

Normative Values of Calf Muscle Flexibility in Healthy Adults: A Weight-bearing Lunge Test Analysis

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ABSTRACT

Introduction: The Weight-Bearing Lunge Test (WBLT) plays a crucial role in assessing calf muscle flexibility. It is regarded as a reliable method for evaluating its reference values. Despite its clinical relevance, normative values for healthy adults are limited.

Aim: To establish normative values for calf muscle flexibility in healthy adults using the WBLT.

Materials and Methods: This cross-sectional study was conducted at Maharishi Markandeshwar (Deemed to be University) Mullana, Ambala, Haryana, India between April 2025 to February 2026 with 500 participants to establish the normative values of the flexibility of the calf muscle. Healthy adults aged between 30 and 50 years were recruited. The WBLT was used as a primary outcome measure. After obtaining informed consent, participants performed the test for both limbs. Three trials were conducted for each limb, and the distance between the wall and the great toe was measured in centimetres. The average of the three trials was recorded for analysis. The normality of data

was assessed using the Kolmogorov-Smirnov test. Descriptive statistics are presented as geometric mean with 95% CI and mean with Standard Deviation (SD) along with range. A p-value <0.05 was considered significant.

Results: The reference values for calf muscle flexibility were 9.94 cm and 9.7 cm for the right and left-sides, respectively. Gender analysis revealed that males recorded higher geometric mean values than females on both sides. Across both genders, asymmetry was seen with the right limb showing slightly greater flexibility than that of left. Flexibility appeared to peak in the 35-39 years group (10.26 cm on the right-side). Widest variations in flexibility (7.76-15.30 cm) were seen in the age group 45-50 years.

Conclusion: This study established normative values for WBLT in adults aged between 30 and 50 years, revealing a constant pattern of bilateral asymmetry where the right limb was more flexible than the left. Flexibility peaked between 35-39 years and declined further, indicating that age is a significant determinant of calf muscle flexibility.

Keywords: Calf muscle flexibility, Genders, Reference values

INTRODUCTION

The calf muscle comprises of two muscles, soleus and gastrocnemius, which play an essential role in gait and postural maintenance. Its attachment with the Achilles tendon enables it to influence ankle movement, and affects the flexibility of the muscle. Adequate calf muscle flexibility is essential for normal gait cycle [1]. Insufficient range may lead to a decreased stride length, gait speed and increases the risk of imbalance [2]. Calf muscle tightness may negatively impact gait and balance [3]. It is characterised by impaired neuromuscular contraction and relaxation, which lead to decreased motion of talocrural joint. Due to this, muscle adapts itself in a shorten position and its flexibility decreases [4].

Individuals with inadequate rehabilitation following muscle injuries or those having sedentary lifestyles are at an increased risk of developing calf muscle tightness. It can also negatively impact movement patterns and coordination [5]. Additionally, it contributes to proprioceptive sensory problems, further compromising balance and stability [6]. It may also lead to conditions like Achilles tendinopathy, ankle instability and plantar fasciitis [7].

The WBLT is a reliable and functional assessment tool for evaluating calf muscle flexibility [8]. By measuring the distance between wall to toe in lunge position, the WBLT provides valuable information about the individual's calf muscle flexibility. WBLT demonstrated high inter-tester and inter-session reliability (ICC 0.80-0.99) in the assessment of calf flexibility in healthy adults, with a robust correlation coefficient ($r = 0.95$), indicating excellent measurement consistency [9]. Studies have shown that calf muscle flexibility during walking and running was found to be significantly associated with WBLT scores.

This suggests that individuals with greater calf muscle flexibility and control in the sagittal plane may exhibit superior WBLT performance [10]. Previous studies have demonstrated strong correlation between WBLT performance and calf muscle flexibility [2,11,12]. Testing in weight-bearing offers more advantages than non-weight-bearing position, as it more accurately simulates the loading conditions experienced in gait cycle [10].

The flexibility of calf muscle can be assessed in both weight-bearing and non-weight-bearing positions [13]. Weight-bearing methods include measuring the distance from the wall to toe, which helps in assessing the calf muscle flexibility in the functional closed-packed position [13]. Also, other angle-based measurement methods are mentioned in the literature. Research suggests that weight-bearing methods are more relevant as they frequently reveal bilateral asymmetries that are not detectable with non-weight-bearing methods [1]. Normative data serve as an essential clinical reference point, which provides a standardised framework for therapists to assess the impairment, monitor progress, and frame rehabilitation protocol accordingly [14,15]. Current literature is constrained by limited sample sizes and lacks reference values of WBLT stratified by gender and age.

