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Effectiveness of various leg muscle training methods on increasing leg muscle strength

M. Frans Surya Pradana[1], Anggi Setiorini[2]*, Suryani Agustina Daulay[3], Helmi Ismunandar[4]

[1]Medical Education Study Program, Faculty of Medicine, University of Lampung, Prof. Dr. Ir. Sumantri Brojonegoro Street No. 1, Gedong Meneng, Bandar Lampung, 35145, Indonesia

[2]Department of Anatomy, Faculty of Medicine, University of Lampung, Prof. Dr. Ir. Sumantri Brojonegoro Street No. 1, Gedong Meneng, Bandar Lampung, 35145, Indonesia

[3]Department of Community Medicine and Public Health, Faculty of Medicine, University of Lampung, Prof. Dr. Ir. Sumantri Brojonegoro Street No. 1, Gedong Meneng, Bandar Lampung, 35145, Indonesia

[4]Department of Orthopedics and Traumatology, Faculty of Medicine, University of Lampung, Prof. Dr. Ir. Sumantri Brojonegoro Street No. 1, Gedong Meneng, Bandar Lampung, 35145, Indonesia

*Coressponding Author. E-mail: anggisetiorini@fk.unila.ac.id

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Abstract: Lower limb muscle strength is crucial for functional human activities, providing body stabilization, maintaining posture, and enabling various movements. Insufficient training can hinder muscle protein synthesis, leading to diminished strength in the lower limbs. Regular training, particularly resistance exercises, is essential for improving this strength. Numerous training methods have been developed, such as resistance training, plyometric exercises, bodyweight exercises, isolation training, movement-based practices, and technology-assisted techniques, though their relative effectiveness remains a topic of ongoing evaluation. This literature review aims to assess the effectiveness of various lower limb strength training methods across diverse populations, including adolescents, athletes, and older adults. The review involved a systematic search of PubMed and Google Scholar, using defined inclusion and exclusion criteria, resulting in 16 eligible studies. The effectiveness of each training method was analyzed by comparing study findings, which incorporated different research designs. All included studies indicated significant improvements in lower limb strength, although the magnitude of the improvements varied based on training intensity, duration, and participant characteristics. Compound and resistance training demonstrated comprehensive strength gains, plyometric exercises improved explosive power, and isolation training was particularly effective for strengthening specific muscle groups. Among older adults, combined training proved to be the most effective, enhancing both strength and balance, as well as functional mobility. These results highlight that no single training method is universally superior, underscoring the importance of customizing exercise programs to meet individual needs and objectives.

Keywords: effectiveness, influence, training methods, increasing, lower limb muscle strength

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INTRODUCTION

The effectiveness of various leg muscle training methods in enhancing leg muscle strength has been a topic of considerable research and interest within the field of sports science and physical education. Leg muscle strength plays a critical role in supporting functional activities, including mobility, balance, and overall physical performance. A wide range of training methods, such as resistance training, plyometric exercises, and bodyweight routines, have been developed to target and strengthen the lower body muscles. While each of these methods has demonstrated positive effects, the comparative effectiveness of different training approaches remains a subject of debate. This study aims to review and evaluate the impact of various training techniques on leg muscle strength, considering factors such as intensity, frequency, and the specific muscle groups targeted. By providing a

comprehensive analysis of these methods, this research seeks to contribute valuable insights into optimizing leg muscle strength training across different populations, from athletes to the elderly, and offer practical recommendations for effective training strategies.

Humans need optimal strength and function of leg muscles to carry out activities his daily life. The leg muscles act as a vital musculoskeletal component because they support weight, maintain posture, and allow for various forms of functional movement such as standing, walking, running, climbing stairs, and jumping. The ability of leg muscles to produce force and stability is an important factor in maintaining a person's mobility, balance, and independence, especially in the elderly and individuals with high physical activity such as athletes (Saputra, 2022).

Leg muscle strength is the effort made by a person to produce maximum contraction of the leg muscles against a load or tension (Ardiansyah, 2020). Individuals who rarely trains his muscles regularly will have a decrease in muscle protein synthesis which leads to protein degradation and can reduce leg muscles strength (Smith et al., 2020). Muscle mass balance is determined by the relationship between Muscle Protein Synthesis (MPS) and Muscle Protein Breakdown (MPB). During immobilization, MPS decreases and triggering the loss of skeletal muscle mass (Brook et al., 2022). The decrease in MPS occurs because the MPS-regulating protein, mammalian target of rapamycin complex 1 (mTORC1) decrease due to lack of physical activity. The decrease in protein synthesis ability is also caused by the phenomenon of anabolic resistance. Anabolic resistance is a condition in which the body is no longer sensitive to physical activity and external protein consumption to increase the ability to stimulate muscle protein synthesis (MPS). This condition exacerbates the decline in muscle strength (Paulussen et al., 2021). The decline in muscle strength in Indonesia has reached a worrying level. Based on prevalence data, muscle disorders in Indonesia reaching 11.9% and a study conducted in Makassar found that 82.2% of respondents experienced weakness in their leg muscles (Riswana, 2024).

