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THE EFFECT OF N-3 LC-PUFA SUPPLEMENTATION ON TENNIS SKILL ACQUISITION IN 10-12 YEAR OLD GIRLS

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ABSTRACT: The purpose of this study was to investigate the effects of 16 weeks of n-3 LC-PUFA (omega 3 long-chain polyunsaturated fatty acid) supplementation on tennis skill acquisition in 10-12 year old girls. This research was a single-blind placebo-controlled trial. 29 girls (10-12 years of age) who had never played tennis before took part in the study. Ball Throws to the Target (BTT) and Tennis Ability Test (TAT) were performed three times. Before participants were allocated to the groups and received n-3 LC-PUFA or olive oil, they underwent preparatory training for three weeks. Anthropometric measurements, nutrition analysis, and 1st BTT and TAT tests were performed and they continued the preparatory training until the 3rd week. Then they were randomly allocated to two groups to receive either n-3 LC-PUFA (omega group; 670 mg · day^{-1}; n=16) or olive oil (placebo group; 670 mg · day^{-1}; n=13) during 16 weeks of tennis training which involved 3 hours per week for 19 weeks. The results show that significant improvements in TAT were found in both groups but the omega group had significantly higher scores than the placebo group at the 3rd measurements. Although there were no differences between groups at all measurements of BTT, the omega group showed significant improvement between the 1st and 3rd measurements. This study suggests that daily 670 mg n-3 LC-PUFA supplementation for 16 weeks might improve tennis ability test scores of 10-12 year old girls.

KEY WORDS: n-3 LC-PUFA, skill acquisition, nutrition, tennis, children

INTRODUCTION

Tennis is a sport which demands a high level of coordination [3,14]. The term "coordination" is defined as the ability to perform complex motor exercises [8,27]. Motor skill acquisition is a constant and dynamic process which has no certain stages. These stages can be explained as changing application of skill over time. For example, over time, accuracy and speed in the movements can be improved and reductions in errors and effortless performance can be observed. These stages are cognitive (understanding), associative (repeat), and autonomous (automatic); this is known as Fitts and Posner's theory. Skill acquisition occurs as a process which generally includes time and repetition. In brief, beginners become a professional with time and true repetition [4]. Skill acquisition shows improvement with time and repetition in tennis as well. Facilitation of the development of new skills has been studied for years in sport literature. Many studies concern the learning styles, instructional strategies, teacher behaviours and learning environments [34].

Omega 3 long-chain polyunsaturated fatty acid (n-3 LC-PUFA) is widely studied, and beneficial effects on human health have been proved. It is an essential fatty acid found in oily fishes in deep seas [1,16,25]. n-3 LC-PUFA supplementation affects brain cognitive functions such as learning [12,13,20,21], coordination, problem solving ability [33] and motor skill [3,4,34] by improving the micro and macro structure of the brain [9,18,28,29,30,32]. In the literature, there couldn't be found any research that investigated the effect of n-3 PUFA on skill acquisition in physical activity or tennis ability.

Skill is presented in two types which are cognitive and motor skill. Motor and cognitive skill developments are interrelated. For example, the cerebellum not only controls motor functions, but also plays a role in cognition as well. The prefrontal cortex plays a role in motor functions and movement control, not simply in cognition [8,34]. Literature reports indicate that n-3 LC-PUFA is effective for cognitive skills. According to this knowledge we have associated tennis skill acquisition with cognitive skill acquisition and we have hypothesized that if n-3 LC-PUFA is effective for cognitive skills, it may be effective in tennis skill acquisition. We investigated in this study the effects of n-3 LC-PUFA on tennis skill acquisition in 10-12 year old girls.

