The Effect of Concurrent Training on Blood Lipid Profile and Anthropometrical Characteristics of Previously Untrained Men

Ehsan Ghahramanloo, Adrian W. Midgley, and David J. Bentley

Background: There is little information regarding the effects of concurrent training (endurance and resistance training performed in the same overall regimen) on blood lipid profile in sedentary male subjects. This study compared the effects of 3 different 8-wk training programs [endurance training (ET), strength training (ST) and concurrent training (CT)] on blood lipid profile and body composition in untrained young men. Methods: A total of 27 subjects were randomly allocated to an ET, ST or CT group which performed either progressive treadmill (ET), free weight (ST) or both the endurance and strength training requirements for 8 weeks. Results: High-density lipoprotein and low-density lipoprotein profiles significantly improved in the ET and CT groups \( (P < .01) \) but not in the ST group. Triglyceride and total cholesterol profiles significantly improved in all 3 training groups. Total fat mass significantly decreased in the ET and CT groups \( (P < .001) \) but not in the ST group, whereas fat free mass significantly increased in the ST and CT groups \( (P < .01) \) but not in the ET group. Conclusions: These results indicate that CT can be used to simultaneously improve both the serum lipid profile and body composition of previously untrained, apparently healthy young men.

Keywords: body composition, cardiovascular health, health promotion, prevention, cholesterol, aerobic exercise

Cardiovascular disease (CVD) is one of the world’s most prevalent noncommunicable, chronic diseases, with mortality exceeding 3.5 million in the developing world in 1990.\(^1\) By 2020, cardiovascular disease is predicted to be the main cause of death in developed countries.\(^1\) It has been documented that serum concentrations of total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and fasting serum concentrations of triglyceride (TG), provides valid information on a person’s potential to suffer from CVD.\(^2\) Both epidemiological and experimental studies have shown that lower TC and LDL-C concentrations, combined with raised HDL-C concentrations, are associated with a reduced risk of CVD.\(^3\)-\(^5\)

Regular physical activity is believed to decrease the risk of CVD by increasing the turnover of lipid substrates, with effects on transport and cell availability.\(^6\) Exercise training is associated with an increase in lipoprotein lipase activity in adipose tissue and skeletal muscle. Increased lipoprotein lipase activity lowers very low-density lipoproteins (VLDL) and chylomicron triglyceride concentrations and enhances clearance of cholesterol-rich VLDL and chylomicron remnants. The VLDL triglycerides are exchanged for cholesteryl esters in LDL and HDL, a process mediated by cholesteryl ester transfer protein, and the triglyceride in HDL and LDL is then hydrolyzed by lipases, causing a decrease in particle size. The decrease in VLDL triglycerides results in the availability of less triglyceride for exchange and is probably a major mechanism underlying the increases in the size of LDL particles and in HDL-C concentrations and particle size.\(^7\)

Previous investigations have shown that endurance training results in beneficial changes in the serum lipid profile.\(^8\)-\(^9\) Available results concerning the effects of strength training on the serum lipid profile are more conflicting.\(^10\)-\(^16\) However this could be a function of the age, gender or initial training status of the subjects as well as the specifics of the resistance training protocol employment (ie, high volume vs. high intensity).\(^14,16,17\) While strength training has the advantage of improving muscular strength and reducing age-related decreases in muscle size (ie, sarcopenia), the majority of reports have suggested that strength training results in no ben-
Concurrent Training and Blood Lipids

Effective changes in the lipoprotein profile\textsuperscript{13–15,18–20} and may in fact produce an adverse effect.\textsuperscript{10} Other studies, however, have reported positive changes in the lipid profile with this type of training.\textsuperscript{11,12,16–21} Simultaneous endurance and strength training has been referred to as concurrent training.\textsuperscript{22} Concurrent training incorporates the benefits of both endurance and strength training with improvements in both the serum lipid profile and muscle function. One study reported that in contrast to endurance training, concurrent training did not positively improve the serum lipid profile of previously sedentary women.\textsuperscript{15} However, there have been no studies that have examined the effects of concurrent training on the serum lipid profiles and CVD risk factors of untrained male subjects. The purpose of this study was therefore to investigate the effects of endurance, strength, and concurrent training on the serum lipid profile and physical characteristics of untrained male subjects. We hypothesized that compared with endurance training, concurrent training would be equally beneficial for improving the serum lipoprotein profile, while having similar beneficial effects as strength training in increasing lean body mass.

