International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Effects of Circuit Training, Resistance Training and Combined Training on Selected Biochemical Variables Among School Boys

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ABSTRACT

The present study investigated the effects of circuit training, resistance training, and combined training on selected biochemical variables among school boys. A total of 60 school boys aged 15–17 years from R.S. Government Higher Secondary School, Paramakudi, Tamil Nadu, were selected and randomly assigned into four equal groups: circuit training group, resistance training group, combined training group, and control group, with 15 participants in each group. The experimental groups underwent their respective training programmes for 12 weeks, while the control group continued routine activities without any special training. The selected biochemical variables were low-density lipoprotein and high-density lipoprotein. Blood samples were collected before and after the training period, and the values were recorded in mg/dl. The data were analysed using analysis of covariance, and Scheffe's post hoc test was applied wherever significant differences were observed. The results revealed significant differences among the groups in both low-density lipoprotein and high-density lipoprotein after the intervention. The combined training group showed the most favourable biochemical response by reducing low-density lipoprotein and increasing high-density lipoprotein levels more effectively than circuit training and resistance training alone. These findings indicate that a structured combination of circuit and resistance training may provide a stronger metabolic stimulus for improving lipid-profile markers among adolescent boys. Therefore, combined training can be recommended as an effective school-based training method for promoting better biochemical health and reducing cardiovascular risk factors among school boys.

Keywords: Circuit training, resistance training, combined training, biochemical variables, low-density lipoprotein, high-density lipoprotein, lipid profile, school boys.

INTRODUCTION

Biochemical variables are important indicators of health-related fitness because they reflect internal changes associated with metabolism, cardiovascular function, and long-term disease risk. Among school-age adolescents, regular physical training may play an important role in improving lipid profile and promoting healthy metabolic regulation. During adolescence, lifestyle habits such as physical activity, diet, and exercise participation can influence future cardiovascular health; therefore, school-based training programmes are useful not only for physical fitness development but also for improving selected biochemical markers.

Low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C) are two important lipid-profile variables commonly used to assess cardiovascular and metabolic health. LDL-C is often considered an unfavorable lipid marker when elevated, because higher LDL-C levels are associated with increased cardiovascular risk. In contrast, HDL-C is considered beneficial because it helps in reverse cholesterol transport and supports cardiovascular protection. In the present study, low-density lipoprotein and high-density lipoprotein were selected as biochemical variables, and both were measured through blood test in mg/dl.

Physical activity and structured exercise are widely recommended for children and adolescents because they support physical fitness, metabolic health, and cardiovascular well-being. The World Health Organization recommends that children and adolescents perform regular moderate-to-vigorous physical activity and include vigorous, muscle-strengthening, and bone-strengthening activities across the week (Bull et al., 2020; WHO, 2024). Such recommendations highlight the need to include systematic training programmes in school settings, especially during adolescence, when health-related habits are formed.

Circuit training is a practical training method that combines a series of exercises performed with limited rest between stations. This method can increase energy expenditure, improve cardiovascular stimulation, and enhance muscular endurance. Recent evidence suggests that 12 weeks of circuit training can improve body composition, cardiorespiratory fitness, and lipid profile in adolescents (Marinho et al., 2022; Mpassi et al., 2024). Therefore, circuit training may be useful for improving biochemical variables such as LDL-C and HDL-C among school boys.

Resistance training is also recognized as an effective method for improving youth health and fitness when it is properly planned and supervised. Although resistance training is commonly associated with strength development, it may also influence biochemical variables by improving muscle mass, insulin sensitivity, lipid metabolism, and overall cardiovascular risk profile. Santos et al. (2020) reported that a 12-week resistance training programme among school adolescents produced beneficial changes in triglycerides, LDL, non-HDL, blood glucose, and blood pressure variables.

A combined training programme may provide stronger benefits because it integrates the metabolic demand of circuit training with the strength and muscular adaptations of resistance training. This dual stimulus may help regulate lipid metabolism more effectively than a single training method. Exercise-based interventions in children and adolescents have been shown to reduce total cholesterol and LDL-C, while changes in HDL-C may depend on training intensity, duration, and participant characteristics (Costa et al., 2020; Racil et al., 2023).

Although previous studies have examined exercise training and lipid-profile changes in adolescents, limited research has compared circuit training, resistance training, and combined training on biochemical variables among school boys. Therefore, the present study was designed to investigate the effect of circuit training, resistance training, and combined training on selected biochemical variables among school boys. The selected biochemical variables were low-density lipoprotein and high-density lipoprotein. The findings may help physical education teachers, coaches, and health professionals understand the role of structured training in improving lipid-profile markers among adolescent boys.

