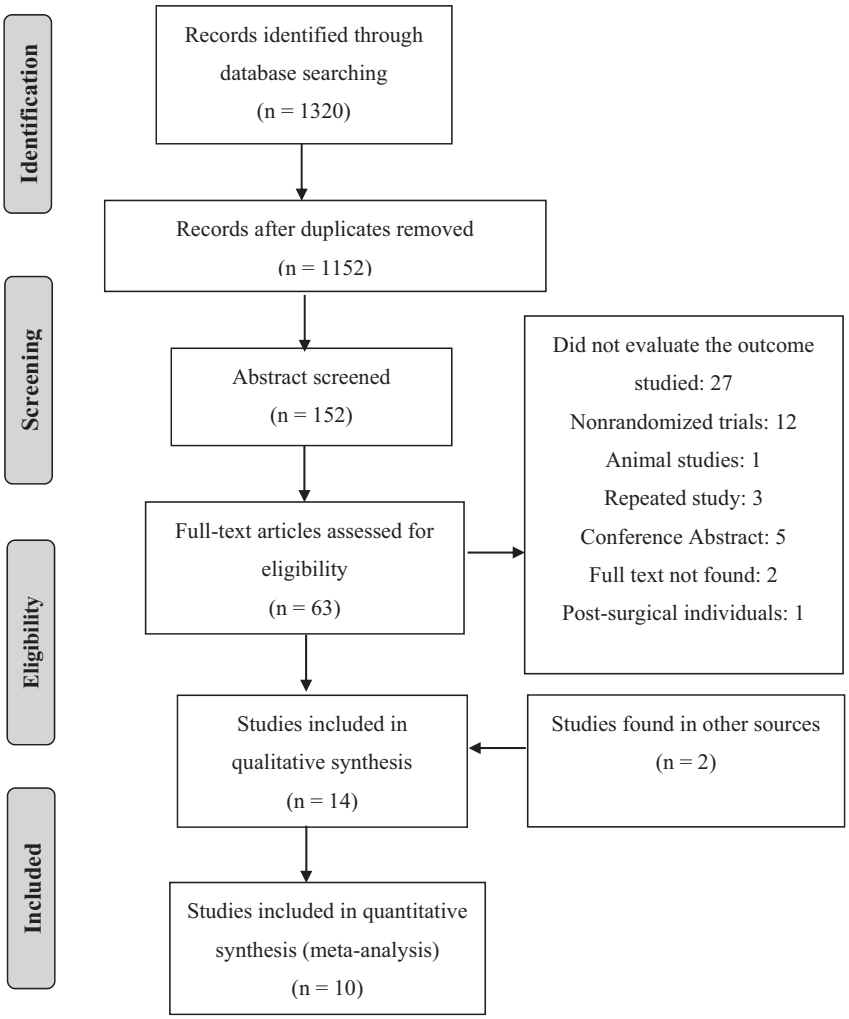

Fig. 1 PRISMA flowchart. Flowchart of the selection of studies presented in the review.

[22, 26, 30, 33]. Five studies reported increased plasma levels of omega-3 [15, 24, 29, 30, 32]. Fearon et al. 2003 reported increased plasma EPA levels in the intervention group [29]. Compared to the control group, Van der Meij et al. 2010 reported a plasma EPA concentration higher than in the control group [32]. In one study, the authors found evidence that some of the control subjects had been taking an exogenous source of EPA [30].

Figure 2 shows the results from the meta-analysis for lean body mass. The analysis included 463 individuals in the intervention group and 445 in the control group. Results showed that omega-3 increased lean body mass by 0.17 kg compared to placebo, but without significant differences between the groups [SMD: 0.17; CI 95%: −0.01, 0.35; $I^2 = 41\%$].

Figures 3 and 4 presents the results from the meta-analysis for BMI and body weight, respectively. Compared to the control group, the supplementation of omega-3 had no significant effects for BMI preservation or gain [SMD: 0.06; CI 95%: −0.16, 0.27; $I^2 = 0\%$]. For body weight, compared to the control group, those that ingested omega-3 gained 0.26 kg [SMD: 0.26; CI 95%: 0.06, 0.45; $I^2 = 46\%$].

