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Coupling GPS with Accelerometer to Measure Physical Activity

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Abstract

Measuring and assessing physical activity is essential to determine the quality of certain activity toward human health. This study is to test the combination of Global Positioning System (GPS) with heart rate monitor and accelerometer in determining levels of moderate to vigorous physical activity among university students during their own capability in limited time. 10 male university students (age: 20.7years± 0.82SD) participate in this pilot study. Two different jogging courses used in this physical activity study. Participants were asked to wear GPS watch with chest-strapped heart rate monitor and accelerometer before starting their activity. They were then were asked to exercise (stretching, slow jogging, brisk walking and running) freely according to their own capability in 90 minutes. Data gathered from the devices are process and analyze in specific software. A minimum of 153 kCal used in this 90 minutes activity and maximum used energy is 263.64 kCal. The respondent's movement during exercise from GPS were able to be map and viewed graphically for better analysis. Results suggested, these two devices can be combined to objectively assess physical activity.

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Keywords: Physical activity; assessment; accelerometer; GPS; Accelerometer

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1. Introduction

Outdoor physical activity can have important benefits for health and well being in older adult populations and in children. There is increasing recognition of the importance of sedentary behaviour, most of which occurs indoors. Thus, to improve health outcomes it is critical to accurately measure physical activity and sedentary time spent in- and outdoors. GPS devices linked with physical activity monitoring devices such as accelerometers (AC) and heart rate monitors (HRM) enables measurement of where and when individuals are active as well as their energy expenditure. GPS devices can be used to detect activity, but because of technical limitations to date, distinguishing between indoor and outdoor activity has been difficult. Some GPS devices now provide information about the number of satellites in view and the strength of the signal received. By calculating the signal strength ratio of satellites in view and satellites that are communicating accurately with the GPS device, it is possible to better estimate time spent indoors and outdoors.

Obesity epidemic and declination in public health has become essential issues nowadays. It is important to understand the factors that contribute to this problem. According to CDC (2007), at least 60% of the world's population is not sufficiently active for the benefit of themselves. One of key factors that contribute to this issue is that walking has declined in recent decades due to an increase in car use and layout of urban environments which are dominated by cars and so do not appeal to pedestrians (Cavill et al., 2007). Thus, physical activity is important in order for a person to maintain their health. A physical activity can be defined as one which involves the movements of the whole body that results in the contraction of skeletal muscles and increases in energy levels (Bouchard et al., 1990). Having valid and reliable measures of physical activity among young people is critical. Traditionally, researcher tends to use survey instrument to assess physical activity among respondent. The challenges in assessing physical activity using survey instrument has led to an increase in popularity of objective measures such as pedometers and accelerometers (Salmon and Okely, 2009). Thus, there is a strong need to use better tools or equipment rather than survey instrument to assess physical activity. Global positioning system (GPS) has now being widely used to assess physical (Maddison and Ni Mhurchu, 2009). GPS technology has the capability of improving our understanding of physical activity by proving the location information. Accurate longitudinal data on physical activity would be particularly helpful in understanding how this factor may impact on health and functional status over human lifespan. Several recent study already being done by researchers to assess physical activity using GPS technology. Schutz and Chambaz (1997) suggested that GPS can be used to assess human locomotion. Global positioning system (GPS) technology provides a tool to better understand individual exposure to social and physical environments (Cummins et al., 2007; Kamel et al., (2001); Krieger (2003)). (Fjørtoft, Kristoffersen et al. 2009) had done a research in schoolyards to assess children's movement pattern and physical activity. They found out that GPS combined with heart rate monitor were capable to objectively captured children's spatial movement together with level of physical activity with specific area. There are also research done in sport domain especially outdoor and field based sport (Edgecomb and Norton, (2006); Pino et al., (2007)).

2. Methodology

10 male respondents selected for this study (age=20.7years ± 0.82SD, BMI=21.6 ± 3.0SD). The respondents were asked to perform body composition analysis before start the physical test. Two running track used in this study which located within the university area that normally used by students and public. The first running track is located in mildly dense tree cover area with length of 2.5 km. The other called 10th College jogging track compromised of two tracks which length 420 m and 1200 m each. The test was first done at the 10th College jogging track at 0940 hour and then followed by the second running track. Before the test started, respondents BMI's were measured using Segmental Body Composition Analysis Tanita (http://www.tanita.com/en/bc-418/,

2012). The respondents required to wear a Garmin Forerunner 305 wrist watch with heart rate monitor stripe into their chest. Figure 1 shows the GPS device used in this study.

