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RELIABILITY OF HEEL RISE TEST IN HEALTHY YOUNG FEMALE POPULATION TO ASSESS THE STRENGTH OF PLANTAR FLEXORS, LAHORE

Original Research

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ABSTRACT

Background: The heel rise test is a widely used functional assessment tool in clinical practice to evaluate plantar flexor strength, endurance, and fatigue. It involves both concentric and eccentric contractions, providing insight into muscle performance and the functional integrity of the lower limb. Due to its diagnostic and rehabilitative significance, it is frequently utilized in musculoskeletal assessments. However, its reliability, particularly in young female populations, requires further validation.

Objective: To determine the reliability of the heel rise test in assessing plantar flexor strength in healthy young females.

Methods: A cross-sectional study was conducted on 47 healthy female participants aged 18 to 25 years. Participants were selected through convenience sampling and underwent a standardized heel rise test. They were instructed to perform maximum heel raises until fatigue while maintaining balance using fingertip support against a wall. The number of completed heel raises was recorded for both feet. To assess test-retest reliability, the procedure was repeated after a 15-minute interval, and the results were compared. Pearson's Correlation Coefficient was used for statistical analysis, with a significance level set at $p \leq 0.05$.

Results: A strong correlation was observed between the two test trials. For the right foot, the mean number of heel raises was 18.23 ± 6.13 in the first reading and 19.34 ± 6.69 in the second, with a correlation coefficient of $r = 0.919$, $p = 0.001$. For the left foot, the mean values were 17.94 ± 6.51 and 19.04 ± 6.98, respectively, with a correlation coefficient of $r = 0.896$, $p = 0.001$.

Conclusion: The heel rise test demonstrated high reliability in assessing plantar flexor strength in healthy young females. Its strong test-retest consistency supports its use as a dependable clinical tool for evaluating lower limb function.

Keywords: Balance, cross-sectional study, heel rise test, plantar flexors, reliability, single-leg heel rise, strength.

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INTRODUCTION

The triceps surae, comprising the gastrocnemius and soleus muscles, plays a crucial role in ankle plantar flexion, contributing significantly to weight-bearing stability and gait mechanics. Optimal functioning of these muscles is essential for maintaining postural stability and mobility. Weakness in the plantar flexors has been associated with various musculoskeletal and neurological conditions, including Achilles tendon rupture, chronic ankle instability, and tendon lengthening, all of which can lead to abnormal gait patterns. Additionally, individuals with neurological disorders such as stroke, cerebral palsy, and muscular dystrophy often exhibit impaired plantar flexor strength, further exacerbating gait abnormalities (1,2). The heel rise test is commonly employed in clinical settings as a functional assessment tool to evaluate the strength, endurance, and performance of the plantar flexors. Unlike manual muscle testing, which relies on isometric strength assessment against external resistance, the heel rise test assesses both concentric and eccentric muscle contractions, offering a more comprehensive evaluation of muscle function (3-5). This test is often preferred due to its practicality, as it allows for a dynamic assessment of plantar flexor performance without requiring specialized equipment. It is also used as a screening tool for lower limb muscle function, particularly in populations at risk for muscular weakness and balance deficits (6).

Several factors influence heel rise test performance, including age, sex, activity level, and ethnicity. Aging has been shown to impact the relationship between plantar flexor strength and balance, with older adults demonstrating reduced performance in single-leg heel rises compared to younger individuals (7). The test is also used to assess functional mobility and balance, particularly in individuals with conditions such as diabetes mellitus, multiple sclerosis, peripheral arterial disease, and inflammatory myopathies, where plantar flexor weakness is a common finding (8,9). Furthermore, it has been found to be a reliable measure of strength in pediatric populations, with studies reporting moderate to good reliability in children (10). Among various clinical assessments for lower limb function, the single-leg heel rise test has been validated as a useful tool for evaluating conditions such as chronic plantar heel pain syndrome, where it is often used in conjunction with other functional assessments like single-leg static stance and half squats (11). Its reliability in assessing plantar flexor strength extends to both healthy individuals and those recovering from injuries, including Achilles tendon rupture. In particular, the test has been recognized as a key metric for evaluating rehabilitation progress following Achilles tendon repair, with studies demonstrating its effectiveness in tracking strength recovery in athletes such as ballet dancers (12-15).

Given the clinical significance of plantar flexor strength assessment, it is imperative to establish the reliability of functional tests such as the heel rise test across diverse populations. While the test is widely regarded as a reliable measure, variations in its outcomes have been reported across different age groups, populations, and testing protocols. Despite its extensive application, limited research has specifically examined the reliability of the heel rise test in young, healthy females. Therefore, this study aims to assess the reliability of the heel rise test in a population of healthy young females at Akhtar Saeed Medical and Dental College, Lahore, to provide further validation of its use as an effective clinical assessment tool for plantar flexor strength.

