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Original Research

Validation of Mi Band Smart Watch for Fitness Tracking

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ABSTRACT

The purpose of this study was to investigate the reliability and validity of Mi Band (Mi Band 4) smart watch for fitness tracking. Fifteen (n=15; Height: 1.71 ± 4.0 m; Weight: 66.5 ± 9.5 kg) recreational athletes (Age 23.0 ± 0.53) volunteered to participate in this study. The participants attended three sessions; one to familiarise them with the procedures and two trials to determine the reliability and validity of Mi Band smart watch in middle distance running. The participants wore the same Mi Band smart watch and were asked to run 5 km on the running track in two occasions separated by seven days. No differences recorded in the environment between trials (Temperature: 27.6 ± 1.1 C°; Humidity: 73 ± 5.3 %: $P < 0.05$). The results showed there were no significant differences between running distance (4.3 ± 0.49, 4.3 ± 0.46 km; $P < 0.05$), pace of running (7.27 ± 0.37, 7.2 ± 0.36, $P < 0.05$) and heart rate (163 ± 10.2, 160 ± 13.3 bpm; $P < 0.05$) between trials. However, calories burned showed significant differences where in Trial 1 participants burned more calories compared to Trial 2 (396 ± 77.3, 376 ± 60.4 kcal; $P > 0.05$). The reliability testing showed strong to moderate reliability in time of completion of running ($r=0.964$, $P < 0.05$) distance of running ($r=0.983$, $P < 0.05$) and pace of running ($r=0.527$, $P < 0.05$). No significant correlation in heart rate between trials and calorie burned ($P > 0.05$). The validity of the Mi Band smart watch showed significant positive correlation between middle distance running and distance recorded in the Mi Band ($r=0.483$, $P < 0.05$). We conclude that the Mi Band underestimated distance running, however the Mi Band is sufficiently reliable and valid for fitness tracking especially in pace of running and exercise intensity.

INTRODUCTION

Smart watches are very common accessories nowadays and widely available from various manufacturers such as Apple, Samsung, Garmin, Xiaomi Mi Band and Fitbit, and can be purchased from online retailers or the manufacturer's websites, as well as from brick-and-mortar stores (Chuah et al., 2016).

These devices offer a variety of features that can be very useful for many users. They are designed to be worn on the wrist and can provide information and assistance in real-time. Most smart watches come equipped with sensors that can track various fitness metrics, including steps taken, distance travelled, calories burned, heart rate, and even sleep quality as well as reminders to stay active throughout the day and other vital signs (Paradiso et al., 2020). Moreover, the data collected by the smart watch can be synced with a fitness app on the smartphone or other device, allowing to track exercise progression and monitor fitness goals (Kaewkannate et al., 2016). Overall, the use of a smart watch for fitness tracking can be a great way to monitor and improve overall health and fitness level.

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The wearables smart watch has become a common approach for quantifying daily physical activity fitness tracking exercise at the present time (Siepmann et al., 2021). The popularity of smart watches is likely to continue to grow as technology improves and more people discover the benefits of these devices (Kim et al., 2015). There were many available brands that range from different prices (Ramkumar et al., 2020). Among the most popular devices are Apple Smart Watch and Garmin. Garmin watches are known for their exceptional Global Positioning System (GPS) tracking capabilities, which are particularly useful for athletes and outdoor enthusiasts (Butte et al., 2012). They also offer features like heart rate monitoring, activity tracking, and smart notifications. Apple Watch, on the other hand, is a versatile smartwatch that offers features like cellular connectivity, fitness tracking, voice commands with Siri, and the ability to make phone calls and send texts directly from the watch. It also has a large app store with a variety of third-party apps (Shih et al., 2015). However, these two are expensive and may not become accessible to fitness enthusiast users. Consequently, users tend to look at the other option of fitness watches.

The Xiao Mi Band (MB) smart watches have become increasingly in demand due to the market value, convenience, and versatility (Hong et al., 2017). Nevertheless, there is lack of studies that have been investigated the accuracy of this device in fitness tracking compared to the popular brands like Apple and Garmin (Pino-Ortega et al., 2021) Studies have been conducted to assess the reliability and validity of smart watches, and the results have been mixed. Some studies have found that certain models of smart watches are reliable and valid in measuring certain health metrics such as heart rate and sleep, while others have found inconsistencies and inaccuracies (Gilinov et al., 2017). Reliability and validity are important aspects of selecting a smart watch. Reliability refers to the consistency and stability of the measurements taken by a smart watch (Atan & Kassim 2020). For example, if a smart watch is measuring heart rate, it should provide consistent readings over time and not be affected by external factors such as movement or temperature changes. Meanwhile, validity refers to the accuracy of the measurements taken by a smart watch (Atan & Kassim 2020). It measures whether the data collected by the smart watch represents the intended construct being measured. Consequently, the aim of this study is to investigate the reliability and validity of Mi Band (Type 4) smart watches in fitness tracking in middle distance running (5km). This current study investigated the distance running, calories burned, heart rate and time taken to finish exercise. It was hypothesis that the Mi Band is reliable and valid in fitness tracking.

