Comparison of Three Physical Activity Trackers while Performing Functional Tasks

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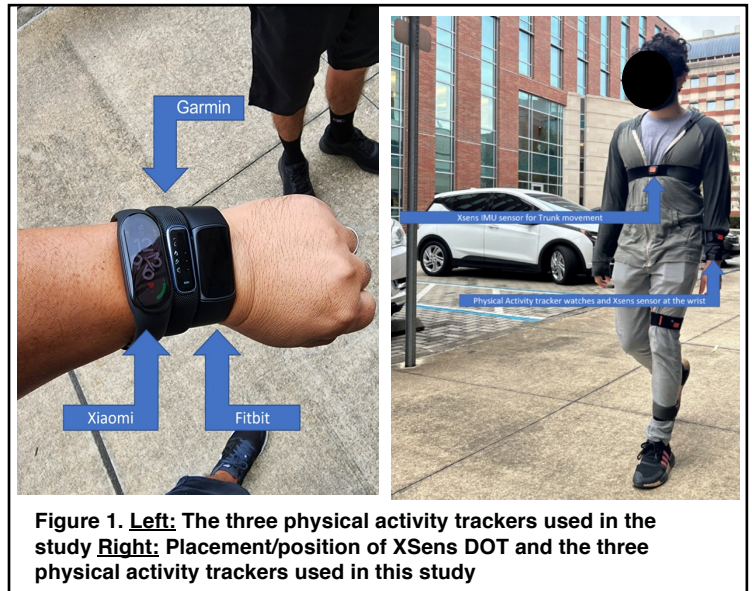
INTRODUCTION

Wearable devices such as fitness trackers, smartwatches, and motion sensors can measure various parameters related to functional mobility, such as gait speed, step count, and distance walked.[1] These devices can also monitor other factors like heart rate, blood pressure, and oxygen saturation, providing additional insights into a person's functional mobility.[2,3] However, it's important to note that the accuracy and reliability of wearable devices can vary depending on the specific device and the individual being assessed.[4] As with any assessment tool, wearable devices for measuring the functional test should be combined with other assessments to obtain a comprehensive understanding of an individual's mobility and balance.[5–7] As the wearable technology evolves and different devices have been used for different studies, researchers and clinicians must stay updated with the latest wearable devices and their performance, especially when used during functional tasks.

This study compared performance using the output parameters (i.e., steps, distance, heart rates) of three latest wearable activity trackers (Fitbit Charge 5, Garmin Vivosmart 4, and the Xiaomi Band 7) during performing of six functional tasks.

METHODS

We conducted an exploratory pilot feasibility study with a convenience sample of four adults over 18 years of age working in our lab, at the University of Florida. Participants wore the Xsens DOT, Fitbit Charge 5, Garmin Vivosmart 4, and Xiaomi Band 7 simultaneously during the trials as shown in Figure 1. All participants completed three trials of each of the six functional and clinical outcome measures in the same order: (a) 30-second chair stand test, (b) six-minute walk test (6MWT), (c) timed up and go (TUG), (d) fast-paced walk test, (e) 10-meter sprint test, and (f) stair climb test. A one-minute post-trial rest period was provided after all outcomes except for the fast-paced walk test and the 10-meter sprint test, where a two-minute and three-minute rest periods were provided respectively to ensure that the heart rate was not very high at the beginning of each subsequent trial. The data from each tracker/device was extracted using the manufacturer-provided Application Programming Interfaces (APIs) and Software Development Kits (SDKs) and downloaded from the online web portal. The output parameters from each physical activity tracker were analyzed separately for each task. Descriptive statistics were used for the data analysis.

Figure 1. Left: The three physical activity trackers used in the study Right: Placement/position of XSens DOT and the three physical activity trackers used in this study

RESULTS

Data from the three physical activity trackers were extracted using the respective APIs and SDKs. The mean and standard deviations for the parameters are presented in Table 1. Heart rate, steps, distance and calories were tracked for all tasks by Fitbit Charge 5, heart rate and steps were tracked for all task by Xiaomi Band 7, while the Vivosmart 4 only tracked heart rate and speed for the 6-minute walk test. Figure 2 shows the visualized data obtained from Garmin Vivosmart 4. This data was presented separately as the data was sparse and not comparable to the data obtained from the Fitbit and Xiaomi devices.

Figure 3 shows the visualized data from the Xiaomi and Fitbit. There was a small difference of 80~200 steps in the total step count, with the Xiaomi estimating a higher number of steps in five out of six tasks in Table 1. Additionally, the user portals did not provide all the information in Table 1, which included the raw data obtained from each device's API and SDK.

