Journal of Exercise and Health Science, Vol. 02, No. 04, Fall 2022, Page 01-15

Research Paper

Effects of Eight Weeks of Progressive Resistance Training and a Subsequent Detraining Period on Post-Diastolic Wall Thickness (PWT) and Interventricular Septal Thickness (IVST) in Sedentary Women

Hassan Naghizade Ghezel Ahmad[1], Hamidreza Fallah Yakhdani[2], Solale Hosseinzade[3], Alireza Babaei Mazreno[4*]

1. Assistant Professor, Faculty of Physical Education and Sports Sciences, Ardakan, Yazd, Iran
2. Assistant Professor, Department of Physical Education and Sports Sciences, Faculty of Psychology and Educational Sciences, Yazd, Iran
3. MSc in Sports Physiology, Yazd Azad University, Yazd, Iran
4. Ph.D. Student in Sports Physiology, Education Organization, Yazd, Iran

Received: 2022/09/02 **Accepted: 2022/12/07**

Abstract

Objective: Physical activity acts as a stimulus for improving cardiovascular risk factors. Therefore, the aim of this research was to investigate the effect of eight weeks of progressive resistance training followed by a detraining period on PWT and IVST indices in sedentary women.

Materials and Methods: In this quasi-experimental study, 32 sedentary women were randomly assigned to two groups: a resistance exercise group (16 subjects) and a control group (16 subjects). PWT and IVST were measured using echocardiography at three stages: before starting the exercise, after 8 weeks of exercise, and after 4 weeks of detraining. The exercise protocol was conducted over 12 weeks, and the collected data were analyzed using independent t-tests, repeated measures analysis of variance, and post hoc tests, with a significance level set at $p < 0.05$ using SPSS 21. **Results**: The mean and standard deviation of the PWT variable in the experimental group were 0.65 ± 0.06 at the pre-test, 0.71 ± 0.05 at the post-test, and 0.66 ± 0.05 during the detraining period. In the control group, these values were 0.70 ± 0.06, 0.68 ± 0.06, and 0.66 ± 0.08, respectively. For the IVST variable, the experimental group had means and standard deviations of 0.65 ± 0.05 at the pre-test, 0.72 ± 0.05 at the post-test, and 0.67 ± 0.04 during the detraining period. The control group had corresponding values of 0.71 ± 0.08, 0.68 ± 0.06, and 0.68 ± 0.08, respectively.

The results indicated a significant difference in PWT and IVST values from the pre-test to the post-test and from the post-test to the end of the detraining period in the experimental group ($p < 0.05$). Additionally, a significant difference in IVST values was observed from the pre-test to the post-test when comparing the experimental and control groups ($p < 0.05$).

Conclusion: The study results suggest that 8 weeks of progressive resistance training resulted in beneficial changes in the structure and function of the heart in sedentary women. However, the 4-week detraining period had adverse effects on these adaptations. Therefore, it is recommended that individuals adhere to exercise regimens systematically and consistently to maintain the benefits achieved and avoid adverse effects from detraining.

Keywords: Progressive Resistance Training, Detraining Period, PWT, IVST, Sedentary Women.

Introduction

An individual's ability to perform sports activities is closely related to the efficiency and performance of various bodily systems. The body's systems have the capacity to adapt to different stimuli and changes, adjusting their tissues to meet incoming demands and the body's needs (Gila, 2022). While all body organs play essential roles in sports activities, the heart's role in supplying the necessary fuel and oxygen, particularly during strenuous physical activities, is particularly crucial (McDonagh, 2021). A healthy heart operates uniquely throughout life, and regular physical activity helps prevent premature aging. Consistent physical activity induces both quantitative and qualitative changes in the heart, leading to beneficial adaptations. When subjected to regular exercise, a healthy heart undergoes changes that support these adaptations, maintaining a consistent and specific rhythm throughout life and resisting the effects of aging (Bazkar, 2021).

