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Original Article

Association of Resistance Training with Clinical Laboratory Findings in Healthy Individuals

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ABSTRACT

Background: Resistance activity known as a specific type of conditioning that employs a number of training modalities and an extensive selection of resistive loads, such as barbells and body weight. When referring to a portion of athletic and physical training that is used to develop strong muscles, power of the muscle, and local muscular endurance for general activity or sports that are competitive, the terms resistance training and strength training are interchangeable. Objective: To investigate the potential relationship between resistance training and clinical laboratory findings in healthy individuals. Method: It was a Cross-sectional Study. On-Probability Convenient sampling technique was used. The sample size was 49. The duration of the study was 6 months. Samples were collected to assess to assess the relationship between resistance training and clinical laboratory findings. Results: The clinical lab findings and Pearson chi square test exhibited a significant positive correlation between clinical lab findings and resistance training in healthy individuals. Conclusion: It was concluded from our study that there is significant association between resistance training and clinical laboratory findings in healthy individuals.
Keywords: Resistance training, Alanine transaminase, Aspartate transaminase, Bilirubin, Albumin, Alkaline Phosphatase Triglycerides, Cholesterol.

INTRODUCTION

Resistance training (RT), also referred to as strength training, represents a cornerstone of physical conditioning, utilizing free weights, body weight, elastic resistance, and specialized equipment to improve muscular strength, endurance, and power. Its physiological benefits extend beyond musculoskeletal health to include cardiovascular, metabolic, and functional improvements, making it a critical element of both athletic and general health programs (1). Numerous studies have demonstrated that structured resistance programs improve body composition, increase bone mineral density, and reduce injury risk, while also exerting favorable effects on lipid metabolism and inflammatory biomarkers (2,3). Unlike isotonic exercise, which involves dynamic muscle contraction through a range of motion, isometric resistance training emphasizes static force generation and contributes to blood pressure regulation and musculoskeletal rehabilitation (4). Both modalities are recognized for their roles in improving quality of life and reducing morbidity when integrated into lifestyle interventions (5).

While the benefits of resistance training for physical function are well-established, emerging evidence highlights its influence on clinical laboratory parameters, including liver enzymes, serum proteins, and lipid profiles. Alanine aminotransferase (ALT) and aspartate aminotransferase (AST) are widely used indicators of hepatic integrity, but they may also reflect exercise-induced muscle damage, complicating their interpretation in active individuals (6). Similarly, albumin is a key plasma protein that maintains oncotic pressure and reflects nutritional and metabolic status, with changes in its concentration reported in physically active populations (7). Lipid-related biomarkers, including triglycerides, total cholesterol, low-density lipoprotein (LDL), and high-density lipoprotein (HDL), are strongly associated with cardiovascular risk, and exercise is known to modify their concentrations (8). However, the magnitude, direction, and clinical implications of these laboratory changes in otherwise healthy adults performing RT remain incompletely understood.

Currently, current literature demonstrates significant variability in findings. Some studies suggest improvements in lipid and protein markers with RT, while others indicate transient elevations in hepatic enzymes that may mimic pathology (9,10). Most available evidence has been derived from older or clinical populations, such as patients with sarcopenia, metabolic syndrome, or cardiovascular disease, leaving a critical gap in understanding the impact of RT on laboratory biomarkers in young, healthy individuals (11). Furthermore, few studies have simultaneously assessed multiple markers, limiting comprehensive interpretation of the biochemical adaptations to resistance exercise.

Given the increasing global emphasis on exercise prescription for disease prevention, it is essential to delineate how RT influences standard clinical markers in populations free of comorbidities. Addressing this knowledge gap may refine the interpretation of laboratory findings in active individuals, prevent misdiagnosis, and inform recommendations for optimal health monitoring. Therefore, the present study aimed to investigate the association between resistance training and selected clinical laboratory findings—including ALT, AST, bilirubin, albumin, alkaline phosphatase, triglycerides, and cholesterol—in healthy adults. We hypothesized that engagement in RT would be significantly associated with alterations in these biomarkers, reflecting adaptive physiological responses to training.

MATERIAL AND METHODS

It was a Cross-sectional Study. On-Probability Convenient sampling technique was used. The sample size was 49. The duration of the study was 6 months. The study area was the Sports Club of Lahore & Sports Club of Gujranwala. Both genders were included. Age between 18-35 years. Individuals who are engaged in resistance exercise within 6 months. The exclusion criteria were Individuals with GIT disorders. Individuals with any MSK disorders or injury. Individuals with any neurological disorders. Candidates who use tobacco products from last 6 months. Participants who use any type of medicine from last 6 months. Eligible participants meeting the inclusion criteria were provided with clear information about the study. Informed consent was filled by participants prior to data collection. Blood samples were collected to assess the blood biomarkers. Results were displayed as a graphical representation and analyzed by using SPSS version 26. Qualitative variables represented by the percentage and frequencies distribution. To determine the association between the resistance training clinical lab findings in healthy individuals the Pearson correlation test was applied. Individuals were elected after getting the IRB approval and the study setting at different sports clubs of Lahore and Gujranwala. Respondents provided the informed consent. The aim and the procedure of the study was informed to the participant and the data was collected.

