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Positive effect of *Saengmaeg-san* intake on blood lipid and arteriosclerosis index during high-intensity training

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고강도 트레이닝 시 생맥산 섭취가 혈중 지질 및 동맥경화 지수에 미치는 긍정적인 영향

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Abstract : The purpose of this study was to investigate the effect of *Saengmaeg-san* intake on blood lipids and arteriosclerosis index in male tennis players. Seventeen male tennis players enrolled in university were assigned to a *Saengmaeg-san* intake group (n=9) and a placebo control group (n=8) according to whether they took *Saengmaeg-san* during 4-week high-intensity tennis training. Tennis training was conducted 5 times a week for 4 weeks, and the exercise intensity was performed at 70-90% of the spare heart rate. The intake of *Saengmaeg-san* was 110ml at a time before breakfast, before, during, during, and after exercise, and after dinner, a total of 7 times,

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770ml per day. For all data, mean and standard deviation were used. Two-way repeated measures ANOVA was used to examine the effect of time and treatment, and Pearson's Correlation was used to examine the relevance of differences in blood lipid responses after treatment. As a result of this study, the *Saengmaeg-san* intake group significantly improved blood lipids (triglyceride, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol) and arteriosclerosis index, and there was a significant correlation appeared between ΔTG, ΔLDL-C, and ΔTC. As a result, the intake of *Saengmaeg-san* during high-intensity training of male college student tennis players can have a positive effect on blood lipids and arteriosclerosis index, suggesting that it can be an effective sports drink as an exercise supplement.

Keywords : High-intensity exercise, Saengmaeg-san, Natural products, Blood lipids, Arteriosclerosis index

요 약 : 본 연구의 목적은 남자 테니스 선수의 생맥산 섭취가 혈중 지질 및 동맥경화 지수에 미치는 영향을 조사하는 것이었다. 남자 대학 테니스 선수 17 명을 4 주간의 고강도 테니스 하계훈련 중 생맥산 섭취 여부에 따라 생맥산 섭취군(n=9)과 위약 대조군(n=8)으로 나누었다. 테니스 하계훈련은 4 주간 주 5 회 실시하였으며, 운동강도는 예비심박수의 70~90%로 실시하였다. 생맥산은 아침 식사 전, 운동 중, 운동 중, 운동 후 1 회 110ml, 저녁 식사 후 1 일 총 7 회 770ml 를 섭취하였다. 모든 데이터에 대해 평균 및 표준 편차를 사용하였으며, 시기간 및 생맥산 섭취그룹의 효과를 확인하기 위하여 반복측정분산분석법을 사용하였고, 생맥산 섭취 후 혈중 지질의 차이에 대한 관련성을 알아보기 위하여 Pearson 의 상관분석을 실시하였다. 본 연구결과, 생맥산 섭취군은 혈중 지질(중성지방, 총콜레스테롤, 고밀도지단백콜레스테롤, 저밀도지단백 콜레스테롤)과 동맥경화지수가 유의하게 개선되었으며, ΔTG, ΔLDL 및 ΔTC 간에는 유의한 상관관계가 나타났다. 결론적으로 남자 대학 테니스 선수의 고강도 트레이닝 시 생맥산 섭취는 혈중 지질 및 동맥경화 지수에 긍정적인 영향을 미칠 수 있어 운동 보조제로서 효과적인 스포츠 음료가 될 수 있음을 시사한다.

주제어 : 고강도 운동, 생맥산, 천연식품, 혈중지질, 동맥경화지수

1. INTRODUCTION

In a tennis match, the player who wins 2 out of 3 sets first wins the game. The time is not fixed, and it is often continued for a long time, so players need various physical fitness factors such as muscular strength and agility as well as cardiorespiratory endurance. The game lasts an average of two to three hours, and in some cases, it lasts more than five hours, and during the game, players' high-intensity training is essential to play these games [1]. Athletes who digest high-intensity exercise show high physical fitness levels, and physical fitness levels show a proportional relationship with triglyceride, low-density lipoprotein cholesterol (LDL-C), total cholesterol (TC) levels and inversely proportional, and high-density lipoprotein cholesterol (HDL-C) [2,3]. Blood lipids cause various cardiovascular diseases, such as high blood pressure, hyperlipidemia, coronary artery disease, and severe sclerosis, and are important factors for predicting cardiovascular diseases [4,5]. triglycerides negatively affect the function of the left ventricle, which plays a role of receiving oxygen from the left atrium and sending it to the whole body [6]. High-intensity training is known to be an effective way to improve cardiorespiratory fitness and blood lipids [7,8], and cardiorespiratory fitness is an important factor

