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EFFECTS OF 8 WEEKS OF ECCENTRIC TRAINING ON HAMSTRING FLEXIBILITY AND MUSCULAR PERFORMANCE AMONG HEALTHY OVERWEIGHT AND OBESE WOMEN

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ABSTRACT

Background: This study was carried out to investigate the effects of 8 weeks of eccentric training on hamstring flexibility and muscular performance among healthy overweight and obese females.

Materials and Methods: Twenty healthy overweight and obese females (N = 20) were recruited and randomly divided into two groups: exercise group (n = 10; age = 40.1 ± 5.4 years; BMI = 33.3 ± 4.9 kg/m^2) and control group (n = 10; age = 44.3 ± 6.9 years; BMI = 29.0 ± 4.0 kg/m^2). This experimental study use comparative analysis of pre and post-training. During both pre and post-training, passive 90°/90° test (hamstring flexibility), vertical jump test (muscle power) and squat test (muscle strength) were carried out. Participants in the exercise group performed eccentric training using thera-band on both legs three times per week for eight weeks while participants in the control group did not perform any exercise. Data analysis was carried out using paired and independent t test to measure significant differences between groups and within group.

Result: The exercise group showed significant increase ($p < 0.05$) in both left and right hamstring flexibility after the eight weeks of intervention. However, muscle strength and power did not significantly ($p > 0.05$) affected by the eccentric training.

Conclusion: Eccentric training has beneficial effects on flexibility by increasing the range of motion of a joint. However, the present study fails to show significant benefits of eccentric training on muscles strength and power. Longer exercise training period might induce significant improvements in both muscle strength and power.

Keywords: Exercise, range of motion, knee joint, resistance band, muscle power, muscle strength

1.0 Introduction

Hamstring is one of the important muscles in our body. It helps in action of knee extension and knee flexion during active daily life. Hamstring muscles contain three major muscles, biceps femoris, semitendinosus and semimembranosus, which composed of type II muscle fibre (Ruslan et al., 2014). This muscle also important in providing the stability to our knee flexion during walking especially at the end of the swing phase until foot flat has been completed (Azahari et al., 2017).

The hamstring flexibility is the most important aspect that should have been considered in our daily life because it can prevent injury (Bandy et al., 1997) and sprain, which can occur if the hamstring muscle is weak. Flexibility is the ability of a muscle to lengthen and allow one joint (or more than one joint in a series) to move through a range of motion, and the loss of flexibility is a decrease in the ability of a muscle to perform.

The eccentric training could result from a lengthening of the respective muscle groups, which in turn may result in an increase in range of movement. Moreover, eccentric resistance training is also known to stiffen tendon aponeuroses (Legner and Milner, 2008), which limit the joint range of movement. Then fascicles do not run parallel to their axis in pennate muscles, it is not known whether an increase in fascicle length would necessarily translate into a lengthening of the whole muscle.

One study had demonstrated that eccentric training induced a larger strength gain in the hamstrings compared to concentric training (Mjolsnes et al., 2004). Moreover, a study by Proske et al. (2004) found that the adaption occurs following eccentric training includes prevention muscle damage and injury. In a separate study, it was found that sub-maximum eccentric training helps in increasing cross-sectional area and isometric strength gains that did not occur in concentric training alone (LaStayo et al., 2000). In addition, eccentric training could be a better prevention strategy against muscle strain when compared to static stretching. To date, despite numerous studies investigating effects of eccentric training on hamstring flexibility among young population with normal weight and elderly, studies in overweight adult is limited.

Exercise has been found to have great effects on the muscle performance. Eccentric training is one of the exercises that can improve muscle performance especially on the muscle strength and power. From a strength and conditioning point of view, eccentric training is very interesting because the strength gains are eccentric-specific. This is because; strength gains after eccentric training are greater when measured in an eccentric test of strength, compared to in a concentric test of strength.

A review article reported that when eccentric exercise was performed at higher intensities compared with concentric training, total strength and eccentric strength increased more significantly (Roig et al., 2009). However, compared with concentric training, strength gains after eccentric training appeared more specific in terms of velocity and mode of contraction. Eccentric training performed at high intensities was shown to be more effective in promoting increases in muscle mass measured as muscle girth.

