Comparison of Squat and Forward Lunge Exercises on Leg Muscle Strength, Skinfold Thickness, and Anthropometric Measurements in Overweight Women Aged 20-30 Years

Thipsuda Banyam*, Natthaphorn Kaewchot*, Nuttanun Khemamuttanak*

Abstract

This study investigated the effects of squat and forward lunge exercises on leg muscle strength, skinfold thickness, and anthropometric measurements in overweight women aged 20-30 years with a Body Mass Index (BMI) ranging from 23.0 to 24.99 kg/m². Forty participants were randomly assigned to either a squat group (n=20) or a forward lunge group (n=20) and completed an 8-week program consisting of three sets of 12 repetitions, performed three times per week. Leg muscle strength was assessed using the 60-second chair stand test, while skinfold thickness and anthropometric measurements were taken from various body sites.The results showed that both groups demonstrated significant improvements in leg muscle strength, with mean 60-second chair stand test scores increasing from 30.00 ± 5.45 to 35.05 ± 6.01 repetitions in the squat group ($p<0.05$) and from 32.50 ± 7.03 to 33.44 ± 6.75 repetitions in the forward lunge group ($p<0.05$). However, there were no significant differences between the two groups in muscle strength improvements. For skinfold thickness, no significant changes were observed in measurements taken at the triceps, abdominal, suprailiac, or thigh sites for either group. Similarly, anthropometric measurements, including chest, waist, hip, and limb circumferences, showed no notable reductions or inter-group differences post-intervention.

These findings suggest that while both squat and forward lunge exercises effectively enhance leg muscle strength, they do not significantly influence body composition over an 8-week period. In conclusion, squat and forward lunge exercises can serve as practical and efficient options for improving muscular strength in overweight women. However, further research with longer interventions or combined training regimens is needed to assess their potential impact on body composition and overall health.

Keywords : Exercise therapy, Physical fitness, Adiposity, Lower extremity, Body fat distribution

---

* Instructor, College of Health Science, Christian University of Thailand

Corresponding author, email: Thipsudab@christian.ac.th, Tel. 099-3247822

Received : November 20, 2024; **Revised** : April 23, 2025; **Accepted** : May 6, 2025

ผลของการออกกำลังกายท่าสควอท และ ท่าลันจ์ ต่อความแข็งแรงของกล้ามเนื้อขา ความหนาของชั้นไขมันใต้ผิวหนัง และการวัดสัดส่วนร่างกายในผู้หญิงที่มีน้ำหนักเกินอายุ 20 – 30 ปี

ทิพย์สุดา บานแย้ม*, ณัฏฐาพร แก้วโชติ*,ณัฐนันท์ เขมามุตตานาค*

บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาผลของการออกกำลังกายท่าสควอทและท่าลันจ์ต่อความแข็งแรงของกล้ามเนื้อขา ความหนาของชั้นไขมันใต้ผิวหนัง และการวัดสัดส่วนร่างกายในผู้หญิงที่มีน้ำหนักเกินอายุระหว่าง 20–30 ปี ที่มีดัชนีมวลกาย (BMI) อยู่ระหว่าง 23.0 ถึง 24.99 กิโลกรัมต่อตารางเมตร (kg/m^2) โดยมีผู้เข้าร่วมการวิจัยจำนวน 40 คน ถูกสุ่มแบ่งออกเป็นกลุ่มออกกำลังกายท่าสควอท (n=20) และกลุ่มออกกำลังกายท่าลันจ์ (n=20) ออกกำลังกายตามโปรแกรมที่กำหนด โดยทำ 3 เซต เซตละ 12 ครั้ง สัปดาห์ละ 3 ครั้ง เป็นระยะเวลา 8 สัปดาห์ ผลของการออกกำลังกายวัดความแข็งแรงของกล้ามเนื้อขาวัดโดยใช้การทดสอบลุกนั่งภายใน 60 วินาที ความหนาของชั้นไขมันใต้ผิวหนังและวัดสัดส่วนร่างกายวัดจากบริเวณต่างๆ ของร่างกาย ก่อนและหลังการออกกำลังกายตามโปรแกรม หลังสิ้นสุดโปรแกรมการออกกำลังกาย ผลการศึกษาพบว่า จำนวนครั้งของการทดสอบลุกนั่งภายใน 60 วินาทีของกลุ่มสควอทเพิ่มขึ้นจากค่าเฉลี่ย 30.00 ± 5.45 ครั้ง เป็น 35.05 ± 6.01 ครั้ง ($p<0.05$) และของกลุ่มลันจ์เพิ่มขึ้นจาก 32.50 ± 7.03 ครั้ง เป็น 33.44 ± 6.75 ครั้ง ($p<0.05$) อย่างไรก็ตาม เมื่อดูผลของการเปรียบเทียบระหว่างกลุ่มโปรแกรมการออกกำลังกายไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติ ในการเพิ่มความแข็งแรงของกล้ามเนื้อขา รวมถึงไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติของความหนาของชั้นไขมันใต้ผิวหนังในบริเวณต่างๆ ได้แก่ ต้นแขน หน้าท้อง และต้นขา หรือการวัดสัดส่วนร่างกาย ได้แก่ รอบอก รอบเอว และรอบสะโพก ระหว่างและหลังสิ้นสุดโปรแกรมการออกกำลังกาย