Figure 5 presents a stratified analysis according to the body composition measurement method (single-frequency bioimpedance vs. multiple-frequency). We observed no statistically significant difference between single and multiple frequency bioimpedance for lean body mass and BMI. However, for body weight, we found a statistically significant difference. The studies that evaluated body composition by multiple-frequency bioimpedance showed that the intervention group gained 0.36 kg [SMD: 0.36; CI 95%: 0.10−0.61; $I^2 = 50\%$] compared to the control group.

Risk of bias

The assessment of the risk of bias in each study can be found in Fig. 6. Five of the 14 studies had all items classified as low risk of bias. In total, >25% of the items were classified as unclear or high risk of bias. The items with more studies classified as unclear were items one (Random sequence generation), three (Blinding of participants and personnel), and four (Blinding of outcome assessment), within four studies each. Item seven (Other bias) also had four studies classified as high risk because authors combined omega-3 with other substances. Figure 7 shows the funnel plot for lean body mass. Our Egger's test showed no asymmetry ($p = 0.8532$).

DISCUSSION

Our main objective was to assess whether supplementation with omega-3 or its components helps maintain or gain lean body mass in patients with cancer. Although the individuals in the intervention group gained 0.17 kg lean body mass, the result was not statistically significant. As a secondary objective, we evaluated whether omega-3 positively affects BMI or body weight. For BMI, our results were not statistically significant; however, we found a significant gain in body weight. Only ten studies provided enough

Table 1. Detailed description of each study included in the systematic review.

Identification	Location	Sample	Age	Duration in weeks	Study design	Lean body mass assessment	Intervention	Control	Diet therapy	Main results
Fearon et al., 2003 [29]	United Kingdom, Netherlands, Canada, Italy, and Belgium	200 individuals with advanced pancreatic cancer	67 years in the intervention group and 68 in the control group	8	Randomized double-blind	Xitron Hydra multiple frequency bioelectrical impedance analyzer	Intervention group: 2 cans containing 32 g protein + 2.2 g EPA in total	Identical supplement without n-3 fatty acids and enhanced antioxidants	Diet diaries were used to assess dietary intake. Total dietary intake was calculated by adding oral supplement consumption to spontaneous food intake	There were no significant differences between groups in lean body mass
Bruera et al., 2003 [33]	Canada	60 individuals with advanced cancer	63 years in the intervention group and 65 in the control group	2	Randomized double-blind	Lean body mass assessed using multiple frequency bioimpedance analysis body composition analyzer	Intervention group: 18 capsules containing 180 mg of EPA and 120 mg of DHA + 1 m of Vit E each	Olive oil	Patients were instructed to record food intake by estimating food quantities with reference to standard portions or household measures. The food items were coded, and the nutrient content estimated using Food Processor II nutrient analysis program with the Canadian Nutrient Data File (Esha Research, Salem, OR)	The intervention group gained 0.49 kg while the control lost 0.55 kg. The differences were not significant between the groups
Moses et al., 2004 [30]	United Kingdom	24 individuals with unresectable pancreatic cancer	Mean age of 68 years between groups	8	Randomized double-blind	Lean body mass assessed using Xitron Hydra multiple-frequency bioelectrical impedance	Intervention group: 2 cans containing 32 g proteins + 12 g fat with +2.2 g EPA in total	Identical supplement without n-3 fatty acids	Diet diaries were used to assess dietary intake. The mean total energy intake (TEI) and macronutrient intakes were calculated using a computerized dietary analysis. The total dietary intake was calculated by adding oral supplement consumption to spontaneous food intake	The intervention group gained 0.3 kg, while the control gained 0.6 kg. The differences were not significant between the groups