This study aimed to establish normative reference values of calf muscle flexibility in healthy adults with WBLT and to quantify variations in these values, stratified by gender and different ages.

MATERIALS AND METHODS

An observational, cross-sectional study was done to establish the normative reference values of calf muscle flexibility among healthy

adults. The Strengthening the Reporting of Observational Studies (STROBE) guidelines were maintained throughout this study. Data collection was conducted at the Physiotherapy Outpatient Department, Maharishi Markandeshwar (Deemed to be University) Mullana, Ambala, Haryana, India from April 2025 to February 2026. Ethical approval for the study was granted by the Institutional Ethical Committee with ethical no (IEC/MMDU/3112). The trial was registered under the number CTRI/2025/04/085291.

Inclusion criteria: Both males and females aged 30 to 50 years were included in the study. Participants who were willing to participate, were able to understand instructions, and could follow the study guidelines were included in the study.

Exclusion criteria: Pregnant or nursing women, those with pain in their back or lower extremities, recent surgery or injury to their lower limbs, taking medications that could affect muscle function, or regularly engaging in high-intensity physical activity or sports were excluded from the study.

Sample size: The sample size was established based on previous literature on calf muscle tightness and its role in limiting the functional range of motion in daily activities [16]. Simple random sampling was used to recruit participants. Informed consent was taken from the eligible participants before data collection.

Subsequently, participants were asked or assessed for demographic details (age, gender, height, weight, Body Mass Index (BMI)), along with if any pain in knee, back, any significant medical history and recent sports activity details, BMI was calculated as weight (kg)/height (m²) and was categorised according to Asia-Pacific guidelines for Asian populations [17]; after which participants were assessed with WBLT.

Outcome Measure

The WBLT provided valuable information about the individual's calf muscle flexibility [16]. It follows the knee-to-wall principle [18], while performing this test the distance between greater toe and wall was measured.

Study Procedure

Participants were instructed to stand in a tandem stance, positioning the contralateral limb approximately 30 cm posterior to the assessment limb. With hands placed on the wall for stability, they were asked to perform a forward lunge, advancing the knee towards the wall, ensuring that the heel remains in firm contact with the floor [19]. The participants were asked to perform three trials. The average value of the three trials was recorded. The calculated average value was used to determine the normative values of the test [20].

STATISTICAL ANALYSIS

Data analysis was executed using IBM Statistical Package for the Social Sciences (SPSS) Statistics, version 26.0. Participants were

stratified into four age groups: 30-34 years, 35-39 years, 40-44 years, and 45-50 years. The normality of data was assessed using the Kolmogorov-Smirnov test (sample size >50). For normal distribution, the results were expressed as mean±SD, and non normal distribution, the results were expressed as geometric mean along with 95% Confidence Interval (CI) and ranges [20].

RESULTS

A total of 500 participants were enrolled in this study, including 236 males and 264 females. The median age (IQR) was 39 (12) years for males and 39 (11) years for females, respectively. The majority of participants were aged between 45-50 years.

As shown in [Table/Fig-1], the normative reference values of 9.94 cm and 9.7 cm for right and left limbs were seen, respectively. A marginal difference in calf muscle flexibility between the two sides was observed, the right-side having a higher value than the left. These findings correlated with the previously reported ranges of 8.5 cm to 13 cm for both sides [21].

Descriptives	Geometric Mean (95% CI)	Range (Min-Max)	Mean±SD
WBLT Right (cm)	9.94 (9.93-10.21)	6.37-15.30	10.07±1.59
WBLT Left (cm)	9.70 (9.69-9.97)	6.20-15.20	9.83±1.61

[Table/Fig-1]: Normative reference values of WBLT for right and left lower limbs. Abbreviations: WBLT: Weight-bearing lunge test; CI: Confidence interval; SD: Standard deviation

As presented in [Table/Fig-2], males exhibited higher geometric mean values for calf muscle flexibility compared to females on both sides. These findings suggested that gender may be one of the determining factors in flexibility of calf muscle [2,19]. In both genders, higher values were observed in the right limb as compared to left limb. This might suggest a correlation between limb dominance and calf muscle flexibility [19].

The calf muscle flexibility across different age groups is shown in [Table/Fig-3], in which a consistent pattern of bilateral asymmetry was observed. The geometric means of right-side consistently showed higher values than the left-side. In the youngest age group (30-34 years), the right-side values were observed slightly higher than the left-side values. Similar results were observed in the 35-39 year group, in which the right-side recorded the highest value of 10.26 cm. In contrast, the 40-44 year group showed a slight decrease in flexibility. A wide range of reference values was observed across all age groups. The highest variation was observed in the 45-50 year group, with a minimum of 7.76 cm and a maximum of 15.30 cm. The narrowest range of flexibility of calf muscle was observed in age group 40-44 years.