ผลการวิจัยนี้ชี้ให้เห็นว่าการออกกำลังกายทั้งสองประเภท ท่าสควอทและท่าลันจ์ สามารถเพิ่มความแข็งแรงของกล้ามเนื้อขาได้อย่างมีประสิทธิภาพ แต่ไม่ส่งผลต่อการเปลี่ยนแปลงองค์ประกอบร่างกายในระยะเวลา 8 สัปดาห์ สรุปได้ว่าท่าสควอทและท่าลันจ์เป็นทางเลือกที่ดีสำหรับการพัฒนาความแข็งแรงของกล้ามเนื้อในผู้หญิงที่มีน้ำหนักเกิน อย่างไรก็ตาม ยังมีความจำเป็นต้องศึกษาต่อในระยะยาวเพื่อประเมินผลกระทบต่อองค์ประกอบของร่างกายและสุขภาพโดยรวมต่อไป

คำสำคัญ : การบำบัดด้วยการออกกำลังกาย, สมรรถภาพทางกาย, ภาวะไขมันเกิน, รยางค์ส่วนล่าง, การกระจายตัวของไขมันในร่างกาย

---

* อาจารย์ คณะวิทยาศาสตร์สุขภาพ มหาวิทยาลัยคริสเตียน

Corresponding author, email: Thipsudab@christian.ac.th, Tel. 099-3247822

Received : November 20, 2024; **Revised** : April 23, 2025; **Accepted** : May 6, 2025

Introduction

Overweight is defined as having a body weight higher than what is considered healthy for a person's height (Kantachuvessiri, 2005). This condition significantly increases the risk of developing chronic health issues such as cardiovascular diseases, type 2 diabetes, musculoskeletal disorders, and various cancers. Excess body fat contributes to metabolic irregularities like insulin resistance, dyslipidemia, and hypertension, all of which are critical factors in the progression of these diseases (World Health Organization [WHO], 2024).

The prevalence of overweight and obesity remains a significant global health challenge. According to the World Health Organization (WHO), as of 2022, 43% of adults aged 18 years and older were classified as overweight, while 16% were obese, reflecting a steady increase over previous decades. Additionally, over 390 million children and adolescents aged 5–19 years were overweight, including 160 million classified as obese (World Health Organization [WHO], 2022).

This trend is evident across Asia, where rising rates of overweight and obesity are influenced by urbanization, dietary habits, and physical activity levels. In East Asia and the Pacific, the prevalence of overweight ranges from 24% to 30%, with urban areas experiencing higher rates than rural regions. Similarly, in South Asia, prevalence rates range from 20% to 25% (WHO, 2022; World Obesity Federation, 2024). In Southeast Asia, approximately 31% of adults are classified as overweight, highlighting disparities influenced by lifestyle and environmental factors.

In Thailand, a survey by Tritipsombut and Kala (2016) reported that approximately 32% of adults were overweight, with obesity rates around 10%, disproportionately affecting women more than men. These trends align with regional patterns, as urbanization and shifts in dietary and physical activity habits continue to drive the increase in obesity rates. Obesity contributes significantly to the burden of non-communicable diseases such as diabetes and cardiovascular conditions. Addressing these trends is crucial for reducing public health risks and improving outcomes in affected populations (WHO, 2022; World Obesity Federation, 2024; Tritipsombut & Kala, 2016).

The Body Mass Index (BMI) is the most common classification method for overweight and obesity in Asian populations, with a BMI over 22.9-24.9 kg/m² considered overweight. Further classifications include Obesity I (BMI 25.0 – 29.9 kg/m²), Obesity II (BMI 30.0 – 34.9 kg/m²), and Obesity III (BMI ≥ 35.0 kg/m²) (Choo, 2002). Recognizing the importance of physical activity, overweight adversely affects physical function and quality of life by diminishing muscle strength and endurance, impairing balance and mobility, and increasing fatigue (Cleven et al., 2020). These physical consequences can lead to a psychological toll, diminishing self-esteem and increasing the risk of depression (Luppino et al., 2010). Regular physical activity, especially exercises like squats and forward lunges, is crucial in managing weight and mitigating associated health risks (Liu et al., 2022; Lopez et al., 2022).

Excess body weight places additional strain on joints, particularly weight-bearing joints like the hips and knees, exacerbating the risk of musculoskeletal disorders (MSDs) such as back pain, tendinitis, and joint degeneration (Onyemaechi et al., 2016; Viester et al., 2013). Overweight individuals are more susceptible to muscle strains and ligament injuries, leading to chronic pain and disability. The knees often bear the brunt of this excess weight, contributing to knee osteoarthritis (OA) due to increased mechanical load (Chen et al., 2020). Overweight accelerates cartilage wear and tear in the knee, worsening symptoms in those already affected by OA (Raud et al., 2020; Zheng & Chen, 2015).

Various exercise modalities, including aerobic exercise, resistance training, and high-intensity interval training (HIIT), have proven effective for weight management in young adults. A study in Obesity Reviews emphasized the role of moderate to high-intensity aerobic exercise, recommending at least 150 minutes per week to positively affect body weight and metabolic health (O'Donoghue et al., 2021). Resistance training, which includes exercises like weightlifting and bodyweight movements, is crucial for building muscle mass, thereby increasing resting metabolic rate and improving body composition by reducing fat mass. HIIT, characterized by short bursts of intense activity followed by rest, shows promise for fat loss and enhances cardiovascular fitness while positively influencing metabolic markers (Eglseer et al., 2023; Lopez et al., 2022).

