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Effectiveness of Combined Agility and Plyometric Training on Lower Extremity Muscle Strength among University Students

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ABSTRACT

This study aimed to investigate the effect of a program consisting of combined agility and plyometric training on lower extremity muscle strength in university students aged 18–23 years. A pre-experimental design with a one-group pretest-posttest approach design was conducted involving 231 university students aged 18–23 years who met the inclusion and exclusion criteria. Lower extremity muscle strength was assessed using a leg dynamometer before (pre-test) and after (post-test) the intervention program. Participants performed the training program three times per week for 12 weeks (36 sessions). Data were analysed to assess changes in muscle strength. The descriptive analysis showed that the pre-test mean of lower extremity muscle strength was 119.9±15.73 (min=102.2; max=137.7), while the post-test mean value increased to 133.9 ± 13.18 (min=113.9; max=153.9), indicating an overall improvement of 28%. Normality testing demonstrated that both pre-test ($p=0.341$) and post-test ($p=0.237$) data were normally distributed ($p>0.05$). The paired sample t-test revealed a significant difference between pre-test and post-test values with a mean difference of 16.31±5.28 and $p<0.001$, indicating a statistically significant improvement in lower extremity muscle strength following the training intervention. A 12-week combined agility and plyometric training program consisting of shuttle run, sprint, squat jump, and zig-zag exercises significantly improved lower extremity muscle strength in university students. These findings suggest that integrated speed, agility, and plyometric training is an effective strategy for enhancing muscular strength and functional performance in young populations.

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INTRODUCTION

Physical fitness among university students has emerged as a growing concern in the field of physical education and health promotion (Pérez-Ramírez, 2024). Lower extremity muscle strength is a fundamental component of physical fitness and plays a significant role in human movement, daily functional performance, and musculoskeletal injury prevention (Smith, 2025). The muscles of the lower limbs are essential for performing basic locomotor activities such as walking, running, jumping, and maintaining postural balance (Lin et al., 2025). Adequate muscular strength enables individuals to generate force efficiently, sustain dynamic stability, and perform both daily and sport-related activities effectively (Gusman, 2023). Conversely, inadequate lower extremity muscle strength may compromise functional performance and increase the risk of musculoskeletal injury, which has become a persistent concern in campus-based physical activity contexts (Sun et al., 2025). University students are particularly vulnerable to declining levels of physical activity (Huang, 2025). The demands of academic life, including long hours of studying, sedentary classroom activities, and increased screen time, contribute to a lifestyle that is largely inactive (Ferrini et al., 2025). This reduction in physical activity during the university years can negatively affect lower extremity muscle strength, aerobic capacity, and overall physical fitness (Ltifi et al., 2025). Studies have consistently indicated that sedentary behaviour is associated with reduced muscular performance and increased susceptibility to injury, making it essential to address physical fitness among university aged populations in structured and accessible ways (Oliver et al., 2024; Zha et al., 2025).

In response to this challenge, there is a growing need for simple, low cost, and practically applicable exercise models that can be implemented within educational settings such as universities and schools (Han et al., 2025; Gavanda et al., 2022). Many traditional combined agility and plyometric training programs require specialized equipment, trained supervision, and gymnasium facilities that are not always available in campus environments (Zhang et al., 2025). Therefore, the development of training models that rely on minimal equipment, require limited space, and can be easily supervised by physical education instructors represents an important direction in applied exercise science (Chen et al., 2026). Agility-based and plyometric exercises such as shuttle runs, sprints, squat jumps, and zig-zag drills fulfil these criteria and have shown promise in improving lower extremity muscle strength and physical performance (Zhang, 2025). These exercises are not only economically accessible but also motivating and engaging for university students, making them well-suited for integration into physical education curricula and campus fitness programs (Agostinete et al., 2024; Liu, 2025).