influencing athletes' performance. In skeletal muscle developed through exercise, lipoprotein lipase increases, which increases the removal rate of triglycerides in the blood and improves blood lipids through a mechanism that increases the movement of lipids and lipoproteins in the body [2].

Tennis players sweat a lot during the game because most of the games are held outdoors, and the games often lead to long hours. Tennis players use a variety of sports drinks to fill moisture and minerals, as sweat shed during the game can adversely affect the game by bringing about loss of moisture and electrolyte in the body and increasing body fatigue [9]. Sports drinks not only replenish lost moisture, but also contain many kinds of minerals and vitamins, so they can quickly recover from fatigue that may occur during exercise [10]. Various functional drinks are being developed for rapid recovery of higher performance. However, since illegal drugs are sometimes used to improve the high performance of athletes. So, the criteria for doping tests are increasing, the choice of functional drinks without illegal drugs is important, and interest in functional drinks has also been applied to oriental drinks.

Recently, as doping regulations have been strengthened, studies on the safety of doping in herbal beverages have been conducted, and as a result of the list of prohibited substances of the International Anti-Doping Agency (WADA), all herbal medicines manufactured for the purpose of relieving fatigue were negative [11]. Oriental drinks use raw materials extracted from natural foods without preservatives or artificial pigments, through which moisture and electrolytes can be consumed [12]. Beverages prepared in this way can be effective drinks for athletes who cannot consume beverages limited to doping carelessly, and *Saengmaeg-san* is an example of a functional beverage prepared from an oriental medicine point of view.

Previous studies on *Saengmaeg-san* intake, it was reported that *Saengmaeg-san* extract had a positive effect on blood pressure and cerebral blood flow in mice [13], and can improve gastrointestinal exercise to prevent gastrointestinal disorders [14]. In addition, a human study showed that the intake of *Saengmaeg-san* could control the elevated of blood glucose level in adult women [15], and could have a positive effect on the physical fitness, oxygen intake, and ventilation of tennis players [16], reducing body composition and blood lipids and free fatty acids in obese middle-aged women [17]. As such, various effects of *Saengmaeg-san* have been verified. However, studies conducted on athletes to use *Saengmaeg-san* as a sports drink are still insufficient, and there is no study on the effect of *Saengmaeg-san* intake on blood lipids in athletes.

Therefore, the purpose of this study is to examine the effect of *Saengmaeg-san* intake on blood lipids during high-intensity exercise in male tennis players and to verify as a sports drink. Based on this, a hypothesis was established that *Saengmaeg-san* intake during high-intensity tennis training will have a positive effect on blood lipids (TG, TC, HDL-C, LDL-C) and arteriosclerosis index.

2. METHODS

2.1. Participants

The number of participants in this study was calculated using G*Power 3.1 by setting effect size: 0.25 (default), significance level: 0.05, and power: 45% [18], the calculated number was 16, and 17 were recruited in consideration of the dropout rate of 10%. Participants in the study were 17 male tennis players (*Saengmaeg-san* intake group: 9 people, placebo control group: 8 people) enrolled in P University, who wanted to voluntarily participate in the study before participating in the study. The selected athletes participated in all training programs and

competitions, and no individual training other than team training was conducted. Participants had no history of injuries or neurological or musculoskeletal disorders, hormone replacement therapy, drug or alcohol abuse, smoking, allergies, chronic diseases, thyroid disorders, eating disorders, or taking supplements that could affect the study. All parameters that could influence the experiment were controlled by examination/interview by a physician and physical examination. The characteristics of the study participants are shown in Table 1.