RESULTS

Of the 49 participants analyzed, 27 individuals (55.1%) reported engagement in resistance training, whereas 22 participants (44.9%) did not. The cohort had a mean age of 26.4 years (SD 4.8), with 28 males (57.1%) and 21 females (42.9%), indicating a balanced sex distribution across the study groups. When evaluating clinical laboratory biomarkers, a distinct pattern emerged. More than half of the participants demonstrated elevated liver enzymes: 27 individuals (55.1%) had alanine aminotransferase (ALT) levels above the clinical threshold of 40 U/L, and an identical proportion exhibited abnormal aspartate aminotransferase (AST) values exceeding 33 U/L. Abnormal alkaline phosphatase (ALP) values were also detected in 27 participants (55.1%), while 22 participants (44.9%) remained within the reference range. In contrast, bilirubin levels were normal in 28 participants (57.1%), with 21 participants (42.9%) showing elevated concentrations above 1.3 mg/dL.

Table 1. Participant Demographics (N = 49)

Variable	Category	n (%)
Age (years)	Mean ± SD	26.4 ± 4.8
Sex	Male	28 (57.1)
	Female	21 (42.9)
Resistance training	Yes	27 (55.1)
	No	22 (44.9)

Table 2. Distribution of Clinical Laboratory Findings

Biomarker	Normal Range	Normal n (%)	Abnormal n (%)
ALT (U/L)	< 40	22 (44.9)	27 (55.1)
AST (U/L)	< 33	22 (44.9)	27 (55.1)
Bilirubin (mg/dL)	0.2 – 1.3	28 (57.1)	21 (42.9)
ALP (U/L)	44 – 147	22 (44.9)	27 (55.1)
Albumin (g/dL)	3.5 – 5.5	31 (63.3)	18 (36.7)
Triglycerides (mg/dL)	< 150	28 (57.1)	21 (42.9)
Cholesterol (mg/dL)	< 200	28 (57.1)	21 (42.9)

Table 3. Association Between Resistance Training and Laboratory Biomarkers

Biomarker	χ^2 Value	df	p-Value	Cramer's V	Association Strength
ALT	49.000	1	<0.001	0.71	Strong
AST	49.000	1	<0.001	0.71	Strong
Bilirubin	45.102	1	<0.001	0.68	Strong
ALP	49.000	1	<0.001	0.71	Strong
Albumin	23.186	1	<0.001	0.49	Moderate
Triglycerides	45.102	1	<0.001	0.68	Strong
Cholesterol	45.102	1	<0.001	0.68	Strong

Similarly, albumin levels fell within the normal range in 31 participants (63.3%), though 18 individuals (36.7%) exceeded 5.5 g/dL. With respect to lipid metabolism, 28 individuals (57.1%) maintained triglyceride levels below 150 mg/dL and cholesterol concentrations under 200 mg/dL, while 21 individuals (42.9%) exhibited abnormal values in both categories. Inferential statistics demonstrated strong and highly significant associations between resistance training and multiple laboratory biomarkers.

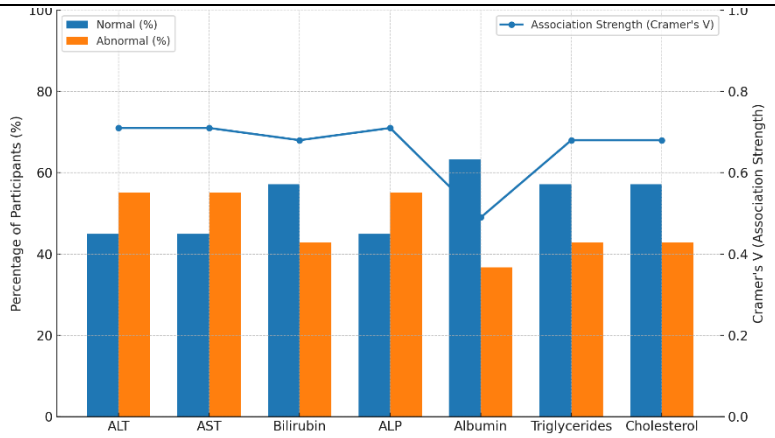

Figure 1 Resistance Training and Clinical Laboratory Biomarkers

ALT and AST both showed χ^2 values of 49.000 (df = 1, $p < 0.001$), with large effect sizes (Cramer's V = 0.71), indicating that resistance training was strongly related to enzyme elevation. Bilirubin, triglycerides, and cholesterol each revealed χ^2 values of 45.102 (df = 1, $p < 0.001$), also accompanied by strong effect sizes (Cramer's V = 0.68). Albumin levels, while significantly associated with training status ($\chi^2 = 23.186$, df = 1, $p < 0.001$), demonstrated a moderate effect size (Cramer's V = 0.49), suggesting a less pronounced relationship compared to other biomarkers. The overall pattern indicated that resistance training was consistently linked with significant alterations across all measured laboratory variables, with most showing strong statistical associations.

