SEONZ
SPORT & EXERCISE SCIENCE
NEW ZEALAND

The Journal of Sport and Exercise Science, Vol. 7, Issue 2, 38-45 (2023)

www.jses.net

JSES
ISSN: 2703-240X

Assessing the Omega-3 Index of a professional cycling team and the influence of ad libitum provision of fish oil during the competitive season

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ARTICLE INFO

Received: 28.02.2022
Accepted: 28.09.2022
Online: 27.10.2023

Keywords:
Elite cycling
Omega-3 fatty acids
Performance nutrition

ABSTRACT

An optimal omega-3 status, which is modified by increased consumption of long chain omega-3 eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), supports cardiovascular and anti-inflammatory physiology. This study described the omega-3 status of riders in a professional cycling team and following ad libitum provision of a fish oil supplement over the course of a competitive season. The omega-3 status of professional riders (n = 23) was assessed via measurement of the Omega-3 Index (O3I), the omega-6/omega-3 (n-6/n-3), and Arachidonic Acid/EPA ratio (AA/EPA) using a finger prick blood sample at the start of the season. A quasi-experimental design provided riders ad libitum access to a fish oil supplement (NAMEDSport, Italy) with advice to consume two capsules per day (1,118 mg EPA + 458 mg DHA). Follow up blood samples were collected (n = 13) at the end of the season (16 – 18 weeks) and expressed according to self-reported achievement of the advised dose. At pre-season, five of the riders returned an O3I > 8% (mean = 7.07%, 95% CI [6.51, 7.63]). The mean n-6/n-3 ratio was greater than 5 (mean = 5.38, 95% CI [4.81, 5.96]), and the AA/EPA was less than 11 (mean = 8.41, 95% CI [6.35, 10.47]). By the end of the season, seven riders self-reported meeting the daily dose recommendations and increased their O3I (pre-season mean = 6.81%, SD = 1.97; post-season mean = 9.06%, SD = 1.06, p < 0.01, Bonferroni adjusted), compared to six riders who reported sub-optimal (inconsistent) intake and the O3I remained unchanged (pre-season mean = 7.11%, SD = 0.75; post-season mean = 7.09%, SD = 0.47, p = 0.97, Bonferroni adjusted). Optimising the omega-3 status of elite cyclists is possible when ad libitum provision of supplemental fish oil enables daily achievement of EPA + DHA intake. Riders consistently consuming two capsules per day elevated and/or maintained optimal omega-3 status alongside the arduous nature of training and competition.

1. Introduction

The physiological demands of professional road cycling require a rider to withstand significant physiological stress (Novak & Dascombe, 2014). Performance nutrition primarily and rightly focusses on carbohydrate and protein intake to enhance physiological and performance outcomes (Burke, 2001). Notwithstanding, the profile of dietary fat including the proportions of saturated, monounsaturated, and polyunsaturated fatty acids is complex and extends beyond simplistic provision of energy. In fact, long chain omega-3 polyunsaturated fatty acids (LCn-3PUFA) have differential impacts for modifying cell membranes of tissues, such as skeletal (Andersson et al., 2002)

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and cardiac muscle (Metcalf et al., 2007) that includes physiological adaptation to both organs (Helge et al., 2001; McLennan 2014). This has resulted in growing interest about LCn-3PUFA intake in athletic populations, and especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) according to dose and duration (Lewis et al., 2020; Murphy & McGlory, 2021).

It is well-established that regular dietary consumption of fish oil leads to the preferential incorporation of EPA + DHA into cardiac and skeletal muscle membrane phospholipids, via replacing omega-6 arachidonic acid (AA), in a dose-related manner (Slee et al., 2010), and according to muscle fibre type (Macartney et al., 2019). Erythrocyte membrane LCn-3PUFA composition correlates closely with human muscle (Harris et al., 2004), has a low biological variability (Harris & Thomas, 2010), and is easy to obtain which makes it the preferred biomarker for confirming incorporation of EPA + DHA into tissue. Several assessments of erythrocyte membrane LCn-3PUFA composition can be made including the well-established Omega-3 Index (O3I: %EPA + DHA) with an optimal target > 8% for heart function (Harris & Von Schacky, 2004). Additionally, the ability of the endurance cyclist to obtain a whole blood AA/EPA ratio < 11 and omega-6/omega-3 (n-6/n-3) ratio < 5, for enhanced anti-inflammatory pathways and pro-resolution actions, has been recently reported as a case study whilst competing at the Tour de France (Macartney et al., 2021a). Collectively, these measures of LCn-3PUFA composition will be referred to as 'omega-3 status' from this point forward.

