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**Caloric Expenditure Using Indirect Calorimetry, Apple Watch Sport, and Fitbit Zip**

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##### ABSTRACT

**Ferrara CM, Smyth S, Mullan E, Burke C**. Caloric Expenditure Using Indirect Calorimetry, Apple Watch Sport, and Fitbit Zip. **JEPonline**2017;20 (3):39-44. The aim of this study was to compare caloric expenditure values during exercise using Apple Watch Sport, Fitbit Zip, and indirect calorimetry. The study included 7 healthy subjects (3 men and 4 women). The subjects completed six 6-min bouts of sitting, treadmill walking, and jogging (sitting, 4.0, 5.6, 6.8, and 8.9 km·hr-1, followed by 4.0 km·hr-1 cool-down) while wearing an Apple Watch Sport and a Fitbit Zip. Oxygen consumption (VO2) was measured using the Cosmed Quark CPET. The data were analyzed using ANOVA (P<0.05). The results are presented as means ± SD. Caloric expenditure values for the Fitbit Zip were significantly higher than values calculated from VO2 for all walking and jogging speeds (P<0.05). In contrast, caloric expenditure values for Apple Watch Sport were not significantly different than values calculated from VO2 (P>0.05). Total caloric expenditure values were also significantly higher for the Fitbit Zip (296.3 ± 33.0 kcals) compared to values calculated using VO2 (195.8 ± 30.4 kcals) and the Apple Watch Sport (201.1 ± 41.5 kcals) (P<0.05). The results of this study suggest that the Fitbit Zip may overestimate caloric expenditure compared to indirect calorimetry. In contrast, caloric expenditure values from the Apple Watch are not different from the indirect calorimetry values. This information may be important for exercise professionals to consider when recommending physical activity trackers to clients.

**Key Words:** Energy Expenditure, Physical Activity, Technology

**INTRODUCTION**

With more than 60% of U.S. adults overweight or obese (5) and less than 50% meeting the recommendations for physical activity (10), it is more important than ever to provide clients with immediate feedback on increasing daily physical activity and caloric expenditure. A number of mobile devices have been developed that are capable of tracking physical activity and estimating caloric expenditure. These devices provide an easy and convenient way for adults to monitor their daily physical activity and caloric expenditure, which may help to promote daily exercise and to combat obesity.

Recent studies have examined the accuracy of a few of these devices, comparing estimates of caloric expenditure to oxygen consumption and caloric expenditure measured via indirect calorimetry. Noah and co-workers (11) compared steps and caloric expenditure using the Fitbit Tracker and the Fitbit Ultra compared to indirect calorimetry measurements. Subjects completed 6-min bouts of treadmill walking, jogging, and stair stepping, with 1 min in between bouts of exercise. The results suggested that step counts and estimates of caloric expenditure using the Fitbit devices were reliable and valid during walking or jogging without an incline, but underestimated caloric expenditure when walking or jogging with an incline. Diaz et al. (3) noted similar results, comparing a Fitbit One and a Fitbit Flex to indirect calorimetry. Additional studies confirmed these results, suggesting that Fitbit devices may be accurate tools to monitor daily physical activity, particularly when walking on a flat surface (1,4,9,12,13). With prices ranging from $45 for the Fitbit Zip to $150 for the Fitbit Ultra, these portable devices may provide clients with an easy way to estimate activity and caloric expenditure.

In 2015, the Apple Watch was released and available for purchase for approximately $350. The Apple Watch has a number of applications that can be utilized to monitor physical activity and caloric expenditure. To our knowledge, no studies have examined how caloric expenditure values using the Apple Activity app compared to indirect calorimetry or other mobile devices. The aim of this study was to compare estimated caloric expenditure during treadmill walking and jogging using the Activity app on an Apple Watch Sport, the Fitbit Zip, and indirect calorimetry. This information will be helpful in determining how new technologies can be used to promote physical activity and monitor caloric expenditure in adults.

###### METHODS

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**Subjects**

Seven healthy individuals (3 males and 4 females) participated in the study. The subjects were at least 18 yrs of age (21 ± 1 yrs, mean ± SD) and had no medical issues that might affect their ability to exercise, including no orthopedic injuries. All subjects were physically active, completing at least 30 min of moderate intensity exercise 3 to 5 d·wk-1. The study was approved by the University Institutional Review Board.

**Procedures**

The subjects wore a Fitbit Zip clipped to the right side of the waist and an Apple Watch Sport that was worn on the right wrist. The test began with the subjects sitting quietly in a chair for 6 min. Then the subjects completed four 6-min walking and jogging exercise bouts on the treadmill. The speed of the treadmill started at a slow walk (4.0 km·hr-1) at 0% grade. Then, the speed was increased every 6 min (5.6 km·hr-1, 6.8 km·hr-1, and 8.9 km·hr-1, all at a 0% grade). At the completion of the 8.9 km·hr-1 bout, the subjects completed a cool-down at 4.0 km·hr-1 at 0% grade for 6 min.

Oxygen consumption was measured using a Cosmed CPET VO2 system. Oxygen consumption at each workload was used to calculate caloric expenditure (5 kcal·L-1 of oxygen consumed). The mean values for oxygen consumption and caloric expenditure for minutes 2 to 5 were calculated for each workload, discarding the first and last minutes.

