

# Comparison Between the Effect of Free Weight and Machine Exercise on the Quadriceps Muscles Among Male Students in IIUM Kuantan

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## ABSTRACT

### Keywords:

resistance training, free weight, machine-based, quadriceps muscle girth

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**Background:** Exercise, particularly resistance training, plays a crucial role in an individual's overall fitness. This research aimed to compare the efficacy of free-weight (FW) versus machine-based (MB) resistance training towards the changes in quadriceps muscle girth among the male students at the International Islamic University Malaysia (IIUM) Kuantan. **Methods:** Twenty-four (N=24) male students (age range) were selected and underwent an eight-week resistance training program. Participants were divided into FW (n=12) and MB (n=12) training groups. Participants trained twice weekly, and quadriceps muscle girth were measured using a measuring tape at week four (W4) and eight (W8). **Results:** Quadriceps size significantly increased with both free weights (52.74±3.22 to 54.43±3.24) and machines (52.66±5.48 to 54.35±5.40) over 4 and 8 weeks (p < 0.001). **Conclusion:** FW and MB were beneficial for individuals seeking to improve their quadriceps muscle size changes following eight weeks of training.

## INTRODUCTION

Many exercises have been introduced, and each of the exercises targets different muscle groups. Most of the exercise can be performed using free weights and machine equipment. Nevertheless, most people still query which of the resistant exercises can be performed to reach their goals, since both offer advantages and disadvantages of their own. At the gym, questions arise on which of the exercises should be added to the regime to achieve specific muscle group hypertrophy. Aerenhouts and D'Hondt (2020) reported that regardless of whether adult male novices in resistance training use machines (M) or free weights (FW), they can expect significant positive training effects within a 10-week period. Furthermore, transitioning from machines to free weight exercises does not result in a decline in progress. Both machine and free weight exercises increase muscle strength in 10-week periods, but there is no clear evidence that muscle size can increase under a 10-week timeframe and which one can contribute more in terms of muscle size. On the other hand, a study by Schoenfeld et al. (2019) found that resistance-trained individuals can significantly improve strength and endurance through just three 13-minute weekly sessions over an 8-week duration. Thus, this study seeks to explore whether muscle size can increase within a 4 to 8-week time frame

and perhaps be able to increase muscle strength and endurance by following the correct training plan. It is essential to achieve this objective as it can improve the knowledge of exercise using free weights and machines. It is also important as the quadriceps are used in most daily movements and physical activities. Moreover, the quadriceps also the most useful muscles in the human body, as they never rest in doing their movement, which is knee extension in daily routine.

## MATERIALS AND METHODS

### Study Design

This study implemented a quasi-experimental study design to investigate the effect of different modes of resistance training programs (FW or MB) on the changes in quadriceps muscle girth measurement.

### Participants

The purposive sampling method was utilised to recruit (N=24) participants who met the inclusion and exclusion criteria. The study involved IIUM Kuantan male students aged 18–25 years, weighing 50–80 kg, who were healthy and free from lower limb musculoskeletal injuries. Exclusion criteria include physical illnesses aggravated by

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exercise, previous knee injuries, regular gym-goers, and those taking protein supplements, ensuring uniformity in dietary intake among participants.

### **Resistance Training Program**

The study was conducted at the IIUM in Kuantan. Participants were randomly divided into two groups of 12, assigned to either free weight or machine exercises, with no control group. The free weight group performed squats, while the machine group used the quadriceps bench. The training programme lasted for 8 weeks, with both groups exercising twice weekly using weights set at 12-RM, a standard load for beginners that can be lifted correctly up to 12 repetitions. Each session consisted of three sets per exercise. A trained researcher supervised all sessions to ensure proper technique and adherence to the protocol.

### **Quadriceps Muscle Girth Measurement**

Quadriceps girth was measured at 18 cm above the anteromedial knee joint line using a measuring tape. Initial measurements were taken with participants in a supine position before the programme began, after obtaining informed consent. Subsequent measurements were conducted at the start of the 4th and 9th weeks using the same methodology to maintain consistency. Data were recorded systematically and analysed using SPSS to ensure accurate and reliable results.

### **Sample Size Calculation**

A priori power analysis was calculated using G-power software version 3.0, which revealed that 24 participants were required to achieve a statistical power of 80% at a significant level of  $p < .05$ , with the effect size of 0.25 (Aerenhouts & D'Hondt, 2020). Therefore, the participants were equally assigned to FW ( $n=12$ ) and MB ( $n=12$ ) resistance training groups.

### **Ethical Consideration**

This study was approved by IIUM's research ethics committee (reference no.: IIUM/504/14/11/2/IREC 2023-KAHS/DPRS) to ensure adherence to ethical standards and the protection of participants' rights throughout the study. Ethical considerations were followed throughout the study, including ensuring participant confidentiality and obtaining the necessary approvals. They were thoroughly briefed on the study's objectives, their right to decline participation at any point, and strict confidentiality measures in place for the collected data. Participants' written informed consent

was obtained before embarking on the study.