Exercise induces structural and functional changes in athletes' hearts, particularly in the left ventricle (Grinougan, 2020). However, the specific effects of exercise on heart structure and function depend on factors such as the type, intensity, duration, and regularity of exercise, as well as initial physical readiness, genetics, and gender (Chu, 2021). Research indicates that long-term and consistent exercise leads to structural changes and adaptations in the left ventricle. Intense, long-term, and repetitive exercise can result in the development of a condition known as 'athlete's heart' (Maddox, 2021; Tucker, 2018). Although sudden cardiac death in young athletes is extremely rare, it receives significant media attention, which heightens concern among the general population. In response to continuous exercise, the athlete's heart exhibits minor changes in internal diameter and more pronounced increases in left ventricular wall thickness (Salzano, 2021). Generally, individuals who engage in regular exercise, compared to non-athletes, have thicker left ventricular walls, larger end-diastolic dimensions, and an enlarged left atrium (Strong, 2018). Some studies have also reported significant increases in wall thickness and left ventricular mass among individuals who perform strength exercises (Gila, 2021). Previous studies have explored the effects of various exercise types, intensities, and durations on individuals of different fitness levels, ages, and genders. Kraemer and colleagues highlighted that detraining, or a period of inactivity following exercise, can diminish the changes induced by exercise, causing them to revert to pre-exercise levels. Detraining is a common phenomenon experienced by many athletes and is inevitably associated with a decline in their performance abilities (Fujiwara, 2021). Various studies have investigated the impact of detraining on cardiovascular and respiratory changes, such as maximal oxygen consumption (Tucker, 2018), muscular and skeletal adaptations, including strength performance (Salzano, 2021), anaerobic power, and metabolic changes like body composition (Strong, 2018) across different time intervals in both athletes and non-athletes. Hansson and colleagues noted that adaptations resulting from endurance exercises are more sensitive to detraining due to their enzymatic basis. In contrast, strength adaptations tend to resist deterioration for a longer time during short periods of detraining, weakening very slowly (Hansson, 2020). Additionally, detraining contributes to reductions in heart and ventricular volumes, which can lead to a decreased stroke volume. Resistance exercise, commonly known as strength or weight training, promotes adaptability in both skeletal and cardiac muscles (Carpes, 2022). Engaging in strength exercises can lead to hypertrophy of the left ventricular chamber due to increased internal pressure. These exercises are associated with a slight increase in the internal diameter and a more substantial increase in the wall thickness of the left ventricle (Salzano, 2021).

Overall, individuals who engage in strength training tend to have greater left ventricular wall thickness, end-diastolic dimensions, and left ventricular chamber diameter compared to non-athletes (Strong, 2018). However, most studies have primarily focused on male athletes, with limited research on the effects of strength training and detraining in women, particularly those with low physical activity. Given that unfavorable physical conditions such as metabolic syndrome, overweight, and obesity are linked to structural, molecular, and functional alterations in vital organs—particularly the cardiovascular system—and can contribute to the development of cardiovascular diseases, it is crucial to enhance organ health at minimal cost whenever possible. Additionally, designing and implementing tailored physical exercise programs aligned with research objectives can help address the many unanswered questions about cardiovascular system adaptations in the absence of exercise. Another important aspect of this research for the community of physically inactive women in Yazd is the examination of the effects of detraining following resistance exercise. Understanding these effects can help prevent the prevalence of cardiovascular diseases. By implementing the exercise protocol designed in this study, it is anticipated that, in addition to potential changes in body composition among physically inactive women, there will also be effects on the structure and function of the left ventricle. Few studies have investigated the effects of resistance training on cardiac structure, and the impact of detraining following such training on the heart's structural characteristics remains underexplored. Therefore, further research is needed to examine the independent effects of resistance exercise and detraining on the structural features of the heart, particularly the left ventricle.

In summary, the primary goal of this study is to determine whether 8 weeks of progressive resistance training, followed by a period of detraining, has a significant impact on Post-Diastolic Wall Thickness (PWT) and Interventricular Septal Thickness (IVST) in physically inactive women.

Research Method

In this quasi-experimental field study, 32 sedentary women, aged 37.45 ± 5.46 years and capable of regular participation in the exercise protocol, were randomly selected and divided into two groups: 1) a Resistance Exercise Group (16 individuals) and 2) a Control Group (16 individuals). The inclusion criteria for the research were: general health and full cardiovascular health (confirmed by a physician), no medication use, no use of sports supplements, non-smoker status, regular participation in the research process for 12 weeks, and no regular or professional physical activities for 6 months prior to the start of the study. The training schedule for the participants included the following: 1. **1RM Bench Press:** Calculated using the specified equation; 2. **1RM Leg Press:** Calculated using the specified equation; 3. **Electrocardiography:** Assessment of structural and functional heart indices.