DISCUSSION

This cross-sectional study aimed to establish normative values of calf muscle flexibility in healthy adults aged 30-50 years using the WBLT. Furthermore, the study also incorporated stratification of

Gender	Geometric mean (95% CI) Right (cm)	Range (Min-Max) Right (cm)	Mean±SD right (cm)	Geometric mean (95% CI) Left (cm)	Range (Min-Max) Left (cm)	Mean±SD left (cm)
Males	10.06 (9.99-10.40)	6.43-15.30	10.19±1.60	9.83 (9.75-10.15)	6.57-15.20	9.95±1.55
Females	9.83 (9.77-10.15)	6.37-14.30	9.96±1.57	9.83 (9.52-9.92)	6.20-14.70	9.72±1.65

[Table/Fig-2]: Gender-specific normative values of WBLT for right and left lower limbs. Abbreviations: WBLT: Weight-bearing lunge test; SD: Standard deviation; CI: Confidence interval

Age (years)	Geometric mean (95%CI) right (cm)	Range (Min-Max) right (cm)	Mean±SD right (cm)	Geometric mean (95%CI) left (cm)	Range (Min-Max) left (cm)	Mean±SD left (cm)
30-34	9.93 (9.79-10.43)	6.43-14.30	10.11±1.88	9.66 (9.53-10.18)	6.20-14.57	9.85±1.88
35-39	10.26 (10.09-10.65)	6.37-14	10.37±1.53	9.90 (9.74-10.30)	6.67-14.70	10.02±1.54
40-44	9.56 (9.42-9.87)	6.70-12.70	9.65±1.33	9.43 (9.30-9.75)	6.57-12.60	9.52±1.33
45-50	10.12 (9.94-10.50)	7.76-15.30	10.22± 1.49	9.84 (9.66-10.26)	6.57-15.20	9.96±1.60

[Table/Fig-3]: Normative reference values of WBLT for right and left lower across different age groups. Abbreviations: SD: Standard deviation; CI: Confidence interval; WBLT: Weight-bearing lunge test

participants based on gender and different age groups. The study was not specifically designed to control for potential confounding variables such as BMI or other physiological factors. Instead, these variables were considered as a part of the natural variability within the population, allowing the derived normative values to more accurately reflect real-world distributions across age and gender. The findings revealed significant bilateral asymmetries, along with gender and age-based variations in values of WBLT.

Bilateral asymmetry was observed in both genders. These findings were consistent with the results reported by Hoch MC and McKeon PO as well as Rabin A et al., which confirmed bilateral asymmetry in calf flexibility during WBLT among healthy individuals [1,22]. In the right limb, higher values of WBLT were observed as compared to the left limb. The present study findings suggested a mean difference of 0.24 cm, which was consistent with a prior study. In contrast, side-by-side differences exceeding 1.5 cm had been strongly linked to increased risk of lower extremity injuries [1].

Gender specific analysis revealed that males demonstrated significantly higher values of WBLT than females; this finding directly aligned with reference values reported by Sean McBride S et al., While interpreting the values of WBLT, higher values show better flexibility of the calf muscle [12].

Calf muscle flexibility negatively correlated with increasing age [22]. This aligned with the findings of this study, in which peak calf muscle flexibility was observed within the 30-34 years and 35-39 years age groups, followed by a slight decline in 40-44 age group. This age-related decline in flexibility contributed to altered balance and gait mechanics [23]. These changes in muscle anatomy or activity levels may have influenced calf muscle flexibility [21]. Several physiological mechanisms responsible for the decline in calf flexibility were joint capsule modifications, increased collagen cross-linking, and localised fibrocartilaginous thickening. These age-related changes led to a progressive loss of muscle elasticity, resulting in muscle tightness [24].

The establishment of these normative values served as a baseline for the therapists to assess abnormal tightness across different age groups. By using these age-stratified reference values, the therapist would be able to develop evidence-based rehabilitative protocols, ensuring that the functional outcomes aligned with the patient's age and gender. The right-sided limb dominance observed in this study may help in designing unilateral rehabilitation protocols in the future. By early detection of deviations in reference ranges, the therapist could initiate preventive strategies such as stretching, proprioception training, and calf flexibility exercises [25].

