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RAPID COMMUNICATION

Low Omega-3 Index in 106 German Elite Winter Endurance Athletes: A Pilot Study

Clemens von Schacky
Omegametrix

Maximilian Kemper, Robert Haslbauer, and Martin Halle
Technical University of Munich

The Omega-3 Index is defined as erythrocyte eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), and represents an individual's status in these two marine omega-3 fatty acids. A target range of 8 to 11% has been suggested, because values below predispose to cardiovascular events, especially sudden cardiac death, as well as to suboptimal brain function, like prolonged reaction times or even depression. Compared with the general population, elite athletes have an increased incidence of sudden death. The Omega-3 Index has not yet been investigated in elite athletes. In an exploratory approach, we determined the Omega-3 Index in 106 consecutive German national elite winter endurance athletes presenting for preparticipation screening, using a well-established analytical procedure (HS-Omega-3 Index). Surprisingly, only one athlete had a value within the target range, but all others had values <8%. We conclude that we have identified a deficiency of EPA and DHA in these elite athletes. This deficiency presents a potential option for prevention of cardiovascular events such as sudden cardiac death, and improving aspects of brain function. It will be important to scrutinize our finding by more thorough epidemiologic studies and appropriate intervention trials.

Keywords: eicosapentaenoic acid, docosahexaenoic acid, cardiovascular disease

The Omega-3 Index is the percentage of the two omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in total erythrocyte fatty acids (von Schacky, 2014). If determined with a highly standardized and specific analytical methodology (HS-Omega-3 Index®), it describes an individual's status in EPA+DHA (von Schacky, 2014). A HS-Omega-3 Index below the target range of 8 to 11% has been found to be associated with increased overall mortality, and to be a risk factor for cardiovascular events, such as sudden cardiac death, fatal and nonfatal myocardial infarction (von Schacky, 2014). Moreover, a low HS-Omega-3 Index is associated with major depression, and suboptimal brain structure and function, as measured as reaction time or executive function (Baghai et al., 2011; Johnston et al., 2013). The HS-Omega-3 Index can be increased by increased consumption of EPA and DHA. This improved various aspects of heart health, such as lowering resting heart rate, increasing heart rate variability, reducing triglycerides, decreasing small dense LDL, increasing large buoyant LDL, and reducing proatherogenic inflammatory biomarkers (von Schacky, 2014). Moreover, this intervention also improved brain structure and various aspects of complex brain function, such as prolonging attention span, reducing reaction time, reducing emotional lability, improving memory, and others (Mazereeuw et al., 2012; Sydenham et al., 2012; Stonehouse et al., 2013; Fontani et al., 2009; Witte et al., 2013).

Sudden cardiac death is a rare event in athletes and has an incidence of 1:44,000 participants per year with a wide range depending on gender, race and age (Chandra et al., 2013; Harmon et al., 2011). Nonetheless, cardiovascular-related sudden death is the leading cause of death and represented 75% of sudden deaths during exertion (Chandra et al., 2013; Harmon et al., 2011). In addition, the parameters of brain function mentioned may also have impact on athletes' performance, and prevalence of cognitive dysfunction and depression appears higher in athletes (Hammond et al., 2013; Hart et al., 2013). As the values of EPA und DHA are virtually unknown in elite athletes, we, in an exploratory approach, determined the HS-Omega-3 Index in this group.

von Schacky is with Omegametrix and Preventive Cardiology, Ludwig Maximilians-University, Munich, Germany. Kemper, Haslbauer, and Halle are with the Dept. of Prevention and Sports Medicine, Technical University of Munich, Munich, Germany. Address author correspondence to Clemens von Schacky at c.vonschacky@omegametrix.eu.