MATERIALS AND METHOD

Participants

The data was collected on fifteen (n = 15, age 23 ± 0.53) recreational runners (Height: 1.71 ± 0.4 m, body mass: 66.3 ± 8.4 kg) volunteered to participate in the study. The participants Body Mass Index (BMI) were 20.1± 0.2 which is fall under normal BMI category and describe the participants leanness or corpulence based on their height and weight and is intended to quantify tissue mass (Jakiwa et al., 2022). A written consent form was obtained from the participants after being thoroughly informed of the benefits and potential risks of the study. The participants were also asked to fill in the Health Screening Questionnaire to ensure that they are healthy, free from any injury and did not on medications that will influence the results

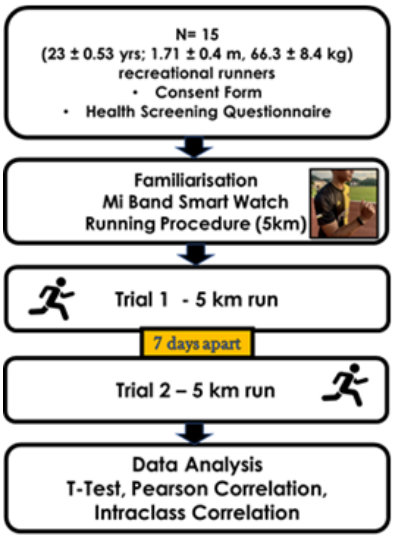

Fig. 1 Methodology used for measuring reliability of the Mi Band smart watch.

Experimental Design

Data was collected and took place on an outdoor running track with no differences seen in environmental conditions between trials (Temperature: 27.6 ± 1.1 C°; Humidity 77.5 ± 5.3%) (Atan & Kassim, 2020). Figure 1 illustrates the experimental design for this study. Recreational runners who trained regularly volunteered to participate in this study. Prior starting the experiment, conduct baseline assessments of participants' fitness levels and physiological characteristics using established methods (e.g., consent form, health screening questionnaires, body composition analysis) to ensure that the participants were fit and healthy to involved in the study.

All participants attended one preliminary session to familiarise themselves with the protocol procedures along with height and body mass measurements. During the familiarisation, participants were explained about the 5 km run procedure and the Mi Band smart watch interface to understand the features including its fitness tracking sensors (e.g., accelerometer, heart rate monitor), supported activities, and data recording capabilities. In addition, the participants were familiarised with the wearable placement to ensure that the Mi Band smart watch is properly worn and configured with pairing the device (smartphone app) and syncing data for further analysis (refer Figure 2).

Following familiarisation, the testing was performed in full on two occasions (separated by 7 days). Participants were asked to refrain from strenuous physical activity 24 hours before each trial, record dietary intake (24 hours before the first protocol) and replicate the same diet prior to trial 2. After donning the Mi Band smart watch, the watch face was set to outdoor running. Then, the participants were ready at the starting position (refer Figure 3), immediately after the “Go” signal, the participants press “Start” and start running 12 x 400 m lap plus 200 m. To enhance reliability, all participants were asked to run on a similar lane (Lane 1 only).

Mi Band 4 Features

Fig. 2 Mi Band (Type 4)

The weight of the Mi Band is 22.1 g and has a 5 ATM water resistance rating. The RAM is 512KB and ROM is 16MB. Meanwhile, the sensors are 3-axis accelerometer + 3-axis gyroscope, PPG heart rate sensor and capacitive proximity sensor. The band sensed GPS only when it is connected to the application in phone. It has six workout modes: Treadmill, exercise, outdoor running, cycling, walking, pool swimming; count steps, distance, and calories burned. Compared to the other Mi Band (5, 6, and 7) The Mi Band 4 is the cheapest, affordable, and sufficient for basic fitness tracking or monitoring exercises and daily activity.