Notwithstanding, there are currently few translational studies in elite endurance athletes taking part in training and seasonal competition. Furthermore, overall study design including omega-3 dose, have incurred some limitations. For example, pharmacological doses of omega-3 fatty acids (> 3500 mg per day which would require an individual to consume approximately 10 typical 330 mg EPA + DHA capsules per day) in elite swimmers (Mickleborough et al., 2003) and paddlers (Delfan et al., 2015) and over short time periods of 3 – 4 weeks respectively or up to 7 weeks in marathon runners (Santos et al., 2013) prevent long term evaluation over a season or more. Dose and time considerations are critical as highly controlled laboratory animal studies demonstrate that a minimum target of 600 – 800 mg of EPA + DHA per day via fish oil optimises skeletal muscle according to fibre type (Macartney et al., 2019) and cardiac membrane concentrations (Slee et al., 2010). This same dose of DHA-rich oil is reflected by improvements in red blood cell membranes over the course of 8 weeks in trained individuals (Hingley et al., 2017). However, it remains to be established, using the biological marker of the erythrocyte membrane, whether *ad libitum* provisions of an evidence-based dose of EPA + DHA is sufficient to maintain optimal omega-3 status in elite endurance riders where protracted physiological stress and fatigue are dominating.

In summary, professional cycling teams are not necessarily aware of the impact of an elite rider's usual dietary fatty acid intake on the omega-3 status of their tissues nor the biological relevance of these fatty acids. Moreover, athletes are scarcely provided advice for LCn-3PUFA intake via supplemental source, and definitely not informed from blood biomarker sampling such as the O3I while simultaneously training and competing. Therefore, this quasi-experimental and translational study aimed to i) evaluate the fatty acid profile of an elite UCI cycling team at the commencement of the season and ii) provide feedback and LCn-3PUFA supplementation advice from these pre-season results in the aim of achieving and maintaining optimal omega-3 status (O3I > 8%; n-6/n-3 < 5; AA/EPA < 11) across the professional season. We hypothesised that a targeted and evidenced-based LCn-3PUFA evaluation and advice program whereby riders received ad libitum access to an EPA + DHA fish oil supplement, alongside usual performance nutrition goals, would optimise and maintain their omega-3 status.

2. Methods

2.1. Participants and ethical approval

Each participant was a professional rider (European), contracted to the same Union Cycliste Internationale registered cycling team, at the time of the study (season 2020). Each rider (n = 23; age = 29 ± 4 years; height = 180 ± 7 cm; body mass = 67 ± 5 kg) took part in a minimum of one grand tour during the course of the study. The study procedures were approved by the University of Wollongong Human Research ethics committee (UOW HE-40421), each participant provided their informed consent and the study was conducted in accordance with the Declaration of Helsinki.

2.2. Study design

This quasi-experimental study was completed during the cycling calendar (2020) in the lead up to and including the three grand tours, described in the previous case study (Macartney et al., 2021a). That season, the European professional cycling races were delayed due to COVID-19 restrictions, and therefore the time points described are in line with the alterations to the professional cycling calendar. The months of July and August were dedicated to early season races leading into the first of these grand tours (Tour de France, France) and extended into October and November (Giro, Italy and Vuelta, Spain). The whole-blood fatty acid profile of each rider (n = 23) was objectively measured in the first week of July (pre-grand tours) and then during the period October to November (post-grand tours) where riders were still available and still competing (n = 13). During the season, the riders were provided with *ad libitum* access to an omega-3 fish oil supplement and were provided advice to achieve optimal omega-3 status as reflected by red blood cell membrane changes. Riders were asked to self-report supplement intake to the team's medical staff according to their success ('yes' or 'no') in achieving the recommendations (daily consumption of the dose). Accordingly, riders were then divided at the end of the season into two groups, either not meeting (Sub-optimal, n = 6) or consistently meeting (Optimal, n = 7) the daily targets for omega-3 fish oil capsule intake. This process of allocation to groups was completed before the whole blood samples were analysed for relative membrane fatty acids content.