Fig. 1. Garmin GPS watch with heart rate monitor

To determine the burned calories for the physical activity, Actigraph activity monitor device was attach to the respondents waist. Figure 2 shows the accelerometer used in this study. Respondents were asked to perform physical activity (running and jogging) at their own capability in one and half hours (0940 to 1110). Since the study used two different devices to assess the physical activity level, both devices was set to record data in one minute interval or 60 second epoch.

Fig. 2. Digital ActiGraph accelerometer device

Two main data will came out as the output from the device used to determine the level of physical activity which are heart rate and activity information come from the GPS watch and energy expenditure that produce by the actigraph device. Garmin Training Centre software was used to view and analyze the data from the Garmin watch while Actilife v5.9.2 was used to analyze the data gathered from the activity monitor device.

Fig. 3. The accelerometer and GPS watch was attached to the respondent's limb

Garmin Training Centre (TM) version 3.2.0 software was used to download the physical activity data gathered from the GPS watch. Several information was produced by the software such as pace, speed, elevation, heart rate and also distance and time. Besides that, the location of the activity courses was also able to be viewed graphically in the software. Figure 4 shows an example of a respondent activity being mapped using the device along with some information regarding the heart rate condition during his physical exercise.

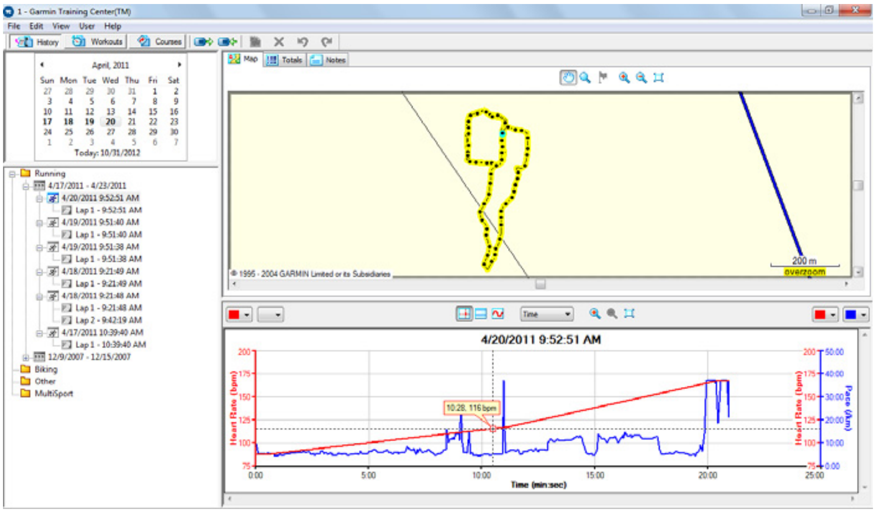

Fig. 4. Graphic view of data gathered from the GPS watch and heart rate monitor

To further analyze the data, a web-based tool, GPS Visualiser (http://www.gpsvisualizer.com, 2012) was used to distinguish the physical activity captured by the GPS watch into per minute basis. A table in form of text data was generated as the result of the conversion process. Data from the Actigraph accelerometer can be downloaded using ActiLife software version 5.0. The main output produced by the software is estimated energy expenditure.

In this study the estimation of energy expenditure used the Freedson Combination (Work Energy and Freedson) (Freedson PS, Melanson E, Sirard J., 1998).

