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Article *in* Scandinavian Journal of Public Health · July 2017

DOI: 10.1177/1403494817717408

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Scandinavian Journal of Public Health, 1–9

STUDY DESIGN ARTICLE

Design of the FINS-TEENS study: A randomized controlled trial assessing the impact of fatty fish on cognitive performance in adolescents

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Abstract

Aims: To describe the rationale, study design, population and dietary compliance in a randomized controlled trial (RCT) investigating the effect of fatty fish on cognitive performance and mental health in adolescents. *Method:* In the Fish Intervention Studies-TEENS (FINS-TEENS) study we individually randomized 478 adolescents (14–15-year-olds) from eight secondary schools in Norway to receive school meal lunches with fatty fish or meat or n-3 supplements three times a week for 12 weeks. Demographic factors, psychological tests and biological measures were collected pre-and post-intervention. Duplicate portions of lunch meals were collected and individual intake recorded throughout the study. *Results:* In total, 481 out of 785 adolescents (61%) agreed to participate and 34 (7%) dropped out. Breakfast consumption was the only group difference in background characteristics. Analyses of selected nutrients in the lunch meals showed higher levels of n-3 fatty acids, vitamin D and n-6 fatty acids in the fish compared to the meat meals. Dietary compliance (score 0–144) revealed that the intake in the Fish group (mean = 59, standard deviation (SD) = 35) were lower than in the Meat group (mean = 83, SD = 31, $p < 0.01$) and Supplement group (mean = 105, SD = 25, $p < 0.01$). ***Conclusions:* The results show that it is possible to conduct a RCT with fatty fish in a school-based setting. The results also emphasize the importance of collecting detailed records of dietary compliance, as this information is important when interpreting and analysing the outcome of dietary interventions.**

Key Words: *Dietary intervention, cognitive performance, mental health, adolescents, biomarkers*

Introduction

A healthy dietary pattern is important for optimal brain development and function [1]. During early life the brain undergoes a rapid development and the most fundamental structures are formed [2]. However, the brain continues to mature until early adulthood and meeting the nutritional requirements during this period is important. Nutrient deficiencies have been found in children and adolescents, both in Europe and in more developing parts of the world. According to the World Health Organization (WHO), the highest deficiency in iodine status is found in Europe [3], and also the intake of iron, vitamin D and folate is found to be insufficient among European children and adolescents [4,5].

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Date received 21 December 2016; reviewed 10 May 2017; accepted 24 May 2017

DOI: 10.1177/1403494817717408
journals.sagepub.com/home/sjp
SAGE

Seafood is the main dietary source of the long-chain omega-3 polyunsaturated fatty acids (n-3 LCPUFA) and vitamin D, as well as an important source of selenium, iodine and high-quality proteins [6–8]. The n-3 LCPUFAs eicosapentaenoic acid (EPA) and especially docosahexaenoic acid (DHA) play an important role in brain function, including neuronal growth, differentiation, and membrane fluidity [9]. A high intake of seafood in childhood and adolescents has been associated with better cognitive performance [10,11], school grades [12,13] and mental health [14]. However, randomized controlled trials (RCTs) with n-3 LCPUFA supplementation show contradictory findings on cognition and behavior in children and youth [15], and it is possible that the effect from seafood may be related to other nutrients typically found in seafood or to the combined effect of these nutrients. In an RCT conducted on 8–11-year-old Danish children (OPUS study), no effects on cognitive performance were found after serving healthy school meals for three months [16]. The school meals comprised seafood, although only once a week. Thus, more studies are needed to disentangle the potential benefits on cognition in children and adolescents from an increased intake of seafood, particularly fatty fish rich in n-3 LCPUFAs and vitamin D.

The primary aim of this paper was to describe the design and study population in the Fish Intervention studies-TEENS (FINS-TEENS), where the adolescents were individually randomized to receive school lunches with either fatty fish or meat or n-3 supplements, three times a week for 12 weeks. The outcomes in the study were concentration performance, literacy skills, mental health and nutritional status. As compliance with the intervention is crucial when investigating the potential effects from dietary interventions, the secondary aim of the present paper was to describe the participants' dietary compliance (a measure of how much the participants actually consumed during the intervention).

