

The Acute Effect of Walking on Ultrasound Measurements from the Achilles InSight Ultrasonometer in College-aged Individuals

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ABSTRACT

International Journal of Exercise Science 9(4): 491-496, 2016. The Achilles InSight bone ultrasonometer is a portable ultrasound device for quantitatively measuring bone composition both safely and inexpensively via the calcaneus. The effect of acute, brisk walking as a possible source of error on the reliability of quantitative ultrasound (QUS) measurements was investigated. Forty-seven participants (17 women, 30 men; age $M \pm SD = 20.44 \pm 1.16$) had their calcaneus measured with the Achilles InSight both before and after a 15-min bout of walking at ($5.63 \text{ km} \cdot \text{h}^{-1}$ (3.5 mph)). The Achilles InSight was deemed reliable via a test-and-retest protocol ($ICC \alpha = 0.94$). The reliability of the Achilles InSight indicated that the measurement was statistically unaffected by the effects of acute, brisk walking.

KEY WORDS: Ultrasound, Achilles InSight, ultrasonometer, osteoporosis, walking

INTRODUCTION

Bone health is a major health concern today (10, 15). The National Osteoporosis Foundation (15) reports that some two million bone fractures and over \$19 million in associated costs occur each year because of osteoporosis. In the United States some 54 million persons have osteoporosis, and roughly one in two women and up to one in four men over the age of 50 incur an osteoporotic bone fracture (15).

Osteoporotic bone fractures are often debilitating. Almost half of those who survive the initial fracture have dramatic changes in their respective lifestyles - often reduced ambulatory skills - and many become bedridden or "chair-bound" (14). Osteoporotic bone fractures are both costly and debilitating, so prevention is the preferred form of treatment (11); thus, effective screening and diagnostic techniques are necessary.

Properly diagnosing osteoporosis requires a physical assessment, identification of risk

factors, and bone mineral density (BMD) testing (6). Dual-energy x-ray absorptiometry (DXA) remains the gold standard for assessing skeletal status (4, 5), more specifically BMD (12), but it is expensive, exposes the participant to low levels of radiation, and generally is hospital based (11). These issues make DXA devices prohibitively difficult to use for general health promotion purposes, and new methods and non-invasive approaches are needed to screen for skeletal health status. An ideal BMD screening device would be inexpensive, and would expose the participant to little, if any, risks or discomfort (7). One such device is quantitative ultrasound (QUS).

Furthermore, the World Health Organization (WHO) has stressed the importance of incorporating technologies beyond DXA, such as QUS, to assess effectiveness of bone health interventions (19). The Achilles InSight is a new-generation QUS system for the measurement of calcaneus bone health using isopropyl alcohol as a coupling agent. The Achilles Insight provides an ultrasound parameter - the os calcis stiffness index (OCSI), which is derived from broadband ultrasound attenuation (BUA) and the speed of sound (SOS), in less than one minute, with real-time imaging of the os calcis (3). According to the International Society for Clinical Densitometry, OCSI, BUA, and SOS are the recommended parameters that may be clinically useful in assessing bone quality (13). An international panel noted the potential of this new technology, but recognized that limited information had been gathered, including new types of QUS devices and the potential error sources of the

ultrasonometer (7). Relating to clinical usage, pre-measurement requirements need to be established prior to assessing bone health using this technology, such as afforded by the Achilles InSight. One such pre-measurement requirement could be limiting walking before the assessment.

The development of QUS has led to innovative screening tools for skeletal health status. These devices are ionizing-radiation free, low cost, portable (7, 13, 20), and correlate significantly with DXA (20). Furthermore, os calcis QUS measurements have been shown to predict osteoporosis-related fractures in women (1, 6, 8, 17, 18, 21).

Often, health assessments are taken after an individual walks from a parking lot to a health care provider's office or perhaps after walking in a shopping mall before a health fair screening. Currently no evidence appears to be available on whether or not walking would cause a disturbance in the ultrasound measurement. This issue was posited to one of the authors of this manuscript at a presentation on bone health at the International Osteoporosis Foundation Annual Meeting. To the authors' collective knowledge, no study has assessed the acute effects of walking on the reliability and accuracy of QUS measurements in college-aged individuals. The aim of this study was to evaluate walking as a possible source of error for QUS measurements involving the Achilles InSight.