Method

In this cross-sectional study, from March to November 2011, we consecutively assessed 106 German national elite winter athletes (potential participants of Olympic Games and their substitutes, mostly endurance sports), presenting for preparticipation screening at the Department of Prevention and Sports Medicine of the Technical University of Munich, Munich, Germany. Body fat was determined by measuring skin fold thickness using the seven-fold model, as described previously (Pressler et al., 2012). For assessment of maximal exercise capacity athletes performed a stepwise exercise test until physical exhaustion on either a cycle ergometer (Excalibur Sport, Lode, Groningen, The Netherlands) or a treadmill (Saturn/quasar/pulsar, HP cosmos, Traunstein, Germany). Physical exhaustion was assumed when athletes were not able to maintain minimum pedal cadence of 70 rpm, or were not able to run the given speed on treadmill. Only those achieving ≥19 on Borg's scale of rate of perceived exertion (RPE) were included to ensure maximal exercise performance. Initial work load for cycle ergometry was between 50 and 100 W, the initial speed for treadmill between 4 and 8 km/h depending on training status. Work load was increased by 30 to 50 W every 3 min on a cycle ergometer or 1 to 2 km/h every 3 min on a treadmill. Increments depended on gender, training status and type of sport performed. Use of cycle ergometer or treadmill and increments in workload depended on gender, training status and type of sport performed. Maximal anaerobic performance was expressed as Watts/kg body weight (Pmax/kg); for conversion of treadmill speed in Watts we used a modified formula from (Kostka et al., 2009).

Venous blood (20 ml) was drawn before exercise in a nonfasting state. Lipid analyses were performed by a commercial laboratory. EDTA-blood samples were sent to Omegametrix, where erythrocyte fatty acid composition was analyzed according to the HS-Omega-3 Index methodology, as previously described (von Schacky, 2014). In short, fatty acid methyl esters were generated from erythrocytes by acid transesterification and analyzed by gas chromatography using a GC2010 Gas Chromatograph (Shimadzu, Duisburg, Germany) equipped with a SP2560, 100-m column (Supelco, Bellefonte, PA) using hydrogen as carrier gas. Fatty acids were identified by comparison with a standard mixture of fatty acids characteristic of erythrocytes. A total of 26 fatty acids were identified and quantified. Results are given as percentage of total identified fatty acids after response factor correction. The coefficient of variation for EPA plus DHA and for most other fatty acids was around 4 rel. %. Analyses were quality-controlled according to DIN ISO 15189.

In compliance with guidance from the ethics committees of the Ludwig Maximilians-University and Technical University of Munich, all data came from routine evaluations of the athletes, no extra procedures were performed, and data were analyzed in an irreversibly anonymized fashion. In such cases, both ethics committees waive the need for approval or consent.

Results

Results are reported in Tables 1 and 2 and Figure 1.

As depicted in Figure 1, we found a statistically normal distribution for the HS-Omega-3 Index. Please note that the HS-Omega-3 Index of only one athlete was in the suggested target range of 8 to 11%.

Discussion

To the best of our knowledge, this is the first report on the Omega-3 Index in athletes. In all but one of the 106 German athletes studied, the Omega-3 Index was below the suggested target range of 8 to 11%. Clearly, our pilot study needs to be substantiated.

In contrast to fish intake, the HS-Omega-3 Index had a statistically normal distribution in every population

Table 1 Clinical Characteristics of Study Subjects (*N* = 106; 69 male, 37 female)

Characteristics	(M ± *SD*)
Age (years)	26.6 ± 6.5
Weight (kg)	79.3 ± 15.1
Height (cm)	179.2 ± 8.4
BMI (kg/m^2)	24.5 ± 3.0
Resting heart rate/min	58.5 ± 10.6
Blood pressure systolic (mmHg)	122 ± 11
Blood pressure diastolic (mmg)	76 ± 8
Fat (% of body weight)	13.8 ± 5.7
Pmax/kg	3.47 ± 0.65
LDL-cholesterol (mg/dl)	112.7 ± 27.4
Triglycerides (mg/dl)	114.1 ± 54.6

Table 2 Erythrocyte Fatty Acid Composition in 106 Athletes as Percent of Total Fatty Acids Analyzed (M ± *SD*)

