Omega-3 Fatty Acids

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Omega-3 fatty acids have a role to play in sports performance! Optimal dose and duration for supplementation may differ between athletes and amateurs.

Omega-3 fatty acids, specifically eicosapentanoic acid (EPA, 20:5n-3) and docosahexanoic acid (DHA, 22:6n-3) are receiving increasing attention in sports nutrition. While the usual focus is that of athletes, questions remain if the different training status between athletes and amateurs influences the response to EPA/DHA, and as to whether amateurs would benefit from EPA/DHA supplementation.

Keywords: Omega-3 Fatty Acids ; athletes ; nutrition ; sports nutrition ; amateurs ; EPA ; DHA

1. Introduction

The main purpose of nutrition for athletes is to compensate for increased energy and nutrient needs. In recent years, the role of omega-3 fatty acids in sport has received increasing research attention [1]. Omega-3 fatty acids are perceived as a potential supplement that may beneficially affect performance, recovery and the risk for illness/injury [2]. Omega-3 fatty acids belong to the family of polyunsaturated fatty acids [3]. While there are fatty acids of varying length, the most important ones are considered to be the very long-chain fatty acids eicosapentanoic acid (EPA, 20:5n-3) and docosahexanoic acid (DHA, 22:6n-3) [4]. The predominant source for EPA/DHA is seafood, particularly fatty fish, such as mackerel and herring. Although food items such as linseed oil and walnut oil have high amounts of the plant-derived omega-3 fatty acid α-linolenic acid (ALA, 18:3n-3) they are not routinely consumed in large quantities. Other food products, such as soybeans, squash and wheat germ cereals contain less ALA but are often consumed in higher amounts and therefore contribute significantly to ALA intake. While EPA can be synthesized from ALA, the conversion of ALA to EPA and further to DHA is characterized by a low conversion rate [5], therefore the consumption of EPA/DHA via seafood is generally recommended. Although the current recommendations stand, it should be noted that there is a substantial genetic variation in the fatty acid metabolism [6].

In the European Union (EU), across all populations, EPA and DHA intake is not adequate; in 74% of the EU countries the intake was found to be lower than the European Food Safety Agency (EFSA) recommendation of 250 mg for EPA and DHA as adequate intake for adults based on cardiovascular considerations [7][8]. The current dietary guidelines for Americans suggest the same value [9]. EPA/DHA are considered safe up to 5 g per day [10]. Although EFSA's recommendation is for the normal, healthy population, it is reasonable to assume that neither athletes nor amateurs consume adequate amounts either considering their higher energy turnover and metabolic flux. In fact, analyses of dietary habits in various athletes found that substantial proportions of the studied populations did not reach the dietary goals for macro- and micronutrients, including EPA/DHA [11][12]. Furthermore, a recent multi-center, cross-sectional study in 404 National Collegiate Athletic Association Division I football athletes revealed that no athlete had an Omega-3 Index associated with low risk [13].

While there are some data that EPA/DHA may improve endurance capacity and promote recovery in athletic populations [14], current evidence lacks consensus [1]. Given the fact that a lot of studies with omega-3 fatty acids were conducted in non-professionals, we also include studies conducted in amateurs (defined as people pursuing an activity for pleasure without payment and not as a job). Broadening the data base may shed more light on the effects of EPA/DHA supplementation on performance parameters. Furthermore, this large section of the population is also of interest as it can potentially benefit from an optimized diet as well. Studies were included when parameters relevant for performance, recovery and risk of illness/injury were reported.

2. Omega-3 Fatty Acids for Sport Performance

The evidence presented here show that EPA/DHA may have the potential to influence not only the metabolic response of muscle to nutrition, but also the physiological functional response to exercise and post-exercise conditions. However, these physiological and metabolic adaptations do not always translate into improved performance.

There seem to be bigger gains for amateurs. It is possible that there is a genuine difference, that amateurs have more to gain from EPA/DHA supplementation, but it could be due to the higher metabolic flux in athletes meaning they require more EPA/DHA to see the benefits (either in terms of dosage or supplementation duration). Alternatively, it could be the case that studies tend to be longer in the amateur groups (from experience, amateurs are more willing to keep training constantly for longer than athletes), so the positive performance gains are more likely to develop in the longer studies more often seen in amateurs. It should also be acknowledged that the potential for performance gains is narrower in athletes due to the law of diminishing returns.