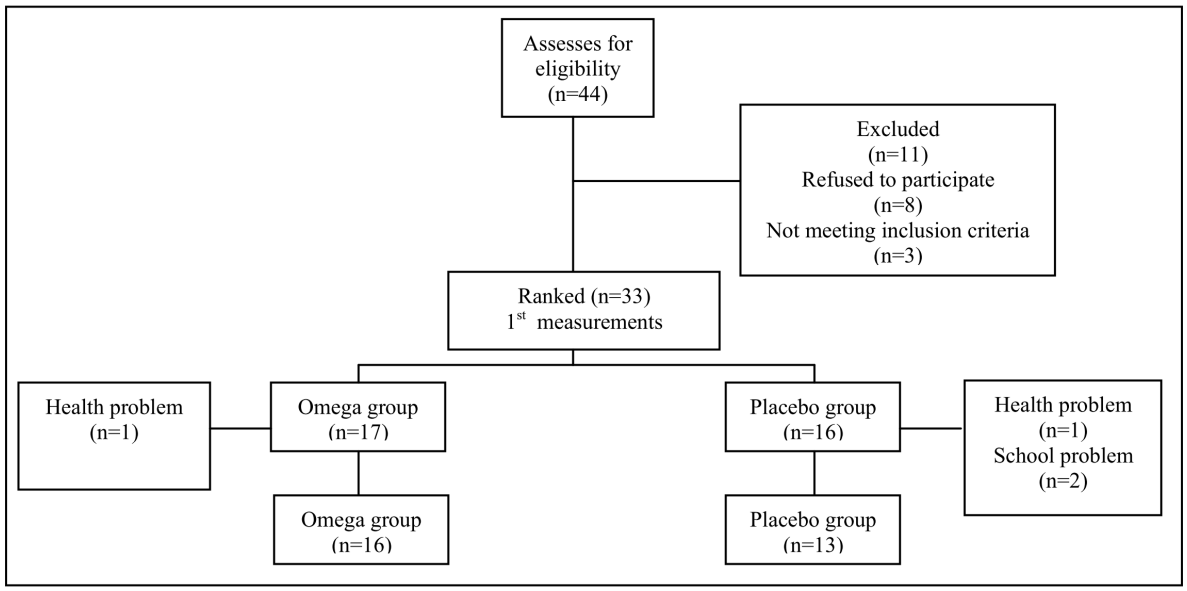

FIG. 1. FLOWCHART OF PARTICIPANTS THROUGHOUT THE STUDY

MATERIALS AND METHODS

Subjects. Forty-four girls who were recruited from public flyers were assessed for eligibility. Three of them did not meet the inclusion criteria, and eight of them refused to participate. Thirty-three 10-12 year old girls voluntarily attended the study. One participant in the omega group left the study because of a health problem and three participants in the placebo group left the study because of school and health problems at the 2nd measurements. In total 29 girls completed the study and statistical analyses were applied to girls who underwent all three measurements (Figure 1). The inclusion criteria were standardized health, willing participation, 10-12 age range, not receiving medication or vitamins, and sedentary girls. The exclusion criteria were sudden illness, coordination disorder, unwillingness to continue the study, not in the 10-12 age range, and ever played tennis before.

Before participants were allocated to the groups, they joined the preparatory training for three weeks so that they could get accustomed to tennis and ambiance. Then, they underwent the 1st measurements of TAT, BTT, anthropometric characteristics, and nutrition analysis, and they were allocated to two groups which were omega (n=17) and placebo (n=16) groups with the method of systematic sample. They were allocated according to their 1st measurement scores of TAT and they had equal rank scores.

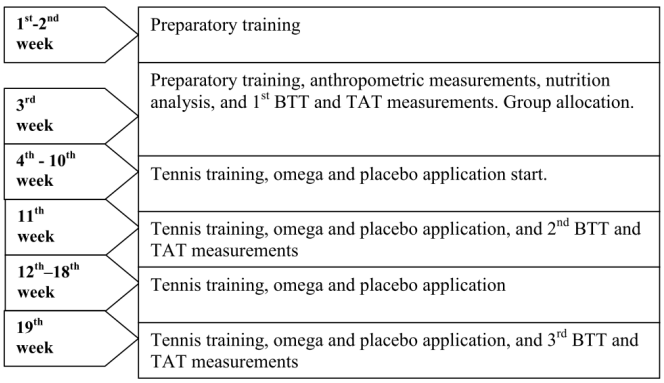

FIG. 2. STUDY DESIGN

After the 1st measurements, application of placebo (olive oil) and omega (fish oil) was started. 670 mg·day^{-1} (2x335 mg) of fish oil was given to the omega group and 670 mg·day^{-1} (2x335 mg) of olive oil was given to the placebo group in addition to their daily diet and they continued to participate in the tennis training. After the 3rd measurements, the experiment was terminated (Figure 2).

