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Accelerometer-Determined Physical Activity Level among Government Employees in Penang, Malaysia

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ABSTRACT

Introduction: A cross-sectional study was carried out to investigate accelerometer-determined physical activity level of 233 Malay government employees (104 men, 129 women) working in the Federal Government Building Penang, Malaysia. **Methods:** Body weight, height, waist and hip circumference, body fat percentage and blood pressure were measured for each respondent. All the respondents were asked to wear an accelerometer for 3 days. Body mass index (BMI) and waist-hip ratio (WHR) were calculated using a standard formulas. Fasting blood sample was obtained to determine the lipid profile and glucose levels of the respondents. **Results:** Based on the accelerometer-determined physical activity level, almost 65% of the respondents were categorised as sedentary. Approximately 50.2% of the respondents were overweight or obese. There were negative but significant relationships between body mass index (BMI) (r=-0.353, $p<0.05$), body fat percentage (r=-0.394, $p<0.05$), waist circumference (WC) (r=-0.198, $p<0.05$) and physical activity level. Sedentary individuals had a higher risk than moderate to active individuals of having a BMI more than or equal to 25 kg / m^2 (OR= 2.80, 95% CI 1.55-5.05), an-risk classified WC (OR= 1.79, 95% CI 1.01-3.20), and a body fat percentage classified as unhealthy (OR= 3.01, 95% CI 1.41-6.44). **Conclusion:** The results of this study suggest that accelerometer-determined physical activity level is a significant factor associated with obesity in this study. The high prevalence of physical inactivity and obesity found among respondents of this study indicate a need for implementing intervention programmes among this population.

Keywords: Accelerometer, Malaysian adults, obesity, physical activity level

INTRODUCTION

Physical activity may be assessed using various methods, including indirect calorimetry, behavioural observation, physiological markers, motion sensors, and the self-report technique (Plasqui & Westerterp, 2007). Accelerometers, often used to measure physical activity, are instruments that quantify the acceleration of the body and have been used in several studies to validate self-report instruments that measure

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physical activity (Craig *et al*., 2003; Cust *et al*., 2008).

Self-report assessments to measure physical activity possess several limitations of reliability and validity when compared with using laboratory measurements of physical activity (Shephard, 2003). These limitations include recall bias, inaccurate estimation of energy expenditure of physical activity, inaccurate estimation of rates of inactivity, response bias and the inability to delineate the absolute levels of physical activity (Prince *et al*., 2008). Lechner, Bolman & Dijke (2006) reported that "overestimators tend to rate their physical activity incorrectly and think that their physical activity is adequate more often in comparison to others."

Slootmaker *et al*. (2009) found that **a**mong adults, the reported time spent on moderate and vigorous physical activity using a physical activity questionnaire exceeded the time measured with the accelerometer, but there was a moderate agreement between self-reported time and objectively measured time spent on moderate physical activity. McMurray *et al*. (2008) concluded that overweight adolescent girls tend to over-report their activity levels, as demonstrated by the calculated ratio of the accelerometer counts and the previous day *physical activity* recall among respondents.

Studies using an accelerometer to assess physical activity status have been carried out in many developed countries (Slootmaker *et al*., 2009; Tudor Locke *et al*., 2010), but data using this technique among the Malaysian population is limited. The majority of the studies that have assessed physical activity in Malaysia used the self-report technique. These studies include the National Health and Morbidity Survey III (Institute of Public Health, 2008), the Malaysian Adult Nutrition Survey (Poh *et al*., 2010), and the My-NCD Malaysia Surveillance 2005/2006 (Disease Control Division, 2006).

Understanding the association between physical activity and health outcomes among free-living respondents requires an objective and reliable method of assessing physical activity levels that is suitable for collecting measurements over a sufficiently representative period of time, yet that is also of minimal discomfort to the respondents (Westerterp, 2009). Therefore, the objective of this study was to determine physical activity level, using the accelerometer as the measurement tool, among government employees in the Federal Government Building in Penang, Malaysia.