Methods

Recruitment and design

All 26 secondary (junior high) schools in the Bergen municipality, Norway, were contacted. Six schools were not invited because they had too few students, nine refused to participate and three schools never replied. Thus, 785 pupils attending 9th grade from eight schools were eligible and invited to take part in the trial. Exclusion criteria were allergy/intolerance to the food/supplements included in the intervention. The adolescents that agreed to participate were randomly assigned to receive lunch with either fatty fish ("Fish") or meat ("Meat") or n-3 supplement ("Supplement") (Figure 1). The intervention was carried out during February–May 2015.

The trial complies with the Declaration of Helsinki and commenced after presentation for the Regional Committees for Medical and Health Research Ethics, and approval of Norwegian Data Protection Official for Research (project number 41030). Written informed consent was obtained from the participants and their caregivers.

Randomization

The participants were stratified according to gender and individually randomized within each school to one of the three treatment groups: Fish, Meat or Supplement. A list comprising the name and gender of all enrolled pupils was prepared in a spreadsheet. Separate pieces of papers, corresponding to the number of enrolled pupils in each school, where 1/3 was marked "Fish", 1/3 marked "Meat" and 1/3 marked "Supplements", were put in two boxes, one for girls and one for boys. One researcher went through the list stating the participant's gender, while another researcher (blinded from the list) drew a note from the correct box stating which of the intervention groups the individual would belong to.

Procedure and measurements

First, the adolescents conducted the d2 test of attention [17] with pen and paper (10–15 minutes). Afterwards, they filled out the electronic questionnaire (20–30 minutes), which included background factors such as age, gender, height and weight, a revised food frequency questionnaire (FFQ) [18], the Strengths and Difficulties Questionnaire (SDQ) [19] and five questions about sleep pattern. After a short break, the adolescents conducted an age-specific reading and spelling test (30–45 minutes) (Fagbokforlaget A/S, Bergen, Norway) and after lunch, biological samples (blood, hair and urine) were collected from the adolescents. The same week as the adolescents were tested at school the parents/caregivers received an email with a link to an electronic questionnaire, assessing marital status, ethnicity, education level and household income, as well as the SDQ. Depending on the number of participants at each school, one or two days were used to administer the tests and collect the biological samples. The same group of researchers and bioengineers administered all the tests in all of the eight participating schools and all data were collected within a period of three weeks both pre- and post-intervention.