Determination of One-Repetition Maximum (1RM): Prior to the main exercise protocol, a familiarization session was conducted due to the participants' novice status. Following this, participants received instruction on proper exercise techniques. They then visited the gym at 5:00 PM to determine their one-repetition maximum (1RM) for the specified exercises.

The one-repetition maximum (1RM) for the specified exercises (Leg Press, Bench Press with a barbell, Seated Row, Sit-up, Calf Raise, Lying Leg Curl, Shoulder Press, Lat Pulldown, Chin-up, and Front Arm Dumbbell Raise) was estimated using the Brzycki equation (1993). To calculate the maximum strength, participants selected a weight based on an initial estimate and performed the exercise to fatigue. The weight used and the number of repetitions completed were then input into the Brzycki equation to estimate the 1RM. In this test, the number of repetitions typically ranged from 6 to 8. For example, suppose that a person in this test repeated the Bench Press movement with a weight of 90 kg seven times; their maximum strength was calculated as follows: (0.0278 × the number of repetitions to fatigue) - 0.0278 / weight moved (kg). In this example: (0.0278 × 7) - 0.0278 / 90 (kg) ≈ 108 kg In the current study, all anthropometric characteristics, as well as the structural and functional parameters of the left ventricle, were measured and recorded at three stages: before the exercise protocol, after 8 weeks of resistance exercise, and after 4 weeks of detraining following the 8 weeks of exercise.

Structural and functional heart variables, including Post-Diastolic Wall Thickness (PWT) and Interventricular Septal Thickness (IVST), were measured using a Zonare echocardiography device (USA, 2012 model) with M-Mode, Spectral Doppler, and 2-D Color Doppler techniques. Measurements were taken in a specialized echocardiography room. Resting heart rate was recorded by counting the pulse for 60 seconds. Prior to the echocardiography, height and weight were measured using a laboratory scale equipped with a height gauge. The exercise program comprised 3 sessions per week, each lasting 90 minutes, conducted at the gym of the Islamic Azad University, Yazd Branch. This 8-week program featured varying intensity levels and was designed based on the principle of progressive overload. The progressive resistance exercise program was designed according to the principles of resistance training and its effects on fat tissue and muscle mass. After participants became familiar with the correct execution of the exercises, the resistance training protocol was implemented for 8 weeks.

Table 3-3- Weightlifting Exercises Performed in Each Exercise Session

Exercises	Muscles Engaged in the Movement
Bench Press	Pectoralis major, pectoralis minor, triceps (all three heads), anterior deltoid, upper pectoral, lower pectoral, anterior serratus
Leg Press	Inner thigh, mid-thigh, quadriceps, outer thigh, vastus lateralis, biceps femoris (bicep of the thigh), semi-tendinous, and membranous
Seated Row	Neck vertebrae flexors, pectoralis major, rectus abdominis, special oblique, quadriceps, shoulder
Lat Pulldown	Pectoralis major, latissimus dorsi, triceps (long head), posterior deltoid, teres major, triceps (small head), pectoralis minor, long head extensor
Hamstring Curls	Semi-membranous, semi-tendinous, biceps femoris, twins

Exercises	Muscles Engaged in the Movement
Shoulder Press (Rear)	Strengthens the shoulder and trapezius muscles
Standing Calf Raises	Twins, soleus, plantar
Front Bicep with EZ Bar	Biceps (both heads), brachialis, anterior deltoid, long head bicep, forearm

These exercises were performed from the first through the eighth session. All data are presented as mean ± standard deviation. Initially, the Shapiro-Wilk test was used to assess the normality of distributions, and Levene's test was applied to check for equality of variances. Subsequent analyses included independent t-tests, repeated measures analysis of variance, and Bonferroni post hoc tests for hypothesis testing. The significance level was set at $p < 0.05$, and all computations were performed using SPSS 21.

Results

Based on the research results, the mean age, height, and weight were 46.5 ± 37.45 years, 40.5 ± 56.16 cm, and 26.10 ± 61.70 kg, respectively.