METHODS

Ethical approval for this study was obtained from the Medical Research Ethics Committee of the Faculty of Medicine and Health Sciences at Universiti Putra Malaysia prior to data collection. Permission to conduct this study was requested from all 20 departments in the Federal Government Building. Seventeen departments granted permission for their employees to participate in this study. All the employees from these 17 departments were invited to participate in this study. The exclusion criteria included respondents with physical disabilities and pregnant women. Out of the 330 eligible employees, 233 agreed to participate and signed the informed consent form. Data were collected from May to July of 2009.

Weight, height, waist and hip circumferences and body fat percentage were measured for all respondents with minimal clothing. A TANITA Body Composition Analyser (TBF-306; Japan) was used to measure body weights (in kilograms) and body fat percentages of the respondents. Classification of body fat percentage was based on the guidelines of Lee and Nieman (2003); unhealthy body fat percentage was defined as $\geq$25% for man and $\geq$32% for women. A SECA Body Meter (Vogel & Halke GmbH & Co., Germany) was used to measure the heights of the respondents to the nearest 0.1 cm while standing erect and without shoes. An unstretchable measuring tape was used to measure waist and hip circumferences. Waist circumference was measured at the midpoint between the lowest rib and the iliac crest, whereas hip circumference was measured at the level of maximal gluteal protrusion.

Body mass index (BMI) was calculated and classified based on the World Health Organisation (1995) guidelines. Data on socio-demographic characteristics were obtained using a pretested questionnaire.

Blood pressure of each respondent was measured in a sitting position and after having rested five minutes by a digital monitor (Omron Digital blood pressure monitor, HEM-780, Japan) and classified as high blood pressure if systolic ≥140mmHg and/or diastolic ≥90mmHg (National Heart, Lung and Blood Institute, 2001). Physical activity level was determined using an accelerometer (Kenz, Suzuken Japan). Each subject was given a demonstration on how to wear the accelerometer. The accelerometer was placed horizontally on the waist and clipped to the subject's belt, skirt or trousers at the right and in line with the knee. All respondents were given the accelerometer for seven days. For two workdays and one weekend day during the time frame, respondents were instructed not to alter their usual physical activities, to wear the accelerometer during all waking hours and not to remove the device except for bathing and sleep. Subjects reported the days and dates of wearing the accelerometer when they returned the devices to the researcher. Respondents' physical activity levels were calculated based on the ratio of total energy expenditure (from the accelerometer) to basal metabolic rate and classified based on FAO/WHO/UNU (2004). Out of 233 respondents, only 210 (92 men and 118 women) complied with wearing the accelerometer for three days.

Blood samples were collected from only 138 respondents, who had agreed to provide twelve-hour overnight fasting venous blood samples. Lipid profiles were determined, including total cholesterol (TC), triglyceride (TG), high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL) and blood glucose levels. The classification of lipid profiles was based on the Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults (2001) and blood glucose level by the American Diabetes Association (2004).

Data analysis

Data were analysed using the Statistical Package for Social Sciences (SPSS) Version 17.0. Socio-demographic data, glucose level, lipid profiles and accelerometer data are reported as frequencies, means, standard deviations and percentages. A Pearson correlation and odds ratio were performed to determine the relationship between the variables studied. A T-test was used to determined mean differences between groups. The significance level was set at $p<0.05$.

RESULTS

The subjects consisted of 44.6% men and 55.4% women (Table 1). Their mean age was 32.45±10.46 years, with the majority (53.2%) being between 18 and 29 years of age. Approximately 47% of respondents had attained formal education up to the high school level, while 35.6% were university graduates. The mean household income was RM1790.19±910.27, and the majority (68.2%) had a total household income of ≤RM 1999.