METHODS

A cross-sectional study was conducted to evaluate the reliability of the heel rise test in assessing plantar flexor strength among healthy female students of Akhtar Saeed Medical and Dental College, Lahore. The study was carried out from May 2023 to December 2023, following approval from the Ethics Review Committee of Akhtar Saeed College of Rehabilitation Sciences, Lahore. Ethical considerations were strictly followed, and all participants provided written informed consent before participation (16). The study included 47 healthy female individuals aged between 18 and 25 years. Participants were recruited using a non-probability convenience sampling technique. The inclusion criteria required individuals to be free from any systemic disease, musculoskeletal disorder, or previous ligament injuries that could compromise plantar flexor function. Participants with a history of lower limb fractures, recent surgeries, chronic pain conditions, or neurological impairments affecting motor control were excluded. The sample size was determined using an Intra-Class Correlation Coefficient (ICC) Estimation calculator to ensure adequate statistical power for reliability assessment (17).

A structured questionnaire was administered to collect demographic information before the heel rise test. The test was conducted under standardized conditions to minimize variability. Participants were instructed to remove their footwear and assume an upright posture with their fingertips placed at shoulder height against a wall for balance support. They were asked to flex the knee of the non-target limb

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to keep it off the floor and perform repeated heel raises by lifting their heels off the ground and standing on the tips of their toes. The test continued until the participants experienced fatigue, at which point the total number of completed heel raises was recorded. The same procedure was then performed for the contralateral limb (11). To assess test-retest reliability, the heel rise test was repeated after a 15-minute rest interval, and the number of completed heel raises for both limbs was recorded again. The rest period was kept consistent across all participants to ensure uniform testing conditions (18).

Environmental factors such as testing surface, time of day, and room temperature were controlled to maintain consistency and minimize external influences on test performance. The tests were conducted in a quiet, temperature-controlled environment on a non-slip, level surface to ensure participant safety and accuracy of results (19). Statistical analysis was performed using SPSS version 26. Descriptive statistics, including mean, standard deviation, and range, were used to summarize the data. Pearson's Correlation Coefficient was applied to determine the reliability of the heel rise test, with a p-value of ≤ 0.05 considered statistically significant.

RESULTS

The study assessed the reliability of the heel rise test in healthy young females by evaluating the correlation between two test readings taken 15 minutes apart. A total of 47 healthy female participants aged 18 to 25 years were included in the analysis. The mean number of heel raises for the right foot in the first reading was 18.23 ± 6.13, while the second reading recorded a mean of 19.34 ± 6.69. A statistically significant strong correlation ($r = 0.919$, $p = 0.001$) was observed between the two readings, indicating high test-retest reliability for the right foot.

Similarly, for the left foot, the mean number of heel raises in the first reading was 17.94 ± 6.51, while the second reading showed a mean of 19.04 ± 6.98. A strong correlation ($r = 0.896$, $p = 0.001$) was also found between the two readings, suggesting consistent results for the left foot. Scatter plots visually represented the correlation between the two readings, demonstrating a clear linear relationship between repeated measures. The findings confirmed that the heel rise test is a highly reliable tool for assessing plantar flexor strength in healthy young females, with minimal variation between repeated trials.