The impact of weak leg muscles in adolescents or adults who are actively exercising and doing activities is injuries in the leg area. Research conducted by Lestari (2022) said that there is a strong relationship between leg muscle strength and the incidence of injury. Muscle injuries account for about 31% of all total injuries with the most vulnerable risk being in the lower extremity region. Feet contribute 77% of muscle injuries, thighs contribute 21% of muscle injuries, knees 23.1% and ankle muscle injuries 38% (Herdiandanu & Djawa, 2020). The elderly are an age category that is prone to experiencing a decrease in muscle mass. A person over the age of 50 experiences a 1-2% decrease in muscle mass in one year Ramadhanti & Renovaldi (2024). Meanwhile, the elderly over 60 years old experience a 3% decrease in muscle mass per year Choirunnisa & Pudjianto (2023) The increase in the decrease in leg muscle strength occurs at the age of 70 years, the muscle strength of the elderly is estimated to decrease by 35-45% compared to when muscle mass is at its peak. This decrease in muscle mass can be a risk of causing falls in the elderly and sarcopenia (Setiorini, 2021). Although many studies discuss the importance of leg muscle strength, the available literature does not provide a comprehensive summary comparing various exercise methods and their effectiveness in different age groups. Most studies are still independent, only examining one type of exercise in a specific population, thus not providing a complete view of which methods are most effective. For example, the studies by Nasrulloh et al (2020) and Kurniawati & Widarti (2023) only focus on bodyweight exercises to increase leg muscle strength without comparing them to other methods such as resistance training, plyometrics, or external load-based exercises. This limitation indicates an important gap in the literature. The urgency is further highlighted because sedentary conditions can reduce muscle protein synthesis and accelerate muscle weakness, making it necessary to have a clearer understanding of the most appropriate exercise methods to prevent muscle strength decline and maintain optimal physical function.

Increasing the strength of the leg muscles is important to do. Regular exercise and physical activity can increase the strength and endurance of frequently trained muscles (Sihombing, 2024). Leg muscle strength training models are very diverse, from these various types have the same goal, which is to train and increase leg muscle strength. Choosing the appropriate method to give the best results in training the leg muscles is important to know. The above phenomenon underlies researchers to conduct research with the aim of reviewing articles related to exercise methods that can increase leg muscle strength.

The urgency of this research stems from the fact that sedentary lifestyles can significantly reduce muscle protein synthesis and accelerate the decline in muscle strength, particularly in the lower limbs. As a result, it is crucial to understand the most effective training methods to prevent muscle strength

decline and maintain optimal physical function across different age groups. With the increasing prevalence of muscle weakness, especially in Indonesia, and the heightened risk of falls and injuries in the elderly, addressing this issue has become an urgent priority. The lack of comprehensive studies comparing various exercise methods highlights a significant gap in the existing literature, underscoring the importance of this research in advancing the field of physical activity and rehabilitation.

The scientific contribution of this research lies in providing a comprehensive comparison of various exercise methods aimed at enhancing lower limb strength. This review will inform the development of practical training programmes tailored to different populations, from adolescents to older adults, and will help guide future research into effective exercise modalities for muscle strength development. By addressing the gap in the existing literature, this study will contribute to the creation of evidence-based practices that can optimise physical performance, prevent muscle-related injuries, and improve functional mobility across diverse demographic groups. This research is expected to have significant implications for the design of more targeted and effective exercise interventions for individuals at risk of muscle weakness and associated injuries.

METHODS

This study used literature review with the narrative review which is carried out through systematic searches on various electronic databases. The literature analyzed is derived from published scientific articles in the full text, both Indonesian and English. The sources were national and international journals accessed through PubMed and Google Scholar, with a range of years of publication between 2020 to 2025. The search process is carried out using a combination of keywords and Boolean operators, namely AND, OR, and NOT, to expand or narrow the scope of the search according to the focus of the research. PubMed searches using a combination of keywords ((leg strength) OR (lower limb muscle strength)) AND (leg exercise method) AND ((effectiveness) OR (lower limb muscle strength improvement)) with the application of the last five years of filters, free full text, and primary data-driven research. This search yielded 397 articles that were considered relevant. All of these articles then went through a screening process so that 4 articles that met the inclusion criteria were obtained.

Google Scholar searches using a combination of keywords "effectiveness" "leg muscle training" "various method" "leg muscle strength improvement". Scientific articles that have been found are then screened based on inclusion criteria, such as title and articles that discuss the effectiveness of models or exercise methods that focus on leg muscles and the results of leg muscle strength from the exercise models. The selection process resulted in 12 articles that met the criteria.