2.1. Increased Performance

It is known that the response of skeletal muscle to exercise can be influenced by the nutritional status of the muscle [15]. This effect is not confined to macronutrients, but EPA/DHA can also potentially influence the exercise and nutritional response of skeletal muscle [16], this in turn can partly explain the observed decrease in soreness. Although the potential for EPA/DHA supplementation to improve muscle mass or function, is supported by mechanistic explanations including structural changes of the muscle cell membranes [17][18] it was found no consistent effect on strength in amateurs. Muscle protein synthesis, a fundamental process in muscle growth, was unchanged after 3.5 g EPA and 0.9 g DHA over 8 weeks, although muscle biopsies revealed that kinase signaling in response to resistance training was altered [19]. However, it has been shown that incorporation of EPA/DHA in muscle cells stimulates foal adhesion kinase, which regulates MPS [20], and may actually have a beneficial effect on muscle protein synthesis. This was shown in amateur females and males in response to anabolic stimuli, in two 8-week intervention studies with 1.86 g EPA and 1.5 g DHA [21][22]. Interestingly, selective improvement in muscle torque and muscle quality after, but not during, exercise was reported in females only [23]. EPA and DHA seemed to optimize the effects of resistance training in amateur elderly females, including dynamic and explosive strength, however these effects did not result in an overall improvement of isometric strength performance [24]. These data corroborate other reports that possibly older adult populations may benefit from EPA/DHA supplementation in the context of preserving muscle mass in an older population [14].

Peroxisome proliferator-activated receptor-gamma coactivator (PGC-1a) is a key regulator of mitochondrial biogenesis. In obese participants, EPA has been shown to stimulate mitochondrial biogenesis [25], which could result in improved endurance regulated via the PGC-1a pathway. It can be hypothesized that lower heart rates and improved O_2 uptake may lead to better O_2 delivery to contracting muscles, thereby enhancing endurance performance [26]. Another mechanism for improved endurance could be that EPA/DHA increase the deformability of RBC, which in turn could increase oxygen delivery to the muscles [27]. It has also been shown that exposure of human myotubes to EPA upregulated specific genes that regulate beta-oxidation [28]. Moreover, clinical evidence suggests that EPA/DHA increase fatty acid oxidation via the carnitine palmitoyltransferase-II [29][30]. These mechanisms may well have contributed to the increased fat oxidation during rest by 19% and during exercise by 27% following supplementation of 3 g/day EPA/DHA over 12 weeks in female adults [31].

2.2. Enhanced Recovery

The concept of muscle damage following intense eccentric exercise is accepted [32]. The acute exercise recovery period is defined as the initial 96 h following exercise [33]. EPA and DHA have been described to increase the structural integrity of muscle cell membranes [18], which in turn may explain the protective effect of EPA/DHA. This has recently been demonstrated in soccer players where 1.1 g/day EPA/DHA combined with 30 g/day whey protein resulted in reduced levels of muscle soreness along with a reduction of plasma CK concentration [34]. Furthermore, exercise-induced muscle damage causes responses that include DOMS and muscle fatigue. It also leads to increased circulating neutrophils and interleukin-1 peaking within 24 h after the exercise, with skeletal muscle levels remaining elevated for 48 h and longer [35]. Inflammation is a key process in muscular repair and regeneration, the potential of EPA/DHA to accelerate the recovery process via immune modulation come into play. EPA/DHA influence immune modulation via increasing interleukin 2 (IL2) [36][37], where an acute dose of fish oil improved markers of inflammation after eccentric exercise in amateur males [38]. The authors found that in 45 amateur males an acute dose of 1.8 g fish oil before a single eccentric exercise bout lead to a smaller exercise-induced elevation in tumor necrosis factor-α (TNF-α) and prostaglandin (PG)E_2 immediately, 24 h, and 48 h after exercise, as well as significantly lower elevation in the concentrations of interleukin 6 (IL-6), CK, and myoglobin (Mb) at 24 and 48 h after exercise.

