Reliability of the Volumental 3D Foot Scanner Before and After Jogging

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Abstract

The Volumental 3D scanner aims to improve traditional measurement methods by providing a 3D model with six different foot measures. Foot measures using the scanner have been collected to analyze the variability in foot dimensions among a North American sample (Jurca, 2019) as well as how shoe sizes differ from brand to brand (Jurca, 2021). **PURPOSE:** To explore the Volumental 3D scanner as a reliable tool for health professionals and athletes. **METHODS:** Twenty participants (age=33.25 ±14.0 yrs, height=169.0 ± 7.5 cm, weight=76.9 ±13.9 kg) were recruited by word of mouth. Participants removed their shoes (socks were not removed) and stood on the platform of the Volumental scanner. Once the scan was completed, participants then jogged for 30 minutes up and down a preplanned route. When they returned, they had their feet scanned a second time. A 2x4 repeated measures ANOVAs was run for each variable. In case of significance, the Bonferroni technique was applied to control for pairwise error. Intraclass reliability was assessed with the Cronbach's Alpha (two-way effects mixed model). Alpha was set at .05 for all tests. **RESULTS:** Statistical analysis revealed that differences between trial and left and right foot for Ball width ($F_{(7, 13)}$=2.46, p=0.076), Length ($F_{(7, 13)}$=1.13, p=0.398), Girth ($F_{(7, 13)}$=2.40, p=0.081), Instep ($F_{(7, 13)}$=1.40, p=0.284), and Instep Girth ($F_{(7, 13)}$=1.40, p=0.284) were not statistically significant. Analysis of Heel Width revealed a significant differences in the left and right foot, ($F_{(7, 13)}$=37.6, p=0.001) with the left heel being more narrow than the right between each trial (p<0.001). Reliability was excellent (above .90, p<.001) for each measures. **CONCLUSION:** These findings suggest that the Volumental 3D scanner provides consistent measurements across multiple scans, supporting its utility for athletes, footwear brands, and health professionals.

Introduction

The purpose of this study is to assess the reliability of the Volumental foot scan app before and after a jog. The justification for conducting this study is that many runner stores, shoe companies, and podiatrists may use this scan app to help customers select proper fitting shoes. Jogging is an activity that many use for health, fitness or performance benefits. Shoes are a primary means of comfort and injury prevention during this activity. In order for the shoes to function properly, they must fit properly. If the app and scanner is reliable, then customers can be confident in the shoes they purchase.

Previous research has utilized the Volumental scanner to determine the widths of men's feet to inform shoe width stock choices for the Canadian market. Foot scans were exclusively done in specialty running shoe stores with barefoot customers and were classified into foot length classes with a length increment of 5 mm (Jurka, Zabkar, & Dzeroski, 2019). For example, Foot length class 270 mm contained foot scans with foot lengths from 267.5 to 272.5 mm. A total of 494,833 sockless scans were conducted, and the highest number of scans collected fell into the range of 270mm, with the mean foot width being 102.0 ± 4.7 mm" (Jurca et al.,2019)

Another study examined the collected foot length and width data from Volumental scanners used in footwear stores across Asia, North America, Australia, and Europe. A total of 1,030,408 scans were collected, comprising of 45.4% female participants and 54.6% male participants. A Kernal density estimation was used to compare the lengths captured within these regions. The data shows that the Australian and Asian regions have shorter foot lengths for male subjects and that females in the Asian region also show to have shorter foot length.

Up to this point, no research has been conducted to examine the reliability of the Volumental Scanner. Ensuring that this machine produces consistent results across multiple scans is essential for its accuracy and usability. Establishing its reliability would help ensure that those who utilize it receive precise and reproducible measurements.

Hypothesis

It was hypothesized that there would be no significant difference between the pre run and post run measurements for the left and right feet on trial one and trial two.

Methods and Procedures

- A&M-SA IRB Approval (#2023-90).
- All participants signed informed consent (table 1).
- Height and weight was self reported.
- Participants engaged in two trials of a 30 minute self-paced moderate-intensity jog no less than two days or more than seven days apart.
- Participants were instructed to run 15 minutes down a preplanned out-and-back path.
- Prior to and immediately after each run, foot measurements were taken on the Volumental 3D scanner (Stockholm, Sweden).

Methods and Procedures, cont.

Table 1. *Descriptive characteristics of participants (Mean ± SD)*

	Total (n= 32)
Age (years)	33.2±14.0
Height (cm)	169.0±7.5
Weight (kg)	76.9±13.9

STATISTICS:

IBM SPSS v29 was used to assess any changes within and between variables. 2x4 repeated measures ANOVAs was run for each variable. In case of significance, the Bonferroni technique was applied to control for pairwise error. Intraclass reliability was assessed with the Cronbach's Alpha (two-way effects mixed model). Alpha was set at .05 for all tests.

Results

There were no significant differences between trial and left and right foot for Ball width ($F_{(7, 13)}$=2.46, p=0.076), Length ($F_{(7, 13)}$=1.13, p=0.398), Girth ($F_{(7, 13)}$=2.40, p=0.081), Instep ($F_{(7, 13)}$=1.40, p=0.284), and Instep Girth ($F_{(7, 13)}$=1.40, p=0.284), tables 2 and 3.