Overall, the number of articles used in this literature review amounted to 16 articles, consisting of four articles from PubMed, and twelve articles from Google Scholar. Articles that have met the criteria are then analyzed based on abstracts, research methods, results, and discussions to obtain relevant information in the preparation of this literature review.

RESULT AND DISCUSSION

Tabel 1. characteristics of article review results

No.	Name (Year)	Title	Results/Conclusions
1.	Oneal, A. O., & Wiriawan, O. (2025)	The Effect of Cycle Split Squat Jump and Burpees Training on Power and Leg Muscle Strength in Students at SMPN 43 Surabaya	This study used a quasi-experimental two-group pretest–posttest design with one group receiving Cycle Split Squat Jump training and the other group receiving Burpees training for more than six weeks. The sampling technique used simple random sampling. The subjects consisted of 20 students from SMPN 43 Surabaya. The results showed a significant increase in leg muscle strength, as evidenced by a t-value of 2.218, which exceeded the t-table value of 1.685, and a significance value of 0.033 ($2.218 > 1.685$; $p < 0.05$).
2.	Faturrahman, M. H. S., Nurhidayat, & Indarto, P. (2023)	Improvement in lower limb power through ankle weight training (an experimental study	This study was a quasi-experiment with a nonequivalent control group design involving 20 male MBO Futsal students. Data analysis used a paired t-test. Ankle weight training was given as the main intervention. The results showed that ankle weight

		on male futsal vocational students)	training was effective in increasing leg muscle power, with an average increase from 47.60 to 57.60 and a p-value < 0.05.
3.	Murod, M. A. (2023)	The effect of combined plyometric training on normal smash skills in terms of leg muscle strength	This study used a 2×2 factorial experimental design with a sample of 60 volleyball athletes categorized based on high and low leg muscle strength levels. The intervention consisted of a combination of plyometric exercises such as box jumps and depth jumps. The results showed that this combination of exercises significantly improved leg muscle strength and normal smash skills. Significant differences were also observed based on leg strength levels, and there was an interaction effect between exercise type and leg strength (F=4.876; p < 0.05).
4.	Fetriani et al (2024)	The effect of weight training on improving leg muscle strength in wrestlers	This study used an experimental design with a sample of 12 wrestlers (eight male and four female) and was analyzed using a t-test. The results showed that weight training had a significant effect on increasing leg muscle strength in both male and female wrestlers.
5.	Nasution et al (2024)	The Effect of Weight Training on Leg Muscle Strength	This study used a one-group pretest-posttest experimental design involving 16 female futsal athletes from Unimed Women FC. After a six-week weight training program, leg muscle strength increased significantly with a significance value of 0.000 < 0.05.
6.	Asriani and Mutiara (2022)	The Effectiveness of Lying Leg Curl Training to Increase Leg Muscle Strength in Futsal Players	This study used a pretest–posttest quasi-experimental design with two groups, namely the intervention group and the control group. Leg muscle strength was measured using a leg dynamometer. The research subjects consisted of 20 futsal players divided into two groups. The results showed that eight weeks of lying leg curl training significantly increased leg muscle strength compared to the control group (p < 0.005).
7.	Batalipu et al (2025)	The Effectiveness of Stair Climbing Exercise in Increasing Leg Muscle Strength for Soccer Performance	This study used a quasi-experiment with a pretest–posttest design without a control group on 16 students of SMPN 1 Bulango Selatan who participated in soccer extracurricular activities. Leg muscle strength was measured using a leg dynamometer. After participating in 14 sessions of stair climbing training, there was a significant increase in leg muscle strength. The initial category of participants who were predominantly at a very low level changed to moderate and low.
8.	Saputra, A. N. (2022)	The Effect of Box Jump, Box Shuffle, and Squat Jump Training on Leg Muscle Strength in Badminton Athletes at Malang State University	This study used a pre-experimental one-group pretest-posttest design with a quantitative approach and involved 15 male athletes from the Malang State University Badminton Club. The plyometric training program, which included box jumps, box shuffles, and squat jumps, was conducted for six weeks with a total of 18 sessions. Lower limb muscle strength was measured using a leg dynamometer. The results showed a significant increase in lower limb muscle strength after the intervention.
9.	Mufti, A., Hermawan, I., & Arifin, Z. (2024)	The Effect of Squat Thrust Training on Lower Limb Muscle Strength, Arm Muscle Strength, and Waist Muscle Strength in Handball	This quasi-experimental one-group pretest–posttest study involved 16 Porda Garut handball athletes with a squat thrust training program for four weeks at a frequency of four times per week. The results showed a significant increase in leg muscle strength with a p-value of 0.00 < 0.05.
10.	Sartika et al (2023)	Improving Leg Muscle Strength Through Squat Training	This quasi-experimental study was conducted over two months with a training frequency of twice a week and a total of 16 squat training sessions. The sample consisted of 11 weightlifters, and leg muscle strength was measured using a vertical jump test. The study showed a 23.62 percent increase in leg muscle strength, with significant results in the t-test (0.000 < 0.05).
11.	Wei-rong et al (2025)	A Study on the Effect of Walking Stick in Lower Limb	This study used a pretest–posttest design and involved 31 subjects aged 55 years and above. The intervention, which consisted of walking stick exercises, was conducted twice a week for 12 weeks, and leg muscle strength was measured using a 30-