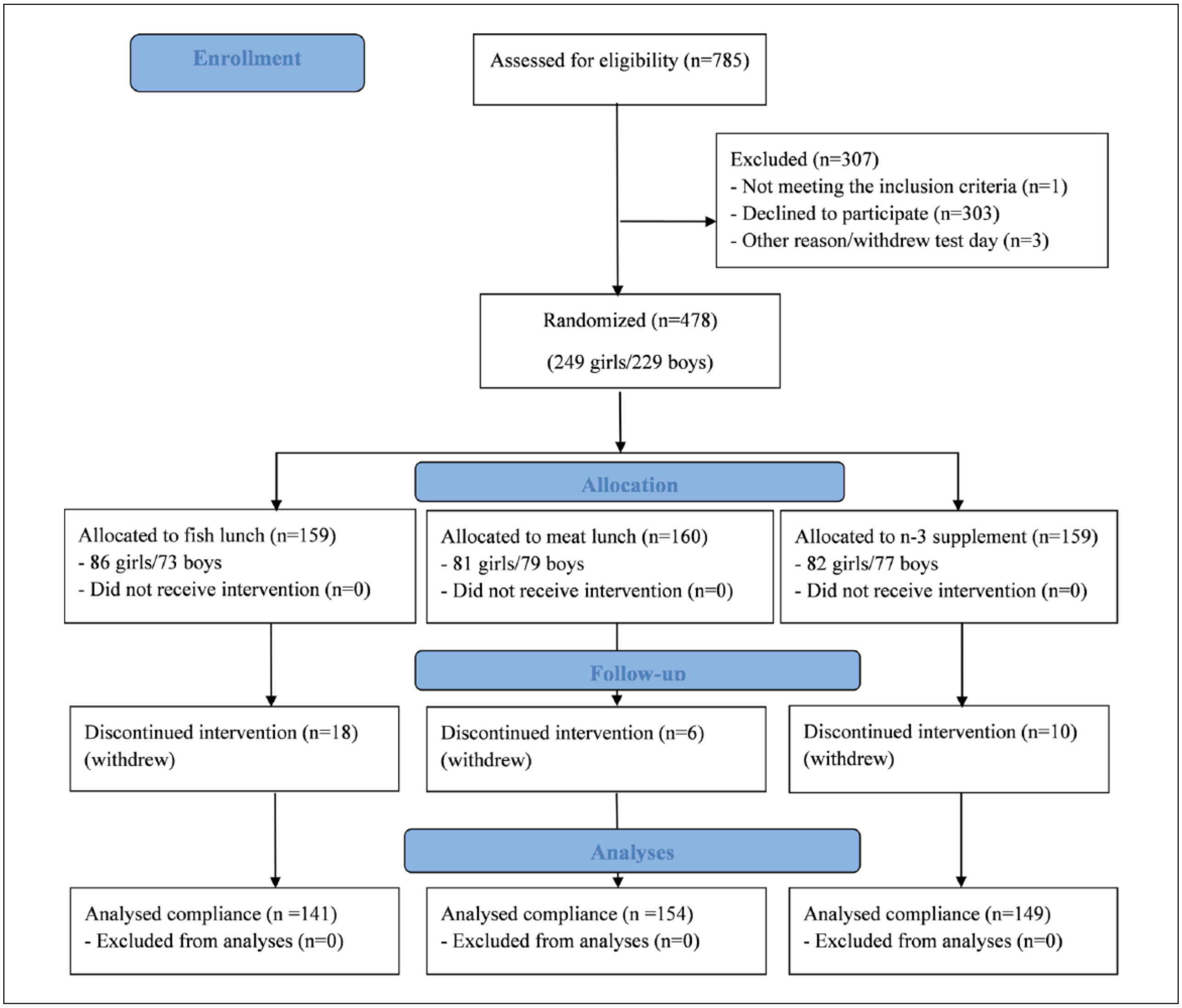

Figure 1. Flow chart for the FINS-TEENS study illustrating the recruitment, participation and drop-out.

The primary outcome for the intervention study was attention and concentration performance (d2 test of attention). The secondary outcomes were literacy skills (reading and spelling), mental health status (SDQ) and nutrient status of selected biological parameters (fatty acid profile, vitamin D, serum-ferritin and urinary iodine concentration).

Dietary intervention

The study meals were developed in cooperation with the research team and prepared and delivered by a catering agency to the schools at lunch time. The amount of fish or meat in each portion was requested to be 80–100 g per serving and all meals were served together with vegetables and pasta, tortilla, focaccia or baguette. In the Fish group, salmon, herring and mackerel were included. In the Meat group, chicken, turkey, beef and lamb (sometimes white cheese together with the chicken/turkey) were included. During the intervention, salmon was served 21 times, herring 10 times and mackerel three times, and white meat was served 24 times (nine times together with white cheese) and red meat was served 10 times (average number of servings = 34, range 30–36). An intake of 90 g fatty fish per portion was used to calculate the number of n-3 capsules in the Supplement group. Each capsule contained 500 mg fish concentrated oil, of which 105 mg was DHA, 158 mg was EPA and 13 mg was docosapentaenoic acid (DPA) (Nycoplus Omega-3 500 mg). Thus, eight capsules per serving corresponded to 90 g of fatty fish. After four weeks, the number of capsules was changed to seven, due to a decision to reduce the frequency of serving n-3 rich mackerel.

Each meal/supplement packet were marked with the participants' name and handed out in the classroom by research assistants. The participants returned the leftovers and the research assistants registered how much each participant had consumed. The registrations were based on how much the participants had eaten on a scale from 0 (none eaten) to 4 (all eaten). Both the amount of the whole meal and the amount of fish or meat consumed were registered in the spreadsheet (separate scorings). The supplements were counted (0–8 the first nine servings, then 0–7 the next 27 servings). Participants' absence from school was registered. All participants were encouraged to continue their regular diets during the intervention and we did not register what the Supplement group had for lunch at school.

