Differential Effects of Continuous and Interval Exercise Training on the Atherogenic Index of Plasma in the Non-Obese Young Male

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Background: The process of atherogenicity is known to be influenced by exercise. However, appropriate exercise stimulus necessary to generate the response and adaptation in sedentary non-obese individuals has not yet been investigated. The purpose of the present study was to compare the effects of an 8-week continuous training and corresponding interval training on the atherogenic index of plasma in sedentary Nigerian males.

Methods: Overall, there were 54 male university students that participated in our study, which used a pretest-posttest control group design. Participants (18 males per group) were assigned into continuous, interval and control groups respectively. During the first two weeks, training was done 3 times weekly for 30 minutes each day, and was increased by 5 minutes every 2 weeks. Continuous training was done at 70-84% of heart rate reserve. Interval training was done at 70-84%/30-39% heart rate reserve in 1:2 minutes work/rest intervals, respectively. The control group did not participate in the training. Data collected were analysed using descriptive, paired t-test, analysis of covariance and Bonferroni post-hoc analysis.

Results: Young sedentary non-obese males were at high risk (atherogenic index of plasma > 0.24) of cardiovascular diseases/conditions. However, continuous training led to significant reductions (p = 0.002) in the atherogenic index of plasma. In contrast, non-significant increase (p = 0.084) followed interval training. After controlling for baseline values, only continuous training still had significant effects on atherogenic index of plasma when compared with other groups.

Conclusions: Continuous training of vigorous intensity is better than a corresponding interval training protocol as a natural anti-atherogenic method of reducing risk of cardiovascular event in sedentary non-obese males.

Key Words: Atherogenicity, Cholesterol, Exercise, Training, Vigorous

INTRODUCTION

The Atherogenic Index of Plasma, is a useful and very sensitive predictor of plasma atherogenicity and cardiovascular risk, and known to be strongly and positively correlated with the fractional esterification rate of high density lipoprotein and inversely correlated with low density lipoprotein particle size. It expresses the logarithm of the ratio of plasma level of triglycerides to the level of high density lipoprotein-cholesterol, and is a marker of atherogenic small low-density lipoprotein particles and small high-density lipoprotein particles. It is a useful diagnostic alternative among Nigerians even when other atherogenic risk parameters appear normal and a better predictor of cardiovascular risk than other previously used lipid parameters.

The roles of exercise as a natural anti-atherogenic
agent have been reported in several earlier studies.\textsuperscript{9-11} Exercise is also known to exhibit an important mechanical endothelial stimulus that heralds a cascade of events that promotes atheroprotection.\textsuperscript{10,12} Despite these benefits, the characteristics of the exercise regimen responsible for these effects have not been properly and unanimously defined. In essence, the term has been used vaguely with respect to the dose-response/adaptation athero-protective role of exercise. To maintain or promote optimum health, the American College of Sports Medicine\textsuperscript{13} currently recommends that all healthy adults 18-65 years of age need moderate-intensity aerobic physical activity for a minimum of 30 minutes, 5 days each week or vigorous-intensity aerobic activity for a minimum of 20 minutes on three days each week or a combination of the two. In light of this recommendation, the present study sought to explore the effects of two contrasting exercise modes on the atherogenic index of plasma in young sedentary male adults. This is with a view to determine which of the continuous or interval vigorous training modalities offers the most desirable benefits on the atherogenic index of plasma. Continuous exercise training involves intensity levels maintained at a steady state throughout the session, while during interval training there are alternating bouts of exercise and recovery/rest. Continuous training uses fatty acids as the predominant source of energy while interval training uses glucose as the predominant source of energy,\textsuperscript{14} therefore, it was hypothesised that continuous training would be superior to interval training in improving the atherogenic index of plasma of sedentary males.

**MATERIALS AND METHODS**

**Research design**
Herein, a single-blind, pretest-post-test control group experimental design was used. Eligible participants were randomized into three groups using a table of random numbers: 1) continuous training group, 2) interval training group or 3) control group.

**Participants**
Sixty-five male students of the Department of Medical Rehabilitation, University of Nigeria, Enugu Campus volunteered to participate in this study, out of which 54 met the inclusion criteria and gave informed consent by signing the consent form before being enrolled. The final participating individuals corresponded to 83.1% of the total volunteers and 55.1% of the overall population. The participants were randomly assigned into the continuous, interval and control groups, respectively resulting in eighteen males per group.