		Strength and Gait of the Elderly	second sit-to-stand test. The results showed a significant increase in the 30-second sit-to-stand test ($p < 0.05$), confirming the effectiveness of walking stick exercises in increasing leg muscle strength.
12.	Zhang et al (2024)	Effects Of Aerobic And Combined Aerobic-resistance Exercise On Motor Function In Sedentary Older Adults: A Randomized Clinical Trial	This randomized clinical trial lasted 24 weeks and involved 60 healthy older adults aged 65–80 years who were divided into three groups: aerobic exercise, combined aerobic-resistance exercise, and health education. The exercise intervention was conducted for 150 minutes per week according to WHO/ACSM guidelines. Lower limb muscle strength was assessed using the 30-second chair stand test. Of the 60 participants, 42 completed the study, and both exercise groups showed a significant improvement in 30-second sit-to-stand ability ($p < 0.05$).
13.	Parolini et al (2024)	Unlocking the Potential: Increasing Muscle Strength in Lower Limbs of Youth Soccer Players over Five Weeks through Mat Pilates Training A Pilot Study	This study used a quasi-experimental design with intervention and control groups. The research subjects consisted of 15 soccer players aged 13–14 years, who were divided into a Pilates group (n=8) and a control group (n=7). The initial evaluation included anthropometry, posture analysis using photography according to the SAPO protocol, and isometric muscle strength measurements using a Lafayette Manual Dynamometer. The Pilates group participated in Mat Pilates exercises consisting of ten core movements, each performed ten times, guided by a certified instructor. Evaluations were conducted before and after the intervention.
14.	Greco et al (2022)	Effects of self-selected versus motivational music on lower limb muscle strength and affective state in middle-aged adults	This study used a randomized repeated measures design with 26 healthy middle-aged men (mean age 50.8 years). Participants underwent lower limb isometric strength testing in three conditions: self-selected music, motivational music, and no music. Measurements included peak force, average force, RFD, fatigue index, as well as FAS (pre-test), RPE, and FS (post-test). Results showed the highest average force in the self-selected music condition (507.3 ± 132.2 N), which was significantly higher than the other two conditions. FAS and FS scores were also significantly higher in the self-selected music condition.
15.	Sadeghi et al (2021)	Effects of 8 Weeks of Balance Training, Virtual Reality Training, and Combined Exercise on Lower Limb Muscle Strength, Balance, and Functional Mobility Among Older Men: A Randomized Controlled Trial	This randomized controlled trial involved 64 older men (mean age 71.8 years) who were divided into four groups: balance training (BT), virtual reality training (VR), combined exercise (MIX), and control. The exercise program was conducted for eight weeks, three times per week for 40 minutes. Quadriceps and hamstring muscle strength in the dominant and non-dominant legs was measured using a Biodex Isokinetic Dynamometer. The results showed significant differences between groups in quadriceps and hamstring strength ($p < 0.05$), with the MIX group showing the greatest improvement in strength, balance, and functional mobility.
16.	Kim et al (2024)	Effects of Taekkyon-based exercise program on balance, lower extremity strength, and gait parameters in community-dwelling older women Randomized controlled trial	This randomized controlled trial involved 48 older women, with a Taekkyon exercise group (n=25; mean age 71.68 years) and a fall prevention group (n=23; mean age 73.65 years). The Taekkyon group exercised twice a week for 12 weeks, while the control group followed a standard fall prevention program. Assessments included balance tests (TUG, one-leg stance, functional reach), lower limb strength (5-chair stand and 30-second chair stand), and gait parameters. Results showed significant improvements in all components in the Taekkyon group compared to the control group, with most values exceeding the normal standards for women aged >65 years.

Based on all the articles analyzed in the literature review, it can be seen that each leg muscle training method has different characteristics, strength, and effectiveness depending on the type of

population, functional needs, and training goals. In general, almost all studies show an increase in leg muscle strength, although the variations vary quite a bit in terms of intensity, duration, and training approach.