METHODOLOGY

Study Design

The present study adopted a pre-test and post-test experimental design to examine the effects of circuit training, resistance training, and combined training on selected biochemical variables among school boys. The independent variables were the three training methods, and the dependent variables were low-density lipoprotein (LDL) and high-density lipoprotein (HDL).

Participants

The participants were selected from R.S. Government Higher Secondary School, Paramakudi, Tamil Nadu. A total of 60 school boys, aged between 15 and 17 years, were selected and randomly divided into four equal groups of 15 each. Group I underwent circuit training, Group II underwent resistance training, Group III underwent combined circuit and resistance training, and Group IV served as the control group.

Grouping of Subjects

Group	Treatment	No. of Subjects
Group I	Circuit Training	15
Group II	Resistance Training	15
Group III	Combined Training	15
Group IV	Control Group	15

Selection of Variables

For the present article, only the biochemical variables from the thesis were considered. The selected biochemical variables were:

1. Low-density lipoprotein
2. High-density lipoprotein

The thesis methodology lists LDL and HDL as the selected biochemical variables for the study.

Criterion Measures

Biochemical Variable	Test Used	Unit of Measurement
Low-density lipoprotein	Blood test	mg/dl
High-density lipoprotein	Blood test	mg/dl

The criterion measure table in the thesis states that both LDL and HDL were assessed through blood test and expressed in **mg/dl**.

Biochemical Assessment Procedure

Blood samples were collected for biochemical analysis before and after the training period. HDL cholesterol was estimated using the **enzymatic colorimetric method** with a Bio Systems Semi Auto Analyser, Model BTS-320. LDL cholesterol was calculated from total cholesterol, triglycerides, and HDL cholesterol using the Friedewald formula.

Training Programme

The training programme was conducted for **12 weeks**. The experimental groups underwent their respective training programmes, while the control group continued routine activities without any special training. The training was conducted for **three days per week**, and each session included warm-up, training activity, and cool-down. The thesis reports that the circuit training group received circuit training, the resistance training group received resistance training, and the combined training group received a combination of circuit and resistance training.

Collection of Data

Pre-test data were collected before the commencement of the training programme, and post-test data were collected after the completion of the 12-week intervention. The biochemical data were collected through blood testing and recorded in their respective units. The thesis states that pre-test and post-test data were collected before and after the 12-week training programme.

Reliability of Tests

The reliability of the biochemical variables was established through the test-retest method. The intra-class correlation coefficient was reported as **0.88 for low-density lipoprotein** and **0.90 for high-density lipop-**

rotein, indicating acceptable reliability for the biochemical measurements.

Statistical Analysis

The collected data were analysed using **analysis of covariance (ANCOVA)** to determine significant differences among the adjusted post-test means of the four groups. Whenever the obtained F-ratio was found to be significant, **Scheffe's post hoc test** was applied to identify the paired mean differences. The level of significance was fixed at **0.05**.

RESULTS

The data collected on the selected biochemical variables were analysed using analysis of covariance (ANCOVA). When the adjusted post-test means were significant, Scheffe's post hoc test was applied. The level of significance was fixed at 0.05. The selected biochemical variables were low-density lipoprotein (LDL) and high-density lipoprotein (HDL).

Table 1

Pre-test, post-test and adjusted post-test means of selected biochemical variables

Variable	Group	Pre-test Mean ± SD	Post-test Mean ± SD	Adjusted Post-test Mean
LDL	Circuit Training	141.73 ± 5.560	136.27 ± 5.04	136.20
	Resistance Training	141.87 ± 1.533	136.93 ± 5.8244	136.80
	Combined Training	141.53 ± 1.453	135.47 ± 3.907	135.60
	Control Group	141.60 ± 1.450	142.67 ± 5.576	142.70
HDL	Circuit Training	45.20 ± 6.061	50.33 ± 4.966	50.36
	Resistance Training	45.13 ± 5.8902	50.00 ± 5.1823	50.08
	Combined Training	45.26 ± 6.110	50.80 ± 5.608	50.77
	Control Group	45.33 ± 5.727	44.266 ± 5.6120	44.187

For **LDL**, a lower value indicates a favourable change, whereas for **HDL**, a higher value indicates a favourable change. The results show that the combined training group produced the most favourable adjusted post-test mean in both LDL and HDL.