Table 2. Measures (mm) of right and left foot before and after trial 1.

	Right		Left	
	Pre	Post	Pre	Post
Ball Width	101.0±6.8	101.1±7.1	99.7±6.8	99.9±7.0
Length	260.2±15.2	260.3±15.0	259.7±15.7	259.4±15.3
Girth	21.2±15.0	251.1±14.9	259.6±15.7	249.4±15.8
Heel Width	69.2±5.0	69.0±5.2	65.9±4.9	66.1±5.0
Instep	61.1±3.3	60.6±3.9	61.2±4.5	60.9±5.0
Instep Girth	248.8±15.5	249.8±16.0	250.2±16.8	250.7±15.9

Table 3. Measures (mm) of right and left foot before and after trial 2.

	Right		Left	
	Pre	Post	Pre	Post
Ball Width	101.2±6.8	101.1±6.9	99.6±6.4	100.1±6.9
Length	260.2±14.7	260.0±14.8	259.5±15.5	259.9±15.5
Girth	251.9±14.6	252.1±15.0	249.4±14.9	249.6±15.2
Heel Width	68.3±5.4	68.3±5.1	65.5±5.2	65.5±4.5
Instep	61.3±4.1	60.7±4.2	61.2±4.6	60.6±4.8
Instep Girth	259.8±16.2	250.5±16.3	251.0±15.8	252.0±15.5

Results, cont.

Analysis of Heel Width revealed a significant difference in the left and right foot, ($F_{(7, 13)}$=37.6, p=0.001) with the left heel being more narrow than the right between each trial (p<0.001), figure 1.

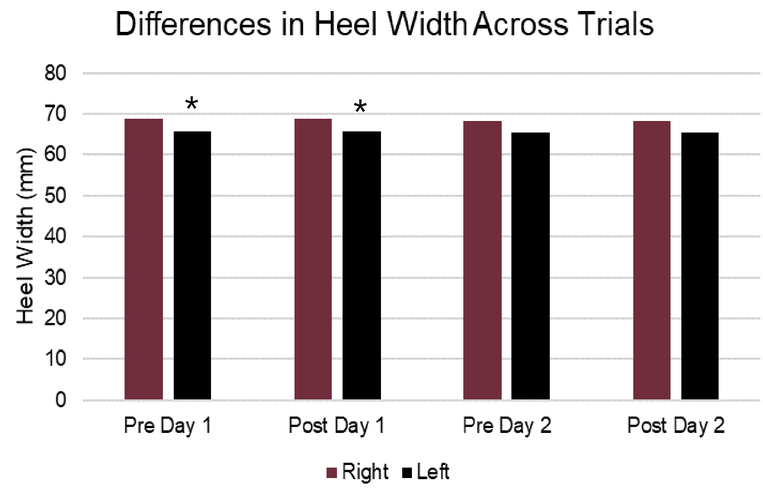

Figure 1. The left heel was significantly narrower than the right between each trial and day (*p < .05).

Reliability was excellent (above .90, p<.001) for each measures. Tables 4 and 5.

Table 4. Left Foot Internal Consistency and Confidence Intervals for each Measure

	Cronbach's	95% CI [LL, UL]
Ball Width	0.994	.957, .990
Length	0.999	.993, .998
Girth	0.994	.957, .990
Heel Width	0.992	.943, .987
Instep	0.988	.914, .980
Instep Girth	0.995	.960, .991

Table 5. Right Foot Internal Consistency and Confidence Intervals for each Measure

	Cronbach's	95% CI [LL, UL]
Ball Width	0.996	.973, .994
Length	0.998	.982, .996
Girth	0.995	.964, .992
Heel Width	0.995	.959, .991
Instep	0.98	.859, .966
Instep Girth	0.993	.948-.988

Conclusion

The Volumental 3D scanner produced reliable readings across trials. The only measure that showed significant differences was the width of the left and right heel, which was only ~3 mm. While effect size was not explored, the magnitude of this difference may not be very meaningful.

One limitation of this study was the inability to monitor participants during their jog. Although the route was predetermined, participants were not observed during their run and may have taken breaks despite being instructed not to.

Another limitation is the potential differences in participant warm up contributing to swelling. While we saw no differences with this study, not having a standardized warm up may allow some joggers to exercise for longer than the allotted 30 minutes. Additionally, any delay the participants may have taken to come back for their second scan may have resulted in the scanner not picking up on changes in the foot dimensions.

Further validation of this machine could be achieved by testing the accuracy of the scanner. The millimeter measurements recorded by the scan could be compared to a gold standard, such as digital or sliding calipers, to assess the scanner's accuracy against true foot measurements.

References

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Jurca, A., Žabkar, J. & Džeroski, S (2019A). Foot width dispersion of male customers in the US and Canada. *Footwear Science, 11(sup1), S163-S165*. https://doi.org/10.1080/19424280.2019.1606307