J. Phys. Ther. Sci. 32: 38–41, 2020

The Journal of Physical Therapy Science

Original Article

Reliability of laser-assisted hindfoot alignment evaluation

Tadasuke Ohnishi, RPT, CPO, PhD[1)*], Mitsumasa Hida, RPT, MS[2,4)], Takayuki Nagasaki, RPT, PhD[3)], Chikamune Wada, PhD[4)]

[1)] *Department of Rehabilitation, Showa Inan General Hospital: 3230 Akaho, Komagane-shi, Nagano 399-4117, Japan*
[2)] *School of Rehabilitation, Osaka Kawasaki Rehabilitation University, Japan*
[3)] *Course of Physical Therapy, Department of Rehabilitation, Faculty of Medical Science and Welfare, Tohoku Bunka Gakuen University, Japan*
[4)] *Graduate School of Life Science and Systems Engineering, Kyushu Institute of Technology, Japan*

Abstract. [Purpose] A goniometer is frequently used for static measurement of hindfoot alignment. However, although goniometer measurements require experience, their reliability and validity remain controversial. We developed a hindfoot alignment measurement method by laser as an alternative measure. The purpose of this study was to examine the reliability of laser-assisted hindfoot alignment evaluation. [Participants and Methods] Two non-expert examiners (without medical knowledge), briefly trained in the use of laser-assisted hindfoot alignment evaluation, evaluated hindfoot alignment in 12 healthy participants. [Results] The ICC of the intra-rater reliability was 0.74 for both examiners and the ICC for inter-rater reliability was 0.43. [Conclusion] The good intra-rater and moderate inter-rater reliability of laser-assisted hindfoot alignment evaluation, when used by non-professionals, suggest the laser-assisted hindfoot alignment evaluation may be appropriate for use in clinical practice settings.
Key words: Hindfoot alignment, Reliability, Laser beam

(This article was submitted Aug. 13, 2019, and was accepted Oct. 17, 2019)

INTRODUCTION

Static measurement of hindfoot alignment in the standing position is frequently conducted to evaluate and treat pathological foot and leg conditions[1–3)]. These measures are generally performed using a goniometer to define the resting frontal plane bisection lines of the posterior calcaneus with the distal lower third of the leg, termed the relaxed calcaneal stance position or leg–heel alignment[4–6)]. However, goniometers have a straight solid structure and so it is difficult to conduct measurements along the curved and often highly uneven calcaneus. In addition, the lower leg axis is frequently curved. According to McPoil et al.[7)], 57 of 58 adult females (98.3%) exhibited some type of tibiofibular varum. Also, if the muscle belly of the lower leg posterior surface is not symmetrical and the muscle belly is large, it is difficult to set a line that bisects the lower leg.

There are many reports on the reliability of static hindfoot evaluation by therapists and doctors using a goniometer, with results ranging from unreliable[8–11)] to moderately reliable at best. Picciano et al. reported that the intra-rater reliability of static hindfoot evaluation by goniometry was only 0.14−0.18 and that the inter-rater reliability was only 0.15 as expressed by the intraclass correlation coefficient (ICC). It was thus concluded that static evaluation of the hindfoot by goniometry was not a reliable clinical tool[12)]. As a solution, a method for measuring hindfoot alignment using a laser beam (hindfoot alignment measurement method with laser beam, HAML) has been devised. In a previous study[13)], strong correlation between HAML and radiographic measures of alignment have been confirmed.

*Corresponding author. Tadasuke Ohnishi (E-mail: dragoonmouse@gmail.com)

The purpose of this study is to verify the intra- and inter-rater reliability of HAML measurement by non-experts.

PARTICIPANTS AND METHODS

The study included 12 healthy participants (7 males, 5 females) (Table 1). The inclusion criteria were ability to stand and support a load on both legs evenly, no obvious deformations, and no lower limb pain. The right foot was measured in all participants. The two examiners tasked with measuring hindfoot alignment were general students without medical knowledge who received a brief lecture about the HAML method from a physical therapist.

First, the subtalar neutral position (STNP) was determined in prone participants by the method of Wernick and Langer[14]. Next, three equally spaced points were drawn that bisected the posterior aspect of the medial and lateral posterior borders of the calcaneus. Another point was drawn on the center of the Achilles tendon at ankle joint height. The laser beam (Cross line laser Quigo; BOSCH Co. Ltd.) was set 3 cm from the ground and 1 m away from the right heel of the participant (Fig. 1).