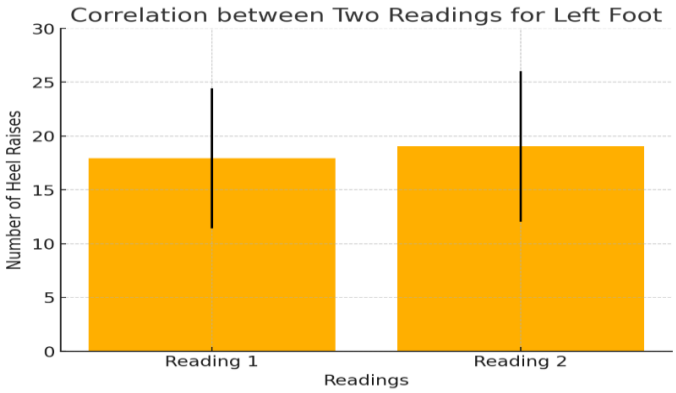

Figure 2 Correlation between Two Readings for Left Foot

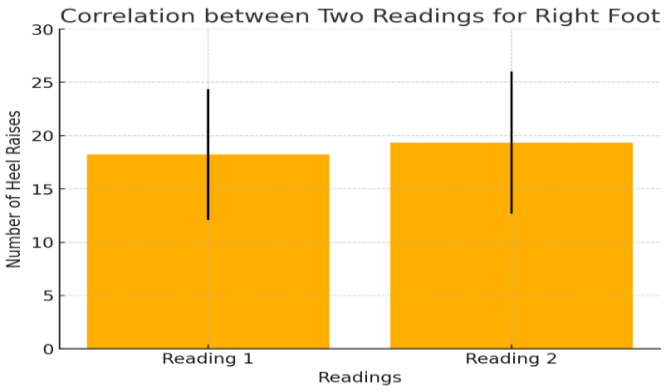

Figure 1 Correlation between Two Readings for Right Foot

Table 1: Correlation between Two Readings for No. of Heel Raises of Right Foot

	Mean	Std. Deviation	N	r	p
Reading 1 for NO. of heel raises of right foot	18.23	6.133	47	.919	.001
Reading 2 for NO. of heel raises of right foot	19.34	6.690	47		

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Table 2: Correlation between Two Readings for No. of Heel Raises of Left Foot

	Mean	Std. Deviation	N	r	p
Reading 1 for NO. of heel raises of left foot	17.94	6.509	47	.896	.001
Reading 2 for NO. of heel raises of left foot	19.04	6.978	47		

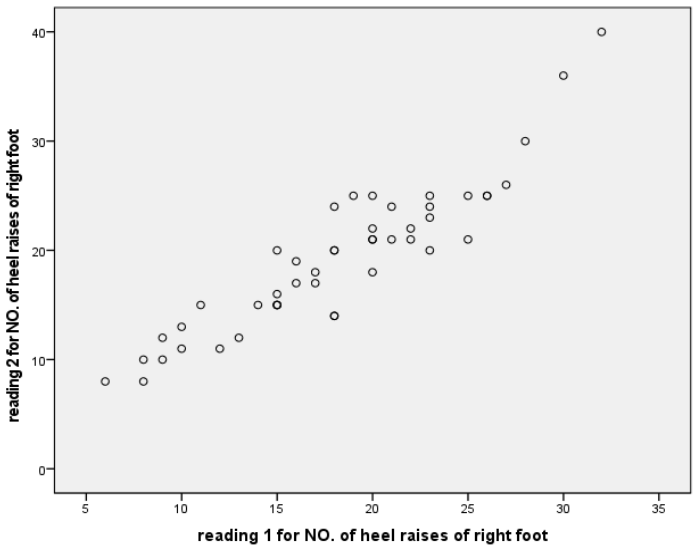

Figure: Scatter Plot of Correlation between Two Readings for No. of Heel Raises of Left Foot

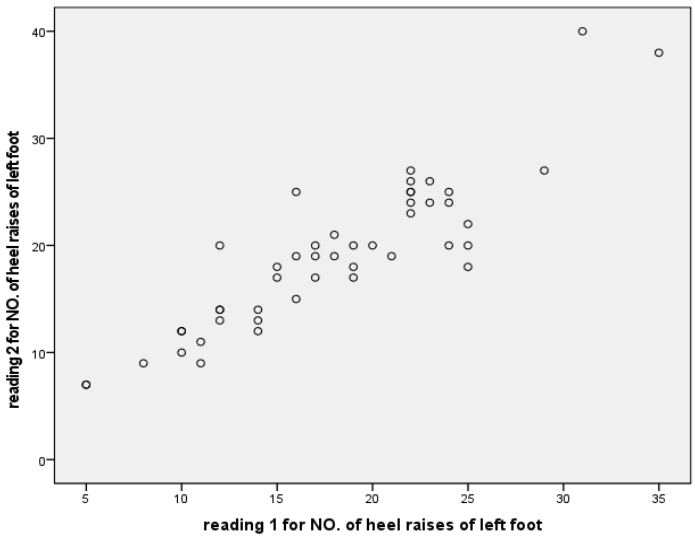

Figure: Scatter Plot of Correlation between Two Readings for No. of Heel Raises of Left Foot

DISCUSSION

The reliability of the heel rise test has been widely investigated in various populations, demonstrating its effectiveness in assessing plantar flexor strength. Previous studies evaluating intra-rater reliability of functional endurance tests have reported high reliability, reinforcing the clinical utility of such assessments in determining muscular endurance and strength. Consistent with prior research, the present study found a strong correlation between two test-retest readings, indicating high reliability in the assessment of heel raises in healthy young females (20). Findings from earlier research on the reliability and normative values of the heel rise test in a healthy population have shown excellent reliability, with high intra-class correlation coefficients reported for both lower limbs. While previous studies included both male and female participants, the current study specifically focused on healthy young female individuals, adding to the growing body of literature on population-specific reliability data. The Pearson correlation coefficients of 0.919 and 0.896 for the right and left foot, respectively, suggest strong reliability in this demographic group. Differences in population characteristics, such as sex and activity levels, may contribute to variations in reported values across studies (21).