Furthermore, in theory EPA/DHA may contribute to insulin-sensitizing effects because EPA and DHA are natural ligands for peroxisome proliferator-activated receptor γ (PPARγ); following activation of PPARγ, nuclear factor kappa B (NF-κB) activity is suppressed, reducing the release of pro-inflammatory cytokines [39]. At a cellular level, fatty acids have an important function in regulating the activity of certain enzymes and by acting as signaling molecules [3]. It has been shown that 1.3 g fish oil consumption over 6 weeks has the potential to ameliorate the exercise-induced decrease in superoxide dismutase activity in sedentary control participants [40]. In the same study, fish oil tended to increase the catalase activity after 1 h of recovery. Together, these findings suggest that EPA/DHA may activate the superoxide dismutase and catalase pathways. Oxidative stress is usually defined by an increased formation of prooxidants and decrease of antioxidants. This disturbance can lead to oxidative damage to cellular components such as lipids, protein and DNA. However, oxidative stress and inflammation are interdependent. Inflammation can develop following oxidative stress, on the other hand inflammation can induce oxidative stress which further enhances inflammation [41]. Exercise mode, intensity, and duration, as well as the subject population tested, can impact the extent of oxidative stress. Furthermore, the use of antioxidant supplements such as EPA/DHA can impact the outcomes. EPA and DHA have been shown to improve muscle function in older adults [42][43]. A recent paper supports the view that EPA/DHA could bring benefits by attenuating the generation of oxidative stress [44]. In this review, preliminary evidence is provided that EPA/DHA may be beneficial in counteracting exercise-induced inflammation. However, current data are inconclusive as to whether EPA/DHA supplementation at the reported dosages is effective in attenuating the immune-modulatory response to exercise and ultimately improve recovery.

2.3. Reduced Risk of Injury/Illness

Optimal sports performance requires optimal health. EIB is a prominent asthma phenotype affecting an estimated 90% of asthma patients and up to 50% of elite athletes [45]. Reduced inflammation ameliorates the severity of asthma and exerts a bronchodilatory effect. The anti-inflammatory effects of EPA/DHA may be linked to a change in cell membrane composition and lipid mediators such as resolvins [46]. Alternatively, the effect may also be mediated by the decreased production of bronchoconstrictive leukotrienes [47].

Certain sports like soccer or rugby can lead to traumatic brain injuries (TBI). As outlined by others, the number of sport-related concussions are increasing globally [48]. Although DHA and EPA have shown promising in vitro and animal evidence of neuronal repair capacities in TBI [49], there has been only one large, controlled intervention study conducted in American football players. The underlying mechanisms for this observation have not been completely elucidated but it is suggested that saturation of brain cells with DHA in particular may facilitate healing after brain trauma, thereby counteracting negative long-term results [50]. Other mechanisms by which specifically DHA could convey neuroprotection include preservation of myelin, alleviation of glutamate cytotoxicity, suppression of mitochondrial dysfunction and down-regulation of alpha-amino-3-hydroxy-5- methyl-4-isoxazolepropionic acid receptor sub- units. Details are discussed elsewhere [48].

References

1. Da Boit, M.; Hunter, A.M.; Gray, S.R. Fit with good fat? The role of n-3 polyunsaturated fatty acids on exercise performance. Metabolism 2017, 66, 45–54.
2. Simopoulos, A.P. Omega-3 fatty acids and athletics. Curr. Sports Med. Rep. 2007, 6, 230–236.
3. Burdge, G.C.; Calder, P.C. Introduction to fatty acids and lipids. World Rev. Nutr. Diet 2015, 112, 1–16.
4. Calder, P.C. Very long-chain n-3 fatty acids and human health: Fact, fiction and the future. Proc. Nutr. Soc. 2018, 77, 52–72.
5. Arterburn, L.M.; Hall, E.B.; Oken, H. Distribution, interconversion, and dose response of n-3 fatty acids in humans. Am. J. Clin. Nutr. 2006, 83, 1467S–1476S.
6. Ameur, A.; Enroth, S.; Johansson, A.; Zaboli, G.; Igl, W.; Johansson, A.C.; Rivas, M.A.; Daly, M.J.; Schmitz, G.; Hicks, A.A.; et al. Genetic adaptation of fatty-acid metabolism: A human-specific haplotype increasing the biosynthesis of long-chain omega-3 and omega-6 fatty acids. Am. J. Hum. Genet. 2012, 90, 809–820.
7. EFSA. Scientific Opinion on Dietary Reference Values for fats, including saturated fatty acids, polyunsaturated fatty acids, monounsaturated fatty acids, trans fatty acids, and cholesterol. EFSA J. 2010, 8, 1461.
8. Sioen, I.; van Lieshout, L.; Eilander, A.; Fleith, M.; Lohner, S.; Szommer, A.; Petisca, C.; Eussen, S.; Forsyth, S.; Calder, P.C.; et al. Systematic Review on N-3 and N-6 Polyunsaturated Fatty Acid Intake in European Countries in Light of the Current Recommendations - Focus on Specific Population Groups. Ann. Nutr. Metab. 2017, 70, 39–50.

