THE PREDICTION OF PHYSICAL ACTIVITY USING TREADMILL VIBRATION

Tsung-Ying Hung, Chiu-Sheng Lin, Chiang Liu*, Chen-Kai Su, and Tzyy-Yuang Shiang
Taipei Physical Education College, Taipei, Taiwan
***National College of Physical Education and Sports, Taoyuan, Taiwan**

A lot of treadmills detect physical activity by running speed which is only horizontal information, but vertical information is also important, such as impact and ground reaction force. This study tried to find out the relationship among the treadmill impact vibration, ground reaction force and human body impact vibration information on runner. Three college males were recruited to walk and run on treadmill at different speeds. Accelerometer on treadmill, accelerometer on human body and four load-cells were used to measure physical activity. The results showed that treadmill vibration was significantly correlated with body impact and ground reaction force. In the same speed, treadmill vibration at running was greater than walking. In order to predict whole physical activity more accurately, three-dimensional information should be used instead of speed only.

KEY WORDS: physical activity, treadmill, vibration, accelerometer.

INTRODUCTION: A commonly accepted fact is that running became the most popular activity through the world. Many people like to run on the treadmill, because it is very convenient and easy to detect the physical activity. A lot of treadmills detect physical activity by running speed which can only measure physical activity in horizontal direction. Vertical direction information is also important, such as impact and ground reaction force. The reason was when people movement could produce three dimensions force. Therefore, except horizontal direction information, the vertical direction information was also important to predict physical activity. Other researchers have already detected human body physical activity by tri-axial accelerometer. Janz (1994) investigated children's physical activity by wearing a CSA accelerometer and heart rate telemetry monitored for 12 h/day for 3 consecutive days. They found that high validity correlations between accelerometry and heart rate telemetry support its validity as an objective method for monitoring physical activity. Therefore, this study tried to compare human body impact vibration with the treadmill impact vibration and ground reaction force.

METHOD: This study recruited three college males as the subjects (age 20.6±1.3 years, height 178.3±2.1cm, and weight 75.8±2.5kg). The experimental design asked the subjects to walk and run on a treadmill at 0.95m/s (walk), 1.86m/s (walk and run), 2.74m/s (run), 3.64m/s (run) and 4.53m/s (run) speeds. During the data collection sessions, a tri-axial accelerometer was attached at 5th lumbar to collect human body impact vibration. A single-axial accelerometer was attached on the surface of treadmill to measure treadmill impact vibration. Four load-cells under treadmill were used to measure ground reaction force. A BioPac MP150 data acquisition system was used to collect the data and the sampling rate was set at 1000 Hz, the sampling time was set at 10 second at each speed (Fig 1).
Analysis Methods: The 10 seconds integral of accelerometer on human body, accelerometer on treadmill and load-cells were calculated to represent the values of physical activity, treadmill vibration and impulse of ground reaction force. These values for the six speed conditions were compared statistically by applying the Pearson's product-moment correlation. The 0.05 level of probability was used to detect statistical correlation.

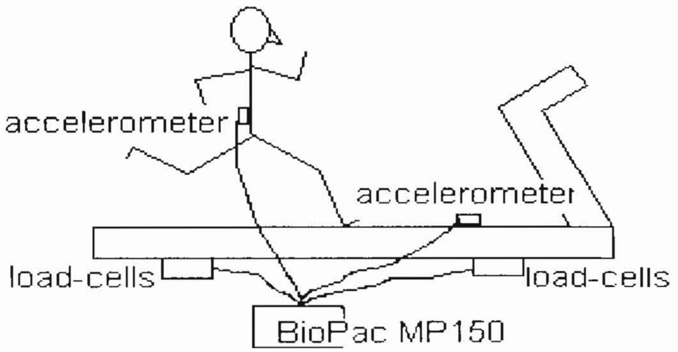

Figure 1: The setup of treadmill accelerometer, body accelerometer, load-cells and BioPac MP150.

RESULTS: The physical activity (PA), treadmill vibration (TV) and integral of ground reaction force (IGRF) created by different speeds of each subject are shown in table 1. Both walking and running conditions had the same trend that all these variables increased with increasing speed (Fig. 2). Besides the speed, different lower extremity movement will affect the physical activity. When treadmill speed is equal to 1.86m/s, the results of physical activity, treadmill vibration and integral of ground reaction force in running were larger than walking condition.
There are significant correlations among physical activity, treadmill vibration and integral of ground reaction force as shown in table 2.