Table 2

ANCOVA summary of selected biochemical variables

Variable	Pre-test F-ratio	Post-test F-ratio	Adjusted Post-test F-ratio	Result
LDL	0.010	6.093*	22.817*	Significant
HDL	0.003	4.950*	23.572*	Significant

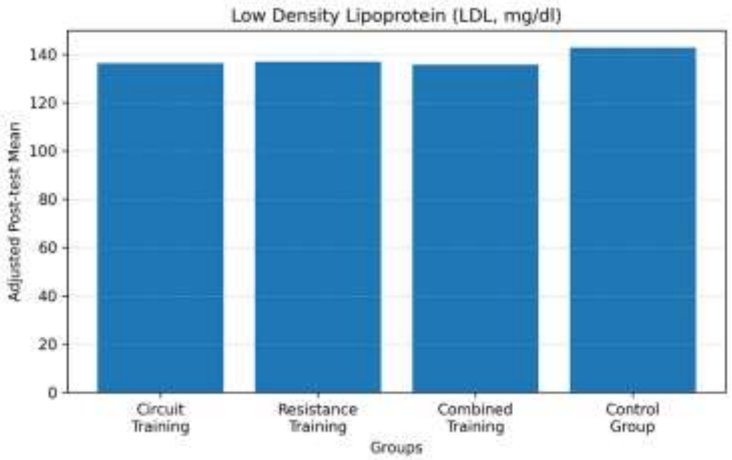
*Significant at 0.05 level.

The pre-test F-ratios were not significant, indicating that the groups were almost equal before the training programme. However, the post-test and adjusted post-test F-ratios were significant for both LDL and HDL, showing that the training interventions produced significant biochemical changes among school boys.

Results on Low-Density Lipoprotein

The adjusted post-test means for LDL were **136.20 mg/dl** for the circuit training group, **136.80 mg/dl** for the resistance training group, **135.60 mg/dl** for the combined training group, and **142.70 mg/dl** for the control group. Since LDL is considered more favourable when reduced, the combined training group showed the best improvement, followed by the circuit training group and resistance training group. The adjusted post-test F-ratio of **22.817** was significant at the 0.05 level, indicating a significant difference among the groups.

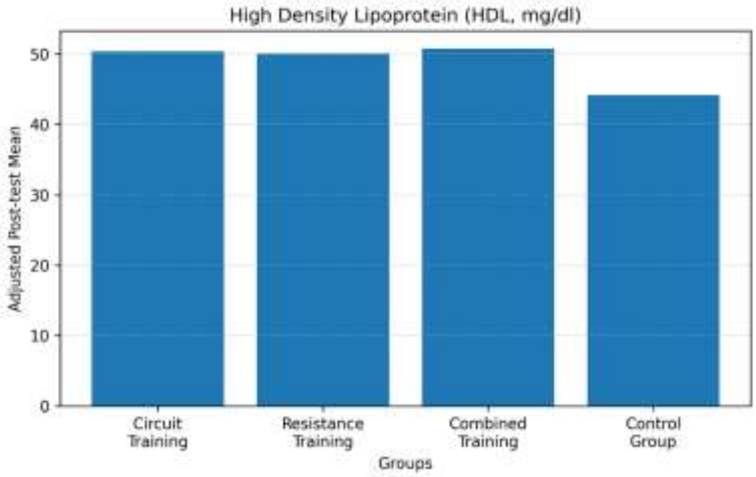
Figure 1:



Results on High-Density Lipoprotein

The adjusted post-test means for HDL were **50.36 mg/dl** for the circuit training group, **50.08 mg/dl** for the resistance training group, **50.77 mg/dl** for the combined training group, and **44.187 mg/dl** for the control group. Since HDL is considered more favourable when increased, the combined training group showed the best improvement, followed by the circuit training group and resistance training group. The adjusted post-test F-ratio of **23.572** was significant at the 0.05 level, showing a significant difference among the groups.

Figure 2:



The findings indicate that circuit training, resistance training, and combined training significantly influenced the selected biochemical variables among school boys. Among the three experimental interventions, combined training produced the most favourable biochemical response, as it reduced LDL to the lowest adjusted post-test mean and increased HDL to the highest adjusted post-test mean. Therefore, combined training appears to be the most effective method for improving selected lipid-profile variables among school boys.

DISCUSSION

The present study examined the effects of circuit training, resistance training, and combined training on selected biochemical variables among school boys. The selected biochemical variables were low-density lipoprotein (LDL) and high-density lipoprotein (HDL), both assessed through blood test and expressed in mg/dl. The results showed that all three experimental training groups produced significant improvement in biochemical variables when compared with the control group. Among the training methods, combined training produced the most favourable response, with the lowest adjusted post-test mean for LDL and the highest adjusted post-test mean for HDL.