The participants stood with feet spread 10 cm apart to control rightward−leftward balance so that the difference in load was within ± 3 kg. Next, varus−valgus alignment was evaluated by projecting a vertical laser line from the ground up. The degree of subtalar joint (STJ) varus−valgus alignment was classified into seven grades. Varus or valgus position of the STJ was determined by the relationship between the laser line and the three equally spaced points. Neutral position was defined as all three mid-calcaneus points on the laser line, strong valgus as all three points outside the laser line, moderate valgus as two points outside, and weak valgus as one point outside. The same definitions were applied for varus positions (Fig. 2, Table 2).

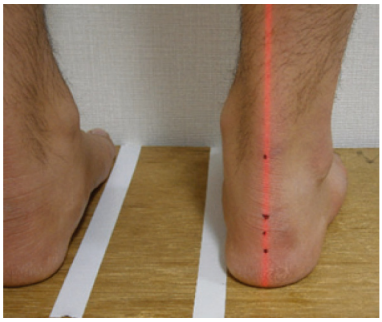

Fig. 1. Measurements were taken with the feet 10 cm apart. The laser beam was directed vertically from the floor to pass through the middle of the Achilles tendon.

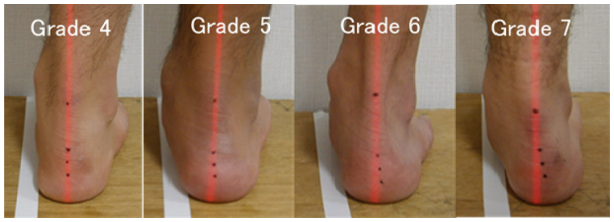

Fig. 2. Hindfoot alignment categories as defined by the HAML method. Grade 4) Neutral position; Grade 5) Mild varus; Grade 6) Moderate varus; Grade 7) Varus.

Table 1. Participant characteristics (n=12)

	Mean ± SD
Age (years)	18 .5 ± 0.7
Height (cm)	168.7 ± 8.8
Weight (kg)	58.9 ± 13.1
BMI (kg/m^2)	20.5 ± 2.7
Gender (male:female)	7:5

N: number of measurements.
Data are presented as mean ± standard deviation.

Table 2. The degree of hindfoot status varus/valgus alignment was subdivided into seven groups by a researcher

Hindfoot status	Grade
Valgus	1
Moderate valgus	2
Mild valgus	3
Neutral position	4
Mild varus	5
Moderate varus	6
Varus	7

A physical therapist with 7 years' clinical experience first received instructions on HAML from the study investigators and then gave a brief (20-min) lecture on the HAML method to the two non-expert examiners. Measurements were repeated twice at intervals of 7 to 10 days for calculation of intra-rater reliability. The SPSS software package (IBM SPSS Statistics 20.0, IL, USA) was used for all statistical analyses. The level of statistical significance was set at p=0.01 (two-tailed). The study was approved by the Human Use Review Board at Showa Inan General Hospital of Iowa (No. 2012-10). All participants provided written informed consent after receiving a thorough explanation of study goals and methods.

RESULTS

Kappa coefficients were used to establish inter-rater and intra-rater reliabilities of HAML. The ICC of the intra-rater reli-

Table 3. The ICCs for intra-rater and inter-rater reliability for HAML (n=12)

	Intra-rater reliability		Inter-rater reliability
	Examiner A	Examiner B	
HAML	0.74**	0.74**	0.43

N: number of measurements; ICC: intraclass correlation coefficient.
**Significant at the 0.01 level (two-tailed).

ability was 0.74 for both examiners and the ICC for inter-rater reliability was 0.43 (Table 3). Inter-rater reliability for HMAL was rated as moderate and intra-rater reliability as good/substantial[15, 16].

DISCUSSION

The intra-rater reliability of HAML was found to be high for evaluating hindfoot alignment on the frontal plane in the standing position, even when conducted by briefly trained non-experts. One reason for this higher reliability compared with goniometry is that it was easy to identify the center point on the Achilles tendon. In addition, the gravity line was easily drawn on the body surface using a laser beam without touching the body surface. Alternatively, Menz[17, 18] suggested that the accuracy and reliability of goniometry are limited due to the problem of bisector positioning because there is potential movement of the skin and soft-tissue structures over the bone during physical contact. We speculated that this could be solved by determining the reference line on the body surface using a laser beam as this non-contact approach would not move the skin or soft tissue on the bone. Moreover, it is difficult to place a hard plastic/metal goniometer against an uneven surface and measure the angle with high accuracy, whereas it is easy to draw a straight line on an uneven surface using a laser. In addition, we simplified the measurement method by adopting a seven-order ordinal scale and defined an appropriate posture in which the weight on both feet was almost equal because standing posture and load condition may change the measured value. These advantages may explain the high intra-rater correlation by measurers without medical knowledge.

