Original Article DOI: 10.52229/pjpt.v7i4.3958

Normative Value of Strength on Lower Extremity among Geriatric Population using Dynamometer: A Cross Sectional Study

Anam Abbas[1], Amna Zia[2], Muhammad Talha Hassan Javed[3], Rahat Afzal[4], Ahmed Jamal[4], Beenish Ashraf[5]

[1]University of Management and Technology, Lahore, Pakistan
[2]Fatima Memorial Hospital, Lahore, Pakistan
[3]Government College University Faisalabad, Faisalabad, Pakistan
[4]Nur International University, Lahore, Pakistan
[5]National Health Service, London, England, United Kingdom

ABSTRACT

Background: The extent of muscle deterioration associated with aging, injury or disease can be gauged with reference to appropriate normative data. Muscle weakness is a predictor for falls, falls-related hospitalization, fractures and comorbidities. **Objective:** The aim of this study was to find the normative value of strength on lower extremity among geriatric population using dynamometer. **Methods:** In this cross-sectional study, 104 older adults participated. Data was collected using the Lower Extremity Functional Scale (LEFS), and strength assessment was performed using a hand-held dynamometer. Concentric and eccentric strength of the hamstring and quadricep muscles were measured bilaterally at 4m/s and 5m/s. **Results:** Out of 104 participants, the mean age was 73.95±6.70, 25% were females and 75% were males, mean weight was 62.85±6.54 Std. Out of 104 participants, the mean strength value of the hamstring was 33.55±7.67, 29.04±6.85, in dominant and non-dominant leg respectively. The mean strength value of the quadriceps was 47.50±10.55 and 43.10±10.99 for dominant and non-dominant leg respectively. The overall mean strength value of the dominant leg was 40.24± 8.74, 36.09± 8.36 for dominant and non-dominant leg respectively. Overall, the t-value showed a significant result with a p-value of 0.000 (< 0.05). **Conclusion:** This study has provided the quantitative strength values of lower extremity muscles; hamstring and quadriceps of dominant and non-dominant leg among geriatric population.

Keywords: : Aging, Handheld, Strength measurement, Muscular power, Portable muscle testing, Quantitative

INTRODUCTION

Age-related loss of skeletal muscle strength, or dyspnea, is a hallmark of impairment that affects the health and wellbeing of older individuals[1]. Muscle strength is important for mobility and other activities of daily living and is central for maintaining independence in older age[2]. Muscle weakness is a predictor for falls, falls-related hospitalization, fractures, comorbidities such as the metabolic syndrome and all-cause mortality. Weakness is one of five physical characteristics considered by Fried et al. to support a diagnosis of frailty, and low muscle strength is a key component of sarcopenia[3]. The extent of muscle deterioration associated with ageing, injury or disease can be gauged with reference to appropriate normative data. We have previously reported normative data for total and appendicular lean mass with and without adjustment for height and body mass index (BMI)[4].

The lower-limb rather than upper-limb weakness specifically compromises functional capacities and increases falls risk. Although there is evidence that handgrip strength is indicative of overall muscle strength, loss of maximal strength is not consistent across all muscle groups and good agreement between handgrip and lower limb strength is not supported in all studies.[5] Furthermore, assessment

***Corresponding Author:** Anam Abbas (anamabbas92@gmail.com)

Received: August 12, 2024 | **Revised:** Oct 29, 2024 | **Accepted:** November 07, 2024

Cite this article as: Abbas A, Zia A, Javed MTH, Afzal R, Jamal A, Ashraf B. Normative value of strength on lower extremity among geriatic population using dynamometer: a cross sectional study. Pakistan Journal of Physical Therapy. 2024;7(4):8-14

of lower limb strength offers an alternative when handgrip strength is not feasible due to hand disability. A role for measuring lower-limb muscle strength in geriatric assessment needs the support of appropriate normative data for quantifying deficits, but there are few published for the lower-limb[6].