The significant reduction in LDL among the experimental groups indicates that structured training may positively influence lipid metabolism in adolescent boys. LDL is generally considered an unfavourable lipid marker when elevated because it is associated with increased cardiovascular risk. In the present study, the combined training group recorded the lowest adjusted post-test LDL value, followed by the circuit training and resistance training groups. This improvement may be due to increased energy expenditure, improved fat oxidation, enhanced muscular activity, and better regulation of lipid transport following the 12-week training intervention. Costa et al. (2020) reported that supervised exercise training can improve lipid profile variables among children and adolescents, supporting the findings of the present study.

The improvement in HDL is also an important finding because HDL plays a protective role in lipid metabolism by supporting reverse cholesterol transport. In the present study, the combined training group showed the highest adjusted post-test HDL value, indicating a better biochemical adaptation compared with circuit training and resistance training alone. This improvement may be due to the combined influence of aerobic-type conditioning from circuit training and muscular adaptations from resistance training. Santos et al. (2020) also observed that resistance training can produce beneficial changes in cardiovascular risk factors among school adolescents, including lipid-related variables.

Circuit training may have contributed to the improvement in LDL and HDL by increasing continuous muscular work, cardiovascular demand, and total energy expenditure. Since circuit training involves a sequence of exercises with limited rest, it may stimulate both aerobic and anaerobic metabolism. This type of training can improve body composition and metabolic regulation, which may indirectly support healthier lipid-profile changes. Marinho et al. (2022) reported that circuit-based training in school settings can improve physical fitness and body composition markers among children, while Moussouami et al. (2024) found that circuit training programmes can positively influence metabolic profile in adolescents.

Resistance training may also have played an important role in improving lipid variables. Resistance exercises increase muscular strength, muscle activation, and lean tissue demand, which can improve glucose and lipid utilization. Although resistance training is commonly associated with strength development, it can also support metabolic health by improving muscle mass and energy metabolism. Faigenbaum et al. (2009) emphasized that properly planned youth resistance training can improve health and fitness outcomes when performed under appropriate supervision. In the present study, the resistance training group showed favourable changes in both LDL and HDL, although the combined training group performed better.

The superior effect of combined training may be explained by its broader physiological and metabolic stimulus. Circuit training mainly provides cardiovascular and conditioning benefits, while resistance training improves muscular strength and metabolic activity. When both methods are combined, they may create a stronger effect on lipid metabolism than either training method alone. This may explain why the combined training group showed the greatest reduction in LDL and the greatest increase in HDL. Racil et al. (2023) also suggested that structured high-intensity training can improve lipid profile and cardiovascular-related markers in adolescents, especially when training intensity and duration are sufficient.

The control group showed comparatively unfavourable changes, with LDL remaining higher and HDL remaining lower than the experimental groups. This indicates that routine school activities alone may not be enough to produce meaningful biochemical improvements. The finding highlights the importance of systematic and progressive training programmes in schools, especially during adolescence, when lifestyle habits and metabolic health patterns begin to develop. Bull et al. (2020) emphasized the importance of regular physical activity and muscle-strengthening activities for children and adolescents, which supports the need for structured exercise programmes in school environments.

Overall, the findings suggest that circuit training, resistance training, and combined training were effective in improving selected biochemical variables among school boys. However, combined training produced the most consistent and favourable biochemical response, particularly by reducing LDL and increasing HDL. Therefore, combined circuit and resistance training may be considered an effective school-based training method for improving lipid-profile markers and promoting better metabolic health among adolescent boys.

CONCLUSION

The present study concluded that circuit training, resistance training, and combined training significantly improved selected biochemical variables among school boys. Among the three training methods, combined training produced the most favourable effect by reducing LDL and increasing HDL levels. These findings indicate that a structured combination of circuit and resistance training can be an effective school-based training approach for improving lipid-profile markers and promoting better metabolic health among adolescent boys. Future studies may be conducted with larger samples, female students, different age groups, and additional biochemical variables such as total cholesterol, triglycerides, blood glucose, and insulin sensitivity.

ACKNOWLEDGEMENT

The authors sincerely thank the Headmaster, teachers, physical education staff, and students of R.S. Government Higher Secondary School, Paramakudi, Tamil Nadu, for their support and cooperation during data collection. The authors also acknowledge the assistance of the trainers and research helpers who supported the testing and training procedures throughout the study.

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