9. Agriculture U.D.o.H.a.H.S.a.U.D.o. 2015–2020 Dietary Guidelines for Americans; US Government Printing Office: Washington, DC, USA, 2015.
10. EFSA. Scientific Opinion on the Tolerable Upper Intake Level of eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA) and docosapentaenoic acid (DPA). EFSA J. 2012, 10.
11. Baranauskas, M.; Stukas, R.; Tubelis, L.; Zagminas, K.; Surkiene, G.; Svedas, E.; Giedraitis, V.R.; Dobrovolskij, V.; Abaravicius, J.A. Nutritional habits among high-performance endurance athletes. Medicina (Kaunas) 2015, 51, 351–362.
12. Von Schacky, C.; Kemper, M.; Haslbauer, R.; Halle, M. Low Omega-3 Index in 106 German elite winter endurance athletes: A pilot study. Int. J. Sport Nutr. Exerc. Metab. 2014, 24, 559–564.
13. Anzalone, A.; Carbuhn, A.; Jones, L.; Gallop, A.; Smith, A.; Johnson, P.; Swearingen, L.; Moore, C.; Rimer, E.; McBeth, J.; et al. The Omega-3 Index in National Collegiate Athletic Association Division I Collegiate Football Athletes. J. Athletic Train. 2019, 54, 7–11.
14. Philpott, J.D.; Witard, O.C.; Galloway, S.D.R. Applications of omega-3 polyunsaturated fatty acid supplementation for sport performance. Res. Sports Med. 2019, 27, 219–237.
15. Beck, K.L.; Thomson, J.S.; Swift, R.J.; von Hurst, P.R. Role of nutrition in performance enhancement and postexercise recovery. Open Access J. Sports Med. 2015, 6, 259–267.
16. Jeromson, S.; Gallagher, I.J.; Galloway, S.D.; Hamilton, D.L. Omega-3 Fatty Acids and Skeletal Muscle Health. Mar. Drugs 2015, 13, 6977–7004.
17. Calder, P.C.; Yaqoob, P.; Harvey, D.J.; Watts, A.; Newsholme, E.A. Incorporation of fatty acids by concanavalin A-stimulated lymphocytes and the effect on fatty acid composition and membrane fluidity. Biochem. J. 1994, 300 (Pt 2), 509–518.
18. Murphy, M.G. Dietary fatty acids and membrane protein function. J. Nutr. Biochem. 1990, 1, 68–79.
19. McGlory, C.; Wardle, S.L.; Macnaughton, L.S.; Witard, O.C.; Scott, F.; Dick, J.; Bell, J.G.; Phillips, S.M.; Galloway, S.D.; Hamilton, D.L.; et al. Fish oil supplementation suppresses resistance exercise and feeding-induced increases in anabolic signaling without affecting myofibrillar protein synthesis in young men. Physiol. Rep. 2016, 4.
20. McGlory, C.; Galloway, S.D.; Hamilton, D.L.; McClintock, C.; Breen, L.; Dick, J.R.; Bell, J.G.; Tipton, K.D. Temporal changes in human skeletal muscle and blood lipid composition with fish oil supplementation. Prostaglandins Leukot. Essent. Fatty Acids 2014, 90, 199–206.