METHODS

Participants

The study group was comprised of a convenience sample of 30 healthy men and 17 healthy women aged 18-22 ($M \pm SD = 20.44 \pm 1.16$). The participants with past injuries requiring orthopedic intervention were excluded from the study as well as any participants who exercised the same day prior to testing. The participants were recruited from the sponsoring university's campus via word of mouth and advertisement. The study was approved by the sponsoring university's Institutional Review Board and carried out in accordance with the institution's protocol for the protection of human subjects. Written informed consent and a primary health questionnaire were obtained from all participants prior to participation. Testing and data collection took place in the university's Human Performance Laboratory (HPL) over a 16-week period.

Protocol

Ultrasound measurements were performed with an Achilles InSight ultrasound device (GE Medical Systems Lunar, Madison, WI). The Achilles InSight provides an ultrasound parameter, the os calcis stiffness index (OCSI), which is derived from BUA and SOS (21). The formula is: $\text{stiffness} = (-0.67 \times \text{BUA}) / (0.28 \times \text{SOS}) - 420$. The researcher preliminarily tested the reliability of the Achilles InSight. On each testing day, prior to commencing data collection, quality assurance was performed by calibrating the device with a dedicated phantom provided by the manufacturer, per the manufacturer's protocol. Each participant sat barefoot in a stable chair facing the device. The right heel was

positioned using a standardized method, and the QUS measurement was taken. The foot then was removed and replaced back in the QUS device for a total of 2 trials, with 10 randomly selected participants.

The protocol for this study included the following: The participant sat barefoot in a stable chair facing the sonographic device for 15 minutes to mimic a resting condition. After the initial 15-minute rest period, the participant's right heel was positioned on a foot-support plate, and his or her leg rested on the calf support to minimize motion (see Figure 1). The heel was placed between the transducers with the ultrasonographic beam from the transmitter transducer propagating laterally through the center of the os calcis. Isopropyl alcohol was applied to the participant's heel to improve transduction. Real-time imaging provided by Achilles InSight ensured proper placement of the participant's calcaneus between the transducers. The OCSI was then recorded in less than one minute, and the results were printed from the device. The participant then walked barefoot on a treadmill for 15 minutes at $5.63 \text{ km} \cdot \text{h}^{-1}$ (3.5 mph), which is a typical freely chosen walking speed for this population (16). Immediately following the walking, a second measurement of the heel was recorded using the same protocol described above. The results of the post-exercise measurement were then printed and stored with the pre-exercise data in a secured, confidential file.

Statistical Analysis

A 2X2 analysis of variance (ANOVA) with repeated measures was used to determine if significant treatment effect (i.e., pre- vs. post-testing) or interaction for sex existed

on the OCSI measurement. The level for rejecting the null hypothesis was set at $p < 0.05$. Effect size is reported using partial eta squared (η_p^2). Measurement consistency was determined via pre- to post-testing by intraclass correlation coefficient (ICC α), typical error, and coefficient of variation (9). To evaluate the variability of the device relative to the magnitude of the measurement, a Bland-Altman plot (2) was created. The summary statistics are reported using $M \pm SD$.



Figure 1. Achilles InSight QUS Device with foot placement before and during measurement.

RESULTS

The walking intervention did not significantly alter the stiffness index measurement ($F = 2.58, p = 0.12, \eta_p^2 = 0.05$). Sex had no effect on pre- and post-testing measurements ($F = 2.30, p = 0.14, \eta_p^2 = 0.05$). All demographic and stiffness index data are reported in Table 1. Strong reliability was observed when participants were tested and retested with no intervention (ICC $\alpha = 0.97$, stiffness index TE = 3.46, CV = 3.3). The walking intervention did not alter the reliability of the stiffness index measurement in either sex or the total sample, as judged by the ICC, TE, and CV (Table 2). Finally, the variability between the pre- and post-testing stiffness index

appears similar across a wide range of measurements (i.e., stiffness indexed between 95 and 163) (Figure 2).

Table 1. Means and standard deviations of participant characteristics.