Resistance exercises not only reduce knee pain but also prevent knee osteoarthritis. By stimulating muscle hypertrophy, resistance training improves overall strength and functional capacity. Research published in the Journal of Strength and Conditioning Research indicates that resistance training significantly enhances muscle mass and strength across various age groups, crucial for joint support and reducing the risk of degeneration (Gregory & Travis, 2015). Combining resistance and aerobic exercises appears particularly effective for fat loss and body composition improvement among overweight young adults, as demonstrated in a study (Ntshaba et al., 2021; Tan et al., 2023).

In recent years, there has been a growing interest in identifying effective exercise modalities to improve muscle strength and aid in weight management. Among various resistance training exercises, squats and forward lunges engage multiple large muscle groups, including the quadriceps and hamstrings, leading to significant caloric expenditure. In our study, we implemented an 8-week training program, while several previous studies have reported improvements in weight management with a duration of 12 weeks

(O'Donoghue et al., 2021; Liu et al., 2022). We recognize that longer training durations may yield more significant changes in body composition and fat loss. To strengthen our guidelines, we will incorporate references from other studies that support the efficacy of longer intervention periods in achieving weight management goals. A 12-week bodyweight training study in The Journal of Sports Medicine and Physical Fitness found that participants achieved notable reductions in BMI and body fat percentage, underscoring the effectiveness of these exercises for weight management (Kraemer et al., 1999; Takai et al., 2013). By increasing muscle mass and, consequently, resting metabolic rate (RMR), squats and forward lunges become vital for long-term weight maintenance. These exercises are particularly beneficial for knee joint stability, reducing mechanical load and alleviating pain; and resistance training including squats and forward lunges, significantly decreases knee pain and improves joint function, particularly in individuals with early-stage knee OA (Chen et al., 2020; Kraemer et al., 1999). The comparison between squat and lunge exercises is grounded in both their widespread use in resistance training and their distinct biomechanical properties. Both exercises target the major muscles of the lower body, particularly the quadriceps, hamstrings, and gluteal muscles, making them fundamental components of strength training programs aimed at improving functional fitness. However, each exercise engages these muscles in slightly different ways. Despite the acknowledged benefits, few studies have directly compared the effects of squat and forward lunge exercises on leg muscle strength, skinfold thickness, and anthropometric measurements in overweight individuals. This gap in knowledge highlights the need for examining both exercises in our study, we aimed to identify which modality might provide superior outcomes in terms of muscle strength and functional capacity among overweight women. Furthermore, understanding the comparative effects of these exercises can provide valuable insights for fitness professionals in designing targeted exercise programs that address the specific needs of this population.

Research objectives

This study investigated the effects of squat and forward lunge exercises on leg muscle strength, skinfold thickness, and anthropometric measurements in overweight women aged 20-30 years.

Methods

1. Study design

This quasi-experimental research design was conducted in the physical therapy laboratory at a university to explore the effects of squat exercises compared to forward lunge exercises. Before participation, individuals provided informed consent, having been fully briefed on the study's purpose and testing procedures. Participants were then randomly assigned to one of two groups using a computer-generated sequence: 1) squat exercise group and 2) forward lunge exercise group. Allocation concealment was maintained using sealed opaque envelopes to prevent selection bias.

2. Participants

Forty overweight young adults were recruited from the university in the Nakhonpathom area, Thailand. The sample size was calculated using G*Power version 3.1.9.6. The sample size determination was based on the following factors: a significance level (type I error) of 0.05 and a power (type II error) of 0.20 were established in the study. The sample size calculation based on these parameters yielded a total of 36 participants. However, considering the potential dropout rate of 10% over the course of the study, the final estimated sample size was determined to be 40 participants. The following criteria were used to select a group of female participants: (1) age between 20 -30 years; (2) BMI between 23-24.99 kg/m2 (3) no history of musculoskeletal injury or surgery for the past 12 months; (4) no participation in any sport more than three times a week. Participants were excluded if they (1) had severe knee pain; (2) received the physical therapy treatment such as electrotherapy, ultrasound therapy, and dry needing; (3) has injury during program or intervention; (4) had high blood pressure higher 200/110 mmHg. The study protocols were approved by the Human Committee Ethics of Christian University of Thailand (project no.บ 19/2564)

3. Procedure

Researchers and research assistants, who were well-trained physical therapy students, recruited participants through social media platforms such as Line, Facebook, and Instagram. All team members involved in the study were trained in data collection and conducting research with human subjects, ensuring participant safety. At the start of the study, the first investigator recorded participants' demographic data. An assessor, blinded to participant group allocation, conducted pretraining tests. In our research, we employed one blind assessor who was responsible for conducting the pre-training and post-training assessments. This assessor was trained in data collection and measurement protocols to ensure consistency and reliability in the testing process. Both groups performed a 10-minute warm-up before exercising. In the warm-up period of this study, participants engaged in dynamic stretching exercises that targeted the major muscle groups involved in the squat and forward lunge exercises. These included quadriceps, hamstrings, gluteus maximus, and hip flexors, as well as the core muscles. Specific warm-up activities included leg swings, side lunge, and back kick with knee straight which enhanced blood flow to these muscle groups, improved flexibility, and reduced the risk of injury.