In addition, eccentric training also showed a trend towards increased muscle cross-sectional area measured with magnetic resonance imaging or computerised tomography. Subgroup analyses suggest that the superiority of eccentric training to increase muscle strength and mass appears to be related to the higher loads developed during eccentric contractions (Roig et al., 2009).

2.0 Materials and Methods

2.1 Research design and location

This study is an experimental study with pre and post-test measurements where, participants performed 3 times per week of eccentric training for 8 weeks. The exercise training and measurements were conducted in the Exercise and Sports Science Laboratory, Universiti Sains Malaysia (USM). This study has been approved by the Human Research and Ethics Committee, Health Campus USM, Kelantan (Approval code: USM/JEPeM/17020115).

2.2 Sample size

Sample size was calculated by using PS Software. Based on a study which was carried out by Ruslan et al. (2014), the power of the study was set at 80% with 95% confident interval, the standard deviation (σ) observed was 7.0 (°) of hamstring flexibility, and difference in population mean (δ) was set at 10.0 (°) of hamstring flexibility. The calculated sample size was 9 participants per group. Considering 10% participants drop-out rate, 10 participants were recruited per group i.e. 20 participants in total.

2.3 Participants

A total of 20 participants were recruited among USM staff for this study. Method of inviting participants was via a poster advertisement and the sampling method used during the recruitment process was a convenience sampling. The inclusion criteria of the participants include healthy overweight female, aged between 35 and 50 years old, sedentary, overweight (body mass index (BMI) of 25 to 29.9 kg/m^2) or obese (BMI ≥ 30.0 kg/m^2), and have no history of impairment to the knee, thigh, hip, or lower back for 1 year before the study. Another inclusion criterion includes exhibited tight hamstrings. Tight hamstring in this study is defined as having at least a 10º knee-extension deficit while the hip is positioned at 90°. In addition, the exclusion criteria include smoker, on medication and involved in other exercise programme.

2.4 Study procedures

In this study, a total of 20 participants were recruited after obtaining ethical approval from Human Research and Ethics Committee, USM. The participants recruited were randomly divided into two groups; exercise group and control group, with 10 participants in each group. After explaining the study procedures and obtaining their informed consent, pre-intervention measurements were carried out. These measurements include height and weight measurements and calculation of BMI. The body weight and height were measured by a body composition analyser (Tanita, Japan) and a stadiometer (Secca, China) respectively. In addition, a passive 90º/90º test, a vertical jump test and a squat test were carried out at pre-intervention to measure hamstring flexibility, muscle power and muscle strength respectively.

2.4.1 Passive 90°/90° test

The passive 90°/90° test was performed by using a double – armed goniometer (JAMARTM Clifton, U.S.A.) to measure hamstrings flexibility. To begin, the participant was asked to lie down on supine position with hip and knee flexed to 90° (Figure 1). The measurement takes place on the lateral epicondyle area of the femur and the goniometer was placed at the centre. Then the lateral malleolus of the tibia and greater trochanter of the femur were marked. The final extension that they can reach was measured and recorded. The zero degree of the knee extension considered as the full hamstring muscle flexibility. No warm up was allowed before the data collection. The measurement was performed on both legs twice to make sure the result is reliable.

2.4.2 Vertical jump test

This test required wall, measuring tape and chalk. During the test, participant was asked to stand beside a wall. Firstly, they were asked to reach up as high as possible with one hand and marked the wall with a chalk at the tips of his fingers (M1). Then the participant jumped as high as possible from a static position and marked the wall with the chalk (M2). The distance between M1 and M2 were calculated and recorded. The test was repeated for 3 times and the average distance was calculated and recorded (Figure 2).

Figure 1: Passive 90°/90° test

Figure 2: Vertical jump test

2.4.3 Squat test

Firstly, participant was asked to stand in front of a chair, facing away from it, with their feet shoulder width apart. Then, participant was required to perform as many squats as possible without stopping. During squats, participant lightly touched the chair with his backside before standing back up and repeats this sequence of movements until she was unable to continue. The test was repeated for 3 times and the average distance was calculated and recorded (Figure 3).