To meet the requirements of the study, participants had to be manifestly healthy with no active participation in sports or any known structured regular exercise backgrounds. Male students between 18-35 years of age were involved in the study. Sedentary status was characterized by a level of physical activity of ≤ 7 evaluated by the Baecke questionnaire as recommended by Daussin et al.\textsuperscript{15} Those who did not pass the medical clearance test done by a physician at the time of the study and those who responded ‘yes’ to any of the questions in the Physical Activity Readiness Questionnaire were excluded.

**Instruments**

**Anthropometric measures**
The instruments used for anthropometrics measurement were a stadiometer, a weighing scale, a Lange skin fold calliper and a tape measure. All anthropometric measurements were obtained with the participant standing upright.

Height was measured by use of a stadiometer, with the subject’s shoulders in a relaxed position and the arms hanging freely. Weight was measured using a weighing scale, with the participant in light clothing without shoes. Measurements were taken in duplicate, with a preselected maximum variation of 0.5 kg for the weight measurement and 0.5 cm for height and circumference measurements. A third measurement was taken if the difference of the first two measurements was greater than the preselected limit. An average of the two closest measurements was used in the analysis. Body mass index (BMI) was calculated as weight (in kilogram)/height squared (in meters\textsuperscript{2}).

**The biochemical profile**
Pre test (24 hours before training) and post test (24 hours after training) blood samples were obtained in the
morning after 12-hour fasting. The blood was allowed to clot and was then centrifuged to separate the serum for lipid analysis. Lipid analysis was done based on the spectrophotometric principle. The analysis was made utilizing an enzymatic photometric test using a wavelength of 520 nm and an optical path of 1 cm and is known as “CHOD PAP”. Serum cholesterol was estimated by mixing 0.01 ml serum sample with 1 ml of working reagent. This mixture was incubated at 37 °C for 5 minutes, and the absorbance of the assay mixture was measured after 60 minutes by a spectrophotometer at 520 nm, against distilled water as a blank. Similarly, different working reagents for all lipids were used for their estimation. The atherogenic index of plasma (AIP) was obtained from the ratio of the logarithm values of triglycerides to high density lipoprotein-cholesterol levels.

Training protocol

The training protocol was based on the protocol and recommendation of the American College of Sports Medicine (ACSM) and Strong et al. This study adopted ACSM’s vigorous intensity aerobic activity guidelines, and the target heart rate was determined using the heart rate reserve method or the Karvonen formula. The target heart rate was ascertained using Heart Rate Reserve = intensity (%) × (maximum Heart Rate – resting Heart Rate) + resting Heart Rate.

The 8-week exercise training program included three training sessions per week (Mondays, Wednesdays and Fridays for continuous training and Tuesdays, Thursdays and Saturdays for interval training) on a stationary cycle ergometer in the gymnasium of the Department of Medical Rehabilitation, University of Nigeria, Enugu Campus. The vigorous intensity range for either protocol used in the present study was 70-84% of Heart Rate Reserve. Due to the fact that exercise training intensity could not be controlled by observation, target heart rate was monitored during each session by using the pulse-meter in the ergometer. In each session, participants had warm up period of 5 minutes. Thereafter, there was a training phase and a subsequent cool-down phase of 5 minutes each. The duration of the training component was 30 minutes during the first 2 weeks, 35 minutes in the 3rd and 4th weeks, 40 minutes in the 5th and 6th weeks and 45 minutes in the last 2 weeks. All training sessions were done in the morning between 6am and 8.30am.

Continuous training group

The aerobic training program followed the general guidelines established by the American College of Sports Medicine. The intensity of the exercise was set at 70-84% of Heart Rate Reserve.

Interval exercise group

The target workload for this group was a work period to reach 70-84% Heart Rate Reserve (vigorous intensity) and rest/recovery to reach 30-39% Heart Rate Reserve (low intensity). A work-recovery ratio of 1:2 (1 minute:2 minutes) was chosen. According to Meyer et al., this work-recovery ratio is known to prevent high lactate accumulation and is well tolerated.

Control group

Participants in this group did not participate in the training but continued with their normal activities of daily living and academic activities.