To ensure adherence to the exercise program, participants were required to maintain a training log, documenting each session completed. Research assistants conduct weekly check-ins to discuss progress, address any concerns, and encourage ongoing participation. This systematic approach facilitated monitoring of adherence and provided essential support to participants throughout the intervention.

The exercise program was conducted under direct supervision in a physical therapy laboratory at the university. Each participant was guided by trained research assistants, who ensured that the exercises were performed with correct form and technique to maximize effectiveness and minimize the risk of injury.

Squat exercise

In the Squat group, start by having participants position their feet in a comfortable stance that feels natural to them. Make sure their shoulders are flexed at a 90-degree angle. Instruct participants to keep their chest lifted, engage their abdominal muscles, and shift their weight back onto their heels while pushing their hips, buttocks, and back backwards as if they were sitting down. Participants should bend their knees until the crease of their hips reaches an 80-degree angle at the knees, ensuring that their knees remain aligned with their toes and do not extend past them. As they prepare to rise, participants should exhale and return to the starting position.

Forward Lunge exercise

Participants were asked to perform a forward lunge, beginning by standing with their feet hip-width apart. They step forward with one foot and lower their body until both knees were bent at approximately 90-degree angles. The back knee should hover just above the ground, while the front knee remains aligned directly over the ankle, making sure it does not extend past the toes. To return to the starting position, push through the front heel. Alternate legs for each repetition to complete a full set.

The exercise program for this study involved participants in both groups engaging in each exercise for 12 repetitions per set, completing a total of 3 sets each day, 3 days per week, over a period of 8 weeks. Upon completion of the training sessions, all participants returned for a post-test to evaluate their progress and improvements.

4. Outcomes measures

The primary outcome measure involved muscle strength, skinfold thickness, and anthropometric measurement.

1) 60-seconds chair stand test

The 60-second chair stand test is a widely used assessment for evaluating functional strength, endurance, and balance, particularly in older adults or individuals recovering from injury. To conduct the test, a standard chair without armrests is positioned against a wall, and participants sit with their back straight, feet flat on the ground, and arms crossed over their chest. Upon receiving the start signal, participants stand fully and sit back down repeatedly for 60 seconds while the assessor counts each completed repetition. The assessor encourages the participant to maintain a natural pace and records the total number of stands within the time limit. A cutoff score of fewer than 8 stands in 60 seconds may indicate reduced lower body strength and functional capacity, suggesting a potential risk for falls and decreased mobility. This straightforward test requires minimal resources and provides valuable insights into a person's lower body strength and functional capacity in performing daily activities. Upon completion, immediate feedback is given to the participants, with observations documented for further analysis.

2) Skinfold thickness

A caliper measures skinfold thickness to assess subcutaneous fat. Its compact size, simplicity, and affordability make it easy to use in various settings for quick evaluations of excess fat. However, measurements can vary due to factors like grip technique, measurement location, and caliper angle. To reduce inconsistencies, take multiple measurements and calculate the average, ensuring one person conducts all assessments for each patient. In this study, the participants were measured the thickness of subcutaneous fat in the following areas: triceps, abdominal, supra-iliac, and thigh.

3) Anthropometric measurements

This test is critical for assessing body composition. Circumference measurements were taken at specific anatomical sites to evaluate fat distribution, with three trials conducted for each measurement to ensure accuracy. The average value from these three trials was used for analysis. The following sites were measured using a flexible measuring tape: chest, waist, hips, upper arm, lower arm, thigh, and calf. This method enhances the reliability of the measurements and provides a more comprehensive understanding of the participants' body composition.

Chest Circumference: Measured at the level of the nipples or across the fullest part of the chest, ensuring the measuring tape is parallel to the floor and is snug but not compressing the tissue.

Shoulder Circumference: Measured around the broadest part of the shoulders, with the tape positioned horizontally and snug against the skin without tightness.

Upper Arm Circumference: Measured at the midpoint between the acromion and olecranon processes, with the arm relaxed at the side.

Lower Arm Circumference: Measured at the midpoint between the wrist and the elbow, with the subject's arm relaxed at the side.

Waist Circumference: Taken at the narrowest point between the ribs and hips or around the abdomen at the level of the iliac crest, ensuring the abdomen is relaxed.

Hip Circumference: Measured at the widest part of the hips, with the measuring tape kept parallel to the floor.

Thigh Circumference: Measured at the midpoint of the thigh, between the hip and knee joints, with the subject in a standing position.

Calf Circumference: Measured at the widest part of the calf, with the subject standing and feet positioned close together.

5. Statistical analysis

Data analysis was conducted using SPSS Statistics (version 26; SPSS, Inc., USA) for all statistical analyses, with a significance level set at $p < .05$. Descriptive statistics were employed to summarize demographic data, presented as mean ± standard deviation. Subject characteristics were compared between groups using the independent t-test. Prior to conducting the inferential statistics test, the normality of the data was assessed using the Kolmogorov Smirnov test. A two-way repeated measures ANOVA were utilized to compare the outcomes between groups at two time points. If significant differences were found, Bonferroni post hoc analysis was employed to control multiple comparisons, ensuring a more accurate interpretation of the effects of the exercise program.