Table 1 Physical activity (PA), treadmill vibration (TV), and integral of ground reaction force (IGRF) in different velocity.

		speed(m/s)					
	subjects	0.95(walk)	1.86(walk)	1.86(run)	2.74(run)	3.64(run)	4.53(run)
	1	1.13	1.21	1.27	1.36	1.42	1.50
PA	2	1.18	1.23	1.32	1.41	1.44	1.55
(nt·sec)	3	1.16	1.21	1.34	1.52	1.64	1.78
	Mean	1.16	1.22	1.31	1.43	1.50	1.61
	±sd	±0.02	±0.01	±0.03	±0.08	±0.12	±0.15
	1	0.265	0.285	0.297	0.315	0.338	0.385
TV	2	0.335	0.344	0.350	0.356	0.385	0.427
(nt*sec)	3	0.272	0.288	0.294	0.312	0.351	0.435
	Mean	0.291	0.306	0.314	0.328	0.358	0.416
	±sd	±0.039	±0.033	±0.031	±0.024	±0.024	±0.027
	1	471.2	1730.9	4060.8	5660.4	6550.7	7141.5
IGRF	2	532.9	1748.9	4692.1	5728.7	6600.2	7226.2
(nt*sec)	3	1041.9	2302.2	5667.3	7134.1	8220.9	8947.9
	Mean	682.0	1927.3	4806.7	6174.4	7123.9	7771.9
	±sd	±313.2	±324.8	±809.3	±831.8	±950.3	±1019.3

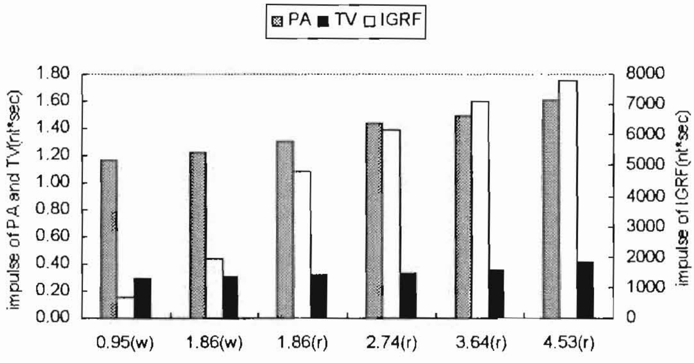

Figure 2: Physical activity (PA), treadmill vibration (TV) and integral of ground reaction force (IGRF) in different treadmill velocity.

Table 2 The correlation coefficients of velocity, PA, TV and IGRF in running condition.

	speed	PA	TV	IGRF
velocity	---	0.996**	0.960*	0.986*
PA		---	0.953*	0.987*
TV			---	0.903
IGRF				---

**P<0.01 *P<0.05

DISCUSSION: There are significant correlation between the integral of human body impact vibration and treadmill impact vibration. This information indicated that vertical acceleration detected by treadmill could be used to predict 3-dimensional physical activity detected by accelerometer on human body. Because product large impact force must had more physical work. So, when people made largest impact force, indicate that physical activity more large. In running condition, treadmill speed has significant correlation (0.996, 0.960) with human body impact vibration and treadmill impact vibration (tab 2). Physical activity could be detected by one of above variables. But treadmill speed is only a variable described the horizontal physical activity which cannot detect the vertical physical activity. As shown in table 1, walking and running in the same speed (1.86m/s) had different human body impact vibration and treadmill impact vibration as well as ground reaction force. Because the impact was different in running and walking condition, even the speed was the same. When the conditions of horizontal were the same. The only one reason to effect physical activity was vertical parameter. So, the impulse of vertical direction had relative with physical activity. This shows the parameter of horizontal and vertical directions were the same important. Whole body physical activity should be detected not only by treadmill speed, but also by vertical sensor. Therefore, we could combine treadmill speed and treadmill impact vibration information to describe more accurate physical activity.

CONCLUSION: Treadmill speed is only one of the variables to predict human body physical activity in treadmill running. According to the high correlations among treadmill speed, the integral of human body impact vibration, the integral of treadmill impact vibration and the integral of ground reaction force. In addition to the treadmill speed, any one of above variables could be used to detect the human body physical activity. Consequently, more accurate whole body physical activity should be detected by three-dimensional information instead of single dimensional information such as treadmill speed. In the future, we can set a vibration receiver (ex. accelerometer) in treadmill. Finally, combine the parameter of time, velocity and impact to predict whole body physical activity accurately.

REFERENCES:

Clarke, T. E., Cooper, L. B., Hamill, C. L., and Clark, D. E.. (1985). The effect of varied rate upon shank deceleration in running. Journal of Sports Sciences. 3, 41-49.

Janz, K. F., Witt, J., and Mahoney, L. T. (1995). The stability of children's physical activity as measured by accelerometry and self-report. Med. Sci. Sports Exerc., Vol. 27, No. 9, pp. 1326-1332.

Janz, K. F. (1994). Validation of the CSA accelerometer for assessing children's physical activity. Med. Sci. Sports Exerc., Vol. 26, No. 3, pp. 369-375.

Washburn, R. A., Cook, T. C., Laporte, R. E.. (1989). The objective assessment of physical activity in an occupationally active group. The Journal of Sorts Medicine and Physical Fitness. Vol. 29, No. 3, pp. 279-284.