2.2. Study design

In this study, to examine the effect of *Saengmaeg-san*, a double-blind experiment was conducted in which the investigator and the study participants, excluding the research director, did not know the information of the assigned group were randomized. All measurements were taken twice before and after exercise treatment for 4 weeks. The design of this study is as shown in Figure 1.

2.3. Training program

The exercise program was conducted for a total of 4 weeks, and the exercise intensity was 70-90% of heart rate reserve (HRR) using POLAR (polar RS400sd, APAC, 90026360, USA) and 15-17 of Rating of Perceived Exertion. The exercise time was 5 times a week, 10 minutes each for warm-up and warm-up exercises, and 60 to 70 minutes for main exercise, a total of 80 to 90 minutes. The exercise program is shown in Table 2.

HRR: heart rate reserve, RPE: rating of perceived exertion

2.4. *Saengmaeg-san* sampling and intake

The *Saengmaeg-san* in this study was extracted using an herbal extractor by

Table 1. Characteristics of Subjects

Variables / Group	Age(yr)	Height(cm)	Weight(kg)	BMI(kg/m^2)
SMS(n=9)	20.0±1.6	177.3±4.0	69.7±7.3	22.2±2.3
Placebo(n=8)	20.0±1.9	175.7±4.0	70.3±7.4	22.3±1.4

SMS: *Saengmaeg-san* group, BMI : Body mass index

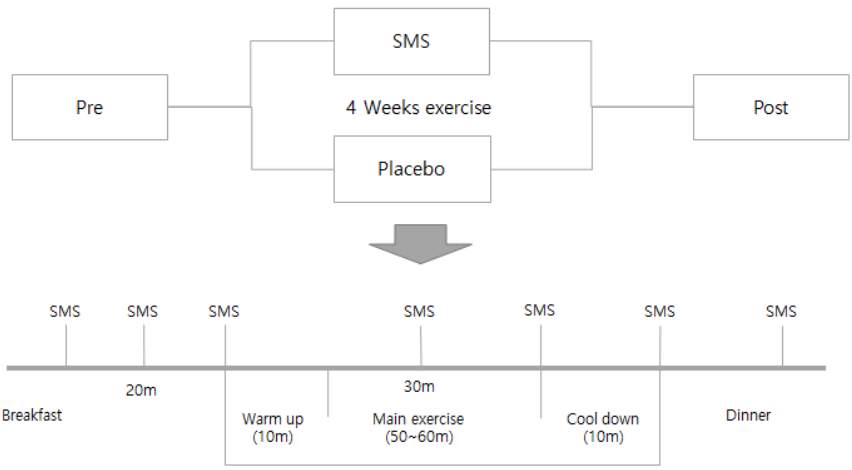

Fig. 1. Study design. SMS: *Saengmaeg-san*

Table 2. Exercise program

Weeks	Order	Exercise	Time	Intensity	Frequency
1~4	Warm-up	stretching & running	10min	70~90% HRR or RPE 15~17	5times/ weeks
	Main exercise	stroke	10min		
		volley stroke	10min		
		open game	40~50min		
	Coll down	stretching & running	10min		

organizing ginseng (7.5g), omija (7.5g), and maekmundong (15g) in a 1:1:2 ratio by referring to the study of Lee [19]. The extracted *Saengmaeg-san* is sealed in a plastic bag and refrigerated and stored at 110ml at a time, once before 20 minutes of exercise, once before start of exercise, once after 30 minutes of main exercise, once after end of main exercise, once after type of exercise program; And after breakfast and dinner, it was taken once, and a total of 770ml of *Saengmaeg-san* was ingested 7 times a day.

2.5. Blood sampling

The study participants maintained fast condition for 12 hours before the test, and blood was collected between 8 a.m. and 10 a.m. All participants were examined in light clothing, and clinical pathologists collected 10ml of blood from the forearm vein using vacuum vessels and needles. After centrifugation, serum was separated and triglyceride (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) were analyzed.