All participants' parents/guardians gave written informed consent and participants gave informed assent prior to inclusion in the study. This research project has been approved by Akdeniz University School of Medicine Ethical Committee of Drug Research (approval number: 5822), Republic of Turkey Ministry of Health, General Directorate of Drug and Pharmacy (approval number: 60994) and Provincial Directorate of National Education (approval number: 01602).

Tennis training

Tennis training sessions lasting one hour, three times a week for 19 weeks and a total of 57 hours (participants' attendance mean was 41.22±1.23 hours; omega=41.08±1.11, placebo=41.39±1.40 hours) and a tennis education programme were scheduled for the two groups.

Gentile's 2x2 teaching chart which constituted part of a motor skill classification system was used in tennis skill education. According to this chart, at the first level person and external stimulant are stable; e.g. hitting a ball which is coming from the same place and elevation, in the same manner and on the same side. At the second level, the person is not stable while the external stimulant is; e.g. skipping and running, hitting a ball which is coming from the same elevation. At the third level, the external stimulant is variable while

the person is stable; e.g. hitting a ball which is coming from a different elevation from the same side. At the fourth and last level, both the external stimulant and the person are variable, such as catching and hitting a ball which is randomly thrown [10].

The fundamentals of tennis technique, which were ground stroke, volley and service drills, were applied. Teaching of all the fundamentals was applied according to the principles 'easy to hard, simple to complicated, and known to unknown'.

Method of n-3 LC-PUFA and placebo application

Fourteen fish oil capsules containing n-3 LC-PUFA or placebo capsules containing olive oil were given to the subjects weekly at the first training session of the week. The dose was a 335 mg capsule after two meals, giving a total dose of 670 mg·day^{-1} per subject, for 16 weeks. Olive oil capsules which were applied as placebo were made out of capsules that had the same appearance and size as the n-3 LC-PUFA capsules. Each week, the project supervisor interviewed the parents and subjects to check that the participants had taken the capsules and whether they had any side effects.

Anthropometric measurements

The height of participants was measured with a stadiometer (Holtain). The aim of this measurement is to measure the distance between vertex points of head and floor. Height was measured in cm. Body mass was measured in light clothes and bare feet with an impedance analyser (Tanita Corporation, Tokyo, Japan, Model TBF 300 A) [5,26].

Nutrition analysis

Participants completed the food consumption form for three days: two of them on weekdays and one of them at the weekend. Food consumption of the participants on their normal diet was analysed with BEBİS (Ebispro for Windows, Turkish version, Stuttgart, Germany; Version 5, 2006; Database: Bundeslebensmittelschlüssel (BLS), (2.3). According to their consumption data, docosahexaenoic acid (DHA) rates taken by participants were determined.

Tennis ability test (TAT)

The aim of this test is to measure tennis ability. One tennis racquet and 22 tennis balls of the same standards were used during the test. The participant was asked to stand on the T point, which was the intersection of two service boxes in the mini-court. Eleven balls were thrown to the participant's left and right sides successively from the tester standing in front of the net. The participant was required to strike the balls alternately as forehand and backhand. It was evaluated as one point when the ball fell into the service boxes in the singles court; two points when it fell between the baseline and the service boxes; and zero point when the ball fell outside of the lines or into the net. At the end of the set, the points were summed and the score of the set was determined. The test was applied as three sets and the best score was recorded. The 2nd and 3rd measurements were made the same as the 1st measurements.

Ball throws to the target test

The aim of this test is to measure the eye-hand coordination. Tape line, tennis balls, packing tape, and three paperboards in different colours were used for the test. The participant stood behind the line which was drawn 3 m away from the wall. The bottom line of the target was stuck 1.5 m high on the wall. The smallest red square at the centre of the target was 10 cm x 10 cm, the blue square on the outer part of the red was 30 cm x 30 cm, and the outermost white square was 60 cm x 60 cm. When the participant hit the red square she got 3 points, the blue square 2 points, and the white square 1 point, and if the participant threw the ball outside of the white square she got zero. The test was repeated twice and the highest score was recorded.

