Evaluation of a Running Sock Designed to Provide Real Time Biofeedback to Runners

Connor R. Wernecke, Erin M. Florkiewicz, Gabriel A. Santiago, Jamie B. Morris, and Donald L. Goss

United States Military Academy, West Point, NY, USA
Email: Donald.l.goss.mil@mail.mil

INTRODUCTION

Recreational running, an activity practiced by many as a way to maintain fitness, results in an alarmingly high rate of lower leg injuries [1]. In the US Military, where running is an important aspect of fitness assessments and conditioning, 45% of injuries are exercise or sports related [2]. Runners with a rear-foot strike (RFS) pattern may demonstrate greater rates of vertical loading than non-rear-foot (NRFS) runners [3]. These greater rates of loading may be responsible for a higher incidence of lower leg injuries [4]. Consequently, much research has been devoted to determining differences in loading rates between running styles and examining correlations between running styles and injury rates [4].

Crowell et al. used accelerometers to measure tibial shock in runners. Researchers trained ten runners with high tibial shock rates using live feedback in an attempt to reduce their lower leg impact while running. After the training period, participants' load rates were reduced by nearly 50% [5]. Given the contribution of high tibial shock rate to the incidence of stress fractures, the researchers concluded that this reduction of load rates may reduce the risk of stress injury [5]. Using real-time biofeedback may be a useful tool in actively altering running mechanics, and preventing or rehabilitating running related injuries.

The purpose of this study was to evaluate the ability of the Sensoria® Smart Sock to provide accurate real-time biofeedback to runners. In order to establish the validity of the Sensoria Smart Sock we compared its accuracy and consistency with that of Novel's PEDAR-X insole system and high speed video capture.

METHODS

This experiment was an observational reliability study. A convenience sample of 40 healthy runners (mean age 31.9 ± 7.6 years, 52% male) at the United States Military Academy at West Point, NY were recruited using a flier posted on Facebook. Plantar pressure data for each runner was gathered using both the Sensoria® Smart Sock system and Novel's PEDAR-X insole system.

The PEDAR-X system is a plantar pressure insole device that attaches by wires to a central unit that sends data via Bluetooth or Fiber Optic Cable to a computer database. The insoles have over 200 sensors and record at a frequency of 200 Hz. Though it is the current gold-standard for measurement of foot strike pattern (FSP) and plantar pressure, the PEDAR-X, valued at $75,000, is much more expensive than the Sensoria® Smart Sock at $199 per bundle and also takes significantly more time to obtain useful data.

The Sensoria® Smart Sock is designed with three textile pressure sensors sewn into the heel, head of the first metatarsal, and head of the 5th metatarsal. An anklet containing an accelerometer connects to the sock magnetically and delivers data via Bluetooth to a mobile application which provides runners with real-time biofeedback on a variety of variables including distance, calories, pace, speed, ascent, descent, altitude, FSP, foot contact time (milliseconds), number of steps, and cadence. The Sensoria Smart Socks used in this study collected data at 32 Hz.

All subjects scheduled and attended a data collection appointment with an average duration of 45 minutes. Subjects were outfitted with the PEDAR-X system and the Sensoria Smart Socks simultaneously to allow for a direct comparison of data. While participants ran for approximately 6-8 minutes on a Life Fitness 97Ti treadmill at their self-selected running speed, FSP, cadence, and speed were collected during three, one-minute trials. Self-selected speed was recorded from the treadmill display and was held constant for all trials. Participants' trials were simultaneously video-taped using a stationary Casio Exilim EX-ZR200 high speed video camera mounted on a Vivitar tripod (57cm lens height, 58cm distance from the treadmill) collecting data at 240 Hz to assess FSP and cadence. FSP was dichotomously characterized as either RFS or NRFS. If the location of initial plantar contact was observed to be in the posterior 1/3 of the foot for the majority of foot strikes they were characterized as RFS. If the location of initial plantar pressure was observed to be in the anterior 2/3 of the foot they were characterized as NRFS. Intraclass correlation coefficients were calculated for speed data between Sensoria and treadmill display. Intraclass correlation coefficients were calculated for cadence between Sensoria and 240 Hz video data. Cohen's Kappa values were calculated for FSP between Sensoria, PEDAR, and 240 Hz high speed video data. Data were analyzed using SPSS v 19.

RESULTS AND DISCUSSION

Incomplete and unusable data were present on 2 subjects. Complete data and analyses were conducted on 38 runners. Intraclass Correlational Coefficient (ICC 2, 1) = 0.99 ICC for cadence reliability between Sensoria and high speed video data. Intraclass Correlational Coefficient (ICC 2, 1) = 0.67 ICC for speed reliability between Sensoria and treadmill display (Table 1).

Table 1: Intraclass Correlation Coefficient (ICC 2, 1) for cadence and speed comparisons between the Sensoria Smart Sock, 240 Hz video data and treadmill display.

	Cadence	**Speed**
ICC Value	0.99	0.67

Comparison of the PEDAR-X vs. Sensoria Smart Sock and high speed video vs. the Sensoria Smart Sock FSP data resulted in 74% agreement and a Kappa coefficient of .51 for both data sets. Comparison of the PEDAR-X vs. high speed video FSP data resulted in 100% agreement and a Kappa coefficient of 1 (Table 2).

Table 2: Statistical comparison of foot strike pattern (FSP) between Sensoria Smart Sock, PEDAR-X, and 240 Hz video data.

	N	**% Agreement**	**Kappa**
PEDAR-X vs. SENSORIA	38	74%	.51
VIDEO vs. SENSORIA	38	74%	.51
PEDAR-X vs. VIDEO	38	100%	1

CONCLUSION

The Sensoria Smart Sock demonstrated excellent reliability detecting cadence, but only moderate reliability for FSP and speed. It is possible that this is due to the study's design which was constrained by one minute trials of data collection conducted on a treadmill. Data collections of longer durations using over ground running should be examined. The Sensoria Smart Sock appears to be a reasonably reliable and potentially useful device for runners seeking real time biofeedback.

REFERENCES

1. van Gent RN, et al. *Br J Sports Med* **41**, 469-480, 2007.
2. Hauret KG. *Am J Sports Med*, 2645 – 2653, 2015.
3. Goss DL. *J of Orthop Sports Phys Ther*, **43(10)**, 685 – 692, 2013.
4. Van Der Worp, *Br J Sports Med*. Jan ePub, 2016.
5. Crowell HP. *Clin Biomech*, **26**, 78 – 83, 2011.