During the intervention, duplicate portions of the meals (from absent participants) were collected several times and compared with respect to weighted portions and selected nutrients. In addition, the content of several undesirable substances was determined.

Biochemical analyses

Energy content and selected nutrients of the lunch meals were determined with respect to energy, fat, protein, vitamin D, iodine and fatty acids. In addition, the amount of dioxin and dioxin-like PCBs, and mercury were assessed in order to evaluate the food safety aspects of the intervention. Certified reference material was selected with regard to the similarity in concentration and matrix to sample material analysed to assess the trueness and precision of the analytical method in use. All methods used are according to NS-EN-ISO 17025 and the laboratory at the National Institute of Nutrition and Seafood Research (NIFES), Bergen, is frequently participating in proficiency tests.

Registrations of dietary compliance

In order to compare the three intervention groups with respect to dietary compliance, the scale used to register the intake of n-3 supplements was transformed into the same scale as the registrations conducted for the intake in the two lunch meal groups. This was done by dividing the summarized intake of n-3 capsules for each participant in the supplement group by the factor 1.8125. This factor was calculated from the ratio 261/144, as the maximum number of n-3 capsules the participant possible could take during the intervention was 261 capsules (reflecting nine days with eight capsules and 27 days with seven capsules), and the maximum intake score in the lunch meal groups was 144 (reflecting the maximum score of 4 over 36 days, meaning that all food was consumed on every serving). As this factor would be the same for different intake levels (e.g. 50% or 100%), the transformation made it possible to compare the summarized intake for each participant in the different groups. This variable was then used to calculate and compare the dietary compliance in the three intervention groups, expressed as the mean of the summarized intake for each group (ANOVA analyses). In addition, we used each participant's summarized intake to express the number of participants (cumulative percentage), who consumed according to different intake levels in each intervention group (Figure 2).

Power calculations

The sample size calculation was based on that the study is a three-armed intervention, with two repeated measurements with an assumed correlation of 0.5. To be able to reveal a meaningful effect of the intervention, a small to moderate effect size ($d = 0.35$) on the main outcome ("d2 test of attention") was applied. Given a power of 80% and a significance level of $\alpha = 0.05$, it was estimated that a sample size of 119 participants in each group was needed. Taking into account a 20% drop-out rate, a total sample of 446 was aimed to enroll in the study.

Statistical analyses

The statistical analyses were carried out by the use of Statistical Package for the Social Sciences (IMB® SPSS® Statistics 22, IBM Corporation, US). Data Analysis and Statistical Software (STATA) version 14 was used to determine the sample size that was needed to be enrolled in the study. The continuous variables were checked for normality using Kolmogorov–Smirnov tests and inspected through histograms. Independent *t*-tests (normally distributed variables) and Mann–Whitney U-tests (non-normally distributed variables) were used to compare the weight and nutrients in the fish and meat meals and to investigate if the completers differed from the non-completers (drop-outs). One-way ANOVA with post-hoc comparison (Tukey HSD (Honest Significant Difference) if significant findings in ANOVA) and chi-square analyses were used to investigate if the three intervention groups differed at baseline (gender, age, height, weight, Cole's ISO BMI criteria for overweight and obesity [20], physical activity, packed lunch at school, eating breakfast, seafood for dinner and n-3 supplements) and to investigate differences with respect to dietary compliance in the three intervention groups.