Muscle strength deteriorates more rapidly and to a greater extent than muscle mass during ageing, and this divergence is suggestive of an ageing-related loss of muscle quality. Muscle quality is generally conceptualized as muscle strength or power per unit of muscle mass and, in this study, we refer to muscle quality as the ratio of muscle strength per unit of lean mass[7]. Recommendations from the FNIH Sarcopenia Project are that appendicular lean mass (ALM, kg) adjusted for body mass index (BMI, kg/m^2) be used for identifying low lean mass, with ALM/BMI cut points of <0.789 m for men and <0.512 m2 for women[8]. Published normative data for hand grip strength are available from many countries, and in most cases, data are divided into age and gender subgroups. Analysis of grip strength by gender shows higher grip by males at all ages, and analysis by age group demonstrates a peak of grip strength in the fourth decade and then a gradual decline in grip strength for both genders. This trend is always present even though some studies divide participants by age gender, and then by right and left hand, while a small number of studies divide participants by age gender and then dominant and non-dominant hand[9].

Grip strength is related to and predictive of other health conditions, although the relationship is not stated to be causative. Normal hand grip strength is positively related to normal bone mineral density in postmenopausal women, with some researchers suggesting that grip strength be a screening tool for women at risk of osteoporosis. Longitudinal studies suggest that poor grip strength is predictive of increased mortality from cardiovascular disease and from cancer in men, even when factors of muscle mass and body mass index are adjusted for[10]. Hand grip strength is negatively associated with physical frailty even when the effects of body mass index (BMI) and arm muscle circumference are removed. Researchers have suggested that the factor related to frailty and disability in later life is the manner in which muscles are used, and this can be measured by hand dynamometry[11].

Many factors can affect muscle strength, including age, gender, anthropometric parameters, nutritional status, and physical activity. Muscle strength has been positively correlated with function, balance, and gait in many disease populations. Anterior cruciate ligament, meniscal injuries due to road traffic accidents and ankle sprains are common in young healthy population, leading to reduced lower extremity muscle strength as the primary impairment. In clinical practice, rehabilitation of these individuals requires reference values for muscle strength in the young, healthy population[12.] The aim of this cross-sectional, population-based study of older adults was to find the normative strength values of lower extremity muscle among geriatric population using dynamometer.

METHODOLOGY

A cross-sectional study was conducted on older adults of both the genders for the assessment of lower extremity strength using hand-held dynamometer. The Lower Extremity Functional Scale (LEFS) was used to assess the functional status and physical status of lower limb. The sample taken for the study comprises of 104 older adults having the age of 65 or above. through a non-probability convenient sampling technique. This research study included participants from 65 to 90 years old consisting of both male and female adults with functional dominant lower limbs who demonstrated ability to use hand-held dynamometer for maximum voluntary contractions. Study participants needed to both follow presented directions while finishing the Lower Extremity Functional Scale (LEFS). The study excluded participants who showed signs of neuromuscular disorders including stroke or Parkinson's disease and severe musculoskeletal conditions affecting lower extremity function and individuals with severe cognitive impairments affecting their ability to follow study instructions. The study excluded participants who failed to properly control their systemic medical conditions such as diabetes or cardiovascular diseases as well as individuals who could not maintain proper testing positions because of pain or physical disabilities. Based on past studies, the hamstring and quadriceps strength were measured using the proper standards. The participants were told to give it their all and produce their maximal force within 4-5 seconds in line with the activity of their muscles. The physical therapist set up the dynamometer and used it to gauge the participant's effort. The positions of the subject and therapist, as well as the location of the dynamometer, are shown in Table 1.

Table 1. Handheld dynamometer positioning

Muscle Group	Position of Therapist	Position of player	Placement of dynamometer
Hamstring	Test side	Short sitting, hip and knee at 90°	Posterior aspect of tibia, above the ankle joint
Quadriceps	Test side	Short sitting, hip and knee at 90°	Anterior aspect of tibia, above the ankle joint

Statistical analysis

IBM SPSS version 21.0 software was utilized for statistical examination. Categorical data were assessed through frequency and percentage calculations, while continuous data were summarized with mean and standard deviation. Appropriate frequency tables and graphs were used for qualitative and demographic details. Cross tabulation was applied to analyze quantitative information. Descriptive statistics included mean and standard deviation (Std.), as well as median (min-max) figures. Pearson's correlation was employed to explore relationships between quantitative variables.