Researched by Oneal & Wiriawan (2025), the cycle split squat and burpee training program was conducted on students of SMPN 43 Surabaya for six weeks, three times per week, at an intensity of 60%–85%, in three sets with rest periods between each sets could provide a significant increase in leg strength (p-value=0.033), so bodyweight-based exercises have proven to be effective for adolescent populations that do not have access to heavy equipment. This exercise focuses on the quadriceps, hamstrings, and gluteus muscles. Cycle split squat jump is done by squatting one leg in front and one foot behind with the athlete changing the position of his feet when in the air. Burpees or squad thrust itself is an exercise that uses almost all body muscles. This exercise was done in several steps. First from a standing position to a push-up position, then followed by a vertical jump. Both of these exercises use a lot of muscle groups, especially leg muscles. Meanwhile, the use of ankle weight in leg muscle training showed a significant increase in the strength of the legs of futsal students (p-value=0.00<0.05) marked by an increase in post-test value of 10.00 compared to before doing ankle weight training. This study indicates that the addition of light external loads is effective in increasing the explosive ability and strength of the leg muscles Faturrahman et al., (2023).

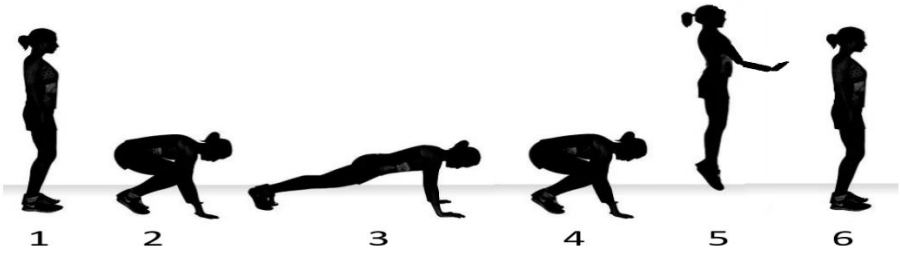

Figure 1. Stages of movement burpee
(Source: Šiska et al., 2024)

Research by Mufti et al (2024) shows that squat thrust exercises (burpees) provide a very significant increase in the strength of the leg muscles of handball athletes. The average squat jump score increased from 32.54 to 60.69 with an increase percentage of 86.5% (p=0.000). The explosive nature of the thrust squat movement and involves a series of squats, leg pushes, and transitions to push-up positions makes this exercise activate the quadriceps, hamstrings, gluteus, and gastrocnemius muscles a lot. A fairly high frequency of exercise, which is four times per week for four weeks, provides a strong neuromuscular stimulus so that the increase in strength takes place more optimally. This exercise also has a positive impact on the arm and waist muscles due to its movement pattern that involves the upper body. The steps in one burpee consist of a basic standing position (1), from which the participant moves after the sound signal to a squatting position (2) and then a lying position (3) with arms extended or slightly bent. In the shortest possible time, followed by a transition from the lying position to a squatting position (4) to a jump (5) and back to the basic position (Šiska et al., 2024).

Research with the squat method conducted by Sartika et al (2023) proves that squat exercises have a significant effect on leg muscle strength. The average vertical jump of the study subjects increased from 48.09 to 59.45 or by 23.62%, with a value of p (0.000<0.05). Squat exercises focus on knee and hip extension flexion movements that use the contraction of the gluteus maximus, quadriceps femoris, hamstring, and gastrocnemius muscles as the drive. The longer duration of sixteen sessions over two months with a frequency of twice per week provides a gradual adaptation time through improved neuromuscular control and metabolic capacity.

Squat thrusts have been found to produce a greater increase in force compared to traditional squats, likely due to the higher intensity of explosive movements, more frequent exercise, and the involvement of a broader range of muscle groups. Despite this difference, both exercises are effective and can be selected based on the specific training goals of each sport. Both squat thrusts and squats have been shown to elicit meaningful physiological adaptations, making them viable components of leg muscle strength development programmes. These findings underscore the flexibility and effectiveness of both exercises in enhancing lower body strength, and their application can be tailored to meet the

needs of different athletes and training objectives. This aligns with the research conducted by Arpannudin et al. (2025), which highlights the importance of understanding the socio-cultural dynamics and organizational solidarity in optimising training strategies across various contexts, including sports training.

Plyometric exercises can be a very effective method in the sports branch of games. Research conducted by Murod (2023) showed that the combination of box jump and depth jump had a significant influence on increasing leg muscle strength by (0.001<0.05). Plyometric exercises also improve volleyball athletes' smash skills, with a significant interaction effect between the type of exercise and the athlete's initial strength level. Similar to research conducted by Murod (2023) and research conducted by Saputra et al (2023), badminton athletes who underwent box jump, box shuffle and squat jump programs for six weeks experienced a significant increase in leg strength. The flexibility and neuromuscular adaptation produced by plyometric exercises make this method very suitable for sports that require high power.

Weight training methods, whether using body weight or external weights, have been shown to significantly enhance leg muscle strength. Research by Fetriani et al. (2024) demonstrated that weight training effectively increased leg muscle strength in wrestling athletes, supporting the findings of Nasution et al. (2024), which reported a significant improvement in leg muscle tightness among female futsal athletes after six weeks of weight training ($p = 0.000$). The training exercises in these studies included leg extensions, machine-seated hip abductions, leg presses, dumbbell hamstring curls, Smith machine standing calf raises, machine-seated hip additions, and leg press calf raises. Both studies utilised a leg dynamometer as the measuring instrument for leg muscle strength, reinforcing the significance of weight training in improving leg muscle performance. These results align with similar findings from Arsenis et al. (2021), which compared flywheel and free weight training methods, further emphasising that weight training, in various forms, is highly effective in improving lower limb strength. This collective body of research highlights the substantial impact of weight training on muscle strength across different sports and populations.

