

Intrarater and Inter-rater Reliability of Pinch Dynamometer for Toe Grip Strength: A Cross-sectional Study

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ABSTRACT

Introduction: Reduced Toe Grip Strength (TGS) is associated with an increased risk of knee pain. In India, toe grip is rarely examined and examination of TGS lacks quantifiable values. The pinch gauge dynamometer is an instrument/tool which is apposite in the assessment of grip strength. The present study is a first of its kind to establish the reliability of pinch gauge dynamometer in assessing TGS.

Aim: To evaluate intrarater and inter-rater reliability of pinch gauge dynamometer in measuring TGS.

Materials and Methods: This cross-sectional study was conducted at the Department of Physiotherapy, Deemed to be the University of Mangalore, Karnataka, India during the 1st week of August 2022.

Out of 30 individuals, 15 were males and 15 were females. TGS was assessed using a pinch gauge dynamometer. For data analysis, the mean of the three trials was used and the reliability test was calculated using the Intraclass Correlation Coefficient (ICC). The level of significance was set at 5%.

Results: Intrarater reliability showed ICC scores of 0.991 and 0.985 for both right and left feet, and inter-rater reliability showed scores of 0.985 and 0.977, respectively. In the female group inter-rater agreement on right side pinch strength was 0.923 and left side was 0.924. Among males inter-rater agreement, right side ICC score was 0.983 and left side was 0.967 between the raters.

Conclusion: The pinch gauge dynamometer is reliable for measuring TGS with excellent intra and inter-rater reliability values.

Keywords: Dynamometer, Intraclass correlation coefficient, Inter-rater reliability, Toe grip

INTRODUCTION

Toe grip is a complex motion that involves the articulation of several forefoot muscles and joints [1]. Flexor hallucis longus, flexor hallucis brevis, lumbricals, flexor digitorum brevis, and flexor digitorum longus are the muscles involved in toe gripping [2]. In recent times, TGS has come under the spotlight as both, single-leg balance and gait speed are greatly influenced by TGS, and it plays a major role in managing fall-related lower limb movement strategies [2]. Furthermore, since the feet and toes are the most common parts of the body that are in contact with the ground, it helps in balancing the body, and prevents falls by coordinated actions of muscles around the ankle to oppose deviations in the centre of mass of the body during activities [3].

Toe function is portrayed as toe flexor strength as well [3] and toe flexor strength is responsible for managing postural control while standing and walking in individuals [4]. Ageing is associated with decrease in TGS and consequently increased risk of falls among the elderly population. Insufficient strength of the great toe can result in hallux valgus or other toe deformities. However, evaluation of TGS is rarely assessed in clinical settings, due to the requirements of specific tools [3].

TGS is measured using force plates, force platforms, or a toe grip dynamometer, which can be inconvenient due to setup costs, portability, and overall application methods in a case-to-case scenario [3]. The pinch gauge dynamometer, due to its appropriate build and working principle, can be used to determine TGS and thus, provides a potential working solution to the addressed issues. There is a paucity of literature on the use of the pinch gauge dynamometer to assess TGS [5,6].

As the instrument is of striking appropriateness and pertinence, it is necessary to study its utility, to measure TGS and test the psychometric properties of the instrument for a healthy moderately active adult population, so that, it can be further used among different population. With this background, the present study was

conducted with an aim to evaluate intrarater and inter-rater reliability of pinch gauge dynamometer in measuring TGS.

MATERIALS AND METHODS

A cross-sectional study was conducted, from 1st August 2022 till 6th August 2022, at the Department of Physiotherapy, Deemed to be University of Mangalore, Karnataka, India. Institutional Ethics Committee (IEC) [NIPT/IEC/MIN/16/2012-2022] approval was obtained.

Inclusion criteria: The study included 30 healthy moderately active adult population [7] with no co-morbidities and who gave consent to participate among which 15 were males and 15 were females, aged 20-25 years.

Exclusion criteria: Participants who had serious ankle or foot injuries or toe deformities, with a history of any muscular or neurological lesions such as spinal cord injury, foot drop that may affect toe functionality, were excluded from the study.

The reliability study was performed by two raters, who were trained in using a pinch gauge dynamometer (Lafayette Pinch Gauge®-J00111). Individuals were seated upright in a chair with their feet placed flat on the floor with the subtalar joint positioned in the neutral position. The pinch gauge dynamometer was placed under the great toe, with the pressure pad directly beneath the metatarsophalangeal joint's distal crease. Following that, participants were instructed to press down with their great toe as hard as, they could for three seconds without lifting the heel, while the tester secured the foot with one hand and ensured that the foot was in the neutral position [Table/Fig-1] [5].

Study Procedure

During the procedure, participants were told not to lean forward. With each trial, the tester read the force generated by the toe on the pressure pad on the gauge and recorded it in kilograms before returning the peak-hold needle to 0. The trials were repeated three times in a row with a five-second interval between them,



[Table/Fig-1]: Test of toe grip strength.

and the mean of the three trials was computed and recorded. The measurement results of the two raters were not revealed to each other. The intrarater and inter-rater reliability was assessed for the total number of participants and for males and females, respectively. ICC of <0.50 was considered as fair, 0.50-0.75 was considered as moderate, 0.75-0.9 was considered as good, and greater than 0.90 was considered as excellent reliability [8].

STATISTICAL ANALYSIS

Statistical analysis of the data was done using Statistical Package for the Social Sciences (SPSS) 23.0. Descriptive statistics were calculated and summarised, which includes mean and standard deviation. Inferential statistics had been carried out in the study. The reliability test was done using ICC. The level of significance was set at 5%.