Materials and Methods

Subjects

Twenty-seven apparently healthy male subjects, aged between 23 and 28 yr, volunteered to participate in an 8-wk training study. The subjects had not been involved in any organized training before volunteering for the study. The subjects were Iranian nationals of the same ethnic background. Before the study, a medical examination was conducted and questionnaires concerning medical history and physical activity patterns were completed. Untrained was defined as not having participated regularly in either endurance or resistance training for at least 6 months. All subjects were asked not to participate in any additional forms of activity throughout the course of the investigation. The subjects were randomly assigned to 1 of 3 training groups. An endurance training group (ET, \( n = 9 \)), a strength training group (ST, \( n = 9 \)), and a concurrent training group (CT, \( n = 9 \)). The mean (SD) characteristics of the participants are shown in Table 1.

Experimental Design

On the initial visit to the laboratory, all subjects were familiarized with the equipment and experimental procedures to remove any potential learning effects. Anthropometric measurements were also taken and a venous blood sample was also obtained at rest for analysis of TC, TG, HDL-C, and LDL-C serum concentrations. The subjects completed these tests over a 24-h period before and after the 8-wk training period.

Body Composition

Body composition measurements were obtained with subjects in minimum attire. Total body mass was measured using standard procedures, with a calibrated digital scale (Karada scan, HBF 362, Japan). Height (without shoes) was measured to the nearest millimeter using a standard calibrated stadiometer. Percentage body fat (%BF) was estimated from the measurements of skinfold thickness (performed pre and post test by the same experienced technician) using the follow formula:\textsuperscript{23}

\[
\%\text{BF} = \left[ (4.95/DB) - 4.50 \right] \times 100,
\]

where \( DB = 1.109380 - 0.0008267(3\text{SKF}) + 0.0000016(3\text{SKF})^2 - 0.0002574(\text{age}) \).

The 3SKF (measured in mm) is the sum of the chest, abdominal, and midthigh skinfolds. The chest skinfold is taken as a diagonal skinfold located one-half the distance between the right nipple and the anterior auxiliary line. The abdominal skinfold is a vertical

<table>
<thead>
<tr>
<th>Variable</th>
<th>Endurance (( n = 9 ))</th>
<th>Strength (( n = 9 ))</th>
<th>Concurrent (( n = 9 ))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pre post</td>
<td>pre post</td>
<td>pre post</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>24.8 ± 1.5 —</td>
<td>25.4 ± 1.0 —</td>
<td>24.4 ± 1.4 —</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>175.3 ± 6.1 —</td>
<td>175.8 ± 5.4 —</td>
<td>176.9 ± 6.7 —</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>71.2 ± 8.8 70.1 ± 8.4</td>
<td>66.0 ± 7.5 67.2 ± 7.5</td>
<td>71.8 ± 10.4 71.5 ± 10.2</td>
</tr>
<tr>
<td>VO(_{2})max (ml/kg/min)</td>
<td>46.1 ± 3.0 49.2 ± 2.3</td>
<td>47.8 ± 3.6 50.0 ± 3.4</td>
<td>47.0 ± 3.8 49.4 ± 3.3</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>13.5 ± 4.7 11.9 ± 4.6</td>
<td>10.8 ± 4.5 10.1 ± 4.4</td>
<td>12.5 ± 5.7 10.9 ± 5.8</td>
</tr>
<tr>
<td>Fat free mass (kg)</td>
<td>57.7 ± 6.0 58.2 ± 6.5</td>
<td>55.2 ± 6.4 57.1 ± 6.1</td>
<td>59.3 ± 5.2 60.7 ± 5.2</td>
</tr>
<tr>
<td>BF%</td>
<td>18.7 ± 4.9 16.8 ± 5.3</td>
<td>16.1 ± 6.1 14.7 ± 5.7</td>
<td>16.7 ± 5.5 14.4 ± 6.1</td>
</tr>
<tr>
<td>BMI</td>
<td>23.2 ± 3.1 22.8 ± 2.9</td>
<td>21.4 ± 3.0 21.8 ± 3.0</td>
<td>22.9 ± 2.9 22.9 ± 3.0</td>
</tr>
</tbody>
</table>