More specific research on certain muscle groups was conducted by Asriani & Mutiara (2022) through the practice of the lying leg curl method, which was proven to significantly increase the strength of leg muscles, especially the hamstring muscles of futsal players. This method of exercise is effective for athletes who require emphasis on the posterior chain muscles, specifically to prevent hamstring injuries. The measurement of leg muscle strength in this study used a leg dynamometer. The first movement performed in the lying leg curl is scapular adduction. The second movement is thoracic spine extension. To build the motor movement correctly, the third movement is hip extension accompanied by convergent contraction of the gluteus maximus muscle. This detail will improve the stability and proper positioning of the pelvic ring. Finally, the fourth movement ends with knee flexion combined with plantar dorsiflexion to effectively contract the posterior thigh muscle chain (Chaves & Reis, 2024).

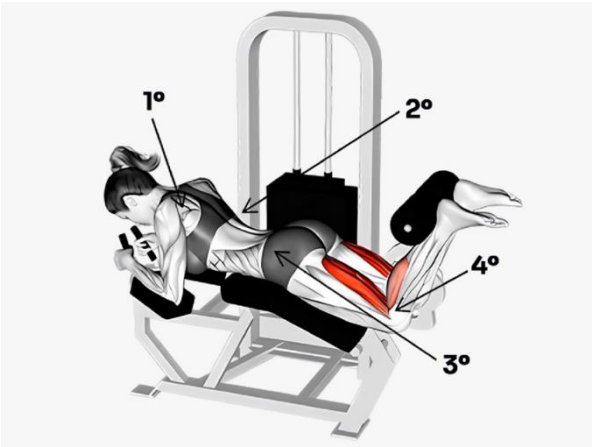

Figure 2. Illustration of exercises *lying leg curl* with focus movement in the knee joint during concentric and eccentric contractions.
(Source: Chaves & Reis, 2024)

Simple methods such as going up and down stairs researched by Batalipu et al., (2025) also gave positive results for junior high school students with a significant increase in leg strength after 14 training sessions. These findings show that repetitive exercises on certain muscles can increase hypertrophy of trained muscles. Up and down stairs exercises involve the hamstring, quadricep, gluteus and muscle groups in the crarris region. In line with Batalipu et al (2025) research, daily functional physical activities such as walking and climbing stairs have been proven to increase lower limb muscle strength (Nerkar et al., 2020). This daily activity-based exercise is suitable for early childhood populations or areas with limited facilities because they are cheap and easy to find.

In the adult and elderly populations, variations in exercise methods show interesting results. Research conducted by Wei-rong et al (2025) found that exercising using a walking stick twice a week for 12 weeks was able to improve 30-second sit-to-stand performance, which is an indicator for measuring leg strength and functionality. Another study conducted by Zhang et al (2024) showed that both aerobic exercise and aerobic-resistance combinations can significantly increase the strength of elderly legs within 24 weeks. Aerobic-resistance combination training appears to be superior because it provides a dual effect on strength, mobility, and endurance.

Research using modern electronic methods such as Virtual Reality (VR) was conducted by Sadeghi et al (2021). This study was conducted by evaluating the effectiveness of three types of exercises: Balance Training (BT); Virtual Reality Balance Training (VR); and Combined Exercise (MIX) compared to the control group (CON) in elderly men. BT is a conventional balance exercise such as standing on one foot and walking in tandem, while VR uses motion sensor-based games that demand coordination, quick reactions, and more complex sensory integration. Meanwhile, MIX combines the two in one training session. CON only carries out daily activities without intervention. ANCOVA results showed a significant increase in quadriceps and hamstring strength, both dominant and non-dominant legs ($p = 0.001–0.04$). The largest increase occurred in the MIX group, followed by VR and BT. These findings suggest that the combination of traditional and virtual-based exercises provides more complete physical and cognitive stimulation, resulting in more optimal neuromuscular adaptation. This combination of exercises takes advantage of the advantages of BT and VR simultaneously, providing greater benefits than a single exercise. The results of this study are important as the basis for the development of a program to increase leg muscle strength as a more comprehensive fall prevention for the elderly population.