2.6. Arteriosclerosis index

The arteriosclerosis index is a major factor predicting coronary artery disease, and the value was calculated using the following three formulas according to the lipid component [20].

Atherogenic Index of Plasma (AIP)
= Log (TG/HDL-C)
Castelli's Risk Index (CRI-I)
= TC/HDL-C
Catelli's Risk Index (CRI-II)
= LDL-C/HDL-C

2.7. Statistical analysis

The data were analyzed using SPSS ver. 27.0 (IBM Corp., Chicago, IL, USA) to calculate the mean (M) and standard deviation (SD) of the measurement items. All statistical analyses were analyzed using SPSS 27.0, and all data were calculated by calculating the mean and standard deviation. Two-way repeated measured ANOVA was used to investigate the effect of *Saengmaeg-san* intake on blood lipids and arteriosclerosis index during high-intensity tennis exercise. Pearson's Correlation was performed by applying the difference values (Δ, delta) between pre- and post-treatment blood lipids to examine the relevance of differences in blood lipid (TG, TC, HDL-C, LDL-C) responses after treatment. All statistical significance levels were set to p=.05.

3. RESULTS AND DISCUSSION

In this study, we investigated the effect of *Saengmaeg-san* intake on blood lipids, based on the hypothesis that *Saengmaeg-san* intake during high-intensity tennis training will have

a positive effect on blood lipids (TG, TC, HDL-C, LDL-C) and arteriosclerosis index. Seventeen tennis players were classified into a *Saengmaeg-san* intake group (n=9) and a placebo control group (n=8). As a result of the study, TG, TC, LDC-C, and arteriosclerosis index were significantly decreased in the *Saengmaeg-san* intake group that met the research hypothesis, and HDL-C was significantly increased, resulting in an interactive effect on all blood lipid variables and arteriosclerosis index, and a significant correlation was found between ΔTG, ΔLDL-C, and ΔTC. These study results suggest that *Saengmaeg-san* intake can have a positive effect on blood lipids in tennis players.

3.1. Effects of *Saengmaeg-san* intake on blood lipids in tennis players

After 4 weeks of the high-intensity tennis program, each group (*Saengmaeg-san*, placebo control group) and time (pre, post) according to the intake of *Saengmaeg-san* were repeatedly measured ANOVA. As a result, all blood lipid variables showed significant differences between interaction effect of time*groups 〈Table 3 and Figure 3〉. TG decreased from 86.78±29.15mg/dl to 71.56±18.16mg/dl in the *Saengmaeg-san* group and increased from 88.38±21.47mg/dl to 94.88±26.34mg/dl in the placebo control group. The interaction effect of time*group (F=11.630), p=.004) showed a significant difference. TC decreased from 158.22±24.28mg/dl to 147.78±23.68mg/dl in the *Saengmaeg-san* group and increased from 153.63±16.32mg/dl to 158.75±19.58mg/dl in the placebo control group. The interaction effect of time*group (F=10.914), p=.005) showed a significant difference. HDL-C increased from 26.11±9.55mg/dl to 73.78±9.58mg/dl in the *Saengmaeg-san* group and decreased from 58.51±11.86mg/dl to 55.68±7.18mg/dl in the placebo control group. With the main effect of time (F=8.687), p=.01) and group (F=5.930, p=.028), the interaction effect

Table 3. Effect of *Saengmaeg-san* intake on blood lipids in tennis players

Variables	Group	pre	post	F-value	
TG (mg/dl)	SMS	86.78±29.15	71.56±18.16##	time	1.875
	Placebo	88.38±21.47	94.88±26.34	group	1.215
				time*group	11.630*
TC (mg/dl)	SMS	158.22±24.28	147.78±23.68##	time	1.274
	Placebo	153.63±16.32	158.75±19.58	group	.099
				time*group	10.914**
HDL-C (mg/dl)	SMS	26.11±9.55	73.78±9.58###	time	8.687**
	Placebo	58.51±11.86	55.68±7.18	group	5.930*
				time*group	23.442***
LDL-C (mg/dl)	SMS	92.67±19.63	74.78±19.73###	time	6.472*
	Placebo	89.88±17.83	99.88±21.31###	group	1.399
				time*group	80.886***