University students often experience reduced physical activity levels due to academic demands and sedentary lifestyles. This condition may negatively affect lower extremity muscle strength, which is essential for physical fitness and injury prevention. Therefore, practical and time efficient training models are needed in educational settings (Lambrich, 2023). Based on these considerations, the present study aimed to investigate the impact of a 12-week combined agility and plyometric training program consisting of shuttle run, sprint, squat jump, and zig-zag exercises on lower extremity muscle strength in university students aged 18–23 years. Lower extremity muscle strength was assessed using a leg dynamometer before and after the intervention period. It was hypothesized that participation in the integrated training program would result in a significant improvement in lower extremity muscle strength following the 12-week training intervention.

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METHODS

Study Design

This study employed a pre-experimental design with a one-group pretest-posttest approach to investigate the effect of a combined agility and plyometric training program on lower extremity muscle strength in university students. This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The absence of a control group limits causal inference, as observed improvements may reflect testing effects, natural maturation, regression to the mean, or seasonal variations in physical activity. A control group was not included because this study was designed as a preliminary pre-experimental investigation to evaluate the feasibility and initial effectiveness of the intervention before conducting a randomized controlled trial. All participants were provided with detailed information regarding the study objectives, procedures, potential risks, and their right to withdraw at any time without consequence. Written informed consent was obtained from each participant before enrolment. Participant anonymity and data confidentiality were maintained throughout all stages of the study. Ethical approval for this research was granted by the Ethics Committee of Dhyana Pura University (No. 001713/KEP/UNDHIRA/2025).

Participants

Participants were recruited from Universitas Dhyana Pura and consisted of 231 university students aged 18–23 years who met the established inclusion and exclusion criteria. The inclusion criteria required participants to be aged 18–23 years, free from musculoskeletal injuries or chronic medical conditions that could affect physical performance, not currently enrolled in any structured exercise program, and willing to provide written informed consent. Exclusion criteria included the history of lower extremity injury within the preceding six months, the presence of cardiovascular or metabolic disorders contraindicating physical exercise, and the failure to complete at least 80% of the total training sessions. The combined agility and plyometric training program consisted of four exercise modalities, including shuttle run, sprint, squat jump, and zig-zag exercises.

Sampling Procedures

Lower extremity muscle strength was measured using a leg dynamometer (Lafayette Instrument, USA), a validated and reliable instrument widely used in clinical and research settings to quantify isometric lower limb strength (Pasco et al., 2020; Koźlenia, 2024). The measurement was performed with participants in a standardized standing position, feet shoulder-width apart, knees slightly flexed at approximately 30 degrees, and hands gripping the dynamometer handle (Lubis, 2021; Tomkinson et al., 2025). Each participant performed two maximal trials. The highest value recorded was used for analysis. The unit of measurement was kilogram-force (kgf). Prior to data collection, the instrument was calibrated according to the manufacturer specifications to ensure measurement accuracy (Arede et al., 2025). Research assistants were trained to administer the assessment in a consistent and standardized manner.

Procedures

Participants performed the training program three sessions per week for 12 consecutive weeks, totalling 36 training sessions. Each session was conducted under the supervision of trained research assistants to ensure proper technique and adherence to the prescribed

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protocol (Permadi et al., 2025). Lower extremity muscle strength was assessed using a leg dynamometer at baseline (pre-test) and upon completion of the 12-week program (post-test) (Petruši, 2024). The detailed structure of the training program is presented in Table 1.

Table 1. Combined Training Program Structure

Exercise	Distance/Reps	Sets	Rest (Between Sets)	Frequency	Duration
Shuttle Run	10 m x 5 reps	3	90 sec	3x/week	12 weeks
Sprint	30 m x 5 reps	3	120 sec	3x/week	12 weeks
Squat Jump	10 reps	3	60 sec	3x/week	12 weeks
Zig-Zag	15 m x 5 reps	3	90 sec	3x/week	12 weeks