**Statistical Analyses**

The data are presented as means ± SD. ANOVA was performed to compare caloric expenditure values for the Fitbit Zip, Apple Watch Sport, and indirect calorimetry. Statistical significance was set at P<0.05.

RESULTS

Caloric expenditure values using the Apple Watch Sport were statistically similar to indirect calorimetry at all of the walking and running speeds (P>0.05). In contrast, caloric expenditure values for the Fitbit Zip were significantly higher than indirect calorimetry values for all walking and jogging speeds (P<0.05, Table 1). Values for caloric expenditure using the Fitbit Zip were between 15.6 to 27.1 kcals higher than the indirect calorimetry values at the different workloads. Total caloric expenditure values were also significantly higher with the Fitbit Zip compared to indirect calorimetry.

**Table 1. Caloric Expenditure (kcals) at Each Stage using the Fitbit Zip, Apple Watch Sport, and Indirect Calorimetry.**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| **Speed of Treadmill** | **Fitbit Zip****Calories** (kcals) | **Apple Watch****Calories**(kcals) | **Indirect Calorimetry****Calories** (kcals) |
|  |  |  |  |
| **Rest** | 12.4 ± 5.7 |  9.0 ± 2.6 | 10.2 ± 1.2 |
| **4.0** km·hr-1 |  38.0 ± 7.2\* | 17.4 ± 4.7 | 22.4 ± 4.1 |
| **5.6** km·hr-1 |  56.7 ± 8.2\* | 32.8 ± 8.3 | 29.6 ± 5.1 |
| **6.8** km·hr-1 |  63.8 ± 12.5\* |  50.9 ± 11.8 |  46.3 ± 10.8 |
| **8.9** km·hr-1 |  78.6 ± 9.4\* |  71.0 ± 29.5 | 62.4 ± 9.8 |
| **4.0** km·hr-1(Cool-down) | 46.7 ± 6.8 |  31.0 ± 17.5 |  25.0 ± 3.25 |
| **Total Calories** |  296.3 ± 33.0\* | 201.1 ± 41.5 | 195.8 ± 30.4 |

\*Significantly different from Apple Watch and indirect calorimetry, P<0.05.

DISCUSSION

The purpose of this study was to compare estimates of caloric expenditure during exercise using an Apple Watch Sport, a Fitbit Zip, and indirect calorimetry. The results suggest that caloric expenditure values were significantly higher for the Fitbit Zip compared to the Apple Watch Sport and indirect calorimetry. This information may be important for exercise professionals to consider when recommending a physical activity tracker to their clients.

Previous studies have compared caloric expenditure values using different activity monitors compared to indirect calorimetry (1,3,4,9,11-13). To our knowledge, this is the first study to compare caloric expenditure values using the Apple Watch to indirect calorimetry measurements. The results of the present study suggest that during walking or running on a level surface, energy expenditure values using the Apple Watch are similar to values measured using indirect calorimetry. In contrast, the present study noted that energy expenditure values using the Fitbit Zip were significantly higher than the indirect calorimetry values. Although a number of previous studies have suggested that the Fitbit Zip is a valid way to measure physical activity, step counts and energy expenditure can be underestimated or overestimated compared to the criterion measure (4,6,8,12).

A number of factors can contribute to inaccuracies in measurements, including where the unit is worn on the body and the differences in the biomechanics of the movement in one person versus another person. Stackpool and co-workers (12) noted that errors in measurements of caloric expenditure are more likely to occur during “non-standard” walking, such as walking uphill or during agility-type drills. In the present study, the activity included walking and jogging on a level surface, thus not considered a “non-standard” activity that may have significantly affected energy expenditure. All subjects wore the Fitbit on the right side of their waist and the Apple watch on the right wrist, so the location of the devices should not have affected the results. It is possible that differences in how a person walks may have affected the results. For example, more hip movement or arm movement may increase energy expenditure values, while less hip or arm movement will lower the energy expenditure values compared to indirect calorimetry. The present investigators did not note large differences in the biomechanics of walking or running in the subjects, which suggests that this factor alone may not fully explain the differences in caloric expenditure between the three measurements. Additional studies are needed to address how position of the devices and differences in the biomechanics of movement may affect caloric expenditure measurements using new activity trackers. Future studies should also include a larger number of activities at different intensities. This information will help to confirm the accuracy of the caloric expenditure values measured using new mobile physical activity trackers.

**Limitations of this Study**

Only 7 subjects completed the study protocol. Although this is a small number of subjects, the results for the subjects suggest higher caloric expenditure values using a Fitbit Zip compared to indirect calorimetry. Another limitation is that only four different speeds were utilized in the treadmill protocol and the percent grade was 0% for all workloads. Additional intensities of exercise, utilizing different speeds, increased grade, as well as different activities should also be examined to see if the intensity of exercise affects the ability of mobile physical activity trackers to accurately estimate caloric expenditure.

### **CONCLUSIONS**

The present study examined the caloric expenditure values estimated by the Apple Watch Sport and the Fitbit Zip compared to indirect calorimetry during level walking and running. The results suggest that while caloric expenditure using the Apple Watch is comparable to indirect calorimetry, values for the Fitbit Zip are significantly higher than indirect calorimetry values. Additional research is needed to compare caloric expenditure of other activities and intensities of exercise. These findings should be important for clinicians and exercise physiology professionals to consider when recommending a mobile physical activity monitor to clients.

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