Fatty Acid	Percent
C14:0	0·32 ± 0·22%
C16:0	22·17 ± 2·42%
C16:1t	0·13 ± 0·07%
C16:1n-7	0·47 ± 0·20%
C18:0	16·01 ± 1·46%
C18:1t	0·35 ± 0·13%
C18:1n-9	15·74 ± 1·33%
C18:2n-6tt	0·14 ± 0·07%
C18:2n-6ct	0·02 ± 0·01%
C18:2n-6tc	0·12 ± 0·04%
Total industrally-produced TFA	0·63%
C18:2n-6	12·31 ± 1·45%
C20:0	0·13 ± 0·04%
C18:3n-6	0·10 ± 0·04%
C20:1n-9	0·23 ± 0·05%
C18:3n-3	0·17 ± 0·05%
C20:2n-6	0·23 ± 0·04%
C22:0	0·29 ± 0·01%
C20:3n-6	1·79 ± 0·34%
C20:4n-6	15·67 ± 1·27%
C24:0	1·24 ± 0·43%
C20:5n-3	0·63 ± 0·23%
C24:1n-9	1·17 ± 0·29%
C22:4n-6	3·10 ± 0·50%
C22:5n-6	0·80 ± 0·16%
C22:5n-3	2·34 ± 0·36%
C22:6n-3	4·34 ± 1·07%
HS-Omega-3 Index	4·97 ± 1·19%

Note. Trans fatty acids are marked with a "t." 16:1t is thought to be ruminant-derived and not to be a health issue, whereas some trans isomers of 18:1 and all trans isomers of 18:2 stem from industrial food production.

studied (von Schacky, 2014, Figure 1). Moreover, neither the baseline HS-Omega-3 Index nor its response to a given dose is predictable with dietary assessments (von Schacky, 2014). Clinical events correlate more closely with levels than with intakes (von Schacky, 2014). Therefore, we used the HS-Omega-3 Index instead of a dietary assessment for this epidemiologic study, and suggest the same for similar studies. For intervention studies, we suggest recruiting according to a low baseline HS-Omega-3 Index and using variable doses of EPA+DHA to reach a predefined target range (e.g., 8 to 11%). It has been reported that erythrocytes in athletes have a higher turnover (i.e., a shorter life span than erythrocytes of sedentary controls; Smith et al., 1999). Since erythrocyte fatty acid composition is largely defined during cell maturation (von Schacky, 2014), an increase in dietary EPA and DHA should be reflected in erythrocyte EPA and DHA faster in athletes than in sedentary controls. The HS-Omega-3 Index reflects EPA and DHA in other cells (eg, in the heart), but it is unclear, whether this is also true in athletes with a higher erythrocyte turnover (von Schacky 2014). Pertinent studies remain to be performed.

The German athletes studied were endurance athletes, as demonstrated by their clinical characteristics in Table 1. Their mean HS-Omega-3 Index was 4·97 ± 1·19% (Table 2), lower than in German patients with

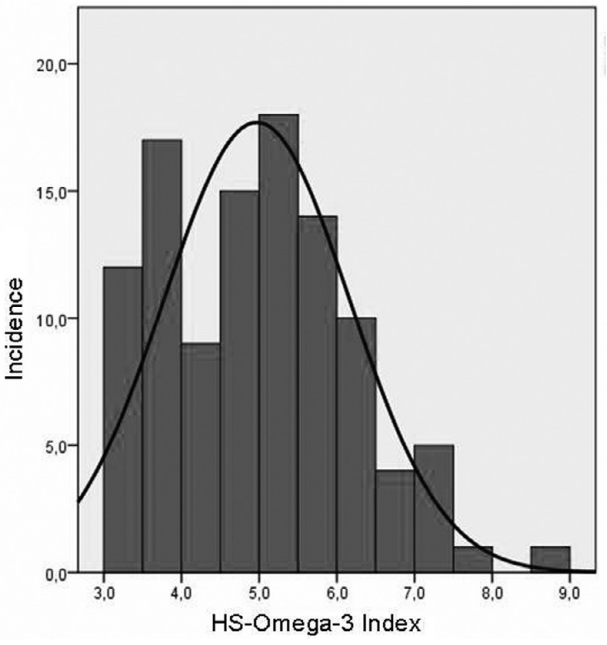

Figure 1 — Distribution of the Omega-3 Index in 106 German Athletes (Mean ± Standard Deviation): 4.97 ± 1.19%. A statistically normal distribution was found, as indicated by the black line.

