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Comparison of the effects of high-intensity resistance training and resistance retraining on serum levels of some indices of muscle damage in inactive young girls

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Abstract

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Purpose: Delayed onset muscle soreness (DOMS) is pain and stiffness that occurs several hours to several days after unusual or intense exercise. It is thought that this exercise causes small damage (micro trauma) to muscle fibers. The aim of the present study was to compare the effects of high-intensity resistance training and resistance retraining on serum levels of some indices of muscle damage in inactive young girls. **Method:** Twenty-four healthy inactive young girls voluntarily participated in the present study. They then randomly divided into two groups of 10. The muscle injury protocol included five stations of biceps and shoulder presses with a barbell, squats, chest press, and leg press. Each movement consisted of three sets of 8 to 12 repetitions, with an intensity of 75% of one repetition maximum. Serum levels of creatine kinase, lactate dehydrogenase, and aspartate aminotransferase enzymes were measured before the activity and at intervals of 1, 26, and 48 hours after it. Analysis of variance with repeated measures and independent t-test were used to analyze the data at a significance level of $p \geq 0.05$. **Results:** there was no significant difference in the changes in creatine kinase, lactate dehydrogenase, and aspartate aminotransferase between the two groups at different stages of measurement after retraining ($p < 0.05$). **Conclusion:** According to the results of the present study, it can be concluded that resistance training cannot be a significant influencing variable on the amount of muscle damage. However, more research in this field is needed.

Keywords: Resistance training, muscle damage, creatine kinase, lactate hydrogenase, aspartate aminotransferase.

Introduction

Recently, it has been shown that muscle fiber breakdown causes muscle soreness following resistance training (Markus et al., 2021). Laboratory sampling of muscles the day after intense exercise shows that bleeding and disconnection of muscle filaments responsible for maintaining muscle fibers, and due to rubbing against each other during muscle contraction, causes muscle soreness (Bartel & Mosabbir, 2021). Delayed onset muscle soreness is another type of soreness that, in addition to causing pain, movement restriction, spasm, swelling and inflammation in the involved muscles, increases the release of certain enzymes such as creatine kinase, lactate dehydrogenase and aspartate aminotransferase in the blood (Rodrigues et al., 2022). According to research results, it takes at least 5 days for the pain caused by damage to the muscles of the body to disappear and even more time is needed to rebuild the functional aspects of the muscles. Creatine kinase (CK), lactate dehydrogenase (LDH), and aspartate aminotransferase are three physiological markers of muscle damage (De Vito et al., 2022). The release of these three enzymes from the intramuscular environment into the blood indicates structural damage to muscle fibers (Zhang et al., 2024). Assessment of these three enzymes provides information about muscle fueling and building that can help physicians and trainers determine activity levels and the type of metabolic adaptation to exercise (Furrer et al., 2023). When skeletal muscle is damaged by injury or overuse, the enzyme CK is released from the muscle cells and its level in the blood increases within an hour (Lopez et al., 2022). The increase in this enzyme is proportional to the amount of damage to the skeletal muscle. In fact, the tension created in the active muscle fibers during contraction causes the enzymes to diffuse into the blood (Egan & Sharples, 2023). Therefore, the diffusion of these enzymes into the interstitial fluid is possible only when the muscle cell membrane is damaged and its permeability is increased. Therefore, the increased release of these enzymes into the blood is a type of muscle response to injury and can be measured as a reliable indicator (Egan & Sharples, 2023).