The results presented in Tables 4-5 indicate that the distribution of the measured variables is normal, as the p-value exceeds the 0.05 significance level, suggesting no significant deviations from normality.

Table 4-5- Shapiro-Wilk Test Results for Data Distribution Normality

Variable	Group	Experimental (16=n)	Control (16=n)	Time	Df	p-value	Df	p-value
PWT	Pre	16	16	Pre	16	0.057	16	0.081
	Post	16	16	Post	16	0.066	16	0.076
	No Exercise	16	16	No Exercise	16	0.059	16	0.071
IVST	Pre	16	16	Pre	16	0.332	16	0.765
	Post	16	16	Post	16	0.543	16	0.617
	No Exercise	16	16	No Exercise	16	0.437	16	0.476

Results of Tables 4-6: Results presented in Tables 4-6 indicate that the p-values are greater than 0.05, supporting the acceptance of the equality of variances (homogeneity of variances), which is a key assumption for conducting parametric statistical tests.

Table 4-6: Levene's Test Results for Equality of Variances

Variable	Time	F	df1	df2	p-value
PWT	Before	491.0	1	30	0.489
	After	662.0	1	30	0.422
	Control	74.2	1	30	0.160
IVST	Before	49.2	1	30	0.163
	After	52.0	1	30	0.821
	Control	524.0	1	30	0.475

Results of Tables 4-7: The results in Table 4-7, comparing the means of dependent variables at the pre-test stage, show no significant difference between the two groups, as the p-value is greater than 0.05. This lack of significance indicates that the groups are homogeneous at the pre-test stage, allowing for the use of parametric statistical tests in hypothesis testing.

Table 4-7- One-Way ANOVA Results for Comparing Pre-Test Means of Dependent Variables (32n=)

Variable	Measure	SS	df	MS	F	p-value
PWT	Between-Group	20.0	1	20.0	660.4	0.059
	Within-Group	129.0	30	4.0		
	Total	149.0	31			
IVST	Between-Group	31.0	1	31.0	818.6	0.114
	Within-Group	138.0	30	5.0		
	Total	169.0	31			

Results of Table 4-16: The results in Table 4-16 show that at the 0.05 significance level (α), there is a significant difference in PWT values between the pre-test and post-test for the experimental and control groups ($P < 0.05$). Additionally, a significant difference is observed from the post-test to the end of the no-exercise period ($P < 0.05$). Thus, the thickness of the left ventricular posterior wall significantly increases from the pre-test to the post-test and significantly decreases from the post-test to the end of the no-exercise period.

Table 4-16- One-Way Analysis of Variance (ANOVA) Results with Repeated Measurements on PWT Values

Variable	Group	Time	SS	df	MS	F	P	Effect Size
PWT	Exercise	Pre-Post-Test	23.0	1	23.0	138.18	0.001*	0.547
		Post-Test-End of No-Ex	18.0	1	18.0	196.9	0.008*	0.380
	Control	Pre-Post-Test	5.0	1	5.0	0.5	0.041*	0.250
		Post-Test-End of No-Ex	3.0	1	3.0	1.9	0.188	0.113

Significant difference at the 0.05 level (P < 0.05).

Table 4-17- One-Way Analysis of Variance (ANOVA) Results with Repeated Measurements on PWT from Pre-Test to End of No-Exercise Period (Three Measurement Stages)

Variable	Group	SS	df	MS	F	P	Effect Size
PWT	Exercise	27.0	2	13.0	427.8	0.001*	0.360
	Control	15.0	2	8.0	187.5	0.012*	0.257

Significant difference at the 0.05 level (P < 0.05).

Results of Table 4-17: The results in Table 4-17 indicate that, at the 0.05 significance level (α), there is a significant difference in PWT values from the pre-test to the end of the no-exercise period across the three measurement stages when comparing the groups (P < 0.05). To identify the specific locations of these within-group differences, a Bonferroni post hoc test was conducted, with results detailed in Table 4-18.

Table 4-18- Bonferroni Post Hoc Test Results between PWT Values

Variable	Group	Time	Pre-Test	Post-Test	End of No-Exercise
PWT	Exercise	Pre-Test	---	53.0 = MD	6.0 = P
		Post-Test	---	---	47.0 = MD
	Control	Pre-Test	---	25.0 = MD	12.3 = P
		Post-Test	---	---	19.0 MD

Significant difference at the 0.05 level (P < 0.05).