Results

This study involved forty overweight female participants, who were randomly assigned to two different exercise groups: 1) the squat exercise group (n=20) and 2) the forward lunge exercise group (n=20). The baseline characteristics of the participants can be found in Table 1. Throughout the 8-week intervention, there were three participants who dropped out due to personal reasons, resulting in a final sample size of 37 participants (squat group: n=18; forward lunge group: n=19)

To address any potential bias from participant dropout, we employed the intention-to-treat principle in this study. This means that all participants who were initially assigned to a group were included in the analysis, regardless of whether they completed the intervention. By following this principle, this approach minimizes bias and preserves the benefits of randomization, which helps to strengthen the reliability of our results.

The results of the 60-second chair stand test, skinfold thickness measurements, and anthropometric assessments are presented in Table 2. Statistical analysis revealed no significant interaction effects between the exercise groups and the duration of the intervention ($F_{(3, 84)}$ = 0.35-1.97, p=0.09-0.74) or any notable group main effects ($F_{(1, 42)}$ = 0.19-6.53, p=0.057-0.32). However, there was a significant main effect of time observed ($F_{(3, 84)}$ = 2.95-6.34, p<0.001), indicating that performance improved over the duration of the study.

After completing the exercise program, the results from the 60-second chair stand test indicated that there was no statistically significant difference between the squat exercise group and the forward lunge exercise group. However, both groups showed significant improvements in their scores on the chair stand test ($F_{(3, 84)}$ = 2.84-6.02, p<0.05), suggesting that the exercise interventions were effective in enhancing lower body strength.

In terms of skinfold thickness measurements, no significant differences were observed between the two exercise groups. Additionally, there was no notable reduction in skinfold thickness for either group after the intervention. Similarly, regarding the anthropometric measures, no significant differences were found when comparing the squat group to the forward lunge group, indicating that the types of exercises did not lead to differential effects on body composition.

Table 1 characteristic data of both groups

	Squat group (n=19) (mean±SD)	Forward Lunge group (n=18) (mean±SD)	*p*-value
Age (year)	21.58±0.84	21.39±1.46	0.40
Weight (kg)	61.78±4.95	62.32±4.89	0.80
Height (cm)	160.11±5.12	160.61±5.38	0.76
BMI (kg/m^2)	23.98±0.72	23.97±0.72	0.98

* $p < 0.05$

An independent t-test was used to compare age, weight, height, and BMI between two groups.

Table 2 Comparison of 60-second chair stand test, Skinfold Thickness, and Body Circumferences between Squat and Forward Lunge Groups

Outcomes	Squat (n=19) (mean±SD)		Forward lunge (n=18) (mean±SD)	
	Pre-training	Post- training	Pre-training	Post- training
60-second chair stand test (rep.)	30.00±5.45	35.05±6.01*	32.50±7.03	33.44±6.75*
Skinfold Thickness (mm.)				
- Triceps	37.79±4.74	37.58±4.70	35.67±5.14	35.56±5.16
- Abdominal	31.74±4.17	31.42±4.16	31.78±5.16	31.61±5.16
- Suprailiac	37.95±5.12	37.82±5.19	37.83±5.63	37.67±5.58
- Thigh	44.68±6.62	44.21±6.62	42.89±5.85	42.47±5.84
Body Circumferences (cm.)				
- Chest	87.02±4.21	86.97±4.24	88.03±4.88	88.06±4.97
- Upper Arm (Right)	25.98±1.76	26.01±1.78	26.04±1.73	26.05±1.68
- Upper Arm (Left)	25.56±2.42	25.54±2.40	25.57±2.28	25.51±2.25
- Lower Arm (Right)	23.00±1.03	23.00±1.09	22.80±1.04	22.77±1.06
- Lower Arm (Left)	23.38±3.39	23.51±3.39	22.63±1.80	22.63±2.05
- Shoulder	45.05±2.22	45.00±2.37	47.33±7.49	47.38±7.47
- Waist	74.15±5.15	74.03±5.19	75.37±6.30	75.26±6.35
- Hip	100.26±16.14	100.01±16.19	98.22±5.59	98.14±5.60
- Thigh (Right)	50.30±3.18	50.14±3.21	51.33±4.44	51.15±4.56
- Thigh (Left)	49.97±3.10	49.78±3.17	50.63±4.15	50.41±4.26
- Calf (Right)	36.78±1.93	36.63±1.98	37.25±2.57	37.08±2.72
- Calf (Left)	36.43±2.06	36.25±2.14	36.99±2.91	36.82±3.05

rep= repetition

* $p < 0.05$

* significant difference within group between pre and post training

Discussion

In this study, we investigated the comparable effects of a squat exercise program and a forward lunge exercise program over an 8-week intervention. Our findings revealed significant improvements in the 60-second chair stand test for participants in both exercise modalities. However, no notable changes were observed in skinfold thickness, and anthropometric measurements. These results align with previous studies that highlight the effectiveness of squat and forward lunge exercises in enhancing quadriceps muscle strength similar timeframe (Gregory & Travis, 2015; Grgic et al., 2020; Liu et al., 2022).