Drummond et al. (2008) studied the effect of resistance exercise (weightlifting) on clinical chemistry parameters in men. They selected 15 healthy, physically fit men who had not done resistance training. The training program used was one hour of weight training (Drummond et al., 2008). Blood samples were taken to assess the parameters creatine kinase, lactate dehydrogenase, aspartate aminotransferase, alanine aminotransferase, bilirubin and myoglobin at intervals up to 7 days after exercise. They observed that the parameters creatine kinase, lactate dehydrogenase, aspartate aminotransferase, alanine aminotransferase and myoglobin increased significantly after exercise and their increase remained up to 7 days after exercise. Khajehlandi et al. (2018) observed a significant increase in creatine kinase enzyme following a session of resistance exercise with 100% of one repetition maximum (Khajehlandi & Janbozorgi, 2018). Pullinen et al. (2011) also showed that a session of intense resistance exercise (leg press) increases delayed onset muscle soreness in men. So far, several studies have investigated serum enzyme changes and the therapeutic effects of supplements, drugs, and stretching exercises to reduce the effects of delayed onset muscle soreness, but none have been able to definitively treat its effects. On the other hand, objective evidence indicates that re-exercise after intense exercise reduces pain, muscle soreness, and symptoms of muscle damage (Pullinen et al., 2011). Few studies have been conducted in this regard, and unfortunately, no study was found that investigated the effect of re-exercise resistance on muscle damage and muscle pain indices. Therefore, the present study was conducted to compare the effects of high-intensity resistance exercise and re-exercise resistance on serum levels of some muscle damage indices in inactive young girls.

Methods

The present study was a semi-experimental study. The statistical population of this study consisted of all inactive female students of Malayer Azad University, aged 19 to 24, who were studying in the academic year 1402-1403. After announcing the call, 85 students from the JET program expressed their willingness to participate in this study.

Then, 24 of the eligible individuals formed the statistical sample of this study and were randomly assigned to two resistance training groups (12 people) and resistance training and retraining groups (12 people). Initially, during a face-to-face meeting, they were advised to refrain from performing intense activities and taking any medication that could affect the results of the study during the study period. Also, comprehensive and complete information about the objectives of the study, blood collection steps, possible risks, and pain after completing the exercise program was provided to them, and then they completed the consent form for participation in the study. Table 1 shows the mean and standard deviation of the individual characteristics of the subjects.

Table 1: General characteristics of subjects (mean and standard deviation)

variables	Resistance	Resistance training re-training
Age (years)	20±1.50	22.62±1.92
Height (cm)	162.25±5.88	166.00±4.92
Weight (kg)	60.87±8.35	65.62±12.50
BMI (kg/m)	22.00±1.27	24.00±3.00
Body fat (percentage)	12.85±5.21	13.00±1.28

Muscle Injury Inducing Protocol

The training session began with a 10-minute warm-up (including 5 minutes of walking and jogging, and 5 minutes of arm and shoulder girdle flexibility and stretching exercises). The resistance training program consisted of five stations, which were, respectively, biceps and shoulder presses with a barbell, squats, chest presses, and leg presses. Each movement consisted of three sets, and each set consisted of 8 to 12 repetitions. A 1.5-minute rest period was included between each set and a 5-minute rest period between each station. The intensity of the activity was 75% of one repetition maximum. Then, the subjects in the resistance training group performed the same protocol again after 24 hours.

Blood sampling and laboratory methods

Blood samples were obtained at baseline (at 9 am and in a fasting state) and then at intervals of 1, 26 (equivalent to 2 hours after retraining in the retraining group), 48 (equivalent to 24 hours after retraining in the retraining group) after the implementation of the protocol, each in an amount of 5 ml was obtained from the brachial vein (antecubital) of the subjects. All blood samples were immediately poured into tubes containing heparin anticoagulant after blood collection and centrifuged for 15 minutes at 3000 rpm. Then, Iranian kits from Pars Azmoun Company with sensitivities of one and five units per liter, respectively, and a 240 GLOBAL biochemistry autoanalyzer manufactured by PBC Company, Italy, were used to measure creatine kinase, lactate dehydrogenase, and aspartate aminotransferase enzymes.

Statistical analysis method

First, the Shapiro-Wilk statistical test was used to check the normality of the data distribution. After ensuring the normality of the data, the analysis of variance in repeated measures statistical test was used to check the difference between the different sampling stages (pre-test with post-tests and post-tests together) and, if significant, the Bonferroni post-hoc test was used to determine the difference between the different sampling stages. Also, the independent t-test was used to compare the results of the two groups at each time step. All calculations were performed using SPSS statistical software version 26 and at a significance level of $p \leq 0.05$.

Results

Independent t-test to compare the means of the two groups at each time point indicated that there was no significant difference between the extroverted training and resistance training and retraining groups in terms of changes in lactate dehydrogenase at time intervals of 1, 26, and 48 hours after activity ($p=0.667$, $p=0.489$, $p=0.753$, respectively).