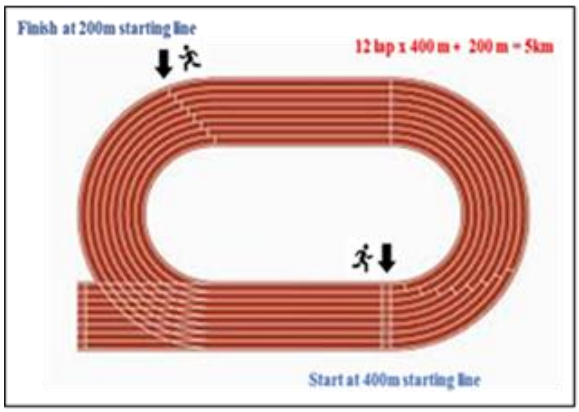

Fig. 3 Schematic representation of the 5 km run

Statistical Analysis

All results are reported as means ± standard deviations. Paired sample t-test was used to determine whether there were any differences in physiological and physical measures between trials. Test-retest reliability was assessed using the Intra-Class-Correlation Coefficient (ICC), the Cronbach Alpha (CA), suggested format outlined by Atkinson & Nevill (1998). The association between the variables was determined by Pearson's correlation analysis. Pearson's correlation (r) and ICC were also used to determine the relative reliability between trials set of scores. In the ICC, the "two-way random" method was used as suggested by Atkinson & Nevill, (1998). All statistical analyses were performed with SPSS software (version 21.0, SPSS Inc, Chicago, IL) with the level of significance set at $p \leq 0.05$.

RESULTS

Time

There were no differences between Trials in time taken to complete the 5 km run ($p = 0.033$) (refer Figure 4). The average mean ± SD in Trial 1 was 32.7 ± 4.1 min and for Trial 2 was 32.1 ± 4.4 min. High correlation were observed in time using Pearson correlation ($r = 0.964$, $n = 15$, $p < 0.05$) and ICC (ICC: 0.97) indicating the reliability and validity of the Mi Band in measuring time in short middle-distance running. The CA has calculated the value of 0.98 indicating a very high level of consistency between trials.

Distance

There was no significant between distance in Trial 1 (4.38 ± 0.49 km) and Trial 2 4.32 ± 0.46 km, $t (14) = 2.348$, $p = 0.034$ (refer Figure 5). There was a perfect positive between two variables, $r = 0.98$ and ICC = 0.99. The results showed there were significant similarity between trials, however it is also showed that the Mi Band smart watch underestimated about 13.9% of the 5 km run. Even the distance was underestimated by the Mi Band, the CA also indicated high internal consistency (0.99).

Heart Rate (HR)

There were a weak positive between trials in HR, $r = 0.243$ and in ICC = 0.210. The CA consistency was weak in the HR (0.41). The CA ranges from 0 to 1. Higher values indicate stronger relationships between the items on your scale. A Cronbach's alpha of .7 or higher is usually considered to be acceptable. In this case, weak consistency displayed in the HR measurement. However, no significant differences between heart rate in Trial 1 (163.2 ± 10.2 bpm) to Trial 2 (160.1 ± 13.3), $t (14) = 0.826$, $p = 0$ .423.

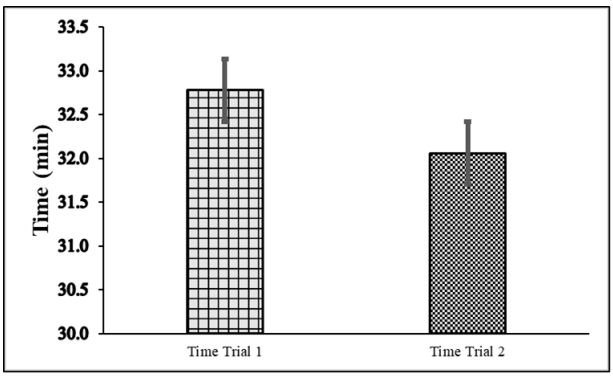

Fig. 4 Mean and SD for time taken to complete 5 km run. No significant differences between trials.

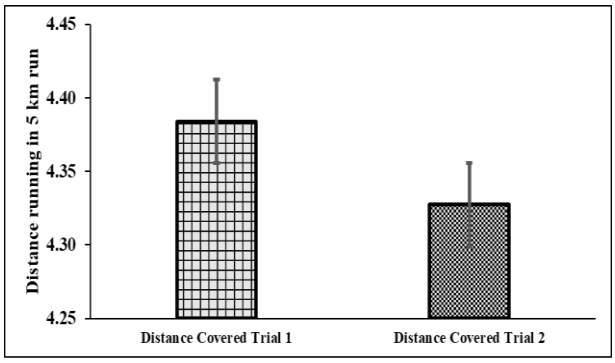

Fig. 5 Mean and SD distance recorded by Mi Band in 5km run. No significant differences between trials.