### **Statistical Analysis**

Data were analysed using the Statistical Package for the Social Sciences (SPSS) Version 12. The statistical tool employed was a paired sample t-test to elucidate the effectiveness of a resistance training program (FW or MB) on quadriceps muscle girth changes. An independent sample t-test was also conducted to compare the effect of different modes of resistance exercises (FW and MB) on quadriceps muscle girth changes in the 4th and 8th weeks, respectively.

### **RESULTS**

The study included 24 male undergraduate students from the International Islamic University Malaysia (IIUM) in Kuantan, Pahang, aged between 18 and 25 and weighing 50–80 kg. Participants were divided equally into two groups, with 12 individuals undergoing free-weight (FW) resistance training and performing machine-based (MB) resistance training from week 4 to week 8.

#### **Effects of Free Weight versus Machine-Based Resistance Training on Different Weeks of Training**

Significant improvement was observed in both free-weight and machine exercise from week 4 to week 8. For free-weight resistance training, the quadriceps girth increased from  $52.74 \pm 3.22$  cm at week 4 to  $54.43 \pm 3.24$  cm at week 8. For machine exercises, the quadriceps girth improved from  $52.66 \pm 5.48$  cm at week 4 to  $54.35 \pm 5.40$  cm at week 8 (Table 1).

#### **Effect of Different Resistance Training Modes on Different Weeks of Training**

In comparing free-weight and machine exercise at respective weeks, there are no significant differences in the mean comparison between free-weight exercise ( $54.43 \pm 3.24$ ) and machine exercise ( $54.35 \pm 5.40$ ) in the week 4th and 8th of training, respectively (Table 2).

### **DISCUSSION**

The current study demonstrated that both resistance training modes contributed to significant quadriceps girth increments following training. Therefore, achieving the desirable results within an eight-week time frame is possible. Different resistance exercise modes must align with the goals of individuals seeking to increase the size of their quadriceps muscles. Individuals with the aim of improving general fitness and aiming for similar

outcomes can opt for the MB resistance training program because of its user-friendly nature and convenience while avoiding the complexities associated with moving plates. This makes them accessible to people of all fitness levels, including newbies who might be less familiar with exercise techniques. Exercise using machines also can isolate muscle groups more effectively (Bergeron, 2022). On the other hand, experienced gym-goers may include squats in their workout regimen, which requires precise biomechanics and adherence to safety measures. Moreover, FW exercise is more flexible since it can be used anywhere. According to Wilke et al. (2020), free weights offer the flexibility of training anywhere as they require minimal equipment and do not rely on specific machines.

The results indicate comparable improvements in quadriceps size for both free weight and machine-based exercises during the 4<sup>th</sup> and 8<sup>th</sup> weeks of training. This is better than the observation by Aerenhouts and D’Hondt (2020), who reported that adult male novices in resistance training, regardless of whether they utilise machine (M) or free-weight (FW) exercises, can expect significant positive training effects within a 10-week period. In addition, the notion that free-weight exercises result in a faster increase in quadriceps size than machine exercises is dismissed.

Instead, we believed a blended approach incorporating FW and MB resistance training might add variety to the workout routine while ensuring consistent improvement in quadriceps size over eight weeks of the training period. Nevertheless, this requires further testing in different

settings. Furthermore, this study indicates that individuals with limited time to go to the gym can use FW resistance training, such as squats or weighted squats, at home to optimise muscle hypertrophy by using the weight they can lift for twelve reps, as demonstrated in this study.

The weight does not require a barbell; athletes can use sufficient tools, such as bottled water and other weights, to increase the mechanical stress of the exercise. If the individual only has limited time to train in the gym, they can use a quad bench instead. Since both exercises can improve the quadriceps muscle, there should be no problem in maximising the use of each resistance exercise to their own benefit.

## CONCLUSION

Significant improvement was observed as the participants experienced increased muscle girth compared to the initial week. On the other hand, there were no noticeable differences in comparing modes of resistance training (FW or MB). Furthermore, both forms of exercise prove beneficial for hypertrophy when performed correctly, highlighting consistent size gains during the 4<sup>th</sup> and 8<sup>th</sup> weeks of training.

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**Table 1:** The effect of resistance training on the changes of quadriceps muscle girth in weeks 4 and 8

Resistance Training	4 <sup>th</sup> Week		8 <sup>th</sup> Week		Mean Differences (95% CI)	t-statistic (df)	p-value
	Mean	S.D	Mean	S.D			
Free-weight	52.74	3.22	*54.43	3.24	-1.691 (-2.04, -1.33)	-10.4 (11)	0.000
Machine Exercise	52.66	5.48	*54.35	5.40	-1.691 (-1.99, -1.38)	-12.07 (11)	0.000

**Table 2:** Comparing the size of quadriceps (cm) in the 4<sup>th</sup> and 8<sup>th</sup> week of training between free weight (n=12) and machine (n=12)

Resistance Training	Free Weight		Machine Exercise		Mean Differences (95% CI)	t-statistic (df)	p-value
	Mean	S.D	Mean	S.D			
4 <sup>th</sup> Week	52.74	3.22	52.66	5.48	0.083 (-3.72, 3.89)	0.045 (22)	0.964
8 <sup>th</sup> Week	54.43	3.24	54.35	5.40	0.083 (-3.69, 3.85)	0.046 (22)	0.964

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