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COMPARATIVE EFFECTS OF DELORME AND MACQUEEN QUADRICEPS MUSCLE RESISTANCE TRAINING ON CARDIORESPIRATORY PARAMETERS IN YOUNG POPULATION

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Abstract

Improving cardiorespiratory fitness is crucial for supporting overall health and well-being, particularly in young individuals. While resistance training is traditionally known for improving muscular strength and endurance, recent evidence highlights its significant benefits for cardiorespiratory fitness as well.

Objective: *This study sought to assess and compare the effectiveness of DeLorme's and MacQueen's protocols on cardiorespiratory parameters through bilateral quadriceps resistance exercises in healthy young adults aged 20 to 30 years.*

Methods: *A randomized clinical trial was conducted involving 30 participants, who were randomly assigned into two evenly distributed groups. Group A underwent bilateral quadriceps resistance training following DeLorme's protocol, with four sessions per week over a three-week period. Group B followed MacQueen's protocol combined with baseline jump squat exercises, completing three sessions per week for three weeks.*

Sampling size and settings: *A convenient sampling method was employed to select 30 participants, who were trained at Goals Gym, Titans Gym, and Al Fahad Fitness Center. Data analysis was performed using SPSS version 23.*

Results: *Both DeLorme and MacQueen resistance training protocols led to significant reductions in systolic blood pressure (SBP), diastolic blood pressure (DBP), respiratory rate (RR), and heart rate (HR). However, the MacQueen protocol demonstrated a more pronounced effect on systolic blood pressure and respiratory rate compared to the DeLorme protocol.*

Conclusion: *Both DeLorme and MacQueen resistance training protocols had significant effects on cardiorespiratory parameters; however, the MacQueen protocol produced more pronounced improvements compared to the DeLorme protocol.*

INTRODUCTION

Cardiorespiratory fitness (CRF) refers to the capacity of the circulatory and respiratory systems to supply oxygen to the mitochondria in skeletal muscles for energy production during physical activity. It serves as

Frontier in Medical & Health Research
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a key indicator of both physical and mental health, as well as academic performance in young individuals [1].

Low or inadequate cardiorespiratory fitness (CRF) is a strong, independent predictor of cardiovascular disease (CVD) and overall mortality in both adults and young people. Alarmingly, it is estimated that only around 40% of adolescents aged 12 to 15 in the United States possess a healthy level of CRF [2]. Furthermore, cardiorespiratory fitness (CRF) has declined over the past six decades both in the United States and globally. While the exact causes remain unclear, factors such as rising obesity rates, increased sedentary behavior, reduced engagement in moderate to vigorous physical activity, and various social and economic shifts are likely contributors [3, 4].

Chronic cardiorespiratory impairments result in a reduction of quadriceps femoris muscle mass, alongside an increase in connective tissue and fibrosis. These changes cause a decline in contractile ability, leading to reduced strength and impaired balance during walking or standing. Additionally, there is a shift from oxidative to anaerobic muscle fibers, causing the muscles to fatigue more quickly. An increase in intramuscular fat, accompanied by local and systemic metabolic changes that elevate cardiovascular risk, also occursThe quadriceps muscle is often impacted in individuals with chronic cardiorespiratory conditions, with females experiencing more pronounced functional impairments than males [5].

Exercise-induced improvements in cardiorespiratory fitness (CRF) are due to structural and functional adaptations that enhance oxygen delivery, such as increased blood volume, improved heart muscle contractility, greater ventricular compliance, and angiogenesis, all of which contribute to increased cardiac output. [6] Cardiorespiratory fitness (CRF) not only reflects an individual's history of physical activity but also indicates their capacity for future aerobic exercise. Higher CRF levels support greater physical activity, creating a positive cycle that promotes an active and fit lifestyle. [7].