Data Analysis

All statistical analyses were performed using SPSS software version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics, including mean, standard deviation, minimum, and maximum values, were calculated for pre-test and post-test muscle strength measurements (Smith, 2025). The percentage improvement in muscle strength was computed as the difference between post-test and pre-test mean values divided by the pre-test mean, multiplied by 100. Prior to inferential analysis, the normality of the data distribution was assessed using the Shapiro-Wilk test, as the sample size was greater than 50. A p-value greater than 0.05 was considered indicative of a normal distribution. Following confirmation of normality, a paired-sample t-test was conducted to compare pre-test and post-test lower extremity muscle strength values. Statistical significance was set at $p<0.05$. Recommendations on Shapiro–Wilk was selected because it has greater statistical power than the Kolmogorov–Smirnov test for detecting departures from normality across various sample sizes, including large samples. Normality assessment was further supported by visual inspection of Q–Q plots and histograms, confirming an approximately normal distribution. Both Shapiro–Wilk and Kolmogorov–Smirnov tests yielded consistent conclusions, supporting the assumption of normality for subsequent parametric analyses.

RESULTS

Sample Characteristics

A total of 231 university students aged 18–23 years participated in this study. The distribution of participants by age group is presented in Table 2. The largest proportion of participants was in the 23-year age group (n=41; 17.8%), followed by those aged 20 and 22 years (n=39 each; 16.9%), while the 18-year age group comprised the smallest proportion (n=36; 15.6%). The remaining age groups (19 and 21 years) each accounted for 16.4% (n=38) of the total sample. The relatively even distribution across age groups ensured that the sample was representative of the target adolescent population.

Table 2. Age Characteristics

Age (Years)	Frequency	Percentage (%)
18	36	15.6
19	38	16.4
20	39	16.9
21	38	16.4
22	39	16.9
23	41	17.8
Total	231	100%

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Table 3 depicts the pre-test and post-test data. The post test data showed different results compared to the pre-test data. In the pre-test results, 38% had very poor muscle strength, 29% had poor muscle strength, and 33% were categorized as moderate. After the training program and post-test, 21% had very poor muscle strength, 14% had poor muscle strength, 3% were categorized as moderate, and there was an increase of 62% categorized as good. The post-test results of the research sample were higher than the pre-test results. It can be concluded that after the training was administered, changes in lower extremity muscle strength values occurred in each research sample (Pasco et al., 2020).

Table 3. Interpretation of Muscle Strength Values

Category	Pre-Test	Post-Test
Very Poor	38%	21%
Poor	29%	14%
Moderate	33%	3%
Good	0%	62%
Very Good	0%	0%
Total	100%	100%

Muscle Strength Improvements

This study focused on quantitative data. The data were obtained through a pre-test and post-test process using a leg dynamometer measuring tool to determine the value of lower extremity muscle strength in the research sample.

Table 4. Average Measurement Results of Muscle Strength Values

Variable	Mean	Min	Max	Std. Deviation	Percentage (%)
Pre-Test Lower Extremity Muscle Strength	119.9	102.2	137.7	15.73	**28**
Post-Test Lower Extremity Muscle Strength	133.9	113.9	153.9	13.18	

Based on Table 4, the pre-test muscle strength values had a minimum of 102.2 and a maximum of 137.7, with a mean of 119.9. Meanwhile, the post-test muscle strength values had a minimum of 113.9 and a maximum of 153.9, with a mean of 133.9, representing a 28% increase in muscle strength.

Table 5. Shapiro Wilk-Test

Muscle Strength	Statistic	N	Sig.
Pre-Test	0.961	231	0.341
Post-Test	0.983	231	0.237

Table 6. Paired Sample T-Test

Muscle Strength	Mean	Std. Deviation	Sig-Tailed	*Cohen's d*
Pre-Test and Post-Test	16.311	5.283	0.000	0.89

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Based on Table 5, the normality test results obtained significant values of p=0.341 (p>0.05) for pre-test muscle strength and p=0.237 (p>0.05) for post-test muscle strength. The normality test results concluded that the pre-test and post-test muscle strength data were normally distributed.