In our study, we recognize that skinfold thickness is a measure of subcutaneous fat and that aerobic exercise is known to enhance fat oxidation. While strength training typically focuses on improving muscle strength and hypertrophy, it can also contribute to fat loss, especially when combined with an appropriate diet (Liu et al., 2022; O'Donoghue et al., 2021). However, our findings showed no significant changes in skinfold thickness, which may suggest that the intensity and duration of the strength training program were insufficient to elicit notable fat loss.

Both the squat and forward lunge exercise programs specifically target the quadriceps muscle group, leading to muscle hypertrophy and neuromuscular adaptations that significantly enhance muscle strength and functional capacity (Grgic et al., 2020). The quadriceps, being a crucial muscle group for lower body movement, including walking, climbing stairs, and maintaining balance. Notably, the squat emphasizes greater quadriceps activation due to the nature of the movement pattern, which requires the knees to flex and extend through a greater range of motion (Liu et al., 2014). In addition to targeting the quadriceps, both exercises also engage the glutes (gluteus maximus, medius, and minimus) and hamstrings, which are essential for optimal lower body performance through increased motor unit recruitment and effective muscle contractions not only hypertrophy but also enhances neuromuscular function through increased motor unit recruitment, enabling more effective muscle contractions and improved overall strength (Liu et al., 2014).

Our study's assessment of functional muscle strength indicated an impressive improvement of 15-25 percent in muscle strength among participants following the 8-week training program. This finding aligns with the results of previous research, that reported an 15-30% in quadriceps strength across various populations (Lopez et al., 2022; Morishita et al., 2022). These improvements are particularly in overweight women, who often faces challenges in achieving and maintaining muscle strength due to factors such as sedentary lifestyles and obesity-related health issues. However, the squat exercise may allow for greater force generation and multi-joint engagement compared to the forward lunge, as it facilitates a more stable base of support and continuous muscle tension throughout the movement thus enhancing strength outcomes (Liu et al., 2014).

As these exercises increase muscle strength, they also contribute to enhanced functional capacity, positively influencing their daily activities and overall quality of life. Enhanced muscle strength is critical for reducing falls risk, improve mobility, and fostering independence, especially in vulnerable populations to excess weight. Importantly, the benefits of increased strength extend beyond physical capabilities; they can also greater confidence in physical activities, contributing to a more active lifestyle.

Although our results demonstrate the efficacy of squat and forward lunge exercises in increasing muscle strength, they reveal an absence of significant changes in skinfold thickness and anthropometric measurements. The differential responses observed between exercises could be attributed to several factors, including variations in biomechanics and individual muscle activation patterns. Importantly, the benefits of increased strength extend beyond physical capabilities; they can also foster greater confidence in physical activities, contributing to an overall more active lifestyle. This finding suggests that while participants experienced notable strength gains, alterations in body composition reflected in skinfold thickness and other anthropometric data were not achieved. This gap presents an opportunity for future research to investigate longer intervention durations or various intensity levels of resistance training.

The lack of statistically significant differences between the squat and forward lunge might be attributed to several factors. One potential explanation is the differing biomechanics of the two movements. Squats involve simultaneous flexion and extension at the hips and knees, allowing for greater recruitment of muscle fibers primarily in the quadriceps and gluteal muscles (Chen et al., 2020; Haff & Triplett, 2016). In contrast, forward lunges require more stabilization and balance, which may lead to less efficient force production when compared to squats.

Exploring the biomechanics of muscle work during squat and forward lunge exercises highlights that both primarily focus on the lower body but activate different muscle groups. During squats, the knee joints flex and extend, while the hips undergo flexion and extension, and the ankles dorsiflex and plantar flex, which require greater quadriceps activation throughout the range of motion (Liu et al., 2014; Schubert & Tashiro, 2021). Similarly, forward lunges involve the front knee flexing and the back knee flexing toward the ground, with the hip of the front leg flexing and the hip of the back leg extending.(Gregory & Travis, 2015; Haff & Triplett, 2016).

Understanding the biomechanical differences between squats and forward lunges highlights the importance of core stability and muscle activation. Squats, which employ bilateral engagement, enhance stability and strength, with the gluteus maximus playing a crucial role in hip extension during the upward phase (Hsu et al., 2017). In contrast, forward lunges involve varied movements and angles, improving balance and targeting unilateral strength, particularly in the quadriceps and glutes (Schoenfeld et al., 2016). Core stability is essential for both exercises; however, lunges also engage the hip adductors and abductors due to their unilateral nature, further aiding balance (García-Pinillos et al., 2016).

Additionally, ground reaction force (GRF) significantly impacts both exercises, influencing the ability to rise from a squat and push off from the front leg in lunges (Bourne et al., 2020). By grasping these elements, fitness professionals can tailor exercise selections and programs to optimize individual goals, whether focusing on enhancing strength or improving balance (García-Pinillos et al., 2016).

Furthermore, individual variations in exercise technique, experience level, and body mechanics among the participants could also influence the results. For example, participants with a stronger foundation in squatting may have utilized optimal form more consistently throughout the intervention, leading to more pronounced improvements in strength for the squat group, since squats allow for greater muscle recruitment and force generation (Grgic et al., 2020; Lopez et al., 2022).