Table 1. continued

Identification	Location	Sample	Age	Duration in weeks	Study design	Lean body mass assessment	Intervention	Control	Diet therapy	Main results
Fearon et al., 2006 [31]	United Kingdom	518 individuals with advanced gastrointestinal or lung cancer	Mean age of 67 years between groups	8	Randomized double-blind	Lean body mass assessed using Bodystat 1500 bioelectrical impedance analyzer at two frequencies	Group 1: Capsules containing 2 g EPA Group 2: capsules containing 4 g EPA	Placebo capsules containing medium-chain triglyceride, which was also blended with the diester oil	Not specified	Group 1 gained 0.6 kg Group 2 lost 0.4 kg Group 3 lost 0.3 kg. The differences were not significant between the groups
Ryan et al., 2009 [15]	Ireland	53 individuals with advanced cancer	62 years in the intervention group and 66 in the control group	3	Randomized double-blind	Lean body mass assessed using Tanita BC 418 MA bioelectrical impedance analyzer at a single frequency	Intervention group: Enteral supplement with 2.2 g of EPA in total	Enteral supplement with placebo (isocaloric, isonitrogenous standard nutritional feed)	Individual energy requirements were calculated for each patient using the Schofield equation, the target was ~30 calories per kilogram per day. Protein requirements were estimated using the Elia table	The intervention group preserved his lean body mass while the control group lost
Van Der Meij et al., 2010 [32]	Netherlands	40 individuals with non-small cell lung cancer	58 years in the intervention group and 57 in the control group	5	Randomized double-blind	Fat-free mass assessed using bioelectrical impedance analysis (Hydra 4200, Xitron Technologies) at multiple-frequency	Intervention group: 2 cans containing Protein + 4.04 g EPA + 1.84 g DHA in total	Placebo cans containing supplements without EPA and DHA isocaloric	Nutritional intake was calculated by a nutrition analysis software application (NEVO 2006)	In the intervention group, the fat free mass decreased less than in the control group
Marques et al., 2013 [21]	Brazil	21 individuals with gastrointestinal cancer	Mean age of 66 years between groups	2	Randomized double-blind	Lean body mass assessed using tetrapolar bioimpedance (BodyStat 1500) at a single frequency	Intervention group: 7 capsules of omega-3 (214 EPA and 113 DHA per capsule)	Capsules of placebo containing soybean oil	Not specified	There were no significant differences between groups in lean body mass
Sánchez-Lara et al., 2014 [22]	Mexico	84 individuals with advanced non-small cell lung cancer	Mean age of 59 years in the intervention group and 61 in the control group	6	Randomized	Lean body mass was assessed using Bodystat Quadscan 4000 multi-frequency	Intervention group: diet plus 2.2 g of EPA daily	Isocaloric diet	Patients of both groups were advised to follow a diet on standardized menus with isocaloric diets	The intervention group preserved his lean body mass while the control group lost

Table 1. continued

Identification	Location	Sample	Age	Duration in weeks	Study design	Lean body mass assessment	Intervention	Control	Diet therapy	Main results
Mocellin et al., 2017 [23]	Brazil	45 individuals with colorectal or gastric cancer	Mean age of 56 years in the intervention group and 51 in the control group	9	Randomized triple-blind	Fat-free mass assessed using single frequency (50 kHz) tetrapolar bio-electrical impedance	Intervention group: Capsules containing 3.6 g omega-3 (1.55 EPA and DHA) in total	Capsules of placebo supplement containing extra-virgin olive oil	Not specified	There were no significant differences between groups in lean body mass. However, subgroup analyses showed that omega-3 preserved the loss of muscle mass
Paixao et al., 2017 [24]	Brazil	37 women with naïve breast cancer	Mean age of 49 years in the intervention group and 53 in the control group	4	Randomized double-blind	Lean body mass assessed using BIA Quantum II instrument at a single frequency	Intervention group: 2 capsules containing 470 mg EPA and 390 mg DHA each	Capsules of placebo containing mineral oil	Nutritional intake was assessed by 24 h recall using NutWin software (1.5.2.51 version)	There were no significant differences between groups in lean body mass
Golkhalkhali et al., 2018 [25]	Malaysia	140 individuals with colorectal cancer	Aged 18 and above	8	Randomized double-blind	The method to assess lean body mass was not specified	Intervention group: 2 sachets containing 700 mg of EPA and DHA each	Sachets biologically inactive placebo preparations identical in appearance MPC and omega-3 fatty acid	Nutritional intake assessment using questionnaire and the 24 h recall method	There were no significant differences between groups in lean body mass
Solís-Martínez et al., 2018 [26]	Mexico	64 individuals with head and neck squamous cell cancer	Mean age of 60 years in the intervention group and 58 in the control group	6	Randomized single-blind	Lean body mass was assessed using bioelectrical impedance analysis (Quantum model IV plus the BC Body Composition Software) at a single frequency	Intervention group: 2 g of EPA	A standard polymeric supplement with 24 g of calcium caseinate	Both groups received two bottles of a polymeric high protein with 40 g of protein and followed a diet based on the Mexican System of Food Equivalents	The internment group had lower weight loss and lean body mass
de la Rosa Oliva et al., 2019 [27]	Mexico	52 women with advanced breast cancer	Mean age of 51 years in the intervention group and 50 in the control group	12	Randomized double-blind	Fat-free mass assessed using bioelectrical impedance (Inbody 720; Biospace, Ltd., Seoul Korea) at multiple frequencies	Intervention group: 4 capsules containing 1.6 g EPA and 0.8 g DHA in total	Capsules of placebo containing sunflower oil	Not specified	There were no significant differences between groups in lean body mass
Hossain et al., 2020 [28]	United Kingdom	61 individuals with colorectal cancer	Mean age of 69 years in the intervention group and 67 in the control group	4	Randomized double-blind	Lean muscle mass assessed using dual-energy X-ray absorptiometry (DXA)	Intervention group: 6 capsules containing 3 g of EPA in total	Capsules of near-identical placebo	Not specified	There were no significant differences between groups in lean body mass