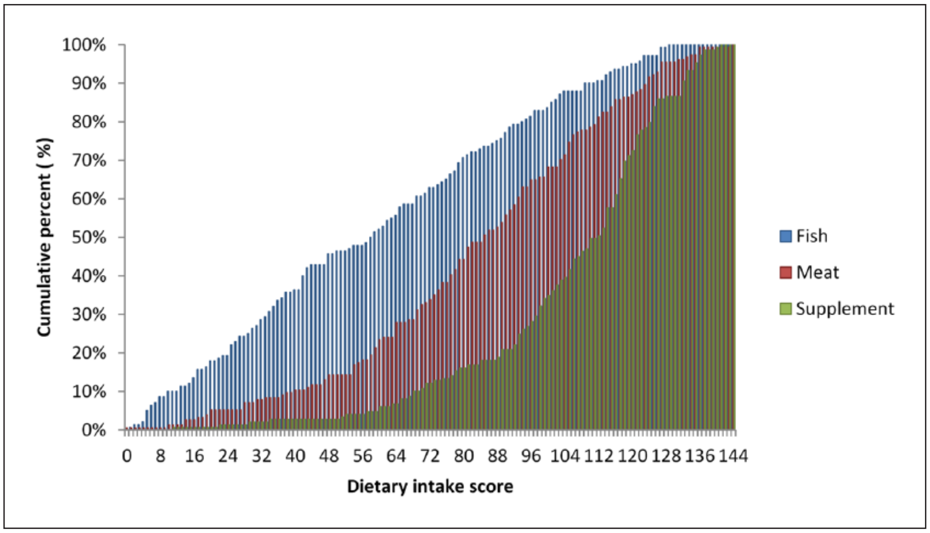

Figure 2. Total intake in the three intervention groups.

Results

Study population

Informed consent was obtained from 481 adolescents and their caregivers (61% of those invited) (Figure 1). At baseline, 472 (99%) adolescents completed the electronic questionnaire measuring descriptive characteristics and dietary habits. There were no differences between the groups at baseline, except for a difference with respect to the intake of breakfast ($p <$ 0.05) (Table I). The adolescents in the Meat group more often reported to eat breakfast compared to the adolescents in the Fish group ($p < 0.05$).

Three adolescents withdrew before randomization and 478 adolescents were randomized to one of the three treatment groups. During the intervention, 34 pupils withdrew from the study and the total number of drop-outs was, thus, 34 (7% from 785; Figure 1). The attrition analysis showed no difference between the completers and non-completers on any of the baseline characteristics described in Table I.

Comparison of the meals

There were no differences in weight of the portions, for neither the whole meal nor the different ingredients, in the two lunch meal groups (Table II). Moreover, the portions typically served in the two groups were similar with respect to energy, fat and level of selected micronutrients, except that the level n-3 LCPUFAs ($p < 0.01$), vitamin D ($p < 0.01$) and n-6 PUFAs were higher ($p < 0.01$) in the fish compared to the meat meals (Table III).

Levels of mercury in the meals were 0.008 mg/kg in the fish meals and 0.002 mg/kg in the meat meals. The mean levels of dioxin and dioxin-like PCBs (ng TEQ/kg) were 0.19 in the fish meals and 0.12 in the meat meals (data not shown).

A comparison of dietary compliance in the three intervention groups

There results revealed significant differences in dietary compliance between the three intervention groups (F (2, 441) = 81.4, $p < 0.01$). The mean intake in the Fish group (mean = 59, SD = 35, range 1–129) was significantly lower than the mean intake in both the Meat group (mean = 83, SD = 31, range 0–144) and the Supplement group (mean = 105, SD = 25, range 11–141, $p < 0.01$).

The results related to dietary compliance are presented as cumulative frequencies in percent in Figure 2. The Y-axis shows how many of the participants (%) in each of the group who consumed according to different levels of intake (summarized intake score for each participant: X-axis). For example, the figure shows that 37% in the Fish, 66% in the Meat and 88% participants in the Supplement group consumed half or more (intake score of ≥ 72) of the meals or capsules served in the study.

Discussion

The FISH-TEENS is the first RCT assessing the impact of fatty fish on cognitive performance, mental health and nutritional status in adolescents. Based on the inconsistency in literature regarding the effect of n-3 supplements on cognition, the FINS-TEENS study is designed to compare the effect of an increased intake of fatty fish to an increased intake of either n-3

Table I. Characteristics of the study population and comparison of the three intervention groups at baseline given as mean (SD) or number (counted).