Values are presented as mean±standard deviation, TG=Triglyceride, TC=Total Cholesterol, HDL-C=High density lipoprotein cholesterol, LDL-C=Low density lipoprotein cholesterol. Note: $^{*}p$<0.5, $^{**}p$<.01, $^{***}p$<.001, $^{\#\#}p$<.01, $^{\#\#\#}p$<.001 vs pre.

of time*group (F=23.442, p=.000) showed significant differences. LDL-C decreased from 92.67±19.63mg/dl to 74.78±19.73mg/dl in the *Saengmaeg-san* group and increased from 89.88±17.83mg/dl to 99.88±21.31 in the placebo control group. The main effect of time (F=6.472, p= .022) and interaction effect of time*group (F=80.886, p=.000) showed significant differences. As a result of the post-hoc analysis, the *Saengmaeg-san* intake group showed a significant difference in all blood lipids (TG: p<.01, TC: p<.01, HDL-C: p<.001, LDL-C: p<.001). Especially HDL-C and LDL-C showed the greatest effect.

In an animal study, consumption of omija for 45 days had a positive effect on TC, TG, and HDL-C in rats [21], and omija extract reduced TC, TG, and LDL in hyperlipidemic rats [22]. A study in which ginseng extract was administered to rats for 4 weeks with voluntary exercise also showed positive effects on TG, TC, HDL-C, and LDL-C [23]. In addition, in a human study, twenty-four obese middle-aged women showed positive effects on body composition, total cholesterol, triglycerides, and free fatty acids after 12 weeks of walking exercise and *Saengmaeg-san* intake, similar to our study [17]. *Saengmaeg-san* is an herbal extract composed of ginseng, omija, and maekmundong. Saponin, a ginsenoside of ginseng, is the main active ingredient and forms bile acids to release cholesterol, thereby reducing blood cholesterol levels, which is effective in hyperlipidemia and antioxidant function [24]. As a component of Schisandra, lignan, a part of polyphenol, is the main active ingredient, and it can decrease serum and liver lipids by increasing the lipolytic gene and decreasing the adipogenic gene [25]. It has been reported that palpebral glands have a protective effect on the liver by inhibiting the necrosis of hepatocytes and the permeability of the liver cell membrane [26]. According to the results of this study, the improvement of blood lipids in the *Saengmaeg-san* intake group was positive for blood lipids by activating the metabolism of fat cells and inhibiting accumulation in the body, as well as the individual effects of ginseng, omija, and maekmundong. It is thought to have influenced the fact that high-intensity training was performed in the placebo control group but no significant difference in blood lipids was observed is

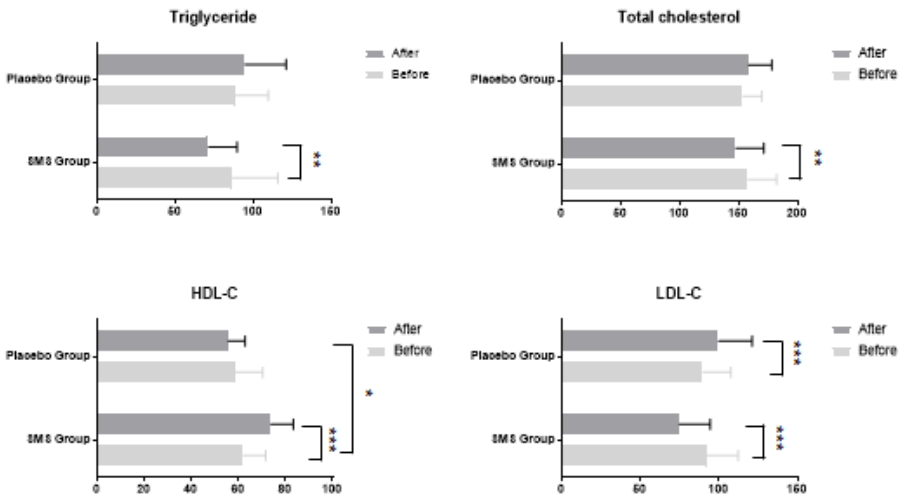

Fig 2. Effect of *Saengmaeg-san* intake on blood lipids in tennis athletes.

thought to be due to the fact that the athletes already have high physical fitness levels and their blood lipids are within the normal range. In view of these results, it is considered that the improvement of the blood lipids of the athletes who are in the normal range of blood lipids is a very meaningful result.