Table 4-20: One-Way Analysis of Variance (ANOVA) Results with Repeated Measurements on IVST Values

Variable	Group	Time	SS	df	MS	F	P	Effect Size
IVST	Exercise	Pre-Post-Test	38.0	1	38.0	862.20	0.001*	0.582
		Post-Test-End of No-Ex	20.0	1	20.0	1000.15	0.002*	0.500
	Control	Pre-Post-Test	5.0	1	5.0	0.005	0.041*	0.250
		Post-Test-End of No-Ex	0.0	1	0.0	0.001	0.333	0.063

Significant difference at the 0.05 level (P < 0.05).

Table 4-21- One-Way Analysis of Variance (ANOVA) Results with Repeated Measurements on IVST from Pre-Test to End of No-Exercise Period (Three Measurement Stages)

Variable	Group	SS	df	MS	F	P	Effect Size
IVST	Exercise	40.0	2	20.0	316.15	0.001*	0.505
	Control	9.0	2	4.0	339.5	0.010*	0.263

Significant difference at the 0.05 level (P < 0.05).

Results of Table 4-21: The results in Table 4-21 show that, at the 0.05 significance level (α), there is a significant difference in IVST values from the pre-test to the end of the no-exercise period across the three measurement stages when comparing the groups (P < 0.05). To identify the specific locations of these within-group differences, a Bonferroni post hoc test was performed, with the results presented in Table 4-22.

Table 4-22- Bonferroni Post Hoc Test Results Between IVST Values

Variable	Group	Time	Pre-Test	Post-Test	End of No-Exercise
IVST	Exercise	Pre-Test	---	69.0 = MD	19.0 = P
		Post-Test	---	---	50.0 = MD
	Control	Pre-Test	---	25.0 = MD	31.0 = P
		Post-Test	---	---	6.0 MD

Significant difference at the 0.05 level (P < 0.05).

Table 4-23- Independent t-test results for showing the difference in IVST means between groups

Variable	Group	Time	Difference	T	df	P	MD
IVST	Exercise	Pre-Post-Test	6.0±6.0	1000.1	30	0.001*	9.0
	Control	Pre-Post-Test	4.0±2.0	5.0	---	0.005*	0.4
	Exercise	Post-End of No-Exercise	5.0±5.0	500.3	30	0.002*	0.5
	Control	Post-End of No-Exercise	2.0±6.0	4.0	---	0.010*	0.2

Significant difference at the 0.05 level ($P < 0.05$).

Conclusion

The results in Table 4-20 indicate a significant difference in IVST values between the exercise and control groups, both from pre-test to post-test and from post-test to the end of the no-exercise period ($P < 0.05$). The eight weeks of resistance training led to a significant increase in IVST among sedentary women. Furthermore, Table 4-21 shows a significant difference in IVST values from pre-test to the end of the no-exercise period (across three measurement stages) when comparing the groups ($P < 0.05$). Consequently, a Bonferroni post hoc test was conducted to identify the specific within-group differences, with the results presented in Table 4-22.

Based on the findings from Tables 4-22 and 4-23, it can be concluded that eight weeks of resistance training significantly increased IVST in sedentary women. However, the subsequent four-week period of inactivity resulted in a significant reduction in the positive effects of the resistance training on IVST. This indicates that a four-week period of inactivity can diminish the benefits of resistance training on IVST in sedentary women.

The results of this research reveal significant differences in PWT values between the pre-test and post-test for both the experimental and control groups ($p < 0.05$). Moreover, significant differences were also observed from the post-test to the end of the detraining period within the exercise group ($p < 0.05$). The results show that the mean thickness of the left ventricular posterior wall at end-diastole (PWT) in the experimental group was 0.65±0.06 at the pre-test stage, 0.71±0.05 at the post-test stage, and 0.66±0.05 at the detraining stage. In the control group, the mean PWT values were 0.70±0.06 at the pre-test stage, 0.68±0.06 at the post-test stage, and 0.66±0.08 at the detraining stage. These results indicate that eight weeks of resistance training led to an increase in PWT, and the subsequent four-week detraining period had a positive effect on preserving the adaptations achieved during the training. Therefore, the thickness of the left ventricular posterior wall at end-diastole (PWT) significantly increased from the pre-test to