The reliability of the heel rise test has also been explored in children, with test-retest evaluations demonstrating moderate to high intra-rater and inter-rater reliability. However, discrepancies in results between studies assessing pediatric and young adult populations may be attributed to physiological differences in muscle strength and endurance across age groups. While previous findings in children reported lower intra-class correlation values, the current study observed a stronger test-retest reliability in young adults, suggesting that the test may yield more consistent results in older populations with more developed musculoskeletal function (19). Additional research has examined the biomechanical contributions of the midfoot in heel rise performance, highlighting that approximately 36% of the movement is generated from midfoot structures. This finding emphasizes the importance of considering foot mechanics when interpreting test results, particularly in individuals with foot pathologies. The present study did not specifically analyze midfoot contributions but focused on overall test reliability, reinforcing its value as a clinical tool for assessing plantar flexor strength (12).

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The application of the heel rise test in pathological conditions such as Achilles tendon rupture has demonstrated its relevance in evaluating functional deficits. Prior studies have reported significantly reduced heel raise repetitions in individuals with Achilles tendon injuries compared to non-injured individuals. The present study, conducted in a healthy population, found higher repetition counts and strong reliability, supporting the test's utility in non-pathological assessments. Given the impact of Achilles tendon integrity on test outcomes, future research should explore its application in post-injury rehabilitation settings to assess recovery progress (14,15). Further investigations have explored predictors of heel rise performance following Achilles tendon rupture, identifying age and repair tightness as critical factors influencing outcomes. Longitudinal studies have indicated that older individuals exhibit poorer performance due to age-related declines in muscular strength and tendon elasticity. While the current study did not examine post-injury recovery, the strong correlation between repeated measures suggests that the heel rise test may serve as a reliable indicator of muscle function in different populations (8,17).

The heel rise test has also been investigated in individuals with chronic ankle instability, with previous studies reporting lower intra-class correlation coefficients compared to those observed in the present study. Despite variations in test-retest reliability across different conditions, findings consistently support its application in clinical and research settings to evaluate lower limb function. The strong reliability observed in the current study further validates its effectiveness in healthy populations (11). Research examining the relationship between heel rise performance and gastrocnemius-soleus muscle length has demonstrated that functional deficits following Achilles tendon rupture are associated with muscle elongation and strength loss. While prior studies have noted reduced heel raise repetitions in individuals with tendon injuries, the present study found higher repetition counts in healthy individuals, further emphasizing the reliability of the test in non-injured populations (12,18).

The findings of this study confirm that the heel rise test is a highly reliable tool for assessing plantar flexor strength in healthy young females. One of the strengths of this study lies in its population-specific reliability assessment, which adds valuable data to existing literature. However, certain limitations should be acknowledged. The study was limited to a specific age group and sex, restricting generalizability to broader populations. Additionally, the 15-minute rest interval between test repetitions may have been insufficient for full recovery, potentially influencing results. Future research should explore the influence of longer rest periods and assess reliability across diverse age groups and clinical populations to further validate the test's applicability in different settings.

CONCLUSION

The findings of this study confirm that the heel rise test is a reliable and effective method for assessing plantar flexor strength in healthy young females. The strong consistency observed between repeated test measures supports its use as a practical and objective tool in clinical settings. Given its ease of administration and ability to evaluate functional endurance, the heel rise test can serve as a valuable assessment for monitoring lower limb strength and guiding rehabilitation strategies. These results contribute to the growing evidence supporting its application in musculoskeletal and rehabilitation practices, reinforcing its role in functional evaluation and clinical decision-making.

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AUTHOR CONTRIBUTIONS

Author	Contribution
Rabia Masood	Substantial contribution to study design, analysis, acquisition of data Manuscript writing Has given final approval of the version to be published
Saadia Perwaiz	Substantial contribution to study design, acquisition and interpretation of data Critical review and manuscript writing Has given final approval of the version to be published
Muhammad Mahmood Alam	Substantial contribution to acquisition and interpretation of data Has given final approval of the version to be published
Zahid Mehmood Bhatti	Contributed to data collection and analysis Has given final approval of the version to be published
Hira Zubair	Contributed to data collection and analysis Has given final approval of the version to be published
Adan Ateeque	Substantial contribution to study design and data analysis Has given final approval of the version to be published
Shehryar Saleem	Contributed to study concept and data collection Has given final approval of the version to be published
Taha Nadeem	Writing - review & editing, assistance with data curation
Humna Irfan	Writing - review & editing, assistance with data curation

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