Table 1. Descriptive Statistics for each physical activity tracker by functional task

30-Second Chair Stand Test					
Device/Outcome	**Heart Rate**	**Steps**	**Distance**	**Calories**	**Speed**
Fitbit Charge 5	90.26 (14.01)	32.23 (3.61)	0.01 (0.002)	4.41 (0.62)	NR
Xiaomi Band 7	95.71 (11.74)	28.36 (14.47)	NR	NR	NR
Garmin Vivosmart 4	NR	NR	NR	NR	NR
6-Minute Walk Test					
Device/Outcome	**Heart Rate**	**Steps**	**Distance**	**Calories**	**Speed**
Fitbit Charge 5	103.96 (14.44)	90.09 (9.25)	0.04 (0.004)	6.85 (0.57)	NR
Xiaomi Band 7	104.37 (9.77)	96.50 (5.01)	NR	NR	NR
Garmin Vivosmart 4	90.16 (34.28)	NR	NR	NR	1.51 (0.17)
Timed Up and Go Test					
Device/Outcome	**Heart Rate**	**Steps**	**Distance**	**Calories**	**Speed**
Fitbit Charge 5	87.67 (12.23)	9.88 (1.65)	0.004 (0.001)	3.20 (0.356)	NR
Xiaomi Band 7	112 (2.83)	30.38 (42.01)	NR	NR	NR
Garmin Vivosmart 4	89.70 (28.71)	NR	NR	NR	NR
Fast Paced Walk Test					
Device/Outcome	**Heart Rate**	**Steps**	**Distance**	**Calories**	**Speed**
Fitbit	89.33 (13.68)	22.92 (3.38)	0.01 (0.002)	3.79 (0.92)	NR
Xiaomi Band 7	109.25 (20.12)	33.98 (8.47)	NR	NR	NR
Garmin Vivosmart 4	NR	NR	NR	NR	NR
10-meter Sprint Test					
Device/Outcome	**Heart Rate**	**Steps**	**Distance**	**Calories**	**Speed**
Fitbit	89.38 (11.26)	13.25 (2.42)	0.006 (0.001)	3.42 (1.05)	NR
Xiaomi	100.39 (13.61)	36.14 (9.87)	NR	NR	NR
Garmin Vivosmart 4	NR	NR	NR	NR	NR
Stair Climb Test					
Device/Outcome	**Heart Rate**	**Steps**	**Distance**	**Calories**	**Speed**
Fitbit Charge 5	96.99 (17.47)	23.35 (10.94)	0.011 (0.005)	4.50 (1.50)	NR
Xiaomi Band 7	89 (5.37)	23.54 (7.10)	NR	NR	NR
Garmin Vivosmart 4	NR	NR	NR	NR	NR