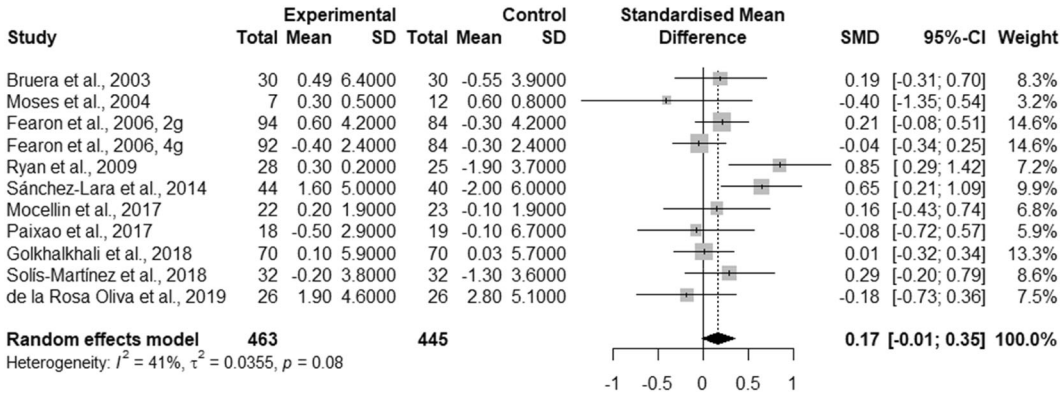

Fig. 2 Forest plot for lean body mass. Forest plot of randomized controlled trials that investigated the effects of supplementation with omega-3 (or its components) and lean body mass.

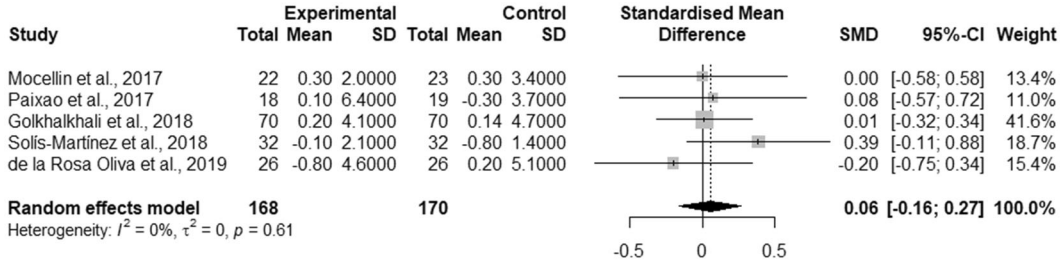

Fig. 3 Forest plot for BMI. Forest plot of randomized controlled trials that investigated the effects of supplementation with omega-3 (or its components) and body mass index (BMI).