Future perspectives should correlate the WBLT values with functional assessments such as the Star Excursion Balance Test (SEBT) and the deep squat component of the functional movement screen. Expanding the study scope to include anthropometric variables such as tibia length, foot length, and BMI, along with occupational cohorts such as sedentary vs prolonged standing, will clarify the extent to which mechanical loading contributes to age and gender related flexibility loss.

Limitation(s)

The study was confined to a restricted area, which reduced the geographic scope and limited the generalisability of the findings. Secondly, while the WBLT is a highly reliable tool to measure functional flexibility of calf muscle, this study did not assess anthropometric measures such as foot length or arch height, which might have influenced the readings of WBLT. The normative values established in this study were based on a specific distance-based WBLT method. In future studies, other methods of WBLT could be used to assess calf muscle flexibility values.

CONCLUSION(S)

This study established normative reference values of flexibility of calf muscle using WBLT in adults aged between 30-50 years. The

results showed a consistent pattern of bilateral asymmetry, right limb showed greater flexibility as compared to left across all age groups. Peak flexibility was observed in 35-39 years age group, followed by a measurable decline in the 40-44 years group, suggesting that age can be a significant factor affecting calf muscle flexibility.

Authors' contribution: CK and SP: Conceptualisation, Designed the study; CK and VR: Data collection and patient recruitment; CK SP, SK: Performed the statistical analysis; CK, PS and AR: Writing original draft; SP: Provided supervision; TS and SK: editing. All the authors have read and agreed to the manuscript of this study.

REFERENCES

- [1] Hoch MC, McKeon PO. Normative range of weight-bearing lunge test performance asymmetry in healthy adults. *Man Ther.* 2011;16(5):516-19. Available from: <https://doi.org/10.1016/j.math.2011.02.012>.
- [2] Gohil R, Tilaye P. Normative data for calf muscle flexibility tested by weight-bearing lunge test in age group of 20-30 years - Pilot study. *Int J Health Sci Res.* 2022;12(2):71-75. Available from: <https://doi.org/10.52403/ijhsr.20220209>.
- [3] Dengiz A, Sekeroz S, Baskan E, Kara G. Effects of gastrocnemius functional massage on lower extremity spasticity, spatio-temporal gait variables and fall risk in patients with stroke: A randomized controlled trial. *PLoS One.* 2025;20(9):0332308. Available from: <https://doi.org/10.1371/journal.pone.0332308>.
- [4] Page P. Current concepts in muscle stretching for exercise and rehabilitation. *Int J Sports Phys Ther.* 2012;7(1):109-19. PMID: 22319684; PMCID: PMC3273886.
- [5] Tellı H, Özel Çakır F. Effects of physical activity level and sedentary behavior on the musculoskeletal system in young adults. *Genel Tip Dergisi.* 2024;34(5):637-49. Available from: <https://doi.org/10.54005/genelip.1424221>.
- [6] Bennell K, Talbot R, Wajswelner H, Techovanich W, Kelly D. Intra-rater and inter-rater reliability of a weight-bearing lunge measure of ankle dorsiflexion. *Aust J of Physiother.* 1998;44(3):175-80. Available from: [https://doi.org/10.1016/S0004-9514\(14\)60377-9](https://doi.org/10.1016/S0004-9514(14)60377-9).
- [7] Powden CJ, Hoch JM, Hoch MC. Reliability and minimal detectable change of the weight-bearing lunge test: A systematic review. *Manual Therapy.* Churchill Livingstone; 2015;20(4):524-32. Available from: <https://doi.org/10.4085/1062-6050-50.5.07>.
- [8] Hoch MC, Farwell KE, Gaven SL, Weinhandl JT. Weight-bearing dorsiflexion range of motion and landing biomechanics in individuals with chronic ankle instability. *J Athl Train.* 2015 ;50(8):833-39. Available from: <https://doi.org/10.1016/j.math.2015.01.004>.
- [9] Naeem FI, Zaidi S, Maqqadas M. Comparative effects of fascial distortion model and foam rolling on pain, calf flexibility and ankle range of motion among high heel users: A randomized clinical trial. *J Mod Health Rehab Sci.* 2025;2(3)01-05.
- [10] Nambiar A, Vavachan N, Prabhu K, Ravichandran H, Shetty K. Normative values of weight bearing lunge test among non-athlete females - A criterion based study. *RGUHS J Physiother.* 2024;4(1):01-05. Available from: https://doi.org/10.26463/rjpt.4_1_4.
- [11] Nelson RT. A comparison of the immediate effects of eccentric training vs static stretch on hamstring flexibility in high school and college athletes. *N Am J Sports Phys Ther.* 2006;1(2):56-61. PMID: 21522215; PMCID: PMC2953312.
- [12] McBride S, Isabelle PL, Gómez-Carrion Á, Farahpour N, Chicoine D, Griffiths I, et al. International normative values for the weight-bearing lunge test across age and sex in 899 healthy adults. *Musculoskelet Sci Pract.* 2026;82:103525. Available from: <https://doi.org/10.1016/j.msksp.2026.103525>.
- [13] Hankemeier DA, Thrasher AB. Relationship between the weight-bearing lunge and nonweight-bearing dorsiflexion range of motion measures. *Athl Train Sports Health Care.* 2014;6(3):128-34 Available from: <https://doi.org/10.3928/19425864-20140501-01>.
- [14] Visser TSS, Neill SO, Hébert-Losier K, Eygendaal D, de Vos RJ. Normative values for calf muscle strength-endurance in the general population assessed with the calf raise application: A large international cross-sectional study. *Braz J Phys Ther.* 2025;29(3):101034. Available from: <https://doi.org/10.1016/j.bjpt.2025.101034>.
- [15] Gao T, Ma Z, Yang N, Zhang S, Shi H, Zhang H, et al. The relationship of peak ankle dorsiflexion angle with lower extremity biomechanics during walking. *J Foot Ankle Res.* 2024;17(2):12027. Available from: <https://doi.org/10.1002/jfa2.12027>.
- [16] Rathı A, Sahasrabudhe P. Inter and intra rater reliability of different measurement techniques of weight-bearing ankle dorsiflexion range of motion. *Int J of Physiother Res.* 2021;9(6):4045-50. Available from: <https://doi.org/10.16965/ijpr.2021.188>.
- [17] Lim JU, Lee JH, Kim JS, Hwang YI, Kim TH, Lim SY, et al. Comparison of World Health Organization and Asia-Pacific body mass index classifications in COPD patients. *Int J Chron Obstruct Pulmon Dis.* 2017;12:2465-75. Available from: <https://doi.org/10.2147/COPD.S141295>.
- [18] Cejudo A, Sainz de Baranda P, Ayala F, Santonja F. A simplified version of the weight-bearing ankle lunge test: Description and test-retest reliability. *Man Ther.* 2014;19(4):355-59. Available from: <https://doi.org/10.1016/j.math.2014.03.008>.
- [19] Chisholm MD, Birmingham TB, Brown J, Macdermid J, Chesworth BM. Reliability and validity of a weight-bearing measure of ankle dorsiflexion range of motion. *Physiother Can.* 2012;64(4):347-55. Available from: <https://doi.org/10.3138/ptc.2011-41>.