the post-test and then decreased from the post-test to the end of the detraining period.
Results from Table 4-16 indicate that, at a significance level of $\alpha = 0.05$, there are significant differences in PWT values between the pre-test and post-test when comparing the experimental and control groups ($p < 0.05$). Furthermore, significant differences were also observed in the exercise group from the post-test to the end of the detraining period ($p < 0.05$). Results from Table 4-17 indicate that, at a significance level of $\alpha = 0.05$, there are significant differences in PWT values from the pre-test to the end of the detraining period (measured at three time points) when comparing the groups ($p < 0.05$). To identify the specific location of these intra-group differences, a Bonferroni post hoc test was conducted, and the results are detailed in Table 4-18. Results from Table 4-18 indicate that in the exercise group, PWT values are significantly different from the pre-test to the post-test and from the post-test to the end of the detraining period ($p < 0.05$). Similarly, in the control group, significant differences were observed in PWT values from the pre-test to the end of the detraining period ($p < 0.05$).
To analyze the differences between the groups regarding PWT values, an independent t-test was conducted to compare the pre-test and post-test means (Gain Score) across the groups. The results of this analysis are presented in Table 4-19. Results from Table 4-19 indicate that the comparison of PWT values between the two groups reveals significant differences based on the pre-test to post-test difference (Gain Score) ($p < 0.05$). Additionally, Table 4-19 shows that there are significant differences in PWT values between the experimental and control groups based on the post-test to detraining period difference ($p < 0.05$). Based on the interpretations of the inferential tests for the fifth hypothesis, the null hypothesis—stating that 8 weeks of increasing resistance training has no significant effect on the thickness of the left ventricular posterior wall at end-diastole (PWT) in low-active women—is rejected. The research hypothesis, which suggests that 8 weeks of increasing resistance training has a significant effect on PWT, is supported. Therefore, it can be concluded that 8 weeks of increasing resistance training significantly increases the thickness of the left ventricular posterior wall at end-diastole (PWT) in low-active women. On the other hand, the interpretations of the inferential tests lead to the rejection of the null hypothesis, which states that 4 weeks of detraining following 8 weeks of increasing resistance training has no significant effect on the thickness of the left ventricular posterior wall at end-diastole (PWT) in low-active women. The research hypothesis, which suggests that 4 weeks of detraining can significantly reduce the positive effects of the resistance training on PWT, is supported. Therefore, 4 weeks of detraining following the resistance training period leads to

a significant reduction in the positive effects of the training on the thickness of the left ventricular posterior wall at end-diastole in low-active women. The results in this section of the research are consistent with studies by Hajighasemi et al. (1389) and Shabkhiz et al. (1393). An increase in ventricular wall thickness is viewed as an adaptation to the elevated blood pressures experienced during strength exercises. It is plausible that resistance exercises elevate blood pressure to a level that triggers structural adaptations in the heart. The exercise regimen may be structured in a manner that induces changes in the thickness of the left ventricular walls. Additionally, the high sensitivity of these variables to the resistance exercise regimen could explain the significant increase in the thickness of the left ventricular walls, both absolutely and relatively, observed in the experimental group during the post-test. Furthermore, the results revealed significant differences in IVST values from the pre-test to the post-test when comparing the experimental and control groups ($p < 0.05$). However, significant differences from the post-test to the end of the detraining period were observed only in the experimental group ($p < 0.05$).

As shown in Table 4-4, the mean thickness of the interventricular septum at end-diastole (IVST) in the experimental group was 0.65±0.05 at the pre-test stage, 0.72±0.05 at the post-test stage, and 0.67±0.04 at the detraining stage. In the control group, the mean IVST values were 0.71±0.08 at the pre-test stage, 0.68±0.06 at the post-test stage, and 0.68±0.08 at the detraining stage. This indicates that 8 weeks of increasing resistance training were associated with an increase in IVST, while the 4-week detraining period that followed helped maintain the adaptations achieved during the training. Therefore, the thickness of the interventricular septum at end-diastole significantly increased from the pre-test to the post-test and subsequently decreased from the post-test to the end of the detraining period.