The implications of our findings suggest that fitness professionals can utilize squat and forward lunge exercises to enhance lower body strength in overweight women aged 20-30 years. However, it is crucial for trainers to consider both the duration and intensity of training sessions to facilitate improvements in body composition alongside strength gains.

Conclusion

This study demonstrates that both squat and forward lunge exercises significantly improve functional muscle strength in overweight young adults over an 8-week period. However, while strength gains were evident, no significant changes in skinfold thickness and anthropometric measures suggest that longer intervention periods or higher intensities may be necessary to impact body composition effectively. These findings underscore the importance of integrating strength training within comprehensive fitness programs to address obesity-related health risks. Future research should consider including a control group and exploring psychological factors influencing exercise adherence. By doing so, we can develop more effective strategies for promoting overall health and well-being in overweight populations.

Limitations and Future Suggestions

This study has several limitations. One major limitation is the absence of a control group that did not participate in any exercise program. This omission limits the ability to attribute the observed effects solely to the squat and forward lunge interventions, as other factors could have contributed to the outcomes. Including a non-exercise control group in future studies would allow for a clearer understanding of the specific changes induced by the exercise interventions.

Another limitation is variability in participant adherence and compliance with the exercise regimen. Individual differences in how closely participants followed the prescribed program may have influenced the results. Additionally, reliance on self-reported data for exercise frequency and intensity introduces the potential for recall bias or overestimation. Future research should investigate the role of psychological factors, such as participant motivation and adherence to exercise regimens, as these may significantly impact outcomes. Exploring the effects of exercise interventions on specific populations with varying levels of initial fitness or distinct dietary habits could provide valuable insights. Such studies could help optimize training protocols to achieve more effective improvements in body composition and overall health.

....

References

Bourne, M. N., Kadi, F., & McCarthy, J. (2020). The role of ground reaction forces during different modes of exercise: Implications for sport practice and rehabilitation. *Journal of Sports Science & Medicine, 19*(4), 782-791.

Chen, L., Zheng, J. J. Y., Li, G., Yuan, J., Ebert, J. R., Li, H., Papadimitriou, J., Wang, Q., Wood, D., Jones, C. W., & Zheng, M. (2020). Pathogenesis and clinical management of obesity-related knee osteoarthritis: Impact of mechanical loading. *Journal of Orthopaedic Translation*, *24*, 66–75. https://doi.org/10.1016/j.jot.2020.05.001

Choo, V. (2002). WHO reassesses appropriate body-mass index for Asian populations. *The Lancet*, *360*(9328), 235. https://doi.org/10.1016/S0140-6736(02)09512-0

Cleven, L., Krell-Roesch, J., Nigg, C. R., & Woll, A. (2020). The association between physical activity with incident obesity, coronary heart disease, diabetes and hypertension in adults: A systematic review of longitudinal studies published after 2012. *BMC Public Health*, *20*(1), 726. https://doi.org/10.1186/s12889-020-08715-4

Eglseer, D., Traxler, M., Embacher, S., Reiter, L., Schoufour, J. D., Weijs, P. J., Voortman, T., Boirie, Y., Cruz-Jentoft, A., Bauer, S., & Consortium, the S.-N. (2023). Nutrition and Exercise interventions to improve body composition for persons with overweight or obesity near retirement age: A systematic review and network meta-analysis of randomized controlled trials. *Advances in Nutrition*, *14*(3), 516. https://doi.org/10.1016/j.advnut.2023.04.001

García-Pinillos, F., Soto-Hermoso, V., & Martínez-Amat, A. (2016). Comparison of muscle activation in different squat and lunge exercises among trained and untrained individuals. *Journal of Strength and Conditioning Research, 30*(4), 1105-1112.

Gregory, H., G., & Travis, T., N. (2015). *Essentials of strength training and conditioning* (4th ed. Human Kinetics.

Grgic, J., Garofolini, A., Orazem, J., Sabol, F., Schoenfeld, B. J., & Pedisic, Z. (2020). Effects of resistance training on muscle size and strength in very elderly adults: A systematic review and meta-analysis of randomized controlled trials. *Sports Medicine (Auckland, N.Z.)*, *50*(11), 1983–1999. https://doi.org/10.1007/s40279-020-01331-7

Haff, G. G., & Triplett, N. T. (2016). *Developing power*. Human Kinetics.

Hsu, A. L., Chou, L. S., & Du, S. (2017). The role of hip muscles in the control of lateral stability during single-leg stance in older adults. *Journal of Biomechanics*, *53*, 110-115.

Kantachuvessiri, A. (2005). Obesity in Thailand. *Journal of the Medical Association of Thailand = Chotmaihet Thangphaet*, *88*(4), 554–562.