Procedure for data collection

Ethical approval was sought and obtained from the institutional ethics committee before the commencement of the study. The training procedure was described to the prospective participants and informed consent was obtained from each subject before participation. Subjects who consented to participate in the study were screened for eligibility using the Baecke questionnaire and the Physical Activity Readiness Questionnaire before being enrolled in the study. Those who met the inclusion criteria were randomly assigned into the continuous group, interval group or the control group. Baseline measurements of anthropometric and biochemical data for each subject were obtained before commencement of training. The participants in the continuous and interval groups participated in the training program three times a week for 8 weeks while the control group had no training during this period. Participants in the training groups exercised three times per week for thirty minutes each day during the first two weeks. The duration was increased by five minutes every two weeks until the eighth week. The participants completed all the exercise sessions, and at the end of the 8th week post test measurements of all the groups were obtained.
Methods of data analysis

Descriptive statistics was used to present pretest and post test measurements by displaying the values as mean and standard deviation. Normality of the data was determined using the Kolmogorov-Smirnov test. Paired t-test was used to examine differences between pretest and post-test measurements of each group while Analysis of Covariance (controlled for baseline values) was used to determine the effects across the groups. Bonferroni Post-hoc analysis was further used to locate the source of the significant differences. The alpha level was established at p < 0.05.

RESULTS

The results are presented in Tables 1-3. Table 1 shows the physical characteristics of the participants across the groups in terms of age, weight, height and body mass index. There were significant reductions in weight and BMI following 8-weeks of interval training and vice-versa after a corresponding duration of non-training. Continuous training did not have any significant change on the weight and BMI.

Table 2 shows that the F ratio for the groups was significant \[ F (2,50) = 6.17, p < 0.05 \].
sis was rejected. This implies that the effects on AIP or high density lipoprotein (HDL) due to groups were not the same. This necessitated a post-hoc test (Table 3), which showed the sources of these significantly different effects. It was concluded that the changes in HDL and AIP of young male adults after an 8-week continuous training regimen were not the same with a corresponding interval training program. Interval training significantly decreased HDL while a non-significant increase in HDL was observed after continuous training. Continuous training significantly decreased AIP while a non-significant increase in AIP was observed after interval training.

**DISCUSSION**

Atherogenic index of plasma, a new marker of atherogenicity is related directly to atherosclerosis risk. People with a high atherogenic index of plasma have a higher risk for coronary heart disease than those with a low atherogenic index of plasma and vice-versa. The finding in the present study shows that only continuous training had the ability to significantly reduce the atherogenic index of plasma of young male adults. This suggests that continuous training is an effective non-pharmacological anti-atherosclerosis therapy for young male adults.

The findings of the study show that there was a significant change in the atherogenic index of plasma only in those who engaged in continuous training. After controlling for baseline values, continuous training had superior ability to reduce the atherogenic index of plasma in sedentary non-obese young males. The findings also showed that vigorous intensity interval training significantly decreased the levels of high density lipoprotein. It suggests that the ability of continuous training to significantly decrease atherogenic index of plasma may be connected with its ability to favourably maintain the levels of high density lipoprotein. The mechanism responsible for the differential effects of continuous and interval training on lipid parameters has not been unanimously described. Sittiwicheanwong studied the alteration of atherogenic low density lipoprotein in sedentary Thai women following exercise. Their findings suggested that even without a change in high density lipoprotein, exercise of appropriate stimulus impedes the shift of large buoyant-low density lipoprotein to more atherogenic small dense low density lipoprotein, thus reducing atherogenic risk. It is possible that the effects on lipid particle size may partially explain the mechanisms involved in continuous training stimulating a superior reduction in atherogenic risk than interval training.

Lipoprotein metabolizing enzymes such as hepatic lipase, post heparin plasma lipoprotein lipase, adipose tissue lipoprotein lipase, lecithin-cholesterol acyltransferase and cholesterol ester transfer protein are known to influence levels of blood TG-rich lipoproteins and high density lipoprotein-cholesterol in obesity. It is also possible that the differential effects on atherogenic index of plasma due to continuous training and interval training may be as a result of differences in influence on the activity of these enzymes in sedentary non-obese males.

Previous studies have asserted that there is a dose-response relationship to an exercise training-induced increase in high density lipoprotein-cholesterol; that greater exercise volumes induce greater high density lipoprotein-cholesterol. This assertion seems to hold for those who engaged in continuous training, while for interval training the reverse is the case. This may suggest the need for caution in using interval training as a modality for sedentary individuals. However, more clarification on other variants of interval training needs to be investigated in this population.