2.4.4 Eccentric exercise training

While participants in the control group performed no exercise training, participants in the exercise group performed eccentric exercise training on both legs 3 days per week for 8 weeks. To perform eccentric training, leg press was carried out by using a resistance band (Green LP Band, USA). To implement leg press, participants were positioned supine with the hip and knee flexed to 90°. The resistance band was wrapped around the heel and the ends of the resistance band were held by hands (Figure 4). During each training session, participants moved their leg up and down slowly; 10 repetitions with a total of 30 seconds of training for each leg with rest interval 30 seconds during repetitions.

Figure 3: Squat test

Figure 4: Eccentric exercise training

2.5 Statistical analysis

All statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 22.0. Independent T test and paired T test were used to measure significant differences between groups and within group respectively. The accepted level of significance was set at $p < 0.05$. Results were reported as means ± standard deviation (SD).

In addition, the following equation was used to calculate mean percentage of difference:

$$\text{Mean \% of difference} = \frac{(\text{Post-test} - \text{Pre-test}) \times 100}{\text{Pre-test}}$$

3.0 Result

3.1 Physical and physiological characteristics

In this study, 10 participants in the exercise group and 10 participants in the control group were recruited. The anthropometry data obtained has been analysed using descriptive statistics and expressed as mean ± SD as tabulated in the Table 1.

Table 1: Physiological characteristics of the participants (N = 20)

	Exercise Group (n = 10)	Control Group (n = 10)	p-value
Age (years)	40.1 ± 5.4	44.30 ± 6.913	0.611
Weight (kg)	78.8 ± 12.4	68.6 ± 10.4	0.579
Height (m)	154.0 ± 5.3	154.17 ± 4.8	0.763
BMI (kg/m^2)	31.3 ± 4.9	29.0 ± 4.0	0.283
Tightness of hamstring (°)	11.4 ± 2.5 (Right leg)	12.1 ± 2.28 (Right leg)	0.522
	12.0 ± 2.5 (Left leg)	12.5 ± 1.78 (Left leg)	0.612

3.2 Passive 90º/90º test for right leg (hamstrings flexibility)

The mean values of the pre and post–test of passive 90º/90º test for right leg are tabulated in Table 2. This test measures the degree of tightness in participants' hamstrings flexibility. The pre-test value between the exercise and control groups was not significantly (p = 0.522) different. However, there was a significant (p < 0.001) difference on the post-test value between groups.

For within group effects, there was a significant (p < 0.001) difference between pre and post-test value in the exercise group. However, in the control group, the pre and post-test value was not significantly (p = 0.196) different.

Table 2: The degree (°) of tightness in participants' hamstrings – right leg

	Exercise Group (n=10)	Control Group (n=10)	p-value
Pre-intervention	11.40 ± 2.50	12.100 ± 2.28	0.522
Post-intervention	9.30 ± 1.83	12.90 ± 2.13	0.001
p-value	0.001	0.196	
Percentage of difference (%)	-18.42	+6.61	

3.3 Passive 90º/90º test for left leg (hamstrings flexibility)

The mean values of the pre and post – test of passive 90º/90º test for left leg are tabulated in Table 3. This test measures the degree of tightness in participants' hamstrings flexibility. The pre-test value between the exercise and control groups was not significantly (p = 0.612) different. However, there was a significant (p < 0.000) difference on the post-test value between groups.

For within group effects, there was a significant (p = 0.007) difference between pre and post-test value in the exercise group. However, in the control group, the pre and post-test value was not significantly (p = 0.096) different.

Table 3: The degree (°) of tightness in participants' hamstrings – left leg

	Exercise Group (n=10)	Control Group (n=10)	p-value
Pre-test	12.00 ± 2.49	12.5 ± 1.78	0.612
Post-test	10.20 ± 1.23	13.50 ± 1.72	0.000
p-value	0.007	0.096	
Percentage of difference (%)	-15	+8	

3.4 Vertical jump test (muscle power)

The mean values of the pre and post–test for muscle power during vertical jump test are tabulated in Table 4. This test measures muscle power of the participants by measuring the highest vertical distance that they can reach by their fingertips during jumping. The pre-test value between the exercise and control groups was significantly ($p = 0.028$) different. However, there was a not significant ($p = 0.757$) difference on the post-test value between groups.