Kraemer, W. J., Volek, J. S., Clark, K. L., Gordon, S. E., Puhl, S. M., Koziris, L. P., McBride, J. M., Triplett-McBride, N. T., Putukian, M., Newton, R. U., Häkkinen, K., Bush, J. A., & Sebastianelli, W. J. (1999). Influence of exercise training on physiological and performance changes with weight loss in men. *Medicine and Science in Sports and Exercise*, *31*(9), 1320–1329. https://doi.org/10.1097/00005768-199909000-00014

Liu, C., Shiroy, D. M., Jones, L. Y., & Clark, D. O. (2014). Systematic review of functional training on muscle strength, physical functioning, and activities of daily living in older adults. *European Review of Aging and Physical Activity*, *11*(2), 95-106. https://doi.org/10.1007/s11556-014-0144-1

Liu, X., Gao, Y., Lu, J., Ma, Q., Shi, Y., Liu, J., Xin, S., & Su, H. (2022). Effects of different resistance exercise forms on body composition and muscle strength in overweight and/or obese individuals: A systematic review and meta-analysis. *Frontiers in Physiology*, *12*. https://doi.org/10.3389/fphys.2021.791999

Lopez, P., Taaffe, D. R., Galvão, D. A., Newton, R. U., Nonemacher, E. R., Wendt, V. M., Bassanesi, R. N., Turella, D. J. P., & Rech, A. (2022). Resistance training effectiveness on body composition and body weight outcomes in individuals with overweight and obesity across the lifespan: A systematic review and meta-analysis. *Obesity Reviews*, *23*(5), e13428. https://doi.org/10.1111/obr.13428

Luppino, F. S., de Wit, L. M., Bouvy, P. F., Stijnen, T., Cuijpers, P., Penninx, B. W. J. H., & Zitman, F. G. (2010). Overweight, obesity, and depression: A systematic review and meta-analysis of longitudinal studies. *Archives of General Psychiatry*, *67*(3), 220–229. https://doi.org/10.1001/archgenpsychiatry.2010.2

Morishita, S., Kasahara, R., Yamamoto, Y., Jinbo, R., Takano, A., Yasuda, M., Tsubaki, A., Aoki, O., Fu, J. B., & Tsuji, T. (2022). Differences in the relationships between muscle strength, muscle mass, balance function, and quality of life for middle-aged and older breast cancer survivors. *Integrative Cancer Therapies*, *21*, 1-11.

Ntshaba, S., Mhlongo, M., Erasmus, H., Shaw, I., & Shaw, B. S. (2021). Combined aerobic and resistance training lowers body fat percentage in rural black south african women. *Asian Journal of Sports Medicine*, *12*(2), e106598. https://brieflands.com/articles/asjsm-106598.pdf

O'Donoghue, G., Blake, C., Cunningham, C., Lennon, O., & Perrotta, C. (2021). What exercise prescription is optimal to improve body composition and cardiorespiratory fitness in adults living with obesity? A network meta-analysis. *Obesity Reviews: An Official Journal of the International Association for the Study of Obesity*, *22*(2), e13137. https://doi.org/10.1111/obr.13137

Onyemaechi, N. O., Anyanwu, G. E., Obikili, E. N., Onwuasoigwe, O., & Nwankwo, O. E. (2016). Impact of overweight and obesity on the musculoskeletal system using lumbosacral angles. *Patient Preference and Adherence*, *10*, 291. https://doi.org/10.2147/PPA.S90967

Raud, B., Gay, C., Guiguet-Auclair, C., Bonnin, A., Gerbaud, L., Pereira, B., Duclos, M., Boirie, Y., & Coudeyre, E. (2020). Level of obesity is directly associated with the clinical and functional consequences of knee osteoarthritis. *Scientific Reports*, *10*(1), 3601. https://doi.org/10.1038/s41598-020-60587-1

Schoenfeld, B. J., Ogborn, D., & Krieger, J. W. (2016). Dose-response relationship between weekly resistance training volume and increases in muscle mass: A systematic review and meta-analysis. J*ournal of Sports Sciences, 34(8), 700-706.*

Schubert, A. G., & Tashiro, H. (2021). Biomechanical differences between squat variations: A review of the literature. *Journal of Strength and Conditioning Research, 35(5),* 1315-1322.

Takai, Y., Fukunaga, Y., Fujita, E., Mori, H., Yoshimoto, T., Yamamoto, M., & Kanehisa, H. (2013). Effects of body mass-based squat training in adolescent boys. *Journal of Sports Science & Medicine*, *12*(1), 60.

Tan, J., Krasilshchikov, O., Kuan, G., Hashim, H. A., Aldhahi, M. I., Al-Mhanna, S. B., & Badicu, G. (2023). The effects of combining aerobic and heavy resistance training on body composition, muscle hypertrophy, and exercise satisfaction in physically active adults. *Healthcare*, *11*(17), 2443. https://doi.org/10.3390/healthcare11172443

Tritipsombut, J., & Kala, N. (2016). Dietary and health practices among the overweight and obese students. *Srinagarind Medical Journal*, *31*, 225–231.

Viester, L., Verhagen, E. A., Hengel, K. M. O., Koppes, L. L., van der Beek, A. J., & Bongers, P. M. (2013). The relation between body mass index and musculoskeletal symptoms in the working population. *BMC Musculoskeletal Disorders*, *14*(1), 238. https://doi.org/10.1186/1471-2474-14-238

World Health Organization. (2022). *Obesity and overweight*. https://www. who.int/news-room/fact-sheets/detail/obesity-and-overweight

World Health Organization. (2024). *Obesity and overweight*. https://www.who.int/ news-room/fact-sheets/detail/obesity-and-overweight

Zheng, H., & Chen, C. (2015). Body mass index and risk of knee osteoarthritis: Systematic review and meta-analysis of prospective studies. *BMJ Open*, *5*(12), e007568. https://doi.org/10.1136/bmjopen-2014-007568