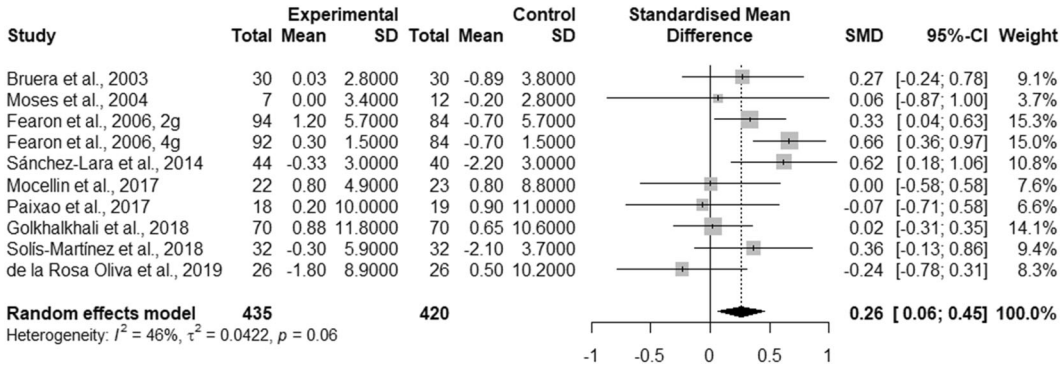

Fig. 4 Forest plot for body weight. Forest plot of randomized controlled trials that investigated the effects of supplementation with omega-3 (or its components) and body weight.

data to be included in the quantitative analysis, demonstrating considerable heterogeneity and a lack of essential data between studies. In the systematic review, only four studies showed benefits compared to placebo. Three of them used EPA alone [15, 22, 26], whereas the fourth used 4.04 g of EPA and a low DHA dose (1.84 g) [32]. This may suggest that EPA is the main component with the potential to preserve lean body mass in catabolic individuals. The literature supports these findings and shows that EPA may have anabolic potential in the muscle through sensitizing skeletal muscle to insulin [12]. Insulin insensitivity is a condition that has been observed in subjects with cancer cachexia. Animal studies have shown that insulin insensitivity preceded weight loss [12]. The main mechanisms that influence the effects of omega-3, especially EPA, are related to the attenuation of catabolic activity in pathways such as protein degradation, lipid mobilization, and reduced glucose consumption in skeletal muscle [13].

We found significant heterogeneity in the intervention time between studies. Some utilized omega-3 for just two weeks [21, 33], while another study used it for 12 weeks [27]. However, this does not seem to make a difference in the results since the two studies that showed positive results had an intervention time of only three and five weeks. Doses used also varied widely. One study even used doses of 18 capsules of omega-3 per day and had no significant results [33], while the two studies with significant results used doses of 2.2 g of EPA [15] and 4.04 g of EPA + 1.84 g of DHA [32]. The maximum recommended dose of omega-3 is 5 g/day. This limit has been established by government agencies such as the Food and Drug Administration (FDA) and The European Food Safety Authority [34].

Although the results showed potential benefits of omega-3, especially EPA, in gaining lean body mass in cancer patients, the literature is still very scarce and heterogeneous. For example, there were differences among the 14 studies in practically all of