established coronary artery disease CAD (5·94 ± 1·41%, von Schacky, 2014). Using a different analytical method, a small study in female athletes found no significant difference in EPA or DHA, as compared with healthy controls (Arsić et al., 2012). Based on current literature, the athletes we studied might have an elevated risk for sudden cardiac death or for fatal and nonfatal myocardial infarction later in life. This, however, remains to be investigated more thoroughly (von Schacky, 2014). Recent meta-analyses of large intervention trials did not find EPA+DHA effective in prevention of most cardiovascular events (Kotwal et al., 2012). Problems of bioavailability of EPA+DHA and of design of the original intervention studies (eg, nonobservance of baseline omega-3 levels) at least contributed to the neutral outcomes (von Schacky, 2014; Schuchardt & Hahn, 2013). The results of the meta-analyses mentioned therefore do not necessarily contradict the concept of a low HS-Omega-3 Index as a risk factor for cardiovascular events. This issue is discussed in more detail elsewhere (von Schacky, 2014; Schuchardt & Hahn, 2013; Superko et al., 2013).

In the Framingham offspring cohort, brain volume, visual memory and executive function correlated with the HS-Omega-3 Index (Tan et al., 2012). Total brain and hippocampal volumes correlated with the HS-Omega-3 Index in the Women's Health Initiative Memory Study (Pottala et al., 2014). By increasing intake of EPA+DHA, brain structure and these and other functions can be improved (Stonehouse et al., 2013; Witte et al., 2013). Of note, improvements in brain structure and complex brain functions correlated with the increase of the Omega-3 Index (Witte et al., 2013). These findings allow the hypothesis that brain structure and function of athletes can be improved by increasing their Omega-3 Index. This, however, remains to be directly demonstrated.

EPA and DHA are considered promising in physical performance optimization (Mickleborough, 2013). Previous intervention studies found that increasing intake of EPA+DHA does not mimic the effects of training: no increase in anaerobic threshold, VO_{2max} or endurance performance (Raastad et al., 1997). However, increased intake of EPA+DHA lowered heart rate at submaximal workload through enhanced stroke volume and cardiac output (Peoples et al., 2008; Buckley et al., 2009). Heart and muscle used oxygen more effectively, and heart rate returned faster to baseline after exercise (Peoples et al., 2008; Buckley et al., 2009). These findings are in keeping with epidemiologic findings in patients with coronary artery disease, where exercise time, exercise capacity and heart rate recovery strongly correlated with the HS-Omega-3 Index (Moyers et al., 2011). Moreover, some parameters of lung function improved after increased intake of EPA+DHA (Tartibian et al., 2010, Mickleborough et al., 2008). No untoward effects were reported in the studies mentioned or in large cardiovascular trials (e.g., Kotwal et al., 2012). Taken together, we consider increasing the HS-Omega-3 Index a promising approach in optimizing physical and mental performance.

The present cross-sectional study had many limitations: Our approach did not allow for assessment of detailed demographics, more vital parameters, dietary factors, asf. Therefore, we cannot determine, whether low intake, a high catabolic rate or other factors were responsible for the low Omega-3 Index found. Samples were taken consecutively, making a systematic bias in our data unlikely. Strengths of the current study are the relatively large number of samples, the use of an objective marker of fatty acids (independent of the uncertainties of assessments of food or diet), and a standardized analytical method, which made the present data well comparable to the data previously reported (von Schacky, 2014; Baghai et al., 2011; Moyers et al., 2011; Tan et al., 2012; Johnston et al., 2013; Pottala et al., 2014).

Taken together, using an exploratory approach, we found only one of 106 German elite winter athletes to be in the target range for the HS-Omega-3 Index of 8 to 11%. All others are at elevated risk for untoward cardiovascular events, and suboptimal brain structure and function. Since EPA+DHA were not observed to have untoward effects, and do not compromise, rather might improve performance of athletes, we conclude that our results open a viable option for prevention of cardiovascular events, and suboptimal brain function in athletes. This option, however, needs to be scrutinized by more thorough epidemiologic studies and by appropriate intervention trials.

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CvS and MH designed the study, evaluated the data, and drafted and finalized the manuscript. MK and RH collected and analyzed the data. All authors approved the final version of the manuscript. CvS founded a laboratory for fatty acids analyses, Omegametrix, which funded the analyses. No other funding.

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