Table 4-20 shows that, at a significance level of $\alpha = 0.05$, there are significant differences in IVST values from the pre-test to the post-test when comparing the experimental and control groups ($p < 0.05$). However, significant differences from the post-test to the end of the detraining period were observed only in the experimental group ($p < 0.05$).Results from Table 4-21 indicate that, at a significance level of $\alpha = 0.05$, there are significant differences in IVST values from the pre-test to the end of the detraining period (measured at three time points) when comparing the groups ($p < 0.05$). To identify the specific location of these intra-group differences, a Bonferroni post hoc test was conducted, and the results are detailed in Table 4-22. Results from Table 4-22 show that in the exercise group, IVST values are significantly different from the pre-test to the post-test and from the post-test to the detraining period ($p < 0.05$).

Table 4-23 indicates that the comparison of IVST values between the experimental and control groups reveals significant differences based on the pre-test to post-test difference ($p < 0.05$). Additionally, IVST values between the experimental and control groups are significantly different based on the post-test to detraining period difference ($p < 0.05$). Based on the interpretations of the inferential tests, the null hypothesis—that 8 weeks of increasing resistance training has no significant effect on the thickness of the interventricular septum at end-diastole (IVST) in low-active women—is rejected. The research hypothesis, which suggests that 8 weeks of increasing resistance training significantly affects the thickness of the interventricular septum at end-diastole (IVST) in low-active women, is supported. Therefore, 8 weeks of increasing resistance training can lead to a significant increase in the thickness of the interventricular septum at end-diastole (IVST) in low-active women. On the other hand, the interpretations of the inferential tests lead to the rejection of the null hypothesis, which states that 4 weeks of detraining following 8 weeks of increasing resistance training has no significant effect on the thickness of the interventricular septum at end-diastole (IVST) in low-active women. The research hypothesis, which suggests that 4 weeks of detraining can lead to a significant reduction in the positive effects of resistance training on IVST, is supported.

In conclusion, the results of this study demonstrate that 8 weeks of increasing resistance training lead to beneficial changes and adaptations in both PWT and IVST.,

References

1. Crisci, G., De Luca, M., D’Assante, R., Ranieri, B., D'Agostino, A., Valente, V., Giardino, F., Capone, V., Chianese, S., Rega, S., Cocchia, R., Israr, M. Z., Debiec, R., Heaney, L. M., & Salzano, A. (2022). Effects of Exercise on Heart Failure with Preserved Ejection Fraction: An Updated Review of Literature. *Journal of Cardiovascular Development and Disease, 9*, 241.
2. McDonagh, T. A., Metra, M., Adamo, M., Gardner, R. S., Baumbach, A., Böhm, M., ... & Chioncel, O. (2022). 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. *European Journal of Heart Failure, 24*, 4-131.
3. Bozkurt, B., Coats, A. J. S., Tsutsui, H., Abdelhamid, C. M., Adamopoulos, S., Albert, N., ... & Universal Definition of Heart Failure: Endorsed by the Canadian Heart Failure Society, Heart Failure Association of India, Cardiac Society of Australia and New Zealand, and Chinese Heart Failure Association. (2021). Universal definition and classification of heart failure: A report of the Heart Failure Society of America, Heart Failure Association of the European Society of Cardiology, Japanese Heart Failure Society, and Writing Committee of the