Research by Parolini et al (2024) regarding Mat Pilates in 15 young football players showed that Pilates is able to increase the isometric strength of the leg muscle. The intervention was carried out through a Mat Pilates program that focused on leg muscle exercise for 5 weeks, with a total of 15 training sessions, each lasting 30 minutes and carried out three times per week. This training method has characteristics that distinguish it from other methods because it emphasizes body control, breathing techniques, and core stability, thus offering a more holistic approach to lower limb strength development. The increase in strength obtained was not primarily due to an increase in muscle mass, but rather to better to better neuromuscular adaptation, such as increased motor unit recruitment and muscle activation efficiency. The study results showed a significant difference in lower limb muscle strength improvement between the Mat Pilates group and the control group. However, this study did not find any meaningful changes in posture after the intervention. In addition, despite the increase in leg muscle strength, there were no signs of muscle hypertrophy, which is in line with the principles of Mat Pilater, which is not designed to trigger hypertrophy, but rather focuses on movement quality and motor control.

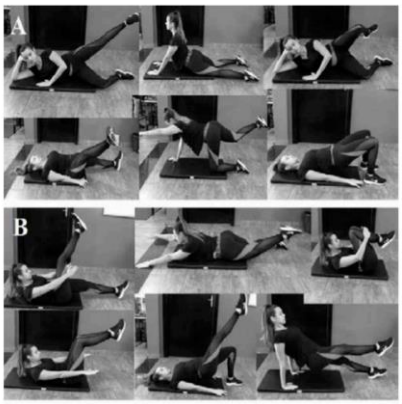

Figure 3. Pilates training sequences. (A) Basic training from top to bottom: Side Kick, Shoulder Bridge, Clamshell, One Leg Circles, Quadruped, The Swan Dive. (B) Intermediate training from top to bottom: Scissor, Swimming, One-Leg Shoulder Bridge, Hundred, The Double Leg
(Source: Parolini et al., 2024)

Another study conducted by Kim et al (2024) regarding Taekkyon-based exercise programs in elderly women also showed a significant increase in leg strength. Taekkyon is a typical Korean martial art that uses bare hands and has distinctive movements. An important element of movement in this martial art is the pumbalkki, which is a triangular walking pattern from one corner point to another, which is considered the basic and most important movement in Taekkyon. This movement involves knee flexion and extension, as well as repetitive movements of the center of the body. This series of lunging and squatting movements can cause eccentric contractions in the quadriceps muscles. Traditional low-intensity martial arts-based approaches have been proven to be safe, fun, and motivationally boosting with expert guidance.

Psychology also helps in exercises to increase the strength of the leg muscles. Research conducted by Greco et al (2022) showed that listening to self-selected music while performing an isometric strength test of the limbs can significantly increase average force compared to motivational music or no music. These results indicate that psychological and motivational aspects can also modulate a person's physical performance.

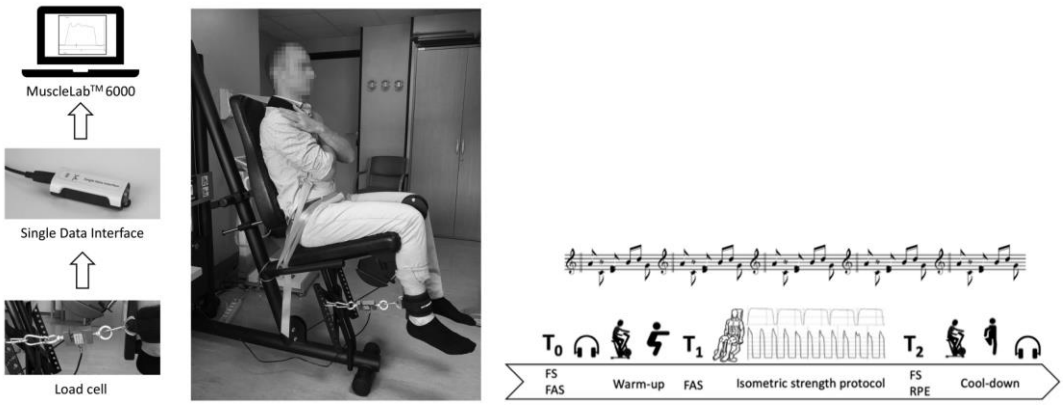

Figure 4. Illustration of a force measurement device and a series of test sessions that include the Feeling Scale (FS), Felt Arousal Scale (FAS), and Rate of Perceived Exertion (RPE)
(Source: Greco et al., 2022)

These findings align with the research by Bozzato et al. (2025), which investigated the influence of music on bench press performance. Their study found that self-selected music led to higher peak power and average power compared to the no-music condition, even though there was a decline in performance between sets. This suggests that the psychological effects of music, particularly the choice of music, may enhance short-term power output, even though fatigue could set in as sets progress.

Moreover, psychological activation levels were significantly higher when participants selected their own music, in contrast to the stimulating music or no-music conditions. This indicates that music has the potential to influence both physical and psychological states during exercise, which can be particularly beneficial for enhancing performance in activities requiring bursts of strength, such as weightlifting.