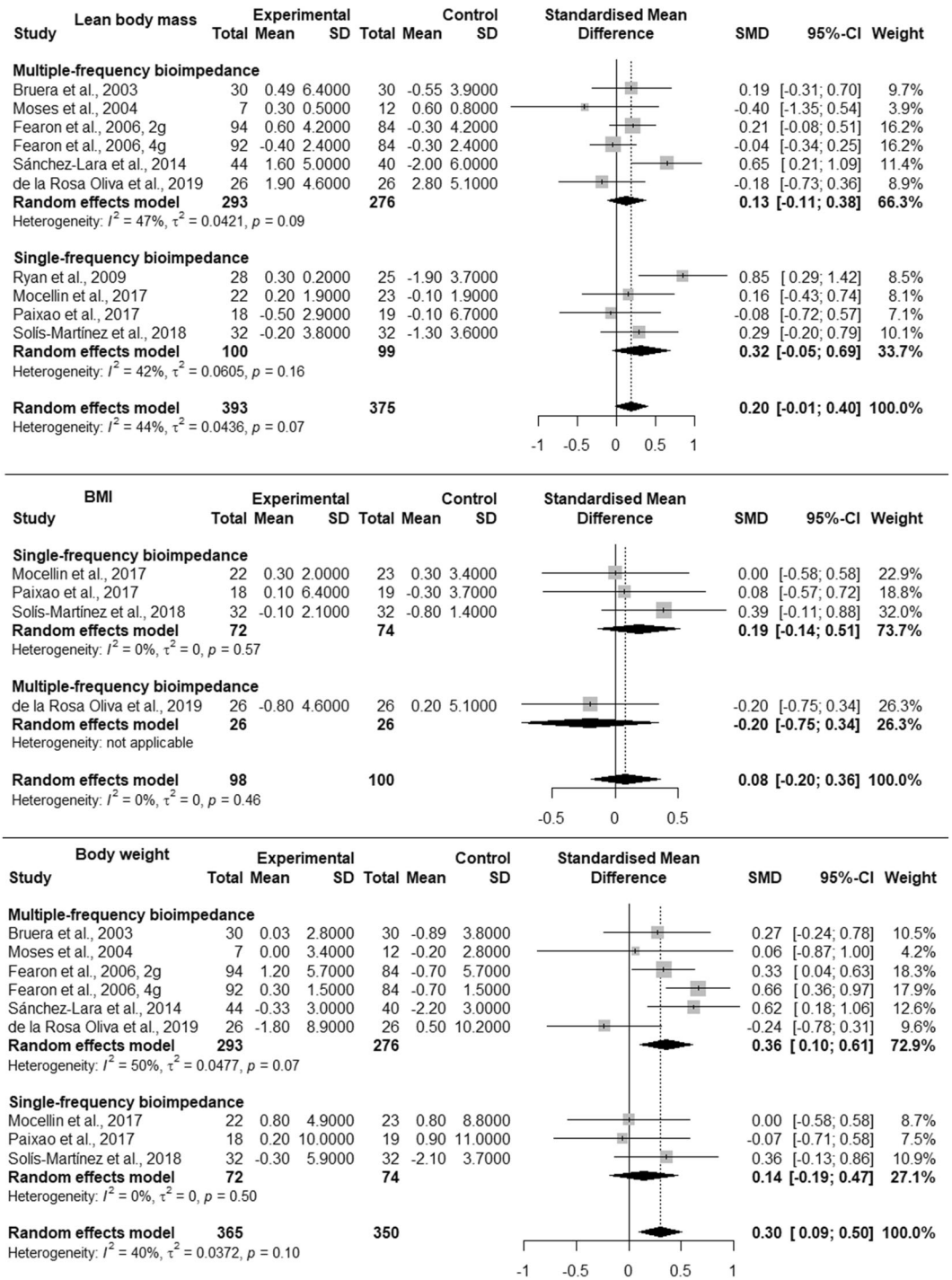

Fig. 5 Forest plot by body composition measurement method. Forest plot of randomized controlled trials that investigated the effects of supplementation with omega-3 (or its components) and lean body mass, BMI, and body weight stratified by body composition measurement method.

them regarding the type of placebo used, duration of intervention, methodological criteria, and dietary intervention. Some studies utilized olive oil as a control. However, olive oil is bioactive associated with weight control, according to a systematic review and meta-analysis published in 2018 [35]. The purpose of a placebo is to be an innocuous substance that does not affect the evaluated outcome. Thus, the choice of an adequate placebo is essential to ensure comparability between the intervention and control groups, without bias in the results.

The Cochrane scale showed >25% of the items as unclear or high risk of bias. Moreover, our bias scale showed essential items classified as unclear risk in the methodology. A poorly performed randomization can be an important bias and negatively influence the results. One of the two studies with positive results combined omega-3 with protein [32]. It becomes difficult to know whether significant effects have been attributed to omega-3 or protein. However, another study combined omega-3 with protein and showed non-significant results compared to placebo [29].