The concept of Progressive Resistance Exercise (PRE) was first introduced by Thomas L. Delorme nearly 60 years ago [8]. This dynamic resistance training method involves applying an external load to contracting muscles and progressively increasing the load as muscle strength develops [9]. Progressive resistance exercise (PRE) encompasses three strengthening methods: the Delorme and Watkins technique, the MacQueen technique, and the Oxford technique. Resistance levels in PRE are determined and advanced based on the repetition maximum [10]. Repetition maximum (rep max) refers to the maximum weight (load) a muscle can lift or move a specific number of times within its full range of motion (ROM) [11] . It is commonly measured as the one-repetition maximum (1RM), which represents the heaviest weight that can be lifted once with correct form through the full available range of motion against gravity [12]. Likewise, the 10-repetition maximum (10RM) is the heaviest load that can be lifted 10 times with proper form through the full range of motion against gravity [13].

The McQueen technique, developed by Dr. Robert McQueen in the 1950s, is a form of progressive resistance training (PRT) that modifies the DeLorme method. McQueen's protocol requires performing four sets of 10 repetitions at 100% of the 10-repetition maximum (10RM). In contrast, DeLorme's protocol involves three sets of 10 repetitions, beginning with 50% of the repetition maximum in the first set, increasing to 75% in the second, and reaching 100% in the third set [14].

These exercises have been shown to enhance cardiac function. The resistance encountered during the exercises prompts stronger contractions of the heart muscle, leading to increased thickness of the left ventricular wall as well as greater mass of the left ventricle and the septum [19]. These adaptations cause an increase in cardiac output and stroke volume, which subsequently leads to a decrease in heart rate.

During exercise, oxygen demand rises, leading to increased blood flow to the working muscles. Heart rate (HR) is controlled by impulses generated by the sinoatrial (SA) node, which is influenced by various factors. Heart rate is regulated by parasympathetic and sympathetic nervous systems. After at least 3–5 weeks of resistance training, sympathetic activity decreases and parasympathetic inhibition at rest is reduced, leading to a lower resting heart rate [15].

Progressive resistance training (PRT) improves endothelial function by boosting the production of nitric oxide (NO), a powerful vasodilator. This

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enhancement increases arterial elasticity and decreases peripheral vascular resistance, contributing to lower blood pressure. Additionally, resistance training helps reduce arterial stiffness, a major factor in hypertension. Overall, PRT is linked to greater nitric oxide availability, improved sympathetic nervous system regulation, and enhanced endothelial health [16]. Long-term resistance training has been demonstrated to decrease overactivity of the sympathetic nervous system (SNS). Reduced SNS activity results in less vasoconstriction and a lower heart rate, both of which help to reduce blood pressure [17].

Progressive resistance training (PRT) strengthens the diaphragm, intercostal muscles, and other accessory respiratory muscles. As these muscles become stronger, less effort is needed to sustain ventilation, resulting in a lower respiratory rate both at rest and during submaximal exercise. Enhanced respiratory muscle endurance also reduces fatigue and promotes more efficient breathing patterns [18]. Progressive resistance training (PRT) enhances the oxidative capacity of skeletal muscles, allowing them to use oxygen more efficiently. This lowers the ventilation requirement to meet oxygen demands, leading to a decreased respiratory rate. Additionally, increased mitochondrial density and expanded capillary networks in the muscles improve oxygen delivery and utilization [19].

2. Methodology

A randomized clinical trial was conducted at Goals Gym, Al Fahad Fitness Center, and Titans Gym in Faisalabad. Participants provided informed consent after being briefed on the study's aims and objectives. They were then selected using a convenient sampling method and randomized by a lottery system. Cardiorespiratory parameters—including resting systolic and diastolic blood pressure, heart rate, and respiratory rate were measured using a sphygmomanometer and pulse oximeter. Thirty participants were divided into two groups: Group A followed the DeLorme technique, while Group B followed the MacQueen technique.