2.3. Whole blood fatty acid profile

At the start and the end of the season, each rider provided a morning fasted and adequately hydrated, blood sample using the finger prick method. The blood was collected according to best

practice guidelines (Omega-Quant, South Dakota, United States) which included maintaining the erythrocyte membrane (no lysis) and relative plasma volume. That is, very gently and without squeezing the finger, the drop of blood was spotted onto the commercially available collection card for independent analysis (Omega-Quant, South Dakota, United States). The sample card was immediately sent to Omega-Quant (USA) to determine the whole-blood fatty acid profile using state of the art gas chromatography. Each fatty acid in the whole blood was individually identified using high quality standards and then described as a relative percentage (%) of all the fatty acids. The red blood cell O3I, a marker of cardiac and skeletal muscle membrane incorporation, was then calculated according to a validated algorithm (r = 0.96) (Harris & Polreis, 2016).

2.4. Description of nutritional objectives

During the season, the cyclists followed the nutritional guidelines given by the nutritionist (MH). The nutrition plan was adjusted to the training program and took into account the personal nutrition goals and team goals for the race season. The team objective during the races was to support the performance and recovery between the stages. During the grand tours, the team consumed personalized meals which were calculated by the nutritionist, taking into account the total energy requirements and macronutrient composition. Fish (100 – 150 g serving) was included as part of the diet 1 – 2 times per week. On race days riders consumed a carbohydrate rich menu, consisting of five meals (breakfast, post-race, arrival at hotel, dinner and pre-sleep), prepared by the team chef. For each stage, the riders received a nutrition plan that was adjusted to the difficulty of the stages.

2.5. Fish oil supplement

All the riders had access to the approved anti-doping omega-3 supplement (NAMEDSport, Italy) which was supplied by their professional team. The Omega-3 Double Plus Soft Gels (1 g each) contained concentrated fish oil and tocopherol-rich extract (antioxidant), for the stability of the fatty acids, in a gelatine capsule (soft gel). Each capsule of LCn-3PUFA rich fish oil contained EPA (559 mg) and DHA (229 mg). To achieve an optimal omega-3 status as rapidly as possible and before the scheduled start of the first grand tour, riders were advised to consume two capsules (NAMEDSport, Italy) each day, providing a total of 1,118 mg of EPA + 458 mg of DHA. This recommendation was employed to be sure that the minimum recommended intake of 600 – 800 mg EPA + DHA was achieved and exceeded by the *ad libitum* provision. Most importantly, the two capsules were consumed with food as part of breakfast and continued through the duration of season in the aim of establishing an O3I > 8%. During the grand tours, riders were reminded face to face about the daily consumption. In the times between the grand tours, the riders were provided the advice, but it was up to the individual to make use of the *ad libitum* supply. At the end of the season, and at the time of the second blood sample, the riders who were re-sampled (n = 13) were then asked to report about their intake on the basis of consistently meeting the recommendations of two capsules per day or not ('yes' or 'no').

2.6. Statistics

Collected data was analysed using GraphPad Prism 9 (GraphPad Software, San Diego, CA, USA) software package. Baseline (pre-tours) blood samples (n = 23) were analysed using descriptive statistics. Follow up blood samples collected (n = 13) at the end of the season (post-tours) were grouped according to self-reported achievement of the advised dose (Sub-optimal or Optimal). Data were analysed using a repeated measures two-way ANOVA with factors of supplement group (Sub-optimal, n = 6; Optimal, n = 7) and time (pre, post). When a significant interaction or main effect was detected, *post-hoc* multiple comparisons were completed and the p-value was adjusted using the Bonferroni procedure. The distribution of continuous data was analysed for normality using the D'Agostino-Pearson omnibus (K2) test and homogeneity of variances was confirmed via Brown-Forsythe test. The data collected was expressed as mean (standard deviation or 95% CI) where appropriate. Alpha was set at $p < 0.05$.