3.2. Effects of *Saengmaeg-san* intake on arteriosclerosis index

The difference in the arteriosclerosis index as a result of repeated measured ANOVA by group and time according to the intake of *Saengmaeg-san* after a 4-week high-intensity tennis program is shown in Table 4. AIP decreased from .126±.182 to -.025±.154 in the *Saengmaeg-san* group (p=.000) and increased from .175±.108 to .222±.121 in the placebo control group (p=.027). The main effect of time (F=11.573, p=.004) and between groups (F=4.568, p=.049), between interaction effect of time*groups (F=42.744, p=.000) showed significant differences. CRI-I decreased from 2.57±.37 to 2.02±.36 in the *Saengmaeg-san* group (p=.000) and increased from 2.68±.43 to 2.89±.48 in the placebo control group (p=.006). Significant differences were found between the main effect of time (F=11.665, p=.004), between groups (F=6.436, p .023). The interaction effect of time*group (F=56.446, p=.000). In CRI-II, the *Saengmaeg-san* intake group decreased from 1.51±.36 to 1.03±.32 (p=.000), and the placebo control group increased from 1.59±.42 to 1.83±.47 (p=.004). Significant differences were found between the main effect of time (F=8.125, p=.012) and between groups (F=5.597, p=.032). And interaction effect of time*group (F=72.225, p=.000).

In a previous study, oral administration of omija extract to diabetes-induced rats lowered cholesterol, triglycerides, and LDL-C and increased HDL-C [27]. Oral administration of saponin for 4 weeks reduced total cholesterol, LDL-C, increase in the arteriosclerosis index was suppressed by showing a dose-response relationship of increasing HDL-C while lowering triglycerides [28]. The arteriosclerosis index (AIP) is a very sensitive factor for the difference between lipoproteins in the family of early myocardial infarction patients and the control family, suggesting that -0.3 to 0.1 is low, 0.1 to 0.24 is medium, and 0.24 or more is high risk [29]. This study was aimed at tennis players, and although athletes in various sports had the characteristics of healthy blood

Table 4. Effect of *Saengmaeg-san* intake on Lipid ratios in tennis players

Variables	Group	pre	Post	F-value	
AIP (logTG/HDL-C)	SMS	.126±.182	-.025±.154$^{\#\#\#}$	time	11.573**
	Placebo	.175±.108	.222±.121$^{\#}$	group	4.525*
				time*group	42.744***
CRI-I (TC/HDL-C)	SMS	2.57±.37	2.02±.36$^{\#\#\#}$	time	11.665**
	Placebo	2.68±.43	2.89±.48$^{\#\#}$	group	6.436*
				time*group	56.446***
CRI-II (LDL-C/HDL-C)	SMS	1.51±.36	1.03±.32$^{\#\#\#}$	time	8.125*
	Placebo	1.59±.42	1.83±.47$^{\#\#\#}$	group	5.597*
				time*group	72.225***

Values are presented as mean±standard deviation. AIP=Atherogenic Index of Plasma, CIR-I, -II=Castelli's Risk Index. $^{*}p$<0.5, $^{**}p$<.01, $^{***}p$<.001, $^{\#\#}p$<.01, $^{\#\#\#}p$<.001 vs pre.

lipids and lower arteriosclerosis index compared to the general person [30], as a result of the study, the arteriosclerosis index decreased from 0.126 to −0.24. It was improved from a medium risk to low risk. The above results suggest that a greater effect can be expected for the general person who is exposed to the risk of cardiovascular disease due to a higher arteriosclerosis index than athletes.