	n	All		Fish		Meat		Supplement		*F*-value/ Chi-Square	*p*-value
Gender (girls/boys) (number)*	476	248/228		85/73		81/79		81/76		0.35	0.84
Age (year) (mean, SD)	472	14.6	0.3	14.6	0.3	14.6	0.3	14.6	0.3	1.07	0.34
Height (meter) (mean, SD)	447	1.69	0.1	1.68	0.1	1.69	0.1	1.69	0.1	1.18	0.31
Weight (kg) (mean, SD)	460	57	11.0	56	11.0	57	9.0	58	11.0	0.69	0.51
Overweight/obese (number, %)†	435	33 (7.6%)		11 (7%)		10 (6.3%)		12 (7.6%)		0.20	0.91
Physical activity (mean, SD)†	471	4.5	0.9	4.5	1.0	4.5	0.9	4.5	0.8	0.31	0.73
Breakfast (mean, SD)‡	472	4.1	1.3	4.0	1.4	4.4	1.1	4.0	1.3	3.74	0.2
Packed lunch (mean, SD)§	472	3.3	1.0	3.3	0.9	3.3	.09	3.3	0.9	0.29	0.75
Seafood dinner (number/week)‖	472	4.1	1.0	4.1	1.0	4.0	1.0	4.1	0.9	0.48	0.62
Omega-3 supplements (yes/no)	471	217/254		78/80		70/87		67/87		3.27	0.51

* Information from electronic questionnaire and separate lists from the schools.
†Cole's criteria for overweight and obesity according to gender, ISO BMI (Body Mass Index).
†Physical activity was measured on a scale from 1 to 5, where 1 was ½ hour or less per week and 5 was 4 hours or more per week.
‡Breakfast was measured on a scale from 1 to 5, where 1 was never and 5 was every day.
§Packed lunch (packed at home and brought to school) was measured on a scale from 1 to 4, where 1 was never and 4 was every day.
‖Seafood as dinner was measured on a scale from 1 to 6, where 1 was never and 6 was four times per week or more.

Table II. Weight of whole portion, oily fish or meat, vegetables and bread/pasta/wraps/pie per portion.

	Fish			Meat			*t*-test	*p*-value
	Mean	SD	Min–Max	Mean	SD	Min–Max		
Whole Portion (g)	233	46	148–341	227	44	152–325	0.74	0.46
Fatty fish or meat/cheese (g)	71	22	32–131	69	18	33–112	0.61	0.54
Bread/pasta/wraps/pie (g)	111	36	46–219	110	35	45–194	0.09	0.93
Vegetables (g)	42	25	7–124	41	24	6–126	0.10	0.93

supplement or comparable lunch meals with meat. Thus, the study has the potential to provide new insight into the relationship between fatty fish, its specific nutrients and how this is related to cognitive function in adolescents.

Study population

The eight schools that agreed to participate in the study were from different geographical and socio-economic districts in the municipality [21]. Although approximately 40% of the adolescents in the participating schools refused to participate, we managed to include adolescents from families with various socio-economic backgrounds; that is, 21%, 52% and 27% of the participants were from families with low, moderate and high household income [22]. Still, it is well-known that those who refuse to participate in health research often are different from those who agree to participate on important variables, such as both nutrition and mental health status [23,24]. Thus, it is possible that adolescents with both an inadequate nutritional status and high levels of mental health problems are underrepresented in the present sample, which could influence the generalizability of findings from the FINS-TEEN study. However, an inclusion rate of 61% is comparable to other dietary interventions with repeated biological sampling from the children or adolescents. In two American dietary intervention studies, the inclusion rate was 59% and 71% [25,26]. However, the inclusion of eligible children in the OPUS, which also included repeated biological samples, was 82% [27]. The high response rate was explained as an effect of the dietary intervention, where "Eating regional, Nordic home-cooked meals with low waste" seemed to have a strong appeal to both the families invited and the schools involved in the study. Taking into account that the dietary intervention in the present study involved fatty fish, which is not typically consumed in an adolescent population [28], and that some participants only received n-3 supplements and no school lunches, the difference in response rate between the present study and the OPUS study could possibly be explained by the difference with respect to the dietary intervention. Still, a low drop-out rate (7%) was achieved and the attrition analyses showed no systematic differences between those who dropped out of the study and

Table III. Analyses of nutrients in the double portions of served fatty fish and meat meals.