For within group effects, there was a not significant ($p = 0.900$) difference between pre and post-test value in the exercise group. However, in the control group, the pre and post-test value was not significantly ($p = 0.119$) different.

Table 4: Muscle power (highest distance reached during vertical jump test in cm)

	Exercise Group (n=10)	Control Group (n=10)	p-value
Pre-test	18.68 ± 3.58	18.34 ±4.48	0.280
Post-test	18.60 ±4.44	18.63 ± 9.38	0.757
p-value	0.900	0.119	
Percentage of difference (%)	-0.43	+1.5	

3.5 Squat test (muscle strength)

The mean values of the pre and post-test for muscle strength during squat test are tabulated in Table 5. This test measures muscle strength by measuring the number of squats that participants can performed during the test. The pre-test value between the exercise and control groups was not significantly ($p = 0.272$) different. However, there was a significant ($p = 0.001$) difference on the post-test value between groups.

For within group effects, there was a not significant ($p = 0.482$) difference between pre and post-test value in the exercise group. However, in the control group, the pre and post-test value was not significantly ($p = 0.204$) different.

Table 5: Muscle strength (number of squats performed during squat test)

	Exercise Group (n=10)	Control Group (n=10)	p-value
Pre-test	41.90 ± 15.029	35.60 ± 9.12	0.272
Post-test	45.20 ± 7.29	31.10 ± 8.61	0.001
p-value	0.482	0.204	
Percentage of difference (%)	+7.9	- 12.6	

4.0 Discussion

4.1 Physical and physiological characteristics

In this study, all the participants completed the pre and post-intervention measurements. The range of age of the participants was between 30 and 50 years old and based on the preliminary screening (health questionnaire), they were healthy without having (current or in the past) any injury around lower limb especially knee and hip joint. According to the World Health Organization (WHO), the range of BMI for overweight adults is between 23 and 29.9 kg/m^2 and for obese is ≥ 30 kg/m^2. Thus, participants in this study fulfil the inclusion criterion set at the beginning of this study i.e. overweight and obese women (Table 1).

In addition, tightness of hamstrings of the participant assessed by the passive 90°/90° test showed that, on average, participants had at least 10° of tight hamstring. This criterion of tight hamstrings was also set at the beginning of this study, thus participants recruited fulfilled this inclusion criterion. During the passive 90°/90° test, the tight hamstring was noticed where participants unable to do knee extension in full range of motion. The zero degree extension was considered full hamstring muscle flexibility (Nelson and Bandy, 2004).

4.2 Hamstrings flexibility

As tabulated in the Table 2 and 3, for both right and left legs, the degree of tightness in participants' hamstrings was significantly reduce in the exercise group but not in the control group. In addition, for left leg, the degree of tightness was significantly increased in the control group (without exercise intervention). The present study findings was similar with a previous study findings where, they found gains achieved in range of motion of knee extension among young male subjects which indicating improvement in hamstring flexibility (Nelson and Bandy, 2004). This previous study employed a 6-week of eccentric training with a control group that done no exercise. It was also reported that eccentric training and static stretching appears to be equally effective in increasing hamstring flexibility (Nelson and Bandy, 2004). Similarly, a few other studies were also reported effectiveness of eccentric training to increase hamstring muscles flexibility (Potier et al., 2009).

The improvement in hamstring flexibility may be due to eccentric contractions and change of morphology associated with the increase in sarcomeres which lead to large adaptation on hamstring muscle (Daniela et al., 2007). Another theory state that improvement in range of motion angle may be due to improvement of hamstrings muscle–tendon unit (Nelson and Bandy, 2004; Potier et al., 2009) and increase in viscoelastic and function changes (Nobrega

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et al., 2005). Furthermore, another hypothesis suggests that improvement of hamstring flexibility is due to sarcomergenesis promoted by eccentric training (Potier et al., 2009). Yet, the mechanism behind the sarcomergenesis is still unclear. In addition, possible explanation may be found in examining the possible mechanism that occurs with stretching (Nelson and Bandy, 2004). The result of this adaptation of the muscle spindle is an increase in length of the muscle involved.

It has been debated if the eccentric training is needed since static stretching also shows improvement in flexibility. However, static stretching has little impact on injury risk or recurrence (O'Sullivan et al., 2012). Thus, further investigation should be carried out on elderly to clarify the effects of eccentric training on flexibility compared with static stretching.