The interpretation of atherogenic index of plasma indicates that for values < 0.11 cardiovascular events risk is reduced; between 0.11-0.21 there is intermediate risk of cardiovascular disease, and > 0.24 indicates high risk. The finding from the present study indicates that

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<tr>
<th>Parameter</th>
<th>Groups</th>
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<tbody>
<tr>
<td>HDL</td>
<td>CT vs. IT</td>
<td>&lt; 0.001*</td>
</tr>
<tr>
<td></td>
<td>CT vs. CTR</td>
<td>0.129</td>
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<tr>
<td></td>
<td>IT vs. CTR</td>
<td>&lt; 0.001*</td>
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<tr>
<td>AIP</td>
<td>CT vs. IT</td>
<td>0.003*</td>
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<td></td>
<td>CT vs. CTR</td>
<td>0.016*</td>
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<td></td>
<td>IT vs. CTR</td>
<td>0.292</td>
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Table 3. Bonferroni post hoc pairwise comparison of the groups

AIP, atherogenic index of plasma; CT, continuous training; CTR, control; HDL, high density lipoprotein; IT, interval training; *, significant at p < 0.05.
young sedentary males have a high risk of cardiovascular events even though their lipid parameters were within the normal range in the environment. This is consistent with Nwagha et al.\textsuperscript{7} who reported that atherogenic index of plasma is a useful diagnostic alternative when other risk parameters appear normal.

A significant reduction in body weight (BW), BMI and HDL-C was obtained in the interval training group after exercise intervention. However, continuous training did not significantly change BW, BMI and HDL. These findings are contrary to the common opinion that exercise-induced HDL-C increases are dependent on reduction in BW and BMI. Evidence has shown that exercise has a substantial dose-dependent effect on lipid profile.\textsuperscript{29} In addition, duration of aerobic exercise rather than the intensity have been identified as the greatest influence on HDL-C levels.\textsuperscript{26} Our findings showed a higher but non-significant increase in HDL-C after continuous training. This may imply that the caloric threshold for inducing significant increases in HDL-C was not reached during the continuous training method adopted in this study. This may suggest the need for time series designs and longitudinal studies to determine the critical points in the alterations of HDL-C during exercise training. Increases in lipoprotein lipase activity have been identified as partially responsible for increases in HDL-C, and vice-versa.\textsuperscript{30} The activity of this enzyme may have implications for the interpretation of our findings, even though the level of lipoprotein lipase was not determined in the present study. It is possible that interval training decreased the activity of lipoprotein lipase which led to significantly decreased HDL-C levels observed in our findings. It may also imply that continuous training non-substantially increased the activity of lipoprotein lipase which led to non-significant increase in HDL-C levels observed in the present study.

Slentz et al.\textsuperscript{31} observed that weight change during an exercise program is all about the degree of caloric imbalance created during the training. Our findings suggest that the control group (the non-exercise group) was in sustained positive energy balance during the 8-week period. It is also possible that the differential physical maturation of the participants in the control group may account for significant increase in weight during the period, as they were not engaged in any exercise training.

Our findings also suggest that interval training led to a sustained negative energy balance resulting in significant weight reduction. The findings also implied a non-significant positive energy balance following continuous training. Studies comparing effects of continuous and interval training modalities of vigorous intensity in previously sedentary young adults are rare. However, in both active and pathological populations decreases in weight following exercise training have been reported.\textsuperscript{31-33} These reports have been based on samples drawn from different age groups, unlike the present study were only young male adults were involved. Nybo et al.\textsuperscript{34} reported that continuous and interval training led to non-significant and significant decrease, respectively, in body weight of middle-aged adults. These assertions imply that there may be a critical point or threshold for the beginning of weight change during training at vigorous intensity or an age range dependent effect of exercise on weight. Future studies may need to incorporate time series designs or longer duration of training to explain these possibilities.

Nevertheless, the present study has some limitations. The nutritional status of the participants was not taken into consideration and may influence the internal validity of the findings. The external validity of this study may be limited by the purposive sample studied. The external validity of our findings needs to be confirmed in other larger populations of similar characteristics.

CONCLUSIONS

Continuous exercise training of vigorous intensity is effective in reducing the risk of cardiovascular events in sedentary non-obese young males who seek to lead a physically active lifestyle. Interval training of vigorous intensity is not as beneficial as continuous training in reducing the lipid atherogenicity associated with sedentary lifestyle in young males.

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the lipoproteins and lipid concentration factors in male athletes. 