21. Smith, G.I.; Atherton, P.; Reeds, D.N.; Mohammed, B.S.; Rankin, D.; Rennie, M.J.; Mittendorfer, B. Dietary omega-3 fatty acid supplementation increases the rate of muscle protein synthesis in older adults: A randomized controlled trial. Am. J. Clin. Nutr. 2011, 93, 402–412.
22. Smith, G.I.; Atherton, P.; Reeds, D.N.; Mohammed, B.S.; Rankin, D.; Rennie, M.J.; Mittendorfer, B. Omega-3 polyunsaturated fatty acids augment the muscle protein anabolic response to hyperinsulinaemia-hyperaminoacidaemia in healthy young and middle-aged men and women. Clin. Sci. (Lond.) 2011, 121, 267–278.
23. Da Boit, M.; Sibson, R.; Sivasubramaniam, S.; Meakin, J.R.; Greig, C.A.; Aspden, R.M.; Thies, F.; Jeromson, S.; Hamilton, D.L.; Speakman, J.R.; et al. Sex differences in the effect of fish-oil supplementation on the adaptive response to resistance exercise training in older people: A randomized controlled trial. Am. J. Clin. Nutr. 2017, 105, 151–158.
24. Edholm, P.; Strandberg, E.; Kadi, F. Lower limb explosive strength capacity in elderly women: Effects of resistance training and healthy diet. J. Appl. Physiol. 2017, 123, 190–196.
25. Laiglesia, L.M.; Lorente-Cebrian, S.; Prieto-Hontoria, P.L.; Fernandez-Galilea, M.; Ribeiro, S.M.; Sainz, N.; Martinez, J.A.; Moreno-Aliaga, M.J. Eicosapentaenoic acid promotes mitochondrial biogenesis and beige-like features in subcutaneous adipocytes from overweight subjects. J. Nutr. Biochem. 2016, 37, 76–82.
26. Macaluso, F.; Barone, R.; Catanese, P.; Carini, F.; Rizzuto, L.; Farina, F.; Di Felice, V. Do fat supplements increase physical performance? Nutrients 2013, 5, 509–524.
27. Tiryaki-Sönmez, G.S.B.; Vatansever-Ozen, S. Omega-3 fatty acids and exercise: A review of their combined effects on body composition and physical performance. Biomed. Human Kinetics 2011, 3, 23–29.
28. Hessvik, N.P.; Bakke, S.S.; Fredriksson, K.; Boekschoten, M.V.; Fjorkenstad, A.; Koster, G.; Hesselink, M.K.; Kersten, S.; Kase, E.T.; Rustan, A.C.; et al. Metabolic switching of human myotubes is improved by n-3 fatty acids. J. Lipid Res. 2010, 51, 2090–2104.
29. Haghravan, S.; Keshavarz, S.A.; Mazaheri, R.; Alizadeh, Z.; Mansournia, M.A. Effect of Omega-3 PUFAs Supplementation with Lifestyle Modification on Anthropometric Indices and Vo2 max in Overweight Women. Arch. Iran Med. 2016, 19, 342–347.