3. Results

3.1. Omega-3 status in the cohort

The usual intake of dietary fatty acids, including the LCn-3PUFA, in a cohort of elite professional cyclists revealed only 22% (5 out of 23) of the riders had an O3I above 8% (mean = 7.07%, 95% CI [6.51, 7.63]; Figure 1A). The mean sum of n-6 PUFA comprised of one third of the relative proportion where AA contributed close to 9% on average (Table 1). The mean n-6/n-3 ratio was greater than 5 (mean = 5.38, 95% CI [4.81, 5.96]; Figure 1B) nonetheless, the mean AA/EPA ratio was less than 11 (mean = 8.41, 95% CI [6.35, 10.47]; Figure 1B) although several riders were > 11 and the maximum was 21.0 in one athlete.

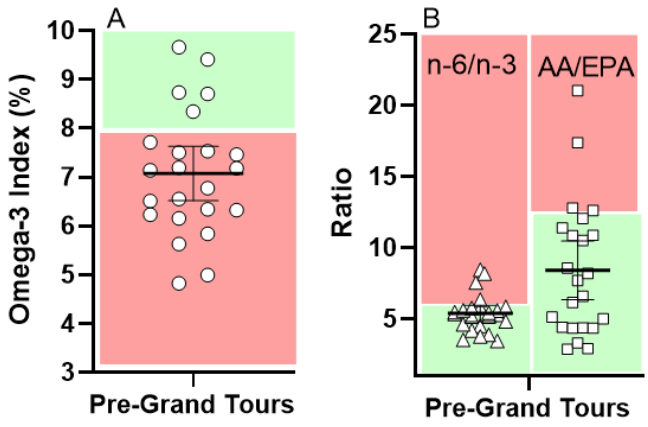

Figure 1: (A) Red blood cell Omega-3 Index (%EPA + DHA) and (B) Whole blood relative fatty acid ratios (%) of n-6/n-3 and AA/EPA of professional team riders (n = 23) before the Grand Tours (pre-season). Green = Optimal zone and pink = Sub-optimal zone for each parameter. Data expressed as mean (± 95% CI) along with individual scatter plot. Abbreviations: n-6/n-3, omega-6 to omega-3 ratio; AA/EPA, Arachidonic acid to Eicosapentaenoic acid ratio.

Table 1: Whole blood relative fatty acid profile (%) and red blood cell Omega-3 status in professional team riders before the Grand Tours (pre-season).

Fatty acid	Mean (%)	SD	Min (%)	Max (%)
Σ SFA	36.1	1.98	32.70	39.60
Σ MUFA	22.7	1.90	19.0	26.80
Σ PUFA	41.2	2.30	36.90	46.20
LA	22.5	2.50	17.90	26.80
AA	8.94	1.25	6.96	11.60
Σ n-6 PUFA	34.5	2.38	31.1	39.4
ALA	0.30	0.10	0.18	0.48
EPA	1.36	0.62	0.43	2.72
DHA	3.69	0.63	2.32	5.52
Σ n-3 PUFA	6.71	1.38	4.33	9.34
n-6/n-3	5.38	1.33	3.44	8.45
AA/EPA	8.41	4.76	2.87	21.0
O3I	7.07	1.29	4.82	9.66

Note: Data collected from professional team riders (n = 23) are expressed as mean and standard deviations unless otherwise noted. Abbreviations: SD, standard deviation; Min, minimum; Max, maximum; SFA, Saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA polyunsaturated fatty acids; LA, Linoleic Acid; AA, Arachidonic Acid; ALA, alpha-Linolenic Acid; EPA, Eicosapentaenoic Acid; DHA, Docosahexaenoic Acid; O3I, Omega-3 Index (EPA + DHA%).