Calories Burned

There were no significant between calories burned in Trial 1 (396.2 ± 77.3 kcal) and Trial 2 (376.7 ± 60.4 kcal); t (14) = 1.213, p = 0.245. The result also indicated strong positive correlation between trials (r = 0.617, ICC = 0.72). These provide evidence the reliability and validity of this watch in measuring calories burned in short middle-distance running. Further assessment of reliability (CA) also showed consistent value for calories burned in 5 km running in both trials (0.84).

Pace

In both trials, participants run around pace 7.27 ± 0.36 and 7.25 ± 0.36. No significant differences were recorded (p = 0.810). There was a moderate positive relationship in pace (r = 0.527, ICC = 0.63) and still indicating the repeatability of the watch in measuring the pace of running. Same trend was observed in the CA where the consistency in the pace of running was 0.74 which considered as acceptable value.

DISCUSSION

Smart watches are becoming increasingly popular as wearable technology that can track fitness, monitor health, and perform other functions. There are several expensive smartwatches available in the market, including the Garmin and Apple Watch. These watches are designed to offer a range of advanced features beyond simply telling time (Henriksen et al., 2018). While these watches can be expensive, they offer a range of features that may be worth the investment for those who want a high-end, versatile smartwatch, users still have an option for low-cost device with minimal price but still offers versatility and same function as high end smart watch (Henriksen et al., 2018). Therefore, it is important to evaluate the reliability and validity of smart watches so that the information's can be shared for the users. Reliability can be assessed through test-retest reliability and validity refers to the accuracy of the measurements taken by a smart watch (Atan & Kassim, 2020). At this point, there has been limited research done in low-cost smart watches compared to expensive smart watches (Choi et al., 2016).

The primary aim of this study was to assess the reliability and validity of Mi Band (Type 4) smart watches in fitness tracking in middle distance running (5km). This current study investigated the distance running, calories burned, heart rate, pace and time taken to finish exercise. The reliability of this smart watch was established through the conduct of two main trials separated by 7 days. This allowed sufficient time for participants to rest between trials and this time frame was in line with other reliability studies that examined the repeatability of tools or equipment's (Atan & Kassim 2020). We found no differences distance running, calories burned, heart rate, pace and time taken to finish exercise between these two trials. Nevertheless, the major concern with this watch is it underestimated distance running about 13.9 % less in 5 km run. There could be several reasons why this Mi Band underestimates the distance. Firstly, may be related to the GPS signal issues (Atan and Kassim 2019; Atan, Foskett, and Ali 2014). This can be effected by the location of testing that surrounded by tall buildings, trees or other obstacles that can interfere with GPS signals (Atan et al., 2023; Barbero-álvarez et al., 2009). The second issue is the running which may also affect the distance in smartwatch. It was reported that if the runner takes short, choppy steps or run on a track with tight turns, smartwatch may underestimate the distance (Xie et al., 2018). Therefore, it is suggested to calibrate the smart watch at every testing or use or to update software that runs the smartwatch. In addition to that, please check if the watch received a strong GPS signal by testing it in an open area and try to run on flat and straight path to minimize the impact of running form on distance measurement.

Overall, the Mi Band smart watch showed moderate to excellent test-retest reliability for all variables that have been measured. Meanwhile, the currents study also indicates that the Mi Band smart watch can perform the functions (distance running, calories burned, heart rate, pace and time taken to finish exercise) accurately. Smartwatches that are designed to track fitness or health-related data, such as heart rate and distance running must be accurate in their measurements to be considered valid. Most smartwatches (Apple and Garmin) go through rigorous testing to ensure their sensors are accurate, but some may be more reliable than others. This current study provide evidence the accuracy on all the functions that have been measured. The Mi Band smartwatch offers an affordable and accessible option for individuals seeking to monitor their fitness levels and activity patterns. While some minor discrepancies were observed in certain metrics, the device's performance remained satisfactory for everyday use and general fitness tracking purposes. It can be concluded that, the Mi Band is sufficiently reliable and valid in fitness tracking. This study can therefore be used when evidence is required with regards to the accuracy of Mi Band smart watch. The Mi Band smart watch represents a cost-effective solution for individuals looking to monitor and improve their fitness levels, with its accurate tracking capabilities and user-friendly interface making it a valuable tool for achieving health and wellness goals.

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