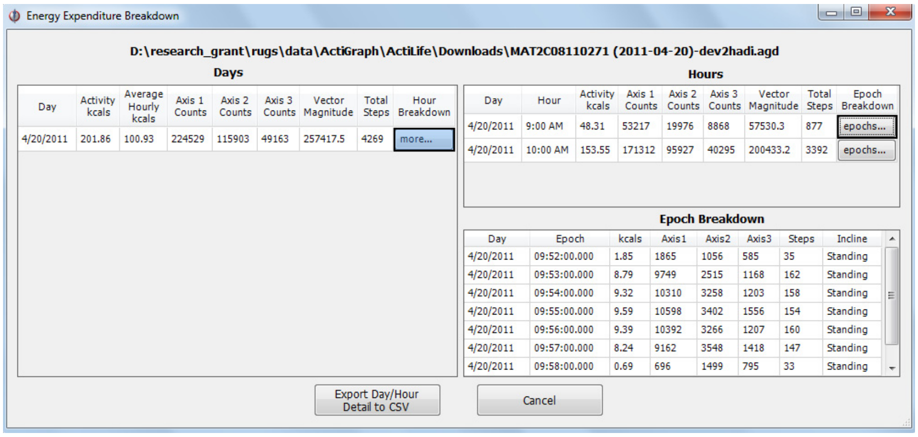

Fig. 5. Example of energy expenditure estimation for one of the subjects

To synchronized data between GPS watch and accelerometer were both *timestamped* the data events as they were recorded making it possible to synchronize based on time stamping method was used. Since both devices were set to record data at 60 second interval, it eases the merging procedure. Physical activity data both devices was started at 9:52 am, therefore the data analysis will start at that time and recorded data before that was ignored. The same process was repeated to all 10 respondents.

3. Results and Discussion

Physical activity monitor devices were able to determine the energy expenditure for respondent's activity in the running park. During the 90 minutes exercise, the lowest result of used calories recorded to be at 153 kcals while the highest is 292.9 kcals. Table 1 shows the energy expenditure results among those 10 respondents.

Table 1. Energy expenditure during the 90 minutes free-exercise

ID	BMI	Activity kCals
1	21.7	236.13
2	19.0	153
3	26.2	263.64
4	21.7	249.26
5	18.2	159.76
6	21.3	137.13
7	19.1	143.43

8	23.8	248.7
9	18.7	216.94
10	26.4	292.9
SD		56.80

Besides that, the devices was also be able to determine the level of intensity of the physical activity performed by the respondents such as sedentary, light, lifestyle, vigorous and very vigorous. Table 2 shows the level of physical activity achieves based on percentage.

Table 2. Level of physical activity achieves based on percentage

	Physical Activity in Percentage (%)					
ID	Sedentary	Light	Lifestyle	Moderate	Vigorous	Very Vigorous
1	42.02	22.69	14.29	6.72	1.68	12.61
2	37.08	30.34	16.85	4.49	2.25	8.99
3	47.93	18.18	11.57	7.44	14.05	0.83
4	24.72	30.34	16.85	10.11	17.98	0
5	43.7	21.85	15.97	5.04	13.45	0
6	17.98	33.71	17.98	10.11	19.1	1.12
7	45.38	15.13	16.81	11.76	10.92	0
8	12.36	34.83	16.85	19.1	5.62	11.24
9	42.86	20.17	15.13	8.4	13.45	0
10	20.22	35.96	16.85	10.11	5.62	11.24
Mean	33.43	26.32	15.92	9.33	10.41	4.6

Referring to Table 2, the mean most of the activity is within the sedentary to lifestyle class which is 33.43, 26.32 and 15.92 percent respectively which is defined as not enough to achieve an effective exercise (CDC, 2007). However, this situation was expected as the respondents were not forced to perform to their peak condition but to exercise freely on their own capability. Apart from that, only 24.34% of the activity categorized in the class of moderate to very vigorous physical activity. These classes were recommended by CDC in order to achieve the benefit of exercising (CDC, 2007).

Results from the GPS watch with heart rate monitor were as shown in figure 4. The capability of capturing the location of the physical activity (longitude and latitude) enable the user to define their place of activity took part. Further than that, additional information such as heart rate also being produced. Table 3 shows the average and maximum heart rate achieved by the respondents during the 90 minutes free-exercise.

Table 3. Mean results for the GPS watch and heart rate monitor

	Mean			
ID	Average Speed (km/h)	Maximum Speed (km/h)	Average Heart Rate (bpm)	Maximum Heart Rate (bpm)
1	9.7	14.8	141.67	173.33

4. Conclusion

Results from this study suggested that both devices can be incorporated to objectively determine the physical activity. By synchronizing data from both devices using *timestamped* method, researchers can further analyze the data and achieve new knowledge especially regarding Active Living Research (ALR). Further research regarding on how to ease the incorporation of the data from both devices such as using Artificial Neural Network is highly recommended. However, if both devices can be modified as one device, it will ease the research activity especially during the data collection and analysis.

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