3.2. Omega-3 status following ad libitum fish oil supplementation

At the completion of the season, thirteen (n = 13) cyclists were available to provide a blood sample. Of these, 54% (7 out of 13) participants reported achieving two capsules per day (1,118 mg EPA + 458 mg DHA) on every day over the course of the season. In contrast, 46% (6 out of 13) participants reported consuming the omega-3 supplement, but not consistently which was best described as 2 – 3 times per week on average. For the 7 riders who self-reported meeting the daily dose recommendations they significantly increased their O3I (pre-season mean = 6.81%, SD = 1.97; post-season mean = 9.06%, SD = 1.06, p < 0.01, Bonferroni adjusted) where in contrast, the six riders who reported inconsistent and sub-optimal intake of the supplement, their O3I remained unchanged (pre-season mean = 7.11%, SD = 0.75; post-season mean = 7.09%, SD = 0.47, p = 0.97, Bonferroni adjusted) (Table 2). Moreover, the elevation of the O3I within the optimal supplement group was underpinned by a significant elevation of whole blood EPA (p = 0.01, Bonferroni adjusted) and DHA (p = 0.01, Bonferroni adjusted) over the duration of the season and this was not observed in the sub-optimal supplement group (EPA p = 0.99 and DHA p = 0.99, Bonferroni adjusted (Table 2).

4. Discussion

This quasi-experimental study investigated the effectiveness of translating a laboratory-based minimal LCn-3PUFA dose to improve the omega-3 status of professional UCI road cyclists across a competitive cycling season. In contrast to other studies in cohorts of elite athletes, we observed higher than expected pre-season baseline omega-3 status (mean O3I > 7%, mean n-6/n-3 < 6, mean AA/EPA < 11) suggesting pre-existing differences in habitual dietary influences that included provisions of 1 – 2 fish meals per week via the team menu. In response to profiling, the omega-3 status was significantly improved in those riders who closely followed the advice of optimal fish oil intake. Yet these same parameters remained unchanged in those riders who did not consistently achieve the daily recommendations over the course of the competitive season. Our novel observations are the first to highlight the efficacy of translating laboratory-based EPA + DHA dosing strategies (Hingley et al., 2017) to real-world *ad libitum* provisions of fish oil in a professional sporting environment. Such an outcome emphasises the critical role of fatty acid profiling for performance nutrition in elite athletes, especially given the complex role of omega-3 status in supporting optimal skeletal and cardiac muscle physiology.

Pre-season baseline mean O3I (7.07%) was higher relative to previous published data. Studies of elite athletes prior to fish oil or dietary intervention are limited but have consistently demonstrated a mean O3I < 5% in collegiate athletes (Anzalone et al., 2019; Drobnic et al., 2017; Heileson et al., 2021; Ritz et al., 2020) and Canadian elite rugby 7s players (Armstrong et al., 2021). Furthermore, in a cohort of 106 German elite winter-endurance athletes consuming their usual training diet, the mean O3I was reported to be < 5% and only one individual was > 8% (von Schacky et al., 2014). It is noteworthy in the current study, those five riders who identified as high for omega-3 status at baseline also reported some use of the omega-3 supplement in the months before the sample. Moreover, although speculative in nature, the higher group mean O3I observed in these riders suggests some habitual consumption of a Mediterranean influenced rather than typical Western-style diet. For example, the team was provided with 1 – 2 fish servings per week. This baseline omega-3 status contrasts with the very low O3I (4.13%) reported in vegan endurance triathletes whose diet is void of LCn-3PUFA (Craddock et al., 2022). Mediterranean diets tend to include a larger percentage of LCn-3PUFA from marine sources. For example, in Spain, fish consumption is approximately 55 g/day vs. approximately 16 g/day in the United States (Blasbalg et al., 2011; Engeset et al., 2006). It is also well-established that the typical Western-style diet is less than optimal in providing LCn-3PUFA (Micha et al., 2014) and this can be implied from global erythrocyte O3I concentrations (Stark et al., 2016). The difference in mean O3I values of the current study relative to previous literature also strengthens the argument for the universal use of baseline erythrocyte EPA + DHA concentration measurements (Anthony et al., 2021), as part of best practice omega-3 study design (Anthony et al., 2023).