Universal Definition of Heart Failure. European Journal of Heart Failure, 23, 352-380.
4. Groenewegen, A., Rutten, F. H., Mosterd, A., & Hoes, A. W. (2020). Epidemiology of heart failure. *European Journal of Heart Failure, 22*, 1342-1356.
5. Cho, D. H., & Yoo, B. S. (2021). Current Prevalence, Incidence, and Outcomes of Heart Failure with Preserved Ejection Fraction. Heart Failure Clinics, 17, 315-326.
6. Maddox, T. M., Januzzi, J. L., Allen, L. A., Breathett, K., Butler, J., Davis, L. L., ... & Masoudi, F. A. (2021). 2021 Update to the 2017 ACC Expert Consensus Decision Pathway for Optimization of Heart Failure Treatment: Answers to 10 Pivotal Issues About Heart Failure With Reduced Ejection Fraction: A Report of the American College of Cardiology Solution Set Oversight Committee. *Journal of the American College of Cardiology, 77*, 772-810.
7. Tucker, W. J., Lijauco, C. C., Hearon, C. M., Angadi, S. S., Nelson, M. D., Sarma, S., ... & Haykowsky, M. J. (2018). Mechanisms of the Improvement in Peak VO2 With Exercise Training in Heart Failure With Reduced or Preserved Ejection Fraction*. Heart, Lung and Circulation, 27*, 9-21.
8. Anker, S. D., Butler, J., Filippatos, G., Ferreira, J. P., Bocchi, E., Böhm, M., ... & Empagliflozin in Heart Failure with a Preserved Ejection Fraction. (2021). *New England Journal of Medicine*, *385*, 1451-1461.
9. Fujiwara, K., Shimada, K., Nishitani-Yokoyama, M., Kunimoto, M., Matsubara, T., Matsumori, R., ... & Shimizu, M. (2021). Arterial Stiffness Index and Exercise Tolerance in Patients Undergoing Cardiac Rehabilitation. *International Heart Journal*, *62*, 230-237.
10. Salzano, A., De Luca, M., Israr, M. Z., Crisci, G., Eltayeb, M., Debiec, R., ... & Rega, S. (2021). Exercise Intolerance in Heart Failure with Preserved Ejection Fraction. *Heart Failure Clinics*, *17*, 397-413.
11. Streng, K. W., Nauta, J. F., Hillege, H. L., Anker, S. D., Cleland, J. G., Dickstein, K., ... & Ng, L. L. (2018). Non-cardiac comorbidities in heart failure with reduced, mid-range, and preserved ejection fraction. *International Journal of Cardiology*, *271*, 132-139.
12. de Barcelos, G. T., Heberle, I., Coneglian, J. C., Vieira, B. A., Delevatti, R. S., & Gerage, A. M. (2022). Effects of Aerobic Training Progression on Blood Pressure in Individuals with Hypertension: A Systematic Review with Meta-Analysis and Meta-Regression. *Frontiers in Sports and Active Living, 4*, 719063.
13. Henson, J., Edwardson, C. L., Davies, M. J., Gill, J. M. R., Heaney, L. M., Khunti, K., ... & Yates, T. (2020). Physical Activity and Lipidomics in a Population at High Risk of Type 2 Diabetes Mellitus. *Journal of Sports Sciences, 38,* 1150-1160.
14. Green, D. J., Hopman, M. T. E., Padilla, J., Laughlin, M. H., & Thijssen, D. H. J. (2017). Vascular Adaptation to Exercise in Humans: Role of Hemodynamic Stimuli. *Physiological Reviews, 97*, 495-528.
15. Ambrosetti, M., Abreu, A., Corra, U., Davos, C. H., Hansen, D., Frederix, I., ... & Vigorito, C. (2021). Secondary Prevention Through Comprehensive Cardiovascular Rehabilitation: From Knowledge to Implementation. 2020 Update. A Position Paper from the Secondary Prevention and Rehabilitation Section of the European

Association of Preventive Cardiology. *European Journal of Preventive Cardiology*, *28*, 460-495.

16. Pandey, A., LaMonte, M., Klein, L., Ayers, C., Psaty, B. M., Eaton, C. B., ... & Greenland, P. (2017). Relationship Between Physical Activity, Body Mass Index, and Risk of Heart Failure. *Journal of the American College of Cardiology*, *69*, 1129-1142.
17. Piepoli, M. F., Abreu, A., Albus, C., Ambrosetti, M., Brotons, C., Catapano, A. L., ... & European Association of Preventive Cardiology of the European Society of Cardiology. (2020). Update on Cardiovascular Prevention in Clinical Practice: A Position Paper of the European Association of Preventive Cardiology of the European Society of Cardiology. *European Journal of Preventive Cardiology*, *27*, 181-205.
18. Knuuti, J., Wijns, W., Saraste, A., Capodanno, D., Barbato, E., Funck-Brentano, C., ... & European Society of Cardiology (ESC). (2020). 2019 ESC Guidelines for the Diagnosis and Management of Chronic Coronary Syndromes: The Task Force for the Diagnosis and Management of Chronic Coronary Syndromes of the European Society of Cardiology (ESC). *European Heart Journal*, *41*, 407-477.