RESULTS

Demographics data were presented in Table 2. Out of 104 participants, the mean age was 73.95 ± 6.70 years, with a minimum of 65 and a maximum of 90. Regarding gender, 26 (25%) were females, and 78 (75%) were males. The height distribution showed that 3 (2.88%) were 5'4, 26(25%) were 5'5, 40 (38.46%) were 5'6, 11 (10.58%) were 5'7, 9 (8.65%) were 5'8, and 15 (14.42%) were 6'1. The mean weight was 62.85 ± 6.537 kg, with a minimum of 50 and a maximum of 72. In terms of dominance, 12 (11.5%) were left-dominant, while 92 (88.5%) were right-dominant. The mean difference in strength values between the dominant and non-dominant legs was 4.38±1.81, ranging from 0.75 to 9.05.

Mean score of lower extremity functional scale was 37.56±8.65. Table 2 presented independent sample t test for dominant and non-dominant leg strength. A significant difference between the dominant leg (DL) and non-dominant leg (NDL), with a mean

Table 2. Descriptive Statistics

Variable	Construct	Descriptive	Percent
Gender	Female	26	25.0%
	Male	78	75.0%
Dominant Side	Left	12	11.5%
	Right	92	88.5%
Strength of dominant leg	Mean ± Std.	40.24± 8.74	
Strength of non-dominant leg	Mean ± Std.	36.09± 8.36	
Strength difference (dominant vs non dominant side)	Mean ± Std.	4.3837±1.80	
Body weight	Mean ± Std.	62.85±6.53	

The Chi-Square analysis showed a significant association between age, LEFS, and mean scores (χ^2 = 728.684, df = 638, p = .004), while the likelihood ratio was not significant (p = 1.000).

Table 3. Independent sample t- test of dominant and non-dominant leg

	Mean Std.	t	**Std. Error Mean**	**p-value**	**Mean difference**	**95% CI**	
						Lower	Upper
Mean difference	4.38±1.81	24.76	0.18	0.000	4.38	4.03	4.73

difference of 4.38 (SD = 1.81), t(103) = 24.76, p < 0.001 was found. The 95% confidence interval for the mean difference ranged from 4.03 to 4.734 8, demonstrating a consistent disparity favoring the dominant leg.

Correlation analysis revealed a weak, non-significant negative relationship between LEFS and the mean difference (Spearman's rho = -0.099, p = 0.319). A significant difference exists between strength levels of dominant and non-dominant leg according to the independent sample t-test (p = 0.000) in Table 3. It supported by a mean difference of 4.38 with confidence interval 4.03 to 4.73. The strong effect arises from the calculated t-value of 24.76.

DISCUSSION

The objective of this study was to find the normative value of strength on lower extremity among geriatric population using dynamometer. The Hand-held dynamometer and Lower Extremity Functional Scale (LEFS) were used for data collection. Those players who meet the inclusion criteria were included in the study. Out of 104 participants, the mean age was 73.95±6.70, 25% were females and 75% were males, mean weight was 62.85±6.54 Std. Out of 104 participants, the mean strength value of the hamstring was 33.55±7.67, 29.04±6.85, in dominant and non-dominant leg respectively. The mean strength value of the quadriceps was 47.50±10.55 and 43.10±10.99 for dominant and non-dominant leg respectively. The overall mean strength value of the dominant leg was 40.24± 8.74, 36.09± 8.36 for dominant and non-dominant leg respectively. Overall, the t-value showed a significant result with a p-value of 0.000 (< 0.05).