However, the inter-rater correlation was only moderate (r=0.43). The main reason for this variability was the difference in defining a point that bisected the posterior aspect of the medial and lateral posterior borders of the calcaneus. This inter-rater reliability is comparable to RCSP (r=0.41)[8]. However, those results were obtained by four podiatrists with 1−7 years' experience. Considering that our results were obtained by non-experts, inter-rater reliability may be readily increased by developing an alternative calcaneus marking method. In particular, it is difficult even for clinician to palpate the outer contour of the calcaneus, so more detailed measurement instructions may be necessary. Using the HAML, non-experts as well as medical professionals (orthopedic doctors, physical therapists, and orthotists) may be able to effectively evaluate foot conditions, especially flat feet. In conclusion, we confirm the high repeatability of HAML measurements, even by non-experts.

Conflict of interest

The authors have no conflicts of interest directly relevant to the content of this article.

REFERENCES

1) Elveru RA, Rothstein JM, Lamb RL, et al.: Methods for taking subtalar joint measurements. A clinical report. Phys Ther, 1988, 68: 678–682. [Medline] [CrossRef]
2) Phillips RD, Christeck R, Phillips RL: Clinical measurement of the axis of the subtalar joint. J Am Podiatr Med Assoc, 1985, 75: 119–131. [Medline] [CrossRef]
3) Root ML, Orien WP, Weed JH: Clinical biomechanics, volume II: normal and abnormal function of the foot. Los Angeles: Clinical Biomechanics Corporation, 1977.
4) James SL, Bates BT, Osternig LR: Injuries to runners. Am J Sports Med, 1978, 6: 40–50. [Medline] [CrossRef]
5) Donatelli R: Biomechanics of the foot and ankle. Philadelphia: F.A. Davis Company, 1990, pp 136−141.
6) Root ML, Orien WP, Weed JH, et al.: Subtalar joint. In: Biomechanical examination of the foot. Los Angeles: Clinical Biomechanics Corporation, 1971.
7) McPoil TG, Knecht HG, Schuit D: A survey of foot types in normal females between the ages of 18 and 30 years. J Orthop Sports Phys Ther, 1988, 9: 406–109. [Medline] [CrossRef]
8) Keenan AM, Bach TM: Clinicians' assessment of the hindfoot: a study of reliability. Foot Ankle Int, 2006, 27: 451–460. [Medline] [CrossRef]
9) Elveru RA, Rothstein JM, Lamb RL: Goniometric reliability in a clinical setting. Subtalar and ankle joint measurements. Phys Ther, 1988, 68: 672–677. [Medline] [CrossRef]
10) Diamond JE, Mueller MJ, Delitto A, et al.: Reliability of a diabetic foot evaluation. Phys Ther, 1989, 69: 797–802. [Medline] [CrossRef]
11) Evans AM, Copper AW, Scharfbillig RW, et al.: Reliability of the foot posture index and traditional measures of foot position. J Am Podiatr Med Assoc, 2003, 93: 203–213. [Medline] [CrossRef]
12) Picciano AM, Rowlands MS, Worrell T: Reliability of open and closed kinetic chain subtalar joint neutral positions and navicular drop test. J Orthop Sports Phys Ther, 1993, 18: 553–558. [Medline] [CrossRef]

13) Ohnishi T, Hida M, Nakamura Y, et al.: Novel method for evaluation of hindfoot alignment in weight-bearing position using laser beam. J Phys Ther Sci, 2018, 30: 474–478. [Medline] [CrossRef]
14) Wernick J, Langer S: A practical manual for a basic approach to biomechanics. New York: Langer Acrylic Laboratory, 1971.
15) Cohen J: A coefficient of agreement for nominal scales. Educ Psychol Meas, 1960, 20: 37–46. [CrossRef]
16) Landis JR, Koch GG: The measurement of observer agreement for categorical data. Biometrics, 1977, 33: 159–174. [Medline] [CrossRef]
17) Menz HB: Clinical hindfoot measurement: a critical review of the literature. Foot, 1995, 5: 57–64. [CrossRef]
18) Menz HB, Keenan AM: Reliability of two instruments in the measurement of closed subtalar joint positions. Foot, 1997, 7: 194–201. [CrossRef]