30. Rokling-Andersen, M.H.; Rustan, A.C.; Wensaas, A.J.; Kaalhus, O.; Wergedahl, H.; Rost, T.H.; Jensen, J.; Graff, B.A.; Caesar, R.; Drevon, C.A. Marine n-3 fatty acids promote size reduction of visceral adipose depots, without altering body weight and composition, in male Wistar rats fed a high-fat diet. Br. J. Nutr. 2009, 102, 995–1006.
31. Logan, S.L.; Spriet, L.L. Omega-3 Fatty Acid Supplementation for 12 Weeks Increases Resting and Exercise Metabolic Rate in Healthy Community-Dwelling Older Females. PLoS One 2015, 10, e0144828.
32. Nedelec, M.; McCall, A.; Carling, C.; Legall, F.; Berthoin, S.; Dupont, G. Recovery in soccer: Part I - post-match fatigue and time course of recovery. Sports Med. 2012, 42, 997–1015.
33. Pereira Panza, V.S.; Diefenthaeler, F.; da Silva, E.L. Benefits of dietary phytochemical supplementation on eccentric exercise-induced muscle damage: Is including antioxidants enough? Nutrition 2015, 31, 1072–1082.
34. Philpott, J.D.; Donnelly, C.; Walshe, I.H.; MacKinley, E.E.; Dick, J.; Galloway, S.D.R.; Tipton, K.D.; Witard, O.C. Adding Fish Oil to Whey Protein, Leucine, and Carbohydrate Over a Six-Week Supplementation Period Attenuates Muscle Soreness Following Eccentric Exercise in Competitive Soccer Players. Int. J. Sport Nutr. Exerc. Metab. 2018, 28, 26–36.
35. Evans, W.J. Muscle damage: Nutritional considerations. Int. J. Sport Nutr. 1991, 1, 214–224.
36. Gray, P.; Gabriel, B.; Thies, F.; Gray, S.R. Fish oil supplementation augments post-exercise immune function in young males. Brain Behav. Immun. 2012, 26, 1265–1272.
37. Da Boit, M.; Mastalurova, I.; Brazaite, G.; McGovern, N.; Thompson, K.; Gray, S.R. The Effect of Krill Oil Supplementation on Exercise Performance and Markers of Immune Function. PLoS One 2015, 10, e0139174.
38. Tartibian, B.; Maleki, B.H.; Abbasi, A. Omega-3 fatty acids supplementation attenuates inflammatory markers after eccentric exercise in untrained men. Clin. J. Sport Med. 2011, 21, 131–137.
39. Magee, P.; Pearson, S.; Whittingham-Dowd, J.; Allen, J. PPARgamma as a molecular target of EPA anti-inflammatory activity during TNF-alpha-impaired skeletal muscle cell differentiation. J. Nutr. Biochem. 2012, 23, 1440–1448.
40. Poprzecki, S.; Zajac, A.; Chalimoniuk, M.; Waskiewicz, Z.; Langfort, J. Modification of blood antioxidant status and lipid profile in response to high-intensity endurance exercise after low doses of omega-3 polyunsaturated fatty acids supplementation in healthy volunteers. Int. J. Food Sci. Nutr. 2009, 60 Suppl. 2, 67–79.
41. Biswas, S.K. Does the Interdependence between Oxidative Stress and Inflammation Explain the Antioxidant Paradox? Oxid. Med. Cell Longev. 2016, 2016, 5698931.
42. Smith, G.I.; Julliand, S.; Reeds, D.N.; Sinacore, D.R.; Klein, S.; Mittendorfer, B. Fish oil-derived n-3 PUFA therapy increases muscle mass and function in healthy older adults. Am. J. Clin. Nutr. 2015, 102, 115–122.
43. Rodacki, C.L.; Rodacki, A.L.; Pereira, G.; Naliwaiko, K.; Coelho, I.; Pequito, D.; Fernandes, L.C. Fish-oil supplementation enhances the effects of strength training in elderly women. Am. J. Clin. Nutr. 2012, 95, 428–436.
44. Gammone, M.A.; Riccioni, G.; Parrinello, G.; D'Orazio, N. Omega-3 Polyunsaturated Fatty Acids: Benefits and Endpoints in Sport. Nutrients 2018, 11, 46.
45. Carlsen, K.H.; Anderson, S.D.; Bjermer, L.; Bonini, S.; Brusasco, V.; Canonica, W.; Cummiskey, J.; Delgado, L.; Del Giacco, S.R.; Drobnic, F.; et al. Exercise-induced asthma, respiratory and allergic disorders in elite athletes: Epidemiology, mechanisms and diagnosis: Part I of the report from the Joint Task Force of the European Respiratory Society (ERS) and the European Academy of Allergy and Clinical Immunology (EAACI) in cooperation with GA2LEN. Allergy 2008, 63, 387–403.
46. Kumar, A.; Mastana, S.S.; Lindley, M.R. n-3 Fatty acids and asthma. Nutr Res Rev 2016, 29, 1–16.
47. Wendell, S.G.; Baffi, C.; Holguin, F. Fatty acids, inflammation, and asthma. J. Allergy Clin. Immunol. 2014, 133, 1255–1264.
48. Oliver, J.M.; Anzalone, A.J.; Turner, S.M. Protection Before Impact: The Potential Neuroprotective Role of Nutritional Supplementation in Sports-Related Head Trauma. Sports Med. 2018, 48, 39–52.
49. Hasadsri, L.; Wang, B.H.; Lee, J.V.; Erdman, J.W.; Llano, D.A.; Barbey, A.K.; Wszalek, T.; Sharrock, M.F.; Wang, H.J. Omega-3 fatty acids as a putative treatment for traumatic brain injury. J. Neurotrauma 2013, 30, 897–906.
50. Bryhn, M. Prevention of Sports Injuries by Marine Omega-3 Fatty Acids. J. Am. Coll. Nutr. 2015, 34 Suppl. 1, 60–61.