Examination of within-group effects using Bonferroni's post hoc test showed that the level of lactate dehydrogenase in the high-intensity

resistance training group increased at time intervals of 1, 26, and 48 hours after activity compared to baseline, but this increase was not significant, (p=0.957, p=0.852, p=0.795, respectively). Also, examining within-group effects using Bonferroni's post hoc test showed that the level of lactate dehydrogenase in the resistance retraining and retraining group increased at intervals of 1, 26 and 48 hours after retraining compared to the baseline, but this increase was not significant, (p=0.836, p=0.563, p=0.963, respectively).

Table 2: Comparison of mean and standard deviation of dependent variable lactate dehydrogenase before and after extroversion training and extroversion retraining

Statistics / Variable	Physical activity stage	group		Significance level p*
		Resistance training	Resistance training and retraining	
Lactate dehydrogenase (International units per liter)	Pre-test (baseline)	377±46	359±61	-
	1 hour after training	389±36	366±30	0.667
	Significance level p**	0.957	0.836	
	26 hours after Resistance training (equivalent to 2 hours after retraining)	338±31	422±58	0.489
	Significance level p**	0.852	0.563	
	48 hours after			

	extroverted training (equivalent to 24 hours after retraining)	400±59	409±82	0.753
	Significance level p**	0.795	0.963	

P* Significant difference with baseline at level (p≤0.05). P** Significant difference with control group at level (p≤0.05).

Independent t-test to compare the means of the two groups at each time point indicated that there was no significant difference between the extroverted training and extroverted retraining groups in terms of creatine kinase changes at time intervals of 1, 26, and 48 hours after the activity (p=0.634, p=0.537, p=.654, respectively).

Examination of within-group effects using Bonferroni's post hoc test showed that the level of lactate dehydrogenase in the high-intensity resistance training group significantly increased at time intervals of 1, 26, and 48 hours after activity compared to baseline, (p=0.003, p=0.026, p=0.044, respectively). Also, examining within-group effects using Bonferroni's post hoc test showed that the level of lactate dehydrogenase in the resistance training and retraining group increased at intervals of 1, 26 and 48 hours after retraining compared to the baseline, but this increase was not significant (p=0.034, p=0.023, p=0.041, respectively).

Table 3: Comparison of mean and standard deviation of dependent variable creatine kinase before and after extroversion training and extroversion retraining

Statistics / Variable	Physical activity stage	group		Significance level p*
		Resistance training	Resistance training and retraining	
Creatine kinase (International units per liter)	Pre-test (baseline)	176±109	159±90	-
	1 hour after training	218±121	221±114	0.634
	Significance level p**	0.003*	0.034*	
	26 hours after Resistance training (equivalent to 2 hours after retraining)	227±114	217±120	0.537
	Significance level p**	0.026*	0.023*	
	48 hours after training (equivalent to 24 hours after retraining)	219±114	205±104	0.654
	Significance level p**	0.044*	0.041*	

P* Significant difference with baseline at level ($p \leq 0.05$). P** Significant difference with control group at level ($p \leq 0.05$).

Independent t-test to compare the means of the two groups at each time point indicated that there was no significant difference between the extroverted training and retraining groups in terms of changes in aspartate aminotransferase at time intervals of 1, 26, and 48 hours after activity (p=0.734, p=0.0243, p=0.335, respectively).

Examination of within-group effects using Bonferroni's post hoc test showed that the level of lactate dehydrogenase in the high-intensity resistance training group significantly increased at time intervals of 1, 26, and 48 hours after activity compared to baseline, (p=0.013, p=0.026, p=0.037, respectively). Also, examining within-group effects using Bonferroni's post hoc test showed that the level of lactate dehydrogenase in the resistance training and retraining group increased at intervals of 1, 26 and 48 hours after retraining compared to the baseline, but this increase was not significant (p=0.044, p=0.037, p=0.012, respectively).