In addition, Dewi et al. (2025) conducted a study on the effect of post-training meals on blood glucose and blood pressure in young soccer athletes. Although the focus of their research was different, it also highlights the importance of external factors (such as nutrition and music) in influencing athletic performance. Their findings, which demonstrated significant changes in blood glucose and blood pressure, underscore the interconnectedness of physical performance with psychological and physiological factors. Both studies provide valuable insights into how external stimuli, whether through music or post-training meals, can influence athletes' physical capacities and recovery processes. These insights can guide further research into optimising athletic performance through psychological activation and nutritional interventions.

Music influences exercise responses through interrelated psychological, psychophysiological, and physiological mechanisms. Psychologically, music, especially preferred music, can increase positive affect, motivation, and feelings of energy during exercise, making the exercise experience more enjoyable and reducing the perception of fatigue. At the psychophysiological level, music plays a role in regulating arousal and lowering the Rating of Perceived Exertion (RPE) through a mechanism of dissociation, which is the distraction of attention from internal sensations such as pain and fatigue to external stimuli in the form of music. Thus, individuals are able to maintain or even increase exercise intensity without a corresponding increase in perceived exertion, as long as the arousal level remains in the optimal zone for performance (Ballmann, 2021).

From a physiological perspective, music affects the body's response through the activation of the nervous system and the regulation of the autonomic nervous system, which is reflected in changes in heart rate, hormonal responses, and neuromuscular efficiency. These effects can support improved performance and tolerance to exercise loads. The review also confirms that music preference is a major determinant of the magnitude of the exercise response. Self-selected music has been proven to be more effective than disliked music or no music in increasing motivation, reducing RPE, improving affective responses, and supporting physical performance. Therefore, individual music preferences play an important role in optimizing exercise responses through the simultaneous interaction of psychological, psychophysiological, and physiological mechanisms (Ballmann, 2021).

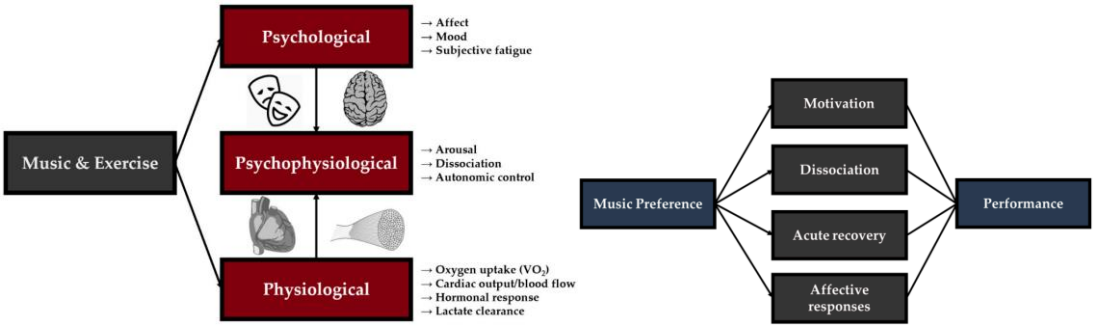

Figure 5. The mechanism of music's influence on exercise response and physical performance through psychological, physiological, and psychophysiological aspects mediated by music preference (motivation, dissociation/decrease in RPE, acute recovery, and affective response)
(Source: Ballmann, 2021)

The study found that exercise interventions without music resulted in higher rates of perceived exertion (RPE), while interventions with music resulted in lower RPE. Music, especially with a tempo of around 120–140 bpm and aligned with participants' preferences, can improve mood, reduce the perception of fatigue, lower physiological stress, and enhance efficiency and physical performance. Preferred music also serves as an effective dissociation tool, helping to lower RPE and increase the duration and quality of exercise. Therefore, using rhythmic and preferred music during aerobic activity can be a beneficial strategy to optimize the exercise experience and outcomes (Jiangang, 2025).

CONCLUSION

A review of sixteen articles shows that various training methods ranging from weight training, plyometrics, bodyweight training, isolation training, movement-based training, to technology-assisted training are generally effective in increasing leg muscle strength in various age groups. However, there is no single method that is superior for all individuals. The effectiveness of training depends on the suitability between training goals, participant characteristics, and functional needs. Thus, the selection of methods must be individualized and targeted in order to achieve optimal strength adaptation. Compound and resistance exercises provide comprehensive strengthening, plyometrics effectively increase power, while isolation exercises are useful for addressing specific muscle imbalances. In older adults, combined exercises including the integration of technology such as virtual reality show the greatest benefits because they support strength as well as balance and mobility.

Scientifically, this review contributes by providing a comprehensive mapping of the effectiveness of various lower-body muscle training methods, which can serve as a reference for sports and health practitioners in designing safe and targeted exercise programs. Further research should include a broader population, longer intervention durations, and the use of technology and psychological approaches to enrich strategies for improving lower limb muscle strength.

CONFLIC OF INTEREST

There are no conflicts of interest related to this research or the publication of this manuscript

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