Abbreviations: BF%, percentage body fat; BMI, body mass index.
skinfold located 2 cm directly to the right of the navel. The midthigh skinfold is located on the quadriceps midway between the top of the patella and the inguinal crease. The foot is placed on a 6-inch step with the knee slightly flexed and muscles relaxed. The fold is lifted parallel to the long axis of the leg.

Fat mass (FM) and fat free mass (FFM) were calculated from the total body mass and %BF.

**Aerobic Capacity**

Maximal oxygen uptake (VO$_{2\text{max}}$) was predicted using a submaximal treadmill test on a motor driven treadmill (Vision fitness, T 9700, Taiwan). The test began at a speed with which each subject could jog comfortably. After 3 min when a steady state HR was achieved, the speed and HR were recorded. VO$_{2\text{max}}$ was predicted using the following formula:\textsuperscript{24}

\[ \text{VO}_{2\text{Max}} = 54.07 - 0.1938 \times \text{Body Weight} + (4.47 \times \text{Speed} / 1.6) - 0.1453 \times \text{Heart Rate} + 7.62 \times \text{Gender} \]

where:
- Speed = km/h
- Gender = 1 for men, 0 for women
- Body weight = kg

**Serum Lipid Profile**

Resting venous blood samples were collected at 10:00 AM after a 12 to 14 h overnight fast and abstinence from exercise for 24 h. In all cases, blood samples were obtained via venipuncture from an antecubital forearm vein. The blood sample was centrifuged at 3000 rpm for 15 min and the resultant serum was then removed and stored at $-70^\circ$C until subsequent analysis. Serum concentrations of TC, TG, and HDL-C were assessed using an automatic analyzer (Technicon, RA 1000, USA). The LDL-C was calculated according to the Friedwald equations.\textsuperscript{25}

**Exercise Training Program**

All training sessions commenced with a warm-up and included a cool-down period of 10 min of treadmill running at 40% to 50% HR$_{\text{max}}$ and stretching exercises. All 3 groups trained on nonconsecutive days 3 times per week. Subjects were omitted if they were absent for 2 consecutive or 3 nonconsecutive training sessions. The ET group participated in a progressive running program on a motor driven treadmill. During the first week subjects exercised for 16 min at 65% of age-predicted HR$_{\text{max}}$ (HR$_{\text{max}} = 220 - \text{age}$). The intensity of training was then increased by 5% every 2 weeks. The duration was also increased 2 min per session each week so the subjects exercised for 30 min at 80% of HR$_{\text{max}}$ by the end of the training period. A telemetric heart rate monitor (model AS, Polar Electro Oy, Kempele, Finland) was used to accurately determine exercise intensity.

The ST group performed a progressive resistance training program using free weights. The resistance

training program involved bench press, squat, lateral pull down, and leg curl (leg curl and lat pull down were performed on a Technogym machine, Italy). During the first week, subjects performed 10 repetitions per set with 2 sets per exercise corresponding to 50% of the 1-repetition maximum (RM). The program intensity and volume increased so that at the end of the program all subjects performed 6 repetitions per set and 3 sets with 80% of 1-RM. During week 4 the volume of training was decreased to allow recovery and avoid overuse injury. After this point, all subjects in the ST and CT groups underwent strength testing for the determination of predicted 1-RM and the intensity of the last 4 weeks of training was based on this midtest result.

The CT group all performed the summation of the same endurance and resistance training programs. The endurance and resistance training were performed on the same day; however, resistance training was always completed first and after 15 to 20 min rest, the subjects performed the endurance training.

**Dietary Intake**

All subjects were graduate students of the same university who lived on campus. Breakfast, lunch, and dinner of all subjects were provided by the university so they all consumed the same diet.

