Steps, energy expenditure and heart rate agreement of five activity trackers

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1. Introduction

Physical activity decreases the risk of chronic diseases and premature death [1]. Activity trackers can record number of steps and heart rate and estimate energy expenditure and distance. These metrics can be used to help encourage behaviour change towards a healthier lifestyle or be used by athletes to help improve performance. The integration of activity trackers within daily life and the datasets they generate, present opportunities to either integrate these measures into *in silico* models or use them as indirect outcome measures of their effectiveness. Assessing the validity of these trackers is therefore important to understand their usefulness.

2. Materials and Methods

The study was approved by the Ethics Review Boards at the Universities of Sheffield and Sheffield Hallam. Twenty-five healthy participants provided informed consent and (12 men, 13 women, body mass 50 to 82.9 kg; stature 167 to 181 cm; age range 26 to 51 years) completed a 30-min treadmill (HP Cosmos Saturn, Germany) walking test whereby speed was increased at 5 min intervals (3,4,5,6, 7.5 and 9 kph, respectively).

Participants concurrently wore five Fitbit trackers: One (FO, waist), Surge (FS, wrist), Flex 2 (FF2, wrist), Charge 2 (FC2, wrist) and Charge HR (FHR, wrist). All trackers assessed steps, distance, and energy expenditure. FS, FC2 and FHR also measured heart rate.

Gold standard (GS) data was obtained by direct observation by video (number of steps, S), expired air analysis (Ultima, CardiO2, USA) (energy expenditure, EE), and a heart-rate monitor (HR) (Polar H10, Polar Electro, Finland).

3. Results

Table 1 reports the correlation coefficients among all fitness trackers and with respect to the GS. For each tracker, Mean Absolute Percentage Error (MAPE) and its standard deviation were calculated. For step count, FO showed the best agreement with GS (2.2±3 % (steps·min^{-1}). Among wrist-worn trackers, FC2 had the best agreement of 8.0±11.7% (steps·min^{-1}). For HR, FHR performed best 5.0±5.7% (beats/10 sec). For EE, MAPE was 32.0-50.95% (cal·min^{-1}).

	GS	Activity trackers					Measure Type
		FHR	FC2	FS	FO	FF2	
GS	1	0.97	0.93	0.89			HR
		0.88	0.88	0.84	0.78	0.84	EE
		0.85	0.90	0.85	0.98	0.85	S
FHR		1	0.94	0.91			HR
			0.90	0.84	0.70	0.82	EE
			0.95	0.88	0.85	0.85	S
FC2			1	0.89			HR
				0.87	0.66	0.84	EE
				0.90	0.89	0.89	S
FS				1			HR
					0.66	0.85	EE
					0.85	0.93	S
FO					1		HR
						0.70	EE
						0.85	S
FF2						1	

Table 1: Correlation coefficients ($p<0.05$).

4. Discussion and Conclusions

In this study, results are in good agreement with previous studies [2-4]. Wrist-worn activity trackers were unable to provide accurate measures for steps, energy expenditure and heart rate. FO outperformed wrist-worn trackers to count steps because it is placed on the waist and closer to the centre of mass. Despite the large absolute measurement errors, we observed strong correlations between trackers, and with GS, indicating consistency and good relative agreement. In conclusion, activity trackers in their current format, because of their good correlation to GS, might be valuable to understand trends in activity and behaviour in healthy individuals.

This work provides the opportunity to derive reliable quantitative measures able to robustly describe these observations and to explore new applications to these activity trackers.

5. References

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