VALIDAITON OF GARMIN FITNESS TRACKER (FENIX 3 HR) BIOMECHANICS

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ABSTRACT

- 17 participants were recruited to determine the validity and accuracy of the Garmin Fenix 3 HR fitness tracker in estimating running biomechanics, specifically stride length, run cadence, vertical oscillation and ground contact time.
- The data collected by the Garmin was compared to data collected from a Bertec instrumented treadmill, Vicon Nexus motion capture system and combined and processed in Visual 3D from the inclined, declined and flat runs. P-value was determined via a paired t-test.
- Overall, we can state with confidence that when used on varied running levels (incline, decline and flat), which would be found during real-world running, the Garmin Fenix 3 HR would accurately estimate a runners stride length and run cadence. It cannot be expected to accurately estimate vertical oscillation or ground contact time during real-world running.

INTRODUCTION

- Fitness trackers are becoming common-place in society, and biomechanical data that used to be available only for elite athletes, is now becoming available for anyone with an activity tracker.
- Fitness trackers have the possibility of revolutionizing health, fitness, physiologic and pathophysiologic research and understanding of the general health of society (Wright et. al., 2017).
- Stride length, run cadence, vertical oscillation and ground contact time, if known, can help to drive training adaptations (Adams et. al., 2018), improve running economy (Folland et. al., 2017), help prevent injuries (Schubert, Kempf, Heiderscheit, 2013), and aid in the recovery of injuries (Willy, 2017)
- The need for independent validation has become more important to drive accuracy in training decisions and physiologic research.

METHODS

- 17 healthy, recreational runners (9 male, 8 female, 28.11 ± 7.38 yrs, 70.26 ± 10.76 kg, 173.77 ± 5.96 cm) were recruited and used for this study.
- Three running conditions (flat, incline (5%), and decline (-5%)) were performed, each trial went for approximately 2:15.
- An instrumented treadmill (Bertec, Inc., Columbus, OH) was used to collect ground reaction force data.
- Infrared markers were placed on the foot and trunk and tracked with a 16 camera Vicon Nexus 2.3 (Vicon, Inc., Oxford, UK) system to collect run cadence, stride length and vertical oscillation. Collections were taken every 30 seconds for 10 seconds.
- The data was compiled and processed using Visual 3D software (5.0, C-Motion, Inc., Germantown, MD,USA) and variables extracted were compared to the data collected by the Garmin Fenix 3 HR (Garmin Ltd., Olathe KS). The user information in the Garmin watch was changed for each participant before the trials began.
- Run cadence, stride length, vertical oscillation, and ground contact time were collected from the Garmin Fenix 3 HR. We then extracted the data from the corresponding data collection times from the Vicon Nexus system to compare the data.
- After data was collected and compiled, we determined the stride length, run cadence, vertical oscillation, and ground contact time in Visual 3D (V3D), for each trial and condition (flat, incline and decline).
- Paired t-tests were run for each of the 4 variables and 3 conditions separately (table 1), as well as an overall t-test for each of the variables with combined conditions (table 2).

RESULTS

- Overall, the Garmin was accurate for stride length and run cadence, but underestimated vertical oscillation and overestimated ground contact time.

	Flat Stride Length (m)		Inclined Stride Length (m)		Declined Stride Length (m)	
	Garmin	V3D	Garmin	V3D	Garmin	V3D
Avg.	2.1 ± 0.3	2.1 ± 0.2	2.1 ± 0.2*	2.2 ± 0.2	2.1 ± 0.3	2.1 ± 0.2
	Flat Run Cadence (steps/min)		**Inclined Run Cadence (steps/min)**		**Declined Run Cadence (steps/min)**	
	Garmin	V3D	Garmin	V3D	Garmin	V3D
Avg.	166.1 ± 9.1*	165.7 ± 9.1	169.2 ± 9.6	169.3 ± 11.0	164.0 ± 11.0	164.0 ± 11.0
	Flat Vertical Oscillation (cm)		**Inclined Vertical Oscillation (cm)**		**Declined Vertical Oscillation (cm)**	
	Garmin	V3D	Garmin	V3D	Garmin	V3D
Avg.	9.7 ± 1.4*	7.7 ± 1.4	8.8 ± 1.2*	7 ± 1.2	10.2 ± 1.2*	8.2 ± 1.6
	Flat Ground Contact Time (ms)		**Inclined Ground Contact Time (ms)**		**Declined Ground Contact Time (ms)**	
	Garmin	V3D	Garmin	V3D	Garmin	V3D
Avg.	271.8 ± 20.8*	276.9 ± 28.3	278.3 ± 24.7	279.2 ± 39.2	266.1 ± 24.3*	276.9 ± 28.3

Table 1. Averages from all conditions, collected by the Garmin Fenix 3 HR and Vicon Nexus, Bertec Instrumented treadmill and compiled in Visual 3D (V3D). p-value was determined via a paired t-test.
* Represents a p-value <0.05

	Stride Length (m)		Run Cadence (steps/min)		Vertical Oscillation (cm)		Ground Contact Time (ms)	
	Garmin	V3D	Garmin	V3D	Garmin	V3D	Garmin	V3D
Avg.	2.1 ± 0.2	2.1 ± 0.2	166.5 ± 10.1	166.4 ± 10.1	9.6 ± 1.5*	7.7 ± 1.5	272.2 ± 23.7*	277.7 ± 32.2

Table 2. Statistics and data from Visual 3D and Garmin Fenix HR3. The data is combined from the 3 conditions for each variable (flat, incline and decline). p-value determined via a paired t-test.
* Represents a p-value <0.05

CONCLUSION

- The Garmin was found to be accurate for the following variables: flat & declined stride length, inclined & declined run cadence, and inclined ground contact time.
- The Garmin was NOT found to be accurate for the following variables: inclined stride length, flat run cadence, flat, inclined & declined vertical oscillation, and flat & declined ground contact time.
- Overall, we can state with confidence that when used on varied running levels (incline, decline and flat), which would be found during real-world running, the Garmin Fenix 3 HR would accurately estimate a runners stride length and run cadence; however, it may not accurately estimate vertical oscillation or ground contact time.
- **Future considerations:** As our study was conducted using a treadmill with the Garmin foot pod, HR strap and Fenix 3 HR, the next step would be to carry out the study outdoors, over ground, to determine if the GPS would assist in the accuracy of the measured variables.

REFERENCES

Adams, D., Pozzi, F., Willy, R. W., Carrol, A., & Zeni, J. (2018). ALTERING CADENCE OR VERTICAL OSCILLATION DURING RUNNING: EFFECTS ON RUNNING RELATED INJURY FACTORS. *International Journal of Sports Physical Therapy*, 633 - 643.

Folland, J., Allen, S. J., Black, M. I., Hadsaker, J. C., & Ferrester, S. E. (2017). Running Technique is an Important Component of Running Economy and Performance. *Medicine & Science in Sports & Exercise*, 1412-1423.

Schubert, A. G., Kempf, J., & Heiderscheit, B. C. (2014). Influence of Stride Frequency and Length on Running Mechanics: A Systematic Review. *Sports Health: A Multidisciplinary Approach*, 210-217.

Willy, R. W. (2018). Innovations and pitfalls in the use of wearable devices in the prevention and rehabilitation of running related injuries. *Physical Therapy in Sport*, 26-33.

Wright, S. P., Brown, T. S., Collier, S. R., & Sandberg, K. (2017). How consumer physical activity monitors could transform human physiology research. *American Journal of Physiology Regulatory, integrative and Comparitive Physiology*, 358,367