Table 4: Comparison of the mean and standard deviation of the dependent variable aspartate aminotransferase before and after extroversion training and extroversion retraining

Statistics / Variable	Physical activity stage	group		Significance level p*
		Resistance training	Resistance training and retraining	
Aspartate aminotransferase (International Units per liter)	Pre-test (baseline)	22.2±0.88	22.3±0.90	-
	1 hour after training	24.8±0.21	24.1±0.14	0.734
	Significance level p**	0.013*	0.044*	
	26 hours after training (equivalent to	25.7±0.14	25.6±0.20	0.243

	2 hours after retraining)			
	Significance level p**	0.026*	0.037*	
	48 hours after training (equivalent to 24 hours after retraining)	26.9±0.84	26.5±0.64	0.335
	Significance level p**	0.037*	0.012*	

P* significant difference with baseline at level (p≤0.05). P** significant difference with control group at level (p≤0.05).

Discussion

The results of the present study showed that the levels of creatine kinase, lactate dehydrogenase, and aspartate aminotransferase enzymes increased in both resistance training and resistance retraining groups compared to the pre-test at time intervals of 1, 26, and 48. This increase for creatine kinase and aspartate aminotransferase enzymes, in addition to being significant, decreased after 48 hours. And this increase was not significant for lactate dehydrogenase and this increase continued until 48 hours later.

In line with the results of the present study, (Isik & Dogan, 2018), (Isik & Dogan, 2018), (Kanda et al., 2014) stated that resistance activity causes muscle damage by increasing AST, CK, and LDH enzymes. These findings indicated that a session of exogenous resistance exercise causes damage and additional stress to the structural state of skeletal muscle. Since extrinsic activity is performed with muscle stretching, local damage to muscle tissue and fragmentation of the lines and destruction of sarcomeres due to sarcomere stretching can cause permeability or rupture of the cell membrane and leakage of enzymes indicative of muscle fatigue, including the most important AST, CK, and LDH, into the blood or lymphatic system. Also, Santos et al. (2021)

showed that high-intensity exercise is associated with increased delayed muscle fatigue and increased extracellular fluid enzymes AST, CK, and LDH, and the levels of indicators, including AST, CK, and LDH, change depending on the type of exercise, its intensity, and its volume (Dos Santos et al., 2021). The results of some studies were inconsistent with the present study. Motameni et al. (2020) reported that a single session of resistance exercise had no significant effect on muscle damage indices in male athletes. Perhaps one of the reasons for the discrepancy in their findings with the present study is the lower intensity of exercise (60% of one repetition maximum) compared to the present study (80% of one repetition maximum) or the difference in intensity and duration of the activity or the type of subjects (athletes or non-athletes). In addition, Evans et al. (1998) reported no significant difference between the increase in muscle damage indices after resistance exercise of the same duration at an intensity of 60 and 80% of maximum voluntary contraction (Motameni et al., 2020). This discrepancy could be due to the difference in the number of contractions or the type of activity used.

Although the main mechanism involved in muscle injury is still not precisely known, the consensus hypothesis is that following intense resistance exercise, initial mechanical injury causes an increase in intracellular calcium, inhibition of cellular respiration, and activation of the Z-line, troponin, and tropomyosin degradation pathways, which in turn stimulates an inflammatory response (increase in neutrophils) (Tavvafian et al., 2020). The accumulation of materials resulting from the destruction of cellular structures during the 6-12 hours after exercise causes the influx of monocytes to the site, which transform into macrophages, characterized by subsequent edema and swelling. The presence of macrophages at the site of injury leads to the biosynthesis of prostaglandins and the stimulation of pain-related nerves (Azizbeigi et al., 2015). Overall, this study showed that performing extroverted training significantly increases biochemical indices of creatine kinase, lactate dehydrogenase, and aspartate aminotransferase in inactive individuals at 1, 26, and 48 hours after exercise (Nikolaidis, 2017). Such

changes appear to be associated with mechanical damage, inflammatory responses, and delayed muscle soreness. Therefore, it is recommended that non-athletes and their coaches start the activity gradually and slowly to reduce muscle damage caused by activities that involve resistance contractions. Another result of the present study showed that performing resistance training had no significant effect on the measured indices. Therefore, it is suggested that in order to achieve comprehensive results about the effects of performing retraining, different protocols such as extroverted retraining (unlike the present study) and with different intensities and volumes should be used.

Conclusion

According to the results of the present study, it can be concluded that resistance retraining cannot be a significant influencing variable on the amount of muscle damage. However, more research in this field is needed.

Conflict of interest

The authors declare that there is no conflict of interest.

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