**Statistical Analysis**

All statistical analyses were performed using SPSS for Windows software (release 16.0; SPSS Inc., Chicago, IL). Normality was checked using Q-Q plots and was deemed plausible for each variable. Central tendency and dispersion were reported as the mean and standard deviation. The effects of the different training interventions on anthropometric characteristics and on the serum lipid profile were determined using 2-way mixed model (group x time) ANOVA. There were notable mean differences (although not statistically significant) between groups for pretraining values for fat mass, fat free mass, body mass index, triacylglycerides, LDL-C, and the lipid ratios. The interaction of group and time for these variables was therefore determined using a 1-way analysis of covariance (using posttraining values as the dependent variable and the pretraining values as the covariate). Assumptions of equality of error variance, equality of regression slopes, and linearity between the dependent variable and the covariate were checked and deemed plausible. However, for total cholesterol and HDL-C the pretraining values did not demonstrate linearity with the posttraining values. Since the mean differences between pretraining values for these 2 variables were deemed acceptably small, the effect of group on time was reported as the interaction term from the 2-way ANOVA. Pearson correlation coefficients were used to investigate the relationship between the change in fat mass and the change in serum lipid variables. Two-tailed statistical significance was accepted
as $P < .05$. The family-wise type I error rate was controlled with a Sidak adjustment for the correlations and all multiple pairwise comparisons.

**Results**

### Anthropometric Characteristics

Pre- and posttraining mean (SD) anthropometric characteristics for each group are shown in Table 1. Mean (SD) pairwise differences and the associated 95% confidence intervals and probability significances are shown in Table 2. All presented data are from subjects that were absent from no more than 1 session during the 8-wk training period. There were no significant main effects for group for any of the anthropometric characteristics. There was a significant 1.5% decrease in BMI over time for the ET group and a significant 1.9% increase in BMI for the ST group, but no significant change for either variable in the CT group. The interaction between group and time was statistically significant for BMI ($F = 5.14; P = .014$): the only significant pairwise comparison was between the ET and ST groups ($P = .012$). Only the ET (12.4%) and CT (16.2%) groups significantly decreased fat mass, although the interaction between training group and time was not significant ($F = 1.42; P = .26$). The ST and CT groups significantly increased fat free mass (3.6% and 2.4%, respectively), whereas the increase for the ET group was not significant. There was a significant interaction between group and time ($F = 3.58; P = .044$), with the ST group increasing fat free mass significantly more than the CT group ($P = .044$).

### Serum Lipids

Pre- and posttraining mean (SD) serum lipid profiles for each group are shown in Table 3. Mean (SD) pairwise differences and the associated 95% confidence intervals and probability significances are shown in Table 2. There were no significant main effects for group for any of the serum lipid measures. The ET and CT groups significantly decreased triglyceride and total cholesterol concentrations (percentage changes shown in Figure 1), although the changes for the ST group and the interaction between training group and time for triglyceride ($F = 0.32; P = .73$) and total cholesterol ($F = 0.033; P = .97$) were not statistically significant. There was a significant increase in HDL-C and a significant decrease in

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean diff†</td>
<td>95% CI</td>
<td>$P$ value‡</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>−1.6 ± 1.4</td>
<td>−2.4,−0.8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Fat free mass (kg)</td>
<td>0.5 ± 1.4</td>
<td>−0.3,1.3</td>
<td>0.2</td>
</tr>
<tr>
<td>BMI</td>
<td>−0.4 ± 0.4</td>
<td>−0.7,−0.05</td>
<td>0.025</td>
</tr>
<tr>
<td>TG (mmol/l)</td>
<td>−0.30 ± 0.23</td>
<td>−0.53,−0.071</td>
<td>0.012</td>
</tr>
<tr>
<td>TC (mmol/l)</td>
<td>−0.82 ± 1.27</td>
<td>−1.56,−0.11</td>
<td>0.025</td>
</tr>
<tr>
<td>HDL-C (mmol/l)</td>
<td>0.50 ± 0.80</td>
<td>0.16,0.84</td>
<td>0.006</td>
</tr>
<tr>
<td>LDL-C (mmol/l)</td>
<td>−1.20 ± 1.05</td>
<td>−1.88,−0.51</td>
<td>0.001</td>
</tr>
<tr>
<td>TC: LDL-C</td>
<td>−1.54 ± 1.22</td>
<td>−2.29,−0.78</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LDL-C: HDL-C</td>
<td>0.60 ± 0.46</td>
<td>0.22,0.98</td>
<td>0.003</td>
</tr>
<tr>
<td>HDL-C</td>
<td>−1.33 ± 1.17</td>
<td>−2.07,−0.58</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; TG, triglycerides; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC:LDL-C, total cholesterol:high-density lipoprotein cholesterol ratio; TC:HDL-C, total cholesterol:low-density lipoprotein cholesterol ratio; HDL-C:LDL-C, low-density lipoprotein cholesterol:high-density lipoprotein cholesterol ratio; diff, difference; 95% CI, 95% confidence interval for the mean difference.