	Total ($N = 47$)	Men ($n = 30$)	Women ($n = 17$)
Age	20.44 \pm 1.16	20.43 \pm 1.22	20.47 \pm 1.07
Height (cm)	176.64 \pm 10.82	182.33 \pm 8.93	166.59 \pm 4.92
Weight (kg)	81.48 \pm 17.27	90.70 \pm 14.53	65.21 \pm 5.89
BMI (kg/m ²)	25.82 \pm 2.99	27.14 \pm 2.67	23.51 \pm 1.95
OCSI At Rest	129.49 \pm 15.09	130.00 \pm 14.73	128.59 \pm 16.14
OCSI Post Exercise	130.81 \pm 16.26	130.10 \pm 14.60	132.06 \pm 19.25

Table 2. Measurement consistency of stiffness index before and after a walking intervention

Metric	Total ($N = 47$)	Men ($n = 30$)	Women ($n = 17$)
Intraclass Correlation Coefficient (ICC α)	0.94	0.93	0.95
Typical Error (Stiffness Coefficient)	3.8	3.8	3.8
Coefficient of Variation (%)	3.1	3.1	3.1

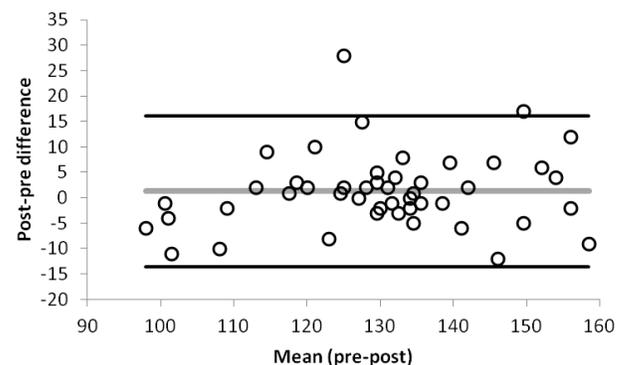


Figure 2. Bland-Altman plot of stiffness index (OCSI) measurements before and after a walking intervention. The mean difference (1.32) is denoted by the middle gray line; whereas the ± 2 SD limits of agreement (± 14.9) are represented by the black lines.

DISCUSSION

Walking could be a source of error for QUS measurements with the Achilles InSight, as it could result in a disruption of the measurement around the calcaneus. To the best of the authors' collective knowledge, no study has investigated the acute effects of walking on QUS measurements. In the present study, the authors aimed to mimic the amount of walking that likely would occur prior to a screening at a health fair or clinical setting using the Achilles InSight. The participants walked on a treadmill at 5.63 km h^{-1} (3.5 mph) for 15 minutes prior to QUS screening of the calcaneus. The results of this study suggest that walking does not affect the OCSI values because the data did not reach statistical significance between the pre- and post-exercise measurements ($\text{ICC } \alpha = 0.94$).

The amount of physical activity to which the participants completed is a limitation of the present study. Fifteen minutes of walking, at a brisk pace, may not have provided an adequate disruptive response for the measurement. Longer and more intense activity potentially could alter the reliability and accuracy of the QUS measurements. However, as previously mentioned, the authors tried to mimic a similar level of physical activity that would occur prior to screening at a health fair or clinical setting, and the results suggest that the Achilles InSight is a reliable screening tool. Further research on both different intensities and durations of walking and other physical activity prior to bone assessment with the Achilles InSight should be conducted.

Many cross-sectional and prospective studies have demonstrated that calcaneus ultrasonometry is effective at determining the risk of osteoporotic fracture when compared to DXA (5). The Achilles InSight is ionizing radiation free, low cost, and portable (7, 13, 20), thus it is a useful and safe alternative to DXA for effectively screening skeletal health status. The present study has improved the validity of the Achilles InSight by indicating an acute bout of walking does not have a statistically significant effect on QUS measurements of the calcaneus. Based on the results of this study, acute, brisk walking, up to 15 minutes in length, does not need to be controlled prior to QUS measurements with the Achilles InSight. Future studies should investigate the effects of longer walking as well as extended periods of standing on measurements from the Achilles InSight to see if measurements are affected.

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