Participants began with a 5-minute warm-up consisting of slow walking, deep breathing, and arm circles. Group A completed bilateral quadriceps resistance training following the DeLorme protocol four times per week for three weeks, performing three sets of 10 repetitions with a 90-second rest between sets. Group B carried out bilateral quadriceps resistance training using the MacQueen protocol three times per week for three weeks, performing four sets of 10 repetitions with a 90-second rest between sets. The ten-repetition maximum (10RM) in weight training represents the highest weight an individual can lift for ten consecutive repetitions. The 10RM was calculated using a maximum load calculator and assessed weekly, with loads adjusted accordingly for all participants. Resting systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), and respiratory rate (RR) were measured prior to group allocation and the commencement of training (pre-values). These parameters were then recorded again after two weeks of training (post-1 values) and after the third week (post-2 values) to track changes in cardiorespiratory function

2.1 Common Treatment

Both group participants were trained with baseline therapy that included exercise jump squats.

2.2 Data Analysis Procedure

The data was analyzed using SPSS(IBM) 23 parametric and nonparametric tests were decided after the assessment of normality.

2.2.1 Difference Between Groups

Mann-Whitney U test (nonparametric test) was used to compare two populations at different intervals.

3. Results

32 participants were assessed for eligibility , of whom 30 were selected for study and allocated into two groups (Group A= 20, Group B= 20). 2 participants dropped out due to some personal reasons (two from group A and two from group B, resulting in an analysis of data from 30 participants).

Table 1: Test for Normality

Description	Shapiro-Wilk

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

	Statistic	df	Sig.
Systolic BP (pre-treatment)	0.971	30	.560
Diastolic BP (pre-treatment)	0.937	30	.075
Heart rate (pre-treatment)	0.931	30	.051
Respiratory rate (pre-treatment)	0.926	30	.038

Table 1 given above illustrates the normality of the Systolic & diastolic BP, Heart Rate (HR) and respiratory rate (RR) as determined by the Shapiro-Wilk test. When examining the results, it is evident that the data of respiratory rate (RR) breach the assumptions of a normality distribution (sig<0.05). In order to analyze the data of respiratory rate (RR) non-parametric tests (Friedman Test within group analysis and Mann Whitney U test for between groups analysis) were applied. In contrast, Systolic, diastolic BP and Heart Rate (HR) follows normal distribution (sig>0.05). In order to analyze the data of the Systolic, diastolic BP and Heart Rate (HR), parametric tests (Repeated Measures ANOVA for within-group analysis and Independent-Samples t-Test for between groups analysis) were applied.

Table 2: Ranks for Pre, Mid and Post-treatment RR (Mann-Whitney U Test)

Ranks				
Respiratory rate	**Groups**	**N**	**Mean rank**	**Sum of ranks**
Pre-treatment	DeLorme Technique	15	14.63	219.50
	MacQueen technique	15	16.37	245.50
	Total	30		
Midline	DeLorme Technique	15	17.07	256.00
	MacQueen technique	15	13.93	209.00
	Total	30		
Post-treatment	DeLorme technique	15	16.73	296.00
	MacQueen technique	15	11.27	169.00
	Total	30		

Table 2 shows the Ranks for pre-treatment, midline and post-treatment respiratory rate. N shows the sample size in each group. At baseline, group A receiving Delorme Technique had a lower mean rank (14.63) compared to group B receiving Macqueen Technique (16.37), suggesting relatively similar or slightly better respiratory rates in the DeLorme group. However, by **midline**, group A showed an increase in mean rank (17.07) while the group B decreased to 13.93, indicating a potential improvement in respiratory rate for the group A receiving Delorme training at this stage. At post-treatment, the mean rank of group A receiving DeLorme training has much higher (16.73), while group B receiving MacQueen technique is lower (11.27). This suggests that, by post-treatment, group B (MacQueen) had lower respiratory

Frontier in Medical & Health Research
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rates (or greater reduction in rate) compared to group A (DeLorme)

Table 3: Intra-group analysis of BP (Repeated Measures ANOVA)