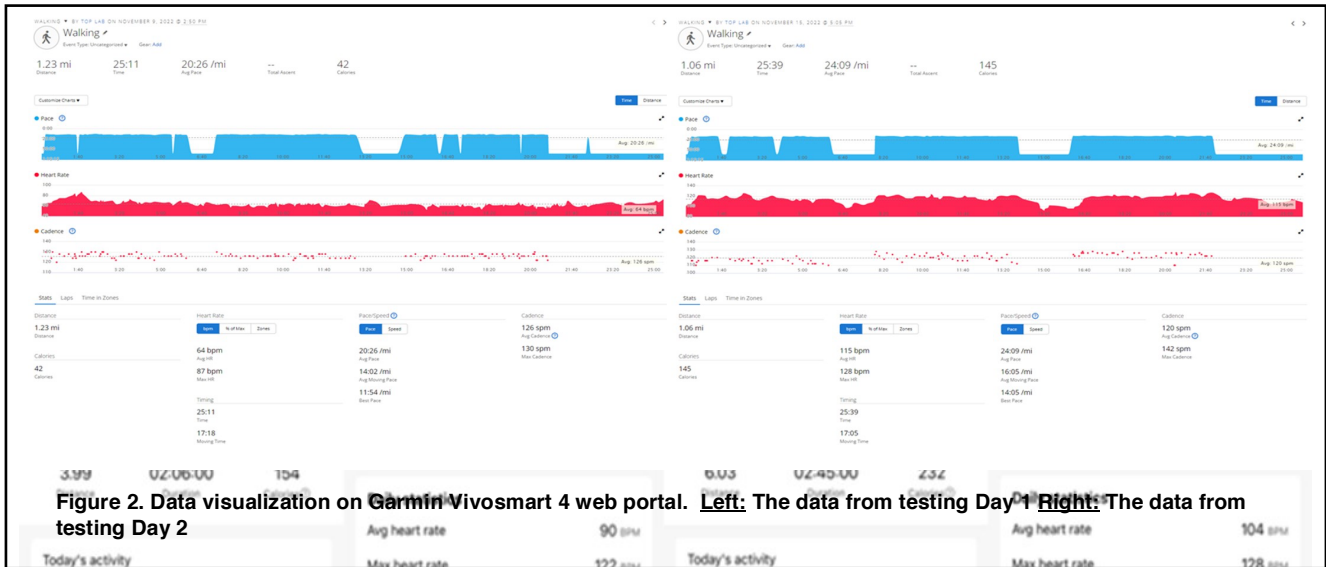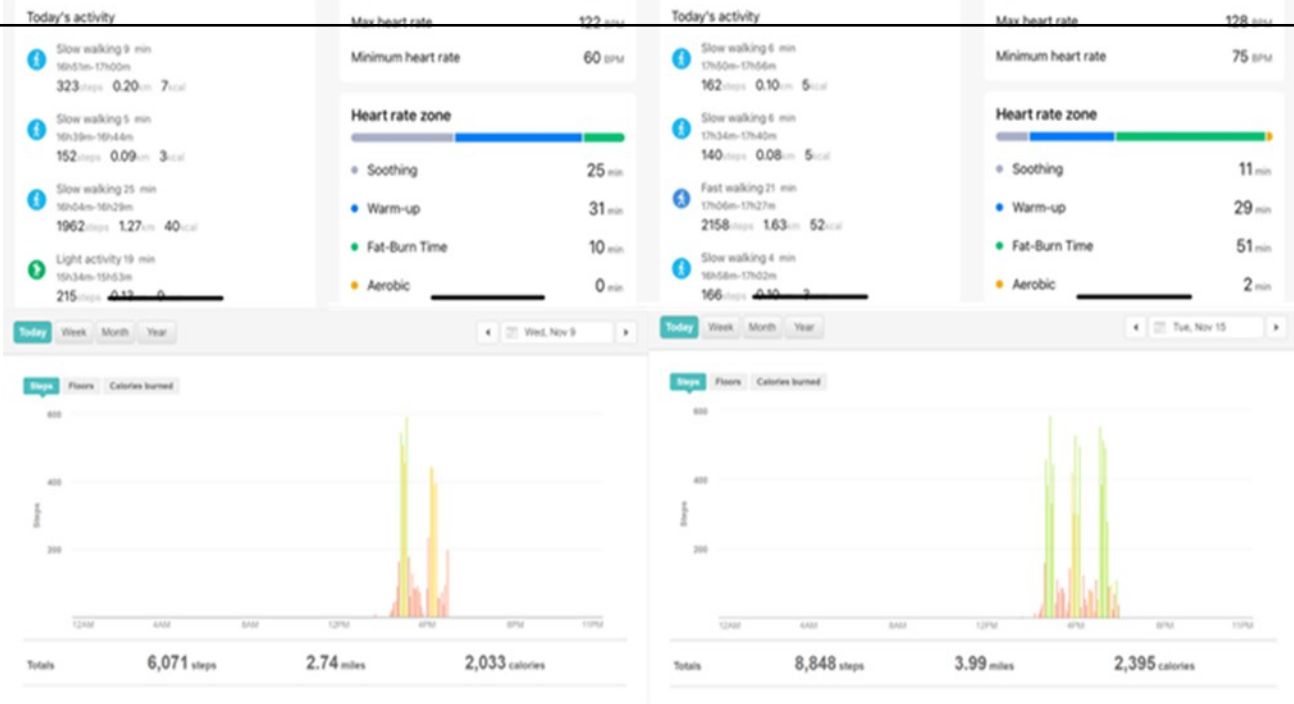**Figure 2. Data visualization on Garmin Vivosmart 4 web portal. Left: The data from testing Day 1 Right: The data from testing Day 2**

Figure 3. Data visualization on Xiaomi Band 7 (top) and Fitbit Charge 5 (bottom); Left: The data from testing Day 1 Right: The data from testing Day 2

DISCUSSION

The Fitbit Charge 5 and Xiaomi Band 7 were able to track heart rate and steps for all different functional tasks performed during the test session and the Garmin Vivosmart 4 tracker was inconsistently across the tasks. This finding showing the underestimation of activity by Garmin Vivosmart 4 is corroborated by existing literature.[8] Fitbit Charge 5 and Xiaomi Band 7 showed some agreements in 30-second Chair Stand Test, 6-minutes walking, and stair climb test, but larger discrepancies in the Timed-up and Go, fast-pace walk, and 10-meter spring test. These findings agreed with the literature that performance of the wearables could be task specific. We noticed that the heart rate was the only common variable that was most consistently recorded across all three devices. While the heart rate and steps data were estimated by the Fitbit as well as the Xiaomi devices, they are not always in complete agreement;[9] There are instances where one or both these trackers over- or underestimate the physical activity data based on the functional task. For instance, during the 30-second chair stand test, the Xiaomi tracker initially overestimated the steps when compared to the Fitbit in some trials while the vice versa was true for the other trials. It is also important here to note that in the Xiaomi band, the steps were never zero, even during periods of rest, indicating a potential inaccuracy due to overestimation. This finding is supported by certain reports highlighting the poor reliability and/or validity of some of these trackers.[10] These results are intriguing and the next steps involve comparing some of the performance measures like distance, cadence, steps, etc., obtained from these physical activity trackers with the data obtained from the XSens DOT, which is known for more accurate human motion tracking.

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