- [20] Sharma N, Kaur S, Kumar P. Reliability and reference norms of heel-to-toe walking, lateral walking, and step-over walking among young adults: A cross-sectional study. *Adv in Rehabil.* 2023;37:28-37. Available from: <https://doi.org/10.5114/areh.2023.128058>.
- [21] Adillón C, Gallegos M, Treviño S, Salvat I. Ankle joint dorsiflexion reference values in non-injured youth federated basketball players: A cross-sectional study. *Int J Environ Res Public Health.* 2022;19(18):11740. Available from: <https://doi.org/10.3390/ijerph191811740>.
- [22] Rabin A, Kozol Z, Spitzer E, Finestone AS. Weight-bearing ankle dorsiflexion range of motion: Can side-to-side symmetry be assumed? *J Athl Train.* 2015;50(1):30-35. Available from: <https://doi.org/10.4085/1062-6050-49.3.40>.
- [23] Hernández-Guillén D, Blasco JM. A randomized controlled trial assessing the evolution of the weight-bearing ankle dorsiflexion range of motion over 6 sessions of talus mobilizations in older adults. *Phys Ther.* 2020;100(4):645-52. Available from: <https://doi.org/10.1093/ptj/pzaa003>.
- [24] VonGaza GL, Chiu LZF. Comparison of alternative methods to improve weight-bearing sagittal plane anterior leg rotation. *J Strength Cond Res.* 2021;35(12):3315-21. Available from: <https://doi.org/10.1519/JSC.0000000000004150>.
- [25] Vicenzino B, Branjerdporn M, Teys P, Jordan K. Initial changes in posterior talar glide and dorsiflexion of the ankle after mobilization with movement in individuals with recurrent ankle sprain. *J Orthop Sports Phys Ther.* 2006;36(7):464-71. Available from: <https://doi.org/10.2519/jospt.2006.2265>.

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