Group	BP (Pre, Midline, Post Treatment)	Descriptive Statistics		Wilks' Lambda				
		Mean±SD	N	Value	F	Hypothesis df	Error df	Sig.
A	Systolic (Pre)	132.60±8.83	15	.128	44.167	2.000	13.000	.000
	Systolic (Midline)	130.20±8.66	15					
	Systolic (Post)	129.06±8.98	15					
	Diastolic (Pre)	89.33±11.48	15	.176	30.483	2.000	13.000	.000
	Diastolic (Midline)	87.86±11.41	15					
	Diastolic (Post)	87.00±11.27	15					
B	Systolic (Pre)	133.26±8.43	15	.075	80.708	2.000	13.000	.000
	Systolic (Midline)	123.40±8.66	15					
	Systolic (Post)	115.46±10.37	15					
	Diastolic (Pre)	88.66±8.96	15	.111	52.302	2.000	13.000	.000
	Diastolic (Midline)	86.26±8.80	15					
	Diastolic (Post)	85.60±8.82	15					

Table 3 shows the analysis of changes in systolic and diastolic blood pressure (BP) over time within each group. In Group A, systolic BP decreased slightly from 132.60±8.83 mmHg pre-treatment to 130.20±8.66 and then 129.06±8.98 mmHg post-treatment. Diastolic BP also showed a slight reduction from 89.33±11.48 mmHg pre-treatment to 87.86±11.41 at midline and then 87.00±11.27 mmHg post-treatment. The p-value of <0.001 indicated a statistically significant difference in BP across time points within the group A. Similarly in Group B, systolic BP decreased from 133.26±8.43 mmHg pre-treatment to 115.46±10.37 mmHg post-treatment. Diastolic BP also decreased from 88.66±8.96 mmHg to 86.26±8.80 and then 85.60±8.82 mmHg. The p-value of <0.001 indicated a statistically significant differences in BP across time points within group B.

Table 4: Inter-group analysis of Systolic and Diastolic BP (Independent Samples t-test)

Groups	Time point	t	df	Mean Difference	95% Confidence Interval		Sig. (2-tailed)
					Lower	Upper	
A & B	Systolic BP (Pre-treatment)	-.211	28	-.667	-7.130	5.796	0.834
A & B	Systolic BP (Midline)	2.149	28	6.800	.319	13.281	0.040
A & B	Systolic BP (Post-treatment)	3.837	28	13.600	6.339	20.861	0.001

Frontier in Medical & Health Research

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A & B	Diastolic BP (Pre-treatment)	.177	28	.667	-7.040	8.374	0.861
A & B	Diastolic BP (Midline)	.430	28	1.600	-6.026	9.226	0.671
A & B	Diastolic BP (Post-treatment)	.379	28	1.400	-6.172	8.972	0.708

Table 4 shows the comparison between Groups A and B of systolic and diastolic BP using the independent samples t-test. At baseline, results showed no significant difference in systolic BP (p=0.83). A significant difference was found in systolic BP between group A and B, at midline (p-value = 0.040) and at post-treatment (p-value = 0.001). Group B receiving MacQueen training showed a greater reduction in systolic as compared to Group A receiving DeLorme training. But in contrast no statistically significant difference was found in diastolic BP at baseline, midline and post-treatment among both groups. Both groups showed almost equal improvement in diastolic BP. At baseline, results showed no significant difference in systolic BP (p=0.83). A significant difference was found in systolic BP between group A and B, at midline (p-value = 0.040) and at post-treatment (p-value = 0.001). Group B receiving MacQueen training showed a greater reduction in systolic as compared to Group A receiving DeLorme training. But in contrast no statistically significant difference was found in diastolic BP at baseline, midline and post-treatment among both groups. Both groups showed almost equal improvement in diastolic BP.

Table 5: Intra-group analysis of HR (Repeated Measures ANOVA)

Group	Heart rate	Descriptive Statistics		Wilks' Lambda				
		Mean±SD	N	Value	F	Hypothesis df	Error df	Sig.
A	Pre-treatment	93.40±14.65	15	.114	50.595	2.000	13.000	.000
	Midline	91.80 ±14.66	15					
	Post-treatment	90.60±14.29	15					
B	Pre-treatment	98.60±14.81	15	.101	57.859	2.000	13.000	.000
	Midline	87.86±14.21	15					
	Post-treatment	80.80±14.75	15					

Table 5 shows the analysis of changes in heart rate (HR) over time within each group. In Group A, HR decreased slightly from 93.40±14.65 per min pre-treatment to 91.80±14.66 and then 90.60±14.29 per minute post-treatment. The p-value of <0.001 indicated a statistically significant difference in HR across time points within group A. Similarly in Group B, HR decreased from 98.60±14.81 pre-treatment to 115.46±10.37 post-treatment. The p-value of <0.001 indicated a statistically significant difference in HR across time points within group B. Results showed that no statistically significant difference was found in heart rate at baseline, midline and post-treatment among both groups. Both groups showed almost equal improvement in reducing the Heart rate in young population.