The current study demonstrated effective translation of laboratory-based LCn-3PUFA dosing evidence into a real-world elite sporting team with the pre-defined goal for riders to optimise and maintain their omega-3 status across the competitive season.

Table 2: Whole blood relative fatty acid profile (%) and red blood cell Omega-3 status in professional team riders before and after 16-18 weeks of *ad libitum* provision of fish oil with concurrent advice.

	Sub-optimal FO Intake (n = 6)		Optimal FO Intake (n = 7)		ANOVA (p-values)		
Fatty acid	Pre Mean (SD)	Post Mean (SD)	Pre Mean (SD)	Post Mean (SD)	Group	Time	Interaction
Σ SFA	35.24 (2.31)	35.19 (1.22)	36.12 (1.30)	35.40 (0.60)	0.47	0.28	0.34
Σ MUFA	21.99 (2.59)	20.93 (1.48)	23.59 (1.32)	21.14 (1.33)	0.31	< 0.01	0.15
Σ PUFA	42.77 (2.18)	43.88 (1.07)	40.29 (1.75)	43.45 (1.71)	0.09	< 0.01	0.08
LA	23.96 (2.12)	24.44 (2.52)	21.59 (1.86)	22.53 (1.66)	0.07	0.08	0.54
AA	9.24 (1.57)	8.54 (1.70)	9.07 (0.67)	8.19 (0.86)	0.69	0.01	0.71
Σ n-6 PUFA	36.15 (2.37)	36.02 (1.55)	33.90 (2.42)	33.71 (2.16)	0.06	0.80	0.97
ALA	0.32 (0.09)	0.31 (0.04)	0.26 (0.05)	0.30 (0.06)	0.31	0.56	0.23
EPA	1.39 (0.47)	1.35 (0.33)	1.21 (0.79)	2.37 (0.74)*	0.12	0.04	0.03
DHA	3.68 (0.35)	3.70 (0.32)	3.62 (1.10)	4.42 (0.72)*	0.40	0.02	0.03
Σ n-3 PUFA	6.61 (0.83)	7.86 (0.60)	6.39 (2.00)	9.74 (0.88)*	0.16	< 0.01	0.03
n-6/n-3	5.57 (1.05)	4.61 (0.51)	5.81 (1.98)	3.49 (0.50)	0.41	< 0.01	0.14
AA/EPA	7.89 (4.97)	6.89 (2.93)	10.42 (5.93)	3.86 (1.59)	0.88	0.04	0.12
O3I	7.11 (0.75)	7.09 (0.47)	6.81 (1.97)	9.06 (1.06)*	0.16	0.02	0.02

Note: Data collected from professional team riders that reportedly followed (Optimal fish oil intake; n = 7) or reportedly did not follow (Sub-optimal fish oil intake; n = 6) supplementation advice. Abbreviations: Int., Interaction; FO, fish oil; SFA, Saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA polyunsaturated fatty acids; LA, Linoleic Acid; AA, Arachidonic Acid; ALA, alpha-Linolenic Acid; EPA, Eicosapentaenoic Acid; DHA, Docosahexaenoic Acid; O3I, Omega-3 Index (EPA + DHA%). * $p < 0.05$ within supplement group pre vs. post (corrected for multiple comparisons using the Bonferroni procedure).

Riders were advised to consume two fish oil capsules per day, providing a daily dose of 1,118 mg EPA + 458 mg DHA. Whilst this is approximately double the daily intake of LCn-3PUFA required to achieve an elevation in O3I in laboratory studies (Hingley et al., 2017; Macartney et al., 2014; Macartney et al., 2021b) this recommendation was employed as there was less than two months to the start of the first grand tour. It is important to recognise that time-course investigations demonstrate tissue incorporation of EPA + DHA typically occurs over several months (Owen et al., 2004). Thus, a slightly higher dose was chosen to ensure marked changes in blood EPA + DHA concentrations within the team's defined time-constraints. To the authors' knowledge, this study is the first to consider the effect of supplementation duration in professionally trained and managed elite athletes with a focus on extreme endurance performance and fatigue management. In fact, future research should aim to vary both the dose and duration of the chosen omega-3 supplementation intervention until each individual athlete achieves a pre-defined change in their membrane omega-3 status, noting this would require serial blood sampling and according to the most recent recommendations for conducting omega-3 studies in training groups (Anthony et al., 2023)