Statistical analysis

Data are expressed as means±standard deviation (S.D.). The differences between the groups and time-dependent changes in the groups were examined in statistical analysis. All data were normally distributed. Significance values (p) lower than 0.05 were considered as significant.

Time-dependent changes of the two groups were examined with repeated measures. Homogeneity of variance was examined with Mauchly's test of sphericity. TAT measurements sphericity was 0.008; because of that Huynh-Feldt values were taken into consideration. BTT measurements sphericity was 0.521 and BTT's sphericity was found as assumed. Repeated measures were applied for each group because the groups had time-dependent impairment of both BTT and TAT. Pairwise comparisons of all three measurement points (1st, 2nd, 3rd) were determined. Independent samples t-test was applied for pairwise comparison of the two groups.

RESULTS

The baseline demographic characteristics, continuity and DHA intakes of the groups are presented in Table 1. No significant differences were found between groups in terms of age, height, weight, attendance at tennis training sessions and DHA intake in their nutritional habits ($p>0.05$). Participants' 2nd DHA intakes were determined at the end of the study in the 3rd measurement week. Omega (DHA=0.27±0.11) and placebo (DHA=0.28±0.17) groups had no differences in their DHA intakes. There were also no differences between groups.

TABLE 1. DESCRIPTIVE CHARACTERISTICS OF STUDY GROUP

	Omega (n=16)	Placebo (n=13)
Age (years)	11.53 ± 1.65	10.59 ± 2.01
Height (cm)	149.50 ± 10.19	145.00 ± 8.32
Body mass (kg)	41.66 ± 13.39	39.73 ± 7.56
Attendance (hour)	41.08 ± 1.11	41.39 ± 1.40
DHA intake (mg·day^{-1})	0.28 ± 0.13	0.27 ± 0.19

Note: DHA: Docosahexaenoic acid

TABLE 2. BALL THROW TO THE TARGET (BTT) AND TENNIS ABILITY TEST (TAT) 1ST -2ND -3RD MEASUREMENTS OF OMEGA AND PLACEBO GROUPS

	Omega (n=16)			Placebo (n=13)		
	1st	2nd	3th	1st	2nd	3th
BTT (points)	15.38 ± 3.63	15.69 ± 3.75	17.13 ± 3.93	14.08 ± 3.42	15.23 ± 1.64	15.23 ± 1.53
TAT (points)	14.88 ± 4.45	15.50 ± 2.87	18.69 ± 2.89$	13.31 ± 3.32	14.46 ± 2.66	15.85 ± 2.51

Note: Values are mean±SD. Omega: omega group, Placebo: placebo group. $ p=0.010 significant difference from placebo.

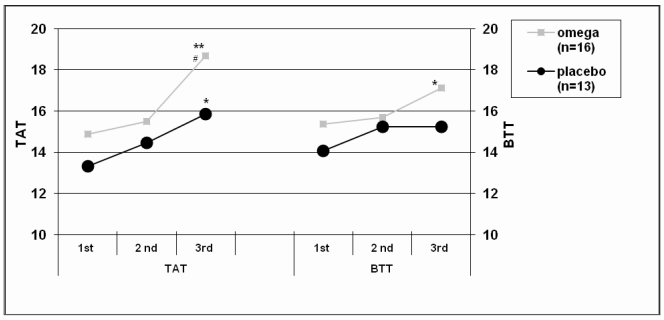

FIG. 3. REPEATED MEASURES ANALYSIS OF 1ST, 2ND AND 3RD MEASUREMENTS OF BALL THROWS TO THE TARGET (BTT) AND TENNIS ABILITY TEST (TAT) OF OMEGA AND PLACEBO GROUPS
Note: * p=0.013, ** p<0.01 significant difference from 1st measurements. # p<0.01 significant difference from 2nd measurements.

There were no significant differences between groups in any measurement of BTT. But there was a significant difference at the 3rd measurement of TAT between groups in favour of the omega group (t (27) =2.78, p=0.010) (Table 2). The omega group showed improvement in BTT scores (F=(2,14)=4.14, p=0.039). This improvement was determined between the 1st and 3rd measurements of BTT (p=0.013). The placebo group showed no significant differences between measurements of BTT (p>0.05).