† Any discrepancies between the prepost differences reported here and Table 1 are due to rounding errors.

‡ Sidak adjusted probability significance.
The key findings were that 8 weeks of concurrent training resulted in significant improvements in the serum lipid profile and FFM that were comparable to the aerobic or strength training, respectively. Furthermore, the concurrent training resulted in significant decreases in FM that were similar to that observed in the ET group. Hence the data from this study indicate that in previously sedentary male subjects, concurrent training results in positive adaptations in FM and blood lipid profile that have previously only been shown to occur with ET or ST performed in isolation.

Only 1 other study has investigated the effects of concurrent training on serum lipid and body composition measures. In that study, combined strength and endurance training resulted in no favorable improvements in TC, HDL-C, or LDL-C concentrations. However, the data were collected in female subjects and it has been suggested that adaptations in the lipid profile of female subjects to physical training may be more resistant to exercise-induced changes than men. Hence the data from the current investigation and that of previous work indicate that concurrent training is potentially beneficial in improving the serum lipid profile, but could vary according to gender.

It has been suggested that the LDL-C:HDL-C ratio is a strong predictor of coronary heart disease (CHD) risk. The significant decreases in LDL-C:HDL-C ratio in this study indicates that concurrent training has a positive effect on CHD risk. The TC:HDL-C ratio is both a screening tool and predictor of CHD in middle-aged men. Stamper et al demonstrated that a decrease as small as 1 unit in the TC:HDL-C ratio accounted for a 53% reduction in the risk of CHD. It is well known that ET favorably improves serum lipids and hence decreases the danger of cardiovascular disease. Hence while this is an important intervention that can be used to protect against cardiovascular disease, it does not have the same effect in terms of increases in muscle mass and decrements in age related endocrine changes influencing muscle size. However the data concerning the effects of

### Table 3 Serum Lipid Concentrations of Previously Sedentary Men Before and After an 8-wk Endurance, Strength, or Concurrent Training Program (Data Are Reported as Mean ± SD)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Endurance (n = 9)</th>
<th>Strength (n = 9)</th>
<th>Concurrent (n = 9)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pre</td>
<td>post</td>
<td>pre</td>
</tr>
<tr>
<td>TG (mmol/l)</td>
<td>1.32 ± 0.43</td>
<td>1.02 ± 0.34</td>
<td>1.20 ± 0.47</td>
</tr>
<tr>
<td>TC (mmol/l)</td>
<td>4.80 ± 0.98</td>
<td>3.97 ± 0.93</td>
<td>4.55 ± 0.49</td>
</tr>
<tr>
<td>HDL-C (mmol/l)</td>
<td>1.28 ± 0.28</td>
<td>1.78 ± 0.81</td>
<td>1.32 ± 0.15</td>
</tr>
<tr>
<td>LDL-C (mmol/l)</td>
<td>2.92 ± 1.00</td>
<td>1.72 ± 0.28</td>
<td>2.68 ± 0.46</td>
</tr>
<tr>
<td>TC:HDL-C</td>
<td>3.90 ± 1.13</td>
<td>2.37 ± 0.40</td>
<td>3.49 ± 0.54</td>
</tr>
<tr>
<td>TC:LDL-C</td>
<td>1.71 ± 0.27</td>
<td>2.31 ± 0.47</td>
<td>1.71 ± 0.15</td>
</tr>
<tr>
<td>LDL-C:HDL-C</td>
<td>2.41 ± 1.07</td>
<td>1.08 ± 0.34</td>
<td>2.06 ± 0.43</td>
</tr>
</tbody>
</table>