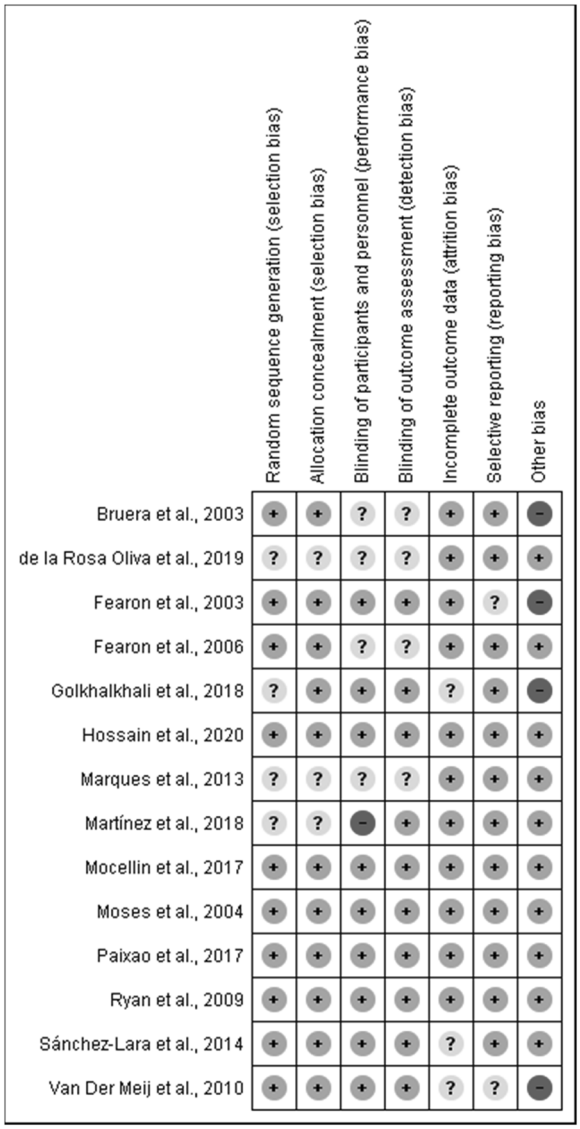

Fig. 6 Cochrane risk of bias. Cochrane risk of bias toll results for included studies.

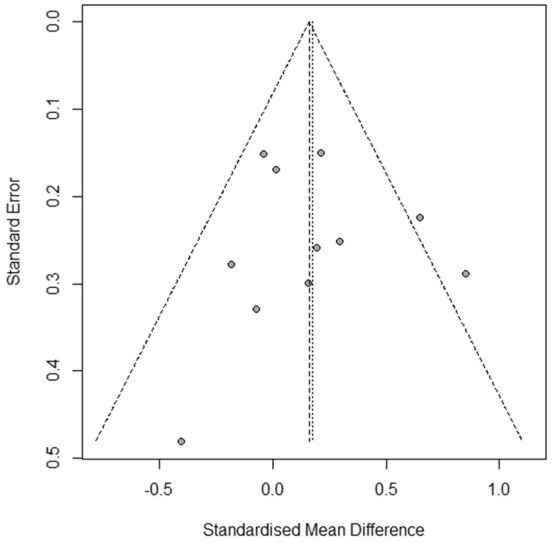

Fig. 7 Funnel plots for assessing the risk of publication bias for lean body mass. Funnel plot assessing the publication bias between the effects of omega-3 supplementation and lean body mass in cancer patients.

This review has several strengths. First, we followed the recommendations of PRISMA to add quality to the study. Second, no restrictions on language or year of publication were included to perform the searches. However, we are not free of limitations. The first one is that studies published in gray literature were not included, such as thesis, which can provide null or negative results that are not published [36]. Moreover, not all studies were included in the meta-analysis. We tried to contact the authors of the other studies but without success. For this reason, the results of the meta-analysis should be interpreted with caution, and further studies are needed. Future studies should mainly assess EPA, as this appears to be the component with the most significant potential for lean body mass preservation among cancer patients. The use of omega-3 should not be discouraged in cancer patients since its use can help cancer survival, increasing chemotherapy's effectiveness [11]. In addition, we found a significant gain in body weight in patients who used omega-3 compared to placebo. This result is important and shows that omega-3 has potential in cachexia so that future perspectives can change current literature.

In conclusion, this systematic review and meta-analysis showed that omega-3 supplementation, compared with placebo, was ineffective in maintaining or gaining lean body mass and BMI among cancer patients. For body weight, we found a statistically significant weight gain. Future studies should conduct experiments mainly with EPA and use doses between two and four grams. In addition, future investigations must use more homogeneous methods, including the type of placebo, duration, and dietary intervention, to ensure comparability between results.

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AUTHOR CONTRIBUTIONS

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COMPETING INTERESTS

The authors declare no competing interests.

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