Pasco *et al.* (2022) conducted a study on lower limb strength and found that muscle quality and strength declined with age in both sexes, with age accounting for 12.9–25.3% of the variation in male muscular strength and 20.8–24.6% in female muscle strength, while having les s impact on muscle quality[26]. Data from young males (n = 89) and females (n = 148) aged 20–39 years provided means and standard deviations for muscle strength and quality for each muscle group, categorized by age decade and with cut-off points comparable to t-scores of 2.0 and 1.0. In contrast, a study with 104 participants reported a mean age of 73.95 ± 6.69 years, with 25% females and 75% males. The mean strength value of the dominant leg was 40.24 ± 8.74, while the non-dominant leg had a mean strength value of 36.09 ± 8.36, resulting in a mean difference of 4.38 ± 1.81. The t-score value indicated a significant result, as the p-value was 0.000, which is < 0.05.

Tedla *et al.* (2022) in his study aimed to establish normative reference values for lower extremity muscle strength and to correlate these values with anthropometric parameters and balance[1]. Lower extremity muscle strength and balance were assessed by baseline hand-held dynamometer and by forward, lateral, and oblique direction reach tests in 421 young male adults between 21 and 23 years of age. The mean and standard deviation of lower extremity strength ranged from 43.83 ± 16.92 lb. to 62.07 ± 10.74 lb. Body weight, body mass index, and balance showed significant effect on lower extremity muscle strength. In contrast to current study, authors used different variables as out of 104 participants the mean age is 73.95±6.69, 25%were females and 75% were males, mean weight is 62.85±6.53, about 48.08% athletes takes balance diet whereas 34.6% are working and 64.42% takes multivitamins. Hence the strength of the muscle strength depends on the diet, work out and health.

Fernanda *et al.* (2021) undertook a study to examine the impacts of sex and side dominance and to establish reference values for handgrip strength, shoulder and ankle range of motion (ROM), and upper-limb and lower-limb stability for juvenile judokas of both sexes[27]. A total of 137 young judokas of both sexes who were under the age of 18 (n= 60) and under the age of 21 (n = 77) were evaluated. The handgrip strength of males was higher in both categories. Males performed better on the mSEBT, and in the under-21 age group, the dominant side of females had larger ankle dorsiflexion ROM than the dominant side of males. The dominant sides of both males and females also showed greater shoulder ER ROM. In contrast to our we have similar results as out of 104 participants the mean age is 73.95±6.699 SD,25% were females and 75% were males, 11.5% had left dominant side whereas 88.5% had right dominant side. The mean of strength value of dominant leg is 40.24± 8.74 and mean of strength value of non-dominant leg is 36.09± 8.36. Hence the strength value of dominant leg is greater than non-dominant leg.

Kerim *et al.* (2020) conducted a study on the relationship between the isokinetic strength of the upper and lower limbs in elite men judokas[28]. His research is set up with randomized repeated measurements in accordance with cross-experimental design. In the study, 15 male elite judokas between the ages of 18 and 21 (mean values: age 19.40±1.24 years, BMI 27.02±5.82 kg/m2) freely participated. Only ER and FLX on DS at 60o s-1 angular velocity showed a significant difference when the correlations between the lower and upper extremities were investigated (P > 0.05). All other indicators showed strong relationships (P > 0.05). In contrast, current study, have different variables with the score values having significant result because the p value was 0.000 which is < 0.05.

CONCLUSION

This study has provided the strength values of lower extremity i.e hamstring and quadriceps of dominant and non-dominant leg among geriatric population.

Ethical Statement: This study has been approved by the Ethical Research Committee (ERC) of University of Management and Technology, Lahore, Pakistan.

Conflicts of Interest: The author declared no conflict of interest.

Funding Support: None

Author's Contribution: **AA:** Concept/design of the work, data acquisition, interpretation of results; **AZ:** Drafting, concept/design of the work, data acquisition; **MTHJ:** Data analysis & interpretation; RA: Literature search, data analysis & interpretation; **AJ, BA:** Critically revising.

All authors gave approval for final manuscript.

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