The omega group showed improvement in TAT (F(2,14)=51.480, p<0.01). Significant differences were found between the 1st and 3rd measurements (p<0.01) and 2nd and 3rd measurements (p<0.01). The placebo group also showed improvement in TAT (F(2,11)=4.16 ; p=0.045). Also a significant difference was found between the 1st and 3rd measurements (p=0.013) (Figure 3).

DISCUSSION

We investigated the effects of n-3 LC-PUFA supplementation on tennis skill acquisition in 10-12 year old girls. To our knowledge, this is the first study to investigate the effects of n-3 LC-PUFA supplementation on tennis skill acquisition.

Girls aged 10-12 years need daily 1000 mg n-3 LC-PUFA [22]. In a recent study, individuals were found to have a daily 0.28 mg DHA intake with their normal diet and it is far less than their needs. Daily 670 mg of n-3 LC-PUFA supplementation might optimize their DHA levels. Physiological effects of low intake of n-3 LC-PUFA reduce visual acuity, platelet aggregation, vessel wall construction and immune function. Also it may represent a risk factor in the pathogenesis of a number of diseases, including cardiovascular and inflammatory diseases [22]. Also low intake of n-3 LC-PUFA is associated with deficits in various brain tissues. Deficits in hippocampus-dependent spatial learning, deficits in frontal cortex-dependent working memory, deficits in olfactory discrimination learning, and elevated behavioural indices of anxiety, aggression and depression have been noted [23]. On the other hand, if there is a relationship between n-3 LC-PUFA consumption and brain function, the most important period of that is during the dynamic development processes.

Studies have shown that motor performance could be enhanced by n-3 LC-PUFA supplementation's effects on activation of neurotransmitters [19]. Animal studies indicated that n-3 LC-PUFA started to accumulate in blood and brain in 2 or 4 weeks but only after 8 or 12 weeks was it effective [1,20,21,24,]. In a recent study, measurements were applied before and after 8 and 16 weeks of n-3 LC-PUFA supplementation so as to observe the effects of n-3 LC-PUFA. Also there were significant differences between two groups in TAT at the 3rd measurements.

Coordination can be developed with repetition like skill acquisition. Hand-eye coordination was examined with BTT and no significant differences were found between groups in this study. In both groups individuals' hand-eye coordination developed with tennis training, not with specific coordination training. Maybe because of that the placebo group was not affected by training but there were significant differences between the omega group's 1st and 3rd measurements and also the omega group was affected by training. According to this result, n-3 LC-PUFA supplementation might improve the effects of training. Previous studies showed that n-3 LC-PUFA supplementation improves the coordination [9] so it was used as a treatment in developmental coordination disorder (DCD) and attention deficit hyperactivity disorder (ADHD) in previous studies [28,11]. Coluccia et al. [7] investigated the effects of n-3 LC-PUFA on motor skills in juvenile adult rats and found that n-3 LC-PUFA significantly improved their motor coordination. Clarke et al. [6] also found positive effects of n-3 LC-PUFA on motor control functions of rats.

Physical properties, age, and repetition are important factors in tennis motor performance [34]. We examined the tennis motor performance with TAT in the present study. There were no significant differences between groups' physical properties, age and repetition number, but there were significant differences in TAT scores of groups.

This result showed that n-3 LC-PUFA might improve the tennis motor performance and also skill acquisition. Previous studies showed that n-3 LC-PUFA supplementation improves cognitive and motor development and performance in healthy children [29,15] and children with phenylketonuria (PKU) [16,17,2]. Motor performance was generally measured with the Movement Assessment Battery for Children (ABC) in previous studies. It measures manual dexterity, ball skills and static and dynamic balance. Stordy [31] found a positive effect of n-3 LC-PUFA on ABC scores of children with dyslexia and dyspraxia disorder. But Richardson et al. [28] did not find any effect of n-3 LC-PUFA on ABC scores.

CONCLUSIONS

We conclude that daily 670 mg n-3 LC-PUFA supplementation might improve tennis ability test scores of 10-12 year old girls in 16 weeks.

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