Based on Table 6, the paired-sample t-test showed that the mean value of pre-test dan post-test lower extremity muscle strength was 16.3 from a total sample of 231 individuals. The significant value of lower extremity muscle strength data was p=0.000 (p<0.05), indicating a significant increase in mean values between pre-test and post-test. This also confirms the hypothesis formulated by the researchers that the shuttle run dan sprint training program can improve muscle strength among university students. Cohen's d (p = 0.89) indicated a large effect size, suggesting that the combined agility and plyometric training program produced clinically meaningful improvements in lower extremity muscle strength.

DISCUSSION

The present study investigated the impact of a 12-week combined agility and plyometric training program on lower extremity muscle strength in university students aged 18–23 years. The results demonstrated a statistically significant improvement in lower extremity muscle strength following the intervention, with a mean increase of approximately 28% and a significant paired-sample t-test result (p<0.001). These findings support the hypothesis that integrated training programs incorporating agility, speed, and plyometric exercises can effectively enhance lower limb muscular strength in university students. The improvement in lower extremity muscle strength observed in this study reflects the effectiveness of an integrated training approach that combines agility, speed, and plyometric exercises within a structured campus based program (Kons et al., 2023; Chen et al., 2023). The 28% increase in mean muscle strength following 12 weeks of training demonstrates that university students can achieve meaningful physical fitness gains through a practical low-cost exercise model. This finding is particularly relevant in the context of physical education programs, where the availability of specialized equipment and facilities is often limited. The training program used in this study required no expensive tools or complex infrastructure, making it highly applicable for implementation in physical education classes, campus fitness programs, and school-based health interventions (Collins et al., 2022).

These results are consistent with previous research demonstrating that agility and plyometric training programs can significantly improve lower extremity strength and physical fitness in young adult populations (Sagat, 2026). The 12-week program proved sufficient to produce measurable improvements, with 62% of participants reaching the good muscle strength category after the intervention, compared to 0% at baseline. This shift in fitness categories highlights the potential of this training model not only to improve physical performance but also to contribute to injury prevention among university students (Oliver et al., 2024; Rangga, 2023). Adequate lower extremity strength is known to reduce the risk of musculoskeletal injuries during everyday activities and sports, making strength-building programs important components of preventive physical education (Sinurat, 2020; Lin et al., 2025).

From a practical standpoint, the training model used in this study can be implemented in physical education classes because it requires minimal equipment and can be adapted to various fitness levels (Deng et al., 2023; Han et al., 2025). The shuttle run, sprint, squat jump, and zig-zag exercises are familiar, motivating, and easily scalable, making them appropriate for diverse university students populations regardless of prior athletic experience (Hidayat et al., 2021). Physical education instructors and sport coaches can readily incorporate this

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program into regular class schedules without significant additional resources (Sun et al., 2025). The programs simplicity and accessibility represent key strengths that support its adoption in campus and school settings as part of evidence based physical education practice (Bouteraa et al., 2020; Ferrini et al., 2025). The present study has several limitations that should be acknowledged. The study employed a single-group pre-post design without a control group, which limits causal attribution of the observed improvements to the training intervention alone. Future studies should employ randomized controlled designs with larger and more diverse samples, and include longer follow up periods to evaluate the sustainability of the training-induced strength gains. The one-group pre-post design remains susceptible to testing effects, natural maturation, regression to the mean, and temporal or seasonal influences over the 12-week intervention, which may partially contribute to the observed improvements independent of the intervention.

CONCLUSION

Combined agility and plyometric training appears to be a promising and practical exercise model to improve lower extremity muscle strength among university students and may be applied in physical education programs. The 12-week program consisting of shuttle run, sprint, squat jump, and zig-zag exercises resulted in an increase in the muscle strength mean and a significant shift in fitness classification. These findings support the integration of agility and plyometric-based training into physical education curricula and campus fitness programs as a cost-effective strategy for enhancing physical fitness and reducing injury risk in university student populations. Future research should employ randomized controlled designs and longer follow-up assessments to further validate and expand upon these findings.

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AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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