3.3. Correlation of changes in blood lipids after intake of *Saengmaeg-san* during high-intensity exercise

Figure 2 shows that the results of Pearson's correlation analysis to find out the relationship between the difference in blood lipids according to the intake of *Saengmaeg-san* after a 4-week high-intensity tennis program. Significant correlations were ΔTG vs ΔLDL-C (r=.639, p=.006), ΔTG vs ΔTC (r=.725, p=.001), ΔLDL-C vs ΔTC (r=.704, p= .002).

The positive correlation between changes in blood lipids means that as triglyceride TG decreases, LDL-C and TC decrease, and as LDL-C decreases, TC decreases. In the case of mice ingested with omija extract, it had a positive effect on TC, TG, HDL-C, and LDL-C [21,22], and a study ingesting ginseng extract also showed a positive effect on TC, TG, and LDL-C [28]. Improvement of blood lipids through natural extracts resulted in improvement of TG, LDL-C, and TC, not of a single variable of blood lipids, and the relevance between changes in blood lipids in the results of this study supports the results of previous studies.

This study has limitations to consider. First, the small sample size makes it difficult to generalize the results. In addition, data on the subjects' lifestyles and health status were not collected separately. Nevertheless, we were able to establish preliminary evidence for the efficacy of *Saengmaeg-san* as a supplement for high-intensity athletes.

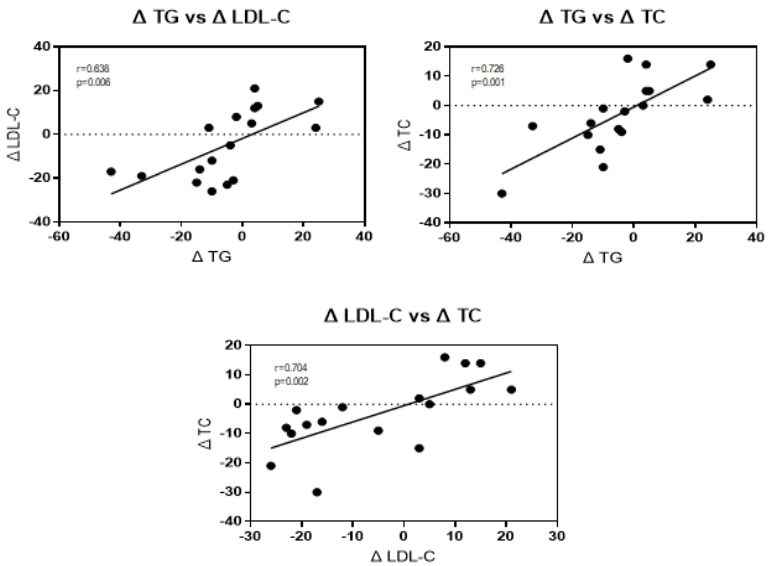

Fig 3. The relationship of blood lipids variables. The results is calculated the change of Triglyceride (TG), Total Cholesterol (TC), High Den density lipoprotein cholesterol (HDL-C), Low density lipoprotein cholesterol (LDL-C) from post measure to baseline.

4. CONCLUSION

This study compared and analyzed before and after experimental treatment to investigate the effect of *Saengmaeg-san* drink intake on blood lipids and arteriosclerosis index in male tennis players during 4-week high-intensity tennis training. As a result, first, intake of *Saengmaeg-san* during high-intensity exercise for 4 weeks has a positive effect on blood lipids in male tennis players. Second, intake of *Saengmaeg-san* during high-intensity exercise for 4 weeks has a positive effect on the arteriosclerosis index of male tennis players. Third, the correlation between the difference in blood lipids before and after the experimental treatment showed a significant positive correlation among ΔTG, ΔLDL-C, and ΔTC. Summarizing the above results, the intake of *Saengmaeg-san* had a positive effect on blood lipids and arteriosclerosis index even in athletes with normal levels. Therefore, *Saengmaeg-san* drink intake would be considered as a valuable exercise supplement for athletes.

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