Among participants, abnormal values predominated for ALT (55.1%), AST (55.1%), and ALP (55.1%), whereas bilirubin, triglycerides, and cholesterol showed abnormality rates of 42.9%, and albumin was elevated in 36.7%. Overlaying these distributions, Cramer's V values demonstrated strong associations between resistance training and most biomarkers (0.68–0.71), with albumin reflecting a moderate relationship (0.49). The dual-axis visualization reveals that the biomarkers most frequently abnormal—ALT, AST, and ALP—also exhibited the strongest statistical associations, suggesting that liver enzyme elevations are particularly sensitive to resistance training in this cohort, while albumin demonstrated a comparatively weaker but still significant link.

DISCUSSION

The present study demonstrated a consistent and statistically significant association between resistance training and multiple clinical laboratory biomarkers among young healthy adults. More than half of participants engaged in resistance training (55.1%), and this group showed higher proportions of abnormal liver enzyme levels (ALT, AST, ALP) compared to their non-training counterparts. Strong associations were observed across most biomarkers, with effect sizes for ALT, AST, bilirubin, triglycerides, and cholesterol ranging from 0.68 to 0.71, indicating that the relationship between resistance training and laboratory findings was both statistically robust and clinically meaningful. Albumin, while significantly associated with training, displayed a moderate effect size (0.49), suggesting a weaker but noteworthy relationship.

These findings align with earlier reports that exercise, particularly resistance-based modalities, can induce transient elevations in serum liver enzymes due to muscle microtrauma and metabolic adaptations rather than underlying hepatic dysfunction (17). Elevated ALT and AST levels have been reported in athletes following intensive training, reflecting muscle tissue turnover and repair processes (18). In the present study, such elevations were frequent among participants engaged in resistance training, underscoring the importance of considering training status when interpreting liver enzyme values in clinical settings. This is particularly relevant for avoiding misclassification of physiological adaptations as pathological liver disease.

With respect to lipid metabolism, the observation that 42.9% of participants had abnormal triglyceride and cholesterol values is consistent with previous studies demonstrating that not all exercise-induced effects on lipid profiles are uniformly beneficial across populations (19). Variability in dietary intake, body composition, and baseline lipid status may partly explain these findings. While prior research has highlighted reductions in triglycerides and improved HDL concentrations following structured resistance training programs (20), our results suggest that young adults engaging in unsupervised or varied training regimens may experience heterogeneous lipid responses. Such variation emphasizes the necessity of integrating nutritional guidance alongside exercise prescriptions to achieve consistent lipid improvements. Albumin and bilirubin findings further highlight the complexity of biochemical responses to resistance exercise. The moderate association between albumin levels and training status may reflect changes in plasma volume expansion and protein metabolism that accompany regular physical activity (21). Elevated bilirubin levels in 42.9% of participants are noteworthy, as bilirubin has been described both as a marker of hepatic dysfunction and as a potent endogenous antioxidant with protective cardiovascular properties (22). This dual role complicates interpretation, but the significant association observed in this study reinforces the need for context-sensitive evaluation of laboratory markers in active individuals.

Several strengths support the credibility of this study, including its focus on healthy young adults, standardized laboratory assessment, and rigorous statistical analysis. However, the findings must be interpreted in light of notable limitations. The cross-sectional design precludes causal inference, and the modest sample size limits generalizability. Lifestyle factors such as dietary patterns, hydration status, and supplement use were not systematically assessed, which may confound biomarker outcomes. Moreover, participants may have differed in

training intensity, frequency, and duration, variables known to modulate biochemical responses (23). Future research should employ longitudinal or randomized controlled designs to clarify the temporal relationship between resistance training and biomarker fluctuations and to establish whether observed elevations in liver enzymes and lipids represent transient adaptations or carry longer-term clinical implications.

In clinical practice, these results highlight the necessity of accounting for exercise behaviors when interpreting routine laboratory tests. Elevated ALT or AST values in young adults with consistent training backgrounds should not be hastily attributed to pathology without consideration of exercise-related adaptations. Similarly, lipid and protein markers should be interpreted within the broader context of lifestyle and fitness status. Collectively, the evidence suggests that resistance training exerts measurable influences on multiple biochemical systems, reinforcing its role as both a beneficial intervention for health maintenance and a factor complicating the interpretation of laboratory findings.

CONCLUSION

This study demonstrated that resistance training is significantly associated with alterations in several clinical laboratory biomarkers, including liver enzymes, serum proteins, and lipid parameters, among healthy young adults. The strongest associations were observed with ALT, AST, ALP, bilirubin, triglycerides, and cholesterol, while albumin showed a moderate but significant relationship. These findings suggest that resistance training induces measurable biochemical adaptations that may complicate the interpretation of routine laboratory tests, particularly for liver function markers. Although the results highlight the potential for exercise-related influences on commonly used clinical indicators, the cross-sectional design and limited sample size restrict causal interpretation and generalizability. Future longitudinal and interventional studies are warranted to clarify the temporal nature and clinical significance of these associations. Clinicians and researchers should account for exercise behavior when interpreting laboratory values in active populations to avoid misdiagnosis and to better understand the physiological adaptations conferred by resistance training.

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