	Fish			Meat			*t*/*z*-value	*p*-value
	n	Median	Min–Max	*n*	Median	Min–Max		
Energy (Kcal/100 g)*	27	227.4	137.9–400.9	26	229.7	145.5–284.1	0.6	0.57
Total fat (g/100 g)*	27	9.3	3.6–19.2	26	8.4	1.4–17.4	1.5	0.13
Protein (g/100 g)†	27	9.8	6.8–23.4	26	11.4	7.9–24.2	–2.1	0.04
Vitamin D (µg/100 g)†‡	27	1.6	0.5–4.7	4	<1	<1	–3.2	0.01
Iodine (ug/100 g)†	27	2.2	0.5–40.5	26	2.0	0.5–9.4	–1.2	0.25
EPA (mg/100 g)†‖	27	94.0	62.0–979.0	26	3.0	0.5–7.0	–6.3	0.01
DHA (mg/100 g)†‖	27	172.0	110.0–1589.0	26	2.5	0.5–19.0	–6.3	0.01
DPA (mg/100 g)†‖	27	34.0	11.0–172.0	26	5.5	0.5–13.0	–6.2	0.01
LA (mg/100 g)†	27	1444.0	436.0–4264.0	26	1098.5	300.0–3533.0	–2.7	0.01
AA (mg/100 g)†	27	26.0	8.0–75.0	26	16.5	7.0–56.0	–1.5	0.14
Sum n-3 (mg/100 g)†	27	774.0	334.0–3950.0	26	140.5	45.8–465.0	–6.2	0.01
Sum n-6 (mg/100 g)†	27	1530.0	454.0–4280.0	26	1140.0	321.0–3550.0	–2.9	0.01
Sum n-3/n-6 (mg/100 g)†	27	0.5	0.1–3.9	26	0.1	0.0–0.4	–5.5	0.01
Sum monounsaturated (g/100 g)†	27	4.5	2.0–8.2	26	2.9	0.5–8.4	–2.9	0.01
Sum polyunsaturated (g/100 g)†	27	2.3	0.8–5.0	26	1.3	0.4–3.7	–4.7	0.01
Sum saturated (g/100 g)†	27	1.9	0.8–7.6	26	2.84	0.6–8.0	–1.6	0.11

*Independent *t*-tests (normal distribution).
†Mann–Whitney U-Test (non-normal distribution).
‡Only four portions of meat meals had vitamin-D levels above limit of quantification (LOQ).
‖The large variation in range in the fish meals reflects the use of different species (mackerel (n=2), herring (n=7) and salmon (n=17)).
n-3: omega-3; n-6: omega-6; EPA: eicosapentaenoic acid; DHA: docosahexaenoic acid; DPA: docosapentaenoic acid; LA: linoleic acid; AA: arachidonic acid.

those who continued on important background variables. The low drop-out rate must not be confused with dietary compliance, as it is possible to participate in a dietary intervention study and at the same time eat little or nothing of what is being served. Thus, collecting separate data of dietary compliance is of the utmost importance when investigating and comparing the effects from various diets or nutrients.

Primary outcomes

The primary outcomes in the study were attention and concentration performance. Several studies have linked both n-3 LCPUFA and seafood to cognitive performance in children and adolescents [10,11,15]. However, attention and concentration were chosen as the primary outcome as these aspects of cognition seems to be easier to influence by a change in diet than other aspects of cognition, such as literacy skills, which may take a longer time to impact [29].

Study meals

In order to provide meaningful comparisons with respect to dietary compliance in the three intervention groups it was important to investigate if the portions that were served in the study were identical, except for the planned differences with respect to n-3 fatty acids and vitamin D. The results revealed that the amount of fish or meat were approximately 70 g per portion, which was somewhat lower than the planned 80–100 g per portion. However, the range of the weight of fish or meat meals was larger than desirable. As the number of capsules was based on 90 g of fatty fish per portion, the level of n-3 LCPUFAs in the Supplement group would be somewhat higher than the amount of n-3 LCPUFAs in the Fish group at a comparable level of intake. Given that there could hypothetically be a dose response between n-3 LCPUFAs and, for example, concentration performance, this could potentially lead to a stronger improvement in the n-3 Supplement group compared to the Fish group at the same level of intake. Higher levels of n-3 LCPUFAs and vitamin D in the fish compared to the meat meals were expected and according to the design. Higher levels of n-6 PUFAs in the fish compared to the meat meals is related to the fact that the level of n-6 PUFAs in the salmon was higher than the level of n-3 PUFAs (n-3/n-6 ratio = 0.8).