Abbreviations: TG, triglycerides; TC, total cholesterol; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; TC:HDL-C, total cholesterol:high-density lipoprotein cholesterol ratio; TC:LDL-C, total cholesterol:low-density lipoprotein cholesterol ratio; LDL-C:HDL-C, low-density lipoprotein cholesterol:high-density lipoprotein cholesterol ratio.
resistance training on serum lipid concentration indicates that this form of training may not result in the same positive adaptations as endurance training.\textsuperscript{13,15,18–20} The significance of the present results is that CT had a desirable outcome on blood lipid profile and in turn cardiovascular risk status. Hence in terms of an intervention aimed at adults reducing cardiovascular risk, concurrent training serves this purpose as well as improving other physical fitness parameters such as aerobic capacity and muscle function.

While the training performed resulted in improvements in blood lipid profile, the ET and CT groups had the same volume of endurance training (same running duration and same \% of HR\textsubscript{max}), but it is possible that the absolute intensity was different in the CT compared with the ET group due to residual fatigue (running speed was different). The CT group performed the resistance training first, and after 15 to 20 min recovery, they performed the endurance training. Although after this break some recovery would have occurred, and while heart rate was monitored at a set percentage of HR\textsubscript{max}, it is probable that recovery was incomplete and strength training may have affected the absolute work output performed during the subsequent endurance training and the potential adaptations to this form of training.\textsuperscript{31} Based on this hypothesis it is possible that the intensity of endurance training could be an important factor rather than that training volume in training induced improvements in blood lipid concentration. Our finding is in agreement with O’Donovan et al\textsuperscript{32} which showed that a high intensity exercise intervention is more effective in improving cardiorespiratory fitness than a moderate intensity intervention of equal energy cost.

Other researchers have proposed that resistance training is unfavorable in terms of the potential benefits of improving blood lipid profile due to limited improvements in VO\textsubscript{2}max, as well as the amount of energy expended during this form of training.\textsuperscript{15} However the results of the current study indicate that both strength and concurrent training have positive effects on serum lipid concentration. We did not control dietary intake nor measure the energy expenditure of the subjects during each session. Hence it is possible that variation in macronutrient intake could have influenced the adaptations observed in each training intervention. However, each subject was randomized to a training group and received a similar ‘mixed diet’ from the same institution. Hence with these considerations, it is unlikely that differences in dietary intake biased the outcomes of each training group.

The CT group performed both forms of training and hence almost double the total training volume (and energy expenditure) compared with the ET and ST groups. Therefore one could argue that the improvement in the CT group should have been almost double. However, this was not observed with similar improvements in blood lipid profile between groups. At the same time, lean body mass was also maintained in the concurrent training group. Hence this has potential implications for individuals looking to maintain overall body mass while improving lean muscle tissue and reducing fat mass as well as improving blood lipid profile. There are also other adaptations to resistance training including improvement in age-related muscle atrophy and endocrine function (that do not occur with endurance training) which could be improved in a regimen of concurrent training.\textsuperscript{32} Hence it would appear that in relatively older and sedentary subjects, or those suffering from obesity and/or dyslipidemia, concurrent training would be a desirable exercise intervention.\textsuperscript{33} However, future studies are required to compare the effects of endurance, resistance or concurrent training in these populations on a variety of clinical outcomes. Furthermore other studies are required to examine the physiological effects of different combinations (volume and intensity of training) of ST and ET in a concurrent training regimen on physiological function and long term exercise adherence.

In conclusion, the results of the current study show that a period of concurrent training results in a number of favorable adaptations in anthropometrical and blood lipid characteristics that have previously been thought of as mutually exclusive in terms of endurance or resistance training performed in isolation. Consequently, for previously untrained, apparently healthy young men aiming to improve health status, concurrent training may be more effective than endurance and strength training alone for simultaneously improving both the serum lipid profile and body composition.

References

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