RESULTS

The mean age of male and females were 23.20±1.08 years and 23.93±0.96 years [Table/Fig-2].

Rater 1-The average TGS of males in the three trials of right and left-side were 5.10±1.97, 5.40±2.29 and 5.26±1.98; 4.53±1.66, 4.4±1.66 and 4.33±1.68, respectively. The ICC for TGS of right side and left side reading in males was 0.973 and 0.979, respectively [Table/Fig-3].

Gender	Mean age (years)	Mean weight (kg)	Mean height (cm)
Male	23.20±1.08	63.1±14.00	170.24±17.76
Female	23.93±0.96	56.2±6.4	157.3±5.9

[Table/Fig-2]: Demographics of male and female.

Rater 1	Male		Female	
	Mean±SD TGS (kgf)	ICC, CI	Mean±SD TGS (kgf)	ICC, CI
Right				
Trial 1	5.10±1.97	0.973 (0.935-0.990)	2.63±1.06	0.962 (0.910-0.986)
Trial 2	5.40±2.29		2.56±0.96	
Trial 3	5.26±1.98		2.60±1.13	
Left				
Trial 1	4.53±1.66	0.979 (0.951-0.992)	2.23±0.7	0.932 (0.838-0.975)
Trial 2	4.40±1.66		2.26±0.7	
Trial 3	4.33±1.68		2.16±0.6	

[Table/Fig-3]: Intraclass correlation of right and left side pinch strength in male and female (Rater 1). TGS, toe grip strength; SD, standard deviation; ICC, Intraclass correlation coefficient; CI, Confidence interval. *Toe grip strength measured in kgf

Rater 2-Among females, the ICC for TGS of both right and left side were 0.984 with (0.962-0.994 CI) and 0.947 with (0.875-0.981 CI). For males, the average TGS for both right and left side in three trials were 5.30±1.84, 5.26±1.82, 5.26±1.56 and 4.46±1.76, 4.40±1.79, 4.43±1.70 respectively. The ICC for right and left side pinch strength readings was 0.983 and 0.979, respectively.

The intrarater and inter-rater reliability of both sides showed an excellent agreement between the measurements [Table/Fig-4,5].

Rater 2	Male		Female	
	Mean±SD TGS (kgf)	ICC, CI	Mean±SD TGS (kgf)	ICC, CI
Right				
Trial 1	5.30±1.84	0.983 (0.960-0.994)	2.66±1.12	0.984 (0.962-0.994)
Trial 2	5.26±1.82		2.73±1.11	
Trial 3	5.26±1.56		2.60±1.16	
Left				
Trial 1	4.46±1.76	0.979 (0.951-0.993)	2.10±0.78	0.947 (0.875-0.981)
Trial 2	4.40±1.79		2.33±0.72	
Trial 3	4.43±1.70		2.33±0.67	

[Table/Fig-4]: Intraclass correlation of right and left side pinch strength in male and female (Rater 2). TGS: Toe grip strength; SD: Standard deviation; ICC: Intraclass correlation coefficient; CI: Confidence interval. *Toe grip strength measured in kgf

Grip strength (Kgf)	ICC	Confidence interval
Female (right side) N=15	0.923	(0.770-0.974)
Female (left side) N=15	0.924	(0.774-0.975)
Male (right side) N=15	0.983	(0.950-0.994)
Male (left side) N=15	0.967	(0.903-0.989)

[Table/Fig-5]: Inter-rater reliability. N: Population size; ICC: Intraclass correlation coefficient

DISCUSSION

The present study established that pinch gauge dynamometer is a reliable instrument to measure TGS in normal healthy individuals. Reliability testing of measurements revealed that instrument was highly reliable in measuring TGS among different individuals of both male and female group.

Shamus J et al., demonstrated the use of pinch gauge dynamometer to assess TGS. However, the psychometric properties of the pinch gauge in assessing flexor hallucis strength is unknown [5]. Thus, the present study is one of its kind which is checking the reliability of the pinch gauge dynamometer for TGS.

Menz HB et al., reported a difference in hallux strength among male and female population with women exhibiting less strength to body size [9]. Similarly, the present study showed a two-fold greater strength among males than females in all three trials at 5.2±0.2 to 2.56±0.1 kg respectively. Also, in the present study, it was seen that the strength of right side was more as compared to left side. In accordance with present study, Uritani D et al., found higher TGS on dominant side as compared to non dominant [3].

Finally, the analysis of intrarater and inter-rater reliability testing established significant excellent agreement between the raters among all three trials for the given population, thus the strength of the present study is that the pinch gauge dynamometer can be considered as an apt tool to measure TGS, therefore more feasible and routine clinical screening of TGS can be conducted. Future research can implement and compare TGS with different age group such as young, middle and old age.

Limitation(s)

Study was conducted among people aged 20-25 years and in healthy people with no foot pathology. Further research could include subjects of a broader age range as well as those with foot/ankle pathology.

CONCLUSION(S)

The intrarater and inter-rater reliabilities of the pinch gauge dynamometer for measuring toe grip strength were excellent, allowing it to be used, in clinical settings.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Sep 07, 2022
- Manual Googling: Oct 17, 2022
- iThenticate Software: Oct 21, 2022 (9%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Aug 21, 2022**

Date of Peer Review: **Sep 23, 2022**

Date of Acceptance: **Oct 22, 2022**

Date of Publishing: **Dec 01, 2022**