In addition, the amount of dioxin and dioxin-like PCBs and mercury were assessed and calculated according to the tolerable weekly intake (TWI) in both the fatty fish and meat meals to evaluate the food safety aspects of the intervention. The intake of dioxin and dioxin-like PCBs per week of the fatty fish meals and the meat meals represented less than 17% and less than 11%, respectively, of the TWI for a participant with average weight (56.9 kg). The intake of mercury covered an even lower percentage of TWI for both meals.

Dietary compliance

The present study also showed that there were large and important differences in dietary compliance between the three groups, and the cumulative percentage showed, for example, that 37% in the Fish group, 66% in the Meat group and 88% in the Supplement group consumed half or more of the meals/supplements served in the study. The difference between the Fish and the Meat group could possibly be explained by the fact that fish is not typically consumed by this age group and that only cold lunch meals were served in the study. Analyses at baseline showed that less than 40% of the adolescents adhered to the recommendations for fish intake and that as many as 26% reported eating fish for dinner less than once monthly [22]. Thus, these results indicate that it is probably more challenging to intervene with seafood than meat. The fact that the intake in the Supplement group was also considerably higher than the intake in both the Fish and the Meat groups also underlines that it is probably easier to intervene with supplements than various food items or whole meals, as intervention with food is more dependent on the participants' food preferences. The difference could also be related to other aspects, such as that food becoming repetitive and boring [30].

However, the large variations between the three groups emphasize the importance of keeping detailed records of dietary compliance, so that this aspect can be taken take into account when analysing and interpreting the various outcomes from an intervention.

Strengths and limitations

The strengths in the present study are the large sample size, the inclusion of pupils from various social backgrounds, analyses of biomarkers and the high level of control over nutritional composition of study meals and record of dietary compliance. The comprehensive sampling of served meals and detailed registration of actual intake from each participant allowed us to calculate and compare the dietary compliance in the three intervention groups, which will be taken into account in the further analyses of effects from the intervention. Even though the adolescents were monitored by the same research staff over the whole study period, who got to know the adolescents and repeatedly reminded them of the importance of returning back all the leftovers, we cannot fully rule out the possibility that some pupils swapped their meals. It was also a limitation that we were not able to weigh the food and the leftovers, which would have yielded an even more accurate estimate of the intake than the research assistants' own estimations in terms of quartiles.

Conclusions

The FINS-TEENS study is the first RCT assessing the impact of an increased intake of fatty fish in an adolescent population. The study investigates the potential impact of fatty fish on concentration performance and literary skills, both of which is important for school performance and learning in general. As fatty fish is rich in both n-3 LCPUFA and other important nutrients, the unique design allows us to investigate if the potential positive effects are related to an increase in n-3 PUFAs and/or other nutrients found in fatty fish.

Acknowledgements

A special thanks to all the pupils and their parents that participated in the study, and to the technical staff and master students at NIFES who participated in the data collection process. A warm thanks to Kyrre Breivik for advice when planning the sample size for this study, to Maria Wik Markhus for drawing blood samples and to Runa Borgund Barnund for extensive and valuable help with the data collection process.

Declaration of conflicting interests

None declared.

Funding

This work was supported by The Norwegian Seafood Research Fund (FHF) (grant number 900842) after consideration by the Research Council of Norway. This study is a part of the FINS project supported by FHF (45.8 mill. NOK). Marine Harvest A/S (MH) supported FINS with 0.6 mill. NOK in cash, in addition to farmed fish, which was used in the meals. Lerøy A/S supported FINS with 0.4 mill. NOK in cash (not used in this study). Pelagia A/S provided herring and mackerel free of charge, which were used in the meals. FHF, MH, Lerøy A/S and Pelagia A/S had no role in the design of the study, in the collection, analyses or interpretation of data, in the manuscript writing or in the decision to publish the results.

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