4.3 Muscle power and strength

Table 4 showed that there was no significant effect of eccentric training on muscle power as measured by the vertical jump test. During this test, the highest height that can be reached by participants (by the tip of their fingers) at pre and post-intervention was compared between and within groups. Meanwhile, the mean number of squats that participants able to do at pre and post-intervention to reflect muscle strength of participants was tabulated in the Table 5.

In the present study, muscle strength was not significantly improved by the eight weeks of eccentric training. Nevertheless, although it was not statistically significant, the results showed that muscle strength was increased (7.9%) in the exercise group but was decreased (12.6%) in the control group. Strength is the ability of nervous and muscular systems to produce enough internal force in connective tissues and muscles to move an external force, such as weight or body against gravity. Unlike power, strength requires no quick movements to produce force nor does it take time as a factor for work. For example, a strong person may take three to five seconds to stand up during a heavy barbell squat, but a powerful person can stand back up in one second. Thus, power is defined as the ability to produce the greatest amount of force in the shortest possible time.

It was reported that greater muscle strength leads to greater power. In the present study, both muscle strength and power were not significantly affected by the 8 weeks of eccentric training.
However, with longer duration (at least 12 weeks), previous studies reported greater beneficial effects on muscle strength and power following eccentric training as compared to concentric training (Vikne et al., 2006; Miller et al., 2006; Behm et al., 2001; Fowles et al., 2000; Guissard et al., 2001). Thus, we speculated that insignificant findings found in the present study might be due to short intervention period employed.

It was suggested that when the muscle is placed under unfamiliar stress, it may leads to changes in the muscle and subsequently impacting the excitability of the motor neuron pool. Eccentric exercise performed at high intensity resulted in significantly greater increased in total strength and eccentric strength compared with concentric training (Roig et al., 2009). Furthermore, compared with concentric training, strength gains after eccentric training appeared more specific in terms of velocity and mode of contraction. Eccentric training performed at high intensities was shown to be more effective in promoting increases in muscle mass measured as muscle girth (Guissard et al., 2001).

In addition, it was also suggested that the superiority of eccentric training to increase muscle strength and mass appears to be related to the higher loads developed during eccentric contractions (Roig et al., 2009). The specialised neural pattern of eccentric actions possibly explains the high specificity of strength gains after eccentric training. Further research is required to investigate the underlying mechanisms of this specificity and its functional significance in terms of transferability of strength gains to more complex human movements. Moreover, eccentric contractions produce less fatigue and are more efficient at metabolic level compared with concentric contractions (Roig et al., 2009).

5.0 Conclusion and recommendations

The present study was conducted to determine the effects of 8 weeks of eccentric training on hamstring flexibility and muscular performance among healthy overweight female adults. The main findings of the present study are summarised as follows:

1. The degree of tightness in participants' hamstrings flexibility are significantly improved after 8 weeks of eccentric training among healthy overweight and obese women.
2. The hamstring muscle power was not significantly affected by 8 weeks of eccentric training among healthy overweight and obese women.
3. The muscle strength was not significantly affected by it showed positive improvement after 8 weeks of eccentric training among healthy overweight and obese women.

Therefore, in the present study, it can be concluded that the eccentric training has beneficial effects on flexibility by increasing range of motion of a joint. However, the present study fails to show significant benefits of eccentric training on muscles strength and power. We speculate that with longer exercise training period, we might found significant improvements in both muscle strength and power.

Future studies might consider following recommendations:

1. Include both gender in the study to see if there is different effects of eccentric training on muscles flexibility, strength and power between men and women.
2. Include different population of participants (e.g. normal BMI, elderly, osteoarthritis patients etc.) to determine the effects of 8 weeks of eccentric training on hamstring flexibility and muscular performance.
3. Increase the duration of eccentric training for at least 12 weeks.

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Declaration

Authors declare that the information above is correct and the manuscript submitted by us is original. We have no conflict of interest to declare and certify that no funding has been received for the conduct of this study and preparation of this manuscript.

Authors' contribution

Author 1: Idea and concept, supervise the data collection and analysis and preparing the manuscript

Author 2: Literature search, conduct the study and analysing the data

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