Both DeLorme and MacQueen resistance training protocols led to significant reductions in systolic blood pressure (SBP), diastolic blood pressure (DBP), respiratory rate (RR), and heart rate (HR). However,

Frontier in Medical & Health Research
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the MacQueen protocol demonstrated a more pronounced effect on systolic blood pressure and respiratory rate compared to the DeLorme protocol.

4.Discussion

This study aimed to examine and compare the effects of DeLorme's and MacQueen's resistance training protocols on cardiorespiratory parameters by administering bilateral quadriceps exercises in a young, healthy population. The findings revealed that MacQueen's protocol led to more significant improvements in cardiorespiratory health indicators.

In 2020, Lorrany da Rosa Santos and colleagues conducted a study suggesting that resistance training programs can help maintain adolescent health and may serve as an adjunct in the early management or reduction of risk factors affecting cardiorespiratory fitness (CRF). The findings of their study align with the results of our research [20].

In 2020, Clare Chung-Wah Yu and colleagues conducted a study to assess the impact of resistance training on cardiovascular health. Their findings demonstrated that a 10-week school-based resistance training program significantly benefited adolescent cardiovascular health, highlighting the importance of offering varied and engaging physical activity opportunities particularly resistance training within the school setting. These studies reinforce the findings of the current research, as the results align with existing literature [21].

Gulunjkar Pooja et al 2017 conducted an experimental study to compare the effectiveness of two strengthening protocols, the Delorme and MacQueen techniques on quadriceps muscles in healthy women. The study concluded that both progressive resistance training methods significantly improved quadriceps strength after four weeks of intervention, with the Delorme technique demonstrating a more pronounced effect compared to the MacQueen technique. [22]

In 2021, Sudeep Kale conducted a study aimed at examining and comparing the effectiveness of the DeLorme and MacQueen resistance training protocols on cardiorespiratory parameters in healthy young women aged 18 to 25 years. Following three weeks of training with the DeLorme protocol, significant improvements were noted in systolic blood pressure (SBP) and heart rate (HR), while diastolic blood pressure (DBP) showed no change. In comparison, the MacQueen protocol resulted in significant improvements across all measured parameters—SBP, DBP, and HR. [15]

The literature consistently highlights the effectiveness of progressive resistance exercises (PRE) in improving cardiorespiratory health indicators, including systolic and diastolic blood pressure, heart rate, and respiratory rate—thereby helping to mitigate emerging cardiovascular issues in the modern era. However, researchers have noted a lack of studies specifically exploring the use of PRE to enhance cardiorespiratory fitness. Both interventions offer foundational treatment protocols for maintaining cardiorespiratory fitness (CRF) metrics in the young population. Previous studies have demonstrated that both the Delorme and MacQueen protocols can significantly enhance quadriceps femoris muscle strength and overall cardiorespiratory fitness.

The study has several limitations. First, the small sample size may limit the generalizability of the findings. Second, the short duration of 3–4 weeks may not capture long-term adaptations. Additionally, the absence of a control group restricts the ability to exclude external factors influencing the study outcomes. The study participants were limited to healthy young individuals, excluding variations in fitness levels and comorbidities. For future research, it is recommended to include a larger sample size and extend the follow-up period to more accurately evaluate the effectiveness and long-term retention of the intervention.

Conclusion

Resistance training positively impacts heart rate (HR), systolic blood pressure (SBP), and respiratory rate (RR), with the MacQueen protocol proving more effective than the DeLorme protocol. Therefore, resistance training should be incorporated into exercise programs.

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