The novel omega-3 evaluation and advice program used in this study significantly improved the omega-3 status in riders (n = 7) that self-reported following their fish oil intake advice across the competitive season (16 – 18 weeks). Whereas omega-3 status remained unchanged in riders (n = 6) that self-reported they did not strictly follow advice over the course of the competitive season. Observational analysis of elite athletic groups has revealed that despite 39% of National Collegiate Athletic Association (NCAA) athletes consuming the recommended amount of dietary fish per week, only 6% met the requirement for EPA + DHA intake (Ritz et al., 2020). Given that the current study was able to demonstrate riders which self-reported as not strictly following supplementation advice still achieved an O3I > 7%, future work investigating the effect of supplemental fish oil in elite athletes should focus on also using human dietary achievable doses ranging from 500 mg/day – 1500 mg/day of long chain omega-3 EPA + DHA. Doses beyond the higher end of this range would require approximately 6 – 10 standard fish oil capsules per day and therefore may become a burden upon the individual's dietary goals with little additional improvement in their omega-3 status.

This study demonstrates that evaluating the omega-3 status of elite cyclists can improve individual advice for the consumption of EPA + DHA without impacting the nutritional plans and goals which typically include total energy requirements and the provision of carbohydrate and protein. However, questions regarding the interaction of omega-3 status with exercise training have been raised. Runners taking part in arduous training were reported to have an association of a higher weekly running distance with a lower O3I and higher AA/EPA (Davinelli et al., 2019). In the same instance, the O3I of National Football League players was also reported to decrease over the competition season (Blue et al., 2019). In contrast, in response to physical activity, exercise trained individuals have been demonstrated to increase

skeletal muscle membrane incorporation of LCn-3PUFA independent of fibre type (Andersson et al., 2000). Our current findings support this by demonstrating that elite riders who consistently consume two fish oil capsules per day (1,118 mg EPA + 458 mg DHA) elevated and/or maintain their already optimal omega-3 status alongside the arduous nature of their training and competition in grand tours. Accordingly, LCn-3PUFA evaluation and supplementation advice appears to be an effective strategy to achieve an optimal omega-3 status despite the presence of very high training volumes and exercise intensity.

Future studies may clarify whether the novel observations highlighting the efficacy of translating laboratory-based EPA + DHA dosing strategies to real-world *ad libitum* provisions of supplemental fish oil in a professional sporting environment are also evident for females. Whilst this investigation did not include females, serum LCn-3PUFA have been demonstrated to differ in women (↓ EPA yet ↑ DHA) compared to males (Mingay et al., 2016) and this may be related to differences in fatty acid metabolism due to the effects of sex hormones (Decsi & Kennedy, 2011). Additionally, the quasi-experimental study design resulted in follow up samples from ten riders being lost either from injury, illness, team list changes or other uncontrollable factors. Nevertheless, this study is an important first step in the critical role of using fatty acid profiling to inform evidence-based LCn-3PUFA dosing strategies for performance nutrition in elite athletes.

In conclusion, evaluating erythrocyte LCn-3PUFA composition of riders in an elite cycling team has demonstrated that there is a wide range of O3I scores in a team of elite athletes professionally racing. Importantly, an elite rider with a consistent daily intake of two high quality omega-3 capsules providing 1,118 mg EPA + 458 mg DHA was able to achieve and maintain optimal omega-3 status (O3I > 8%; n-6/n-3 < 5; AA/EPA < 11) whilst training for and competing in the grand tours. The long-term approach is to determine if manipulating cell membrane incorporation in favour of EPA + DHA can physiologically support the stress of endurance training and competition, especially over the longer-term career and lifespan of elite athletes.

Conflict of Interest

The authors declare no conflict of interests.

Acknowledgment

The authors thank the cyclists and team support staff for their time and contribution to this study.

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