Based on the BMI classification, 30% of the respondents were overweight and 20.6% obese. The proportion of respondents classified as having an acceptable waist-hip ratio was higher among the men than women (94.2% vs. 78.3%). The majority of the respondents (72.9% women vs. 66.3% men) was categorised as having excessively high or unhealthy fat percentage levels. Based on blood pressure classification, 15.0% of the respondents had elevated systolic blood pressure (≥140 mmHg), and 10.3% had elevated diastolic blood pressure (≥90 mmHg). Total daily energy expenditure

Table 1. Descriptive statistics of socio-demographic, anthropometric characteristics and blood pressure of respondents

Characteristics	*Men (n=104)* *n (%)*	*Women (n=129)* *n (%)*	*Total (n=233)* *n (%)*
Age (years)			
18-29	48 (46.2)	76 (58.9)	124 (53.2)
30-39	24 (23.0)	31 (24.0)	55 (23.6)
40-49	16 (15.4)	10 (7.8)	26 (11.2)
50-59	16 (15.4)	12 (9.3)	28 (12.0)
Marital status			
Single	34 (32.7)	41 (31.8)	75 (32.2)
Married / divorced / widowed	70 (67.3)	88 (68.2)	158 (67.8)
Education level			
Primary and secondary school	22 (21.2)	18 (14.0)	40 (17.1)
High school / equivalent certificate	56 (53.8)	54 (41.9)	110 (47.3)
University / equivalent certificate	26 (25.0)	57 (44.1)	83 (35.6)
Total household income			
≤RM 1999	70 (67.3)	89 (69.0)	159 (68.2)
RM 2000-RM 2999	25 (24.0)	26 (20.2)	51 (21.9)
≥RM 3000	9 (8.7)	14 (10.8)	23 (9.9)
BMI (kg / m²)			
Underweight (<18.5)	5 (4.8)	6 (4.7)	11 (4.7)
Normal (18.5-24.9)	46 (44.2)	59 (45.7)	105 (45.1)
Overweight (25-29.9)	31 (29.8)	38 (29.5)	69 (29.6)
Obese (≥30)	22 (21.2)	26 (20.1)	48(20.6)
Waist circumference (cm)			
Acceptable (♂<90 cm, ♀<80 cm)	53 (51.0)	70 (54.3)	123 (52.8)
At risk (♂≥90 cm, ♀≥80 cm)	51 (49.0)	59 (45.7)	110 (47.2)
Waist-hip ratio			
<1.0 for men / <0.85 for women (acceptable)	98 (94.2)	101 (78.3)	199 (86.9)
≥1.0 for men / ≥0.85 for women (at risk)	6 (5.8)	28 (21.7)	34(13.1)
Fat percentage (%)			
Unhealthy ♂≤5%, ♀ ≤8%)	-	-	-
Acceptable range (lower end) (♂=6-15%, ♀ =9-23%)	7 (6.7)	8 (6.2)	15 (6.4)
Acceptable range (upper end) (♂=16-24%, ♀ =24-31%)	28 (26.9)	27 (20.9)	55 (23.6)
Unhealthy (too high) (♂≥25%, ♀ ≥32%)	69 (66.4)	94 (72.9)	163 (70.0)
Blood Pressure			
Systolic BP (mmHg)			
<140	84 (80.8)	114 (88.4)	198 (85.0)
≥140	20 (19.2)	15 (11.6)	35 (15.0)
Diastolic BP (mmHg)			
<90	90 (86.5)	119 (92.2)	209 (89.7)
≥90	14 (13.5)	10 (7.8)	24 (10.3)

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Table 1. Continued

	Mean±SD	*Mean±SD*	*Mean±SD*	**p value*
Age (years)	34.61±12.33	31.30±9.30	32.45±10.46	0.01
Total household income (RM)	1791 .47± 971.29	1789.15± 861.78	1790.19± 910.27	NS
BMI (kg/m^2)	26.10±5.05	25.85±5.64	25.96±5.38	NS
Waist Circumference (cm)	89.67 ± 12.33	79.85 ± 13.16	84.24 ±13.68	0.00
Waist-hip ratio	0.90±0.07	0.80±0.06	0.84±0.89	0.00
Fat percentage (%)	27.68±7.71	37.30±8.74	33.00±9.57	0.00
Systolic BP (mmHg)	127.90±15.00	118.52±14.58	122.71± 15.46	0.00
Diastolic BP (mmHg)	78.11±9.82	75.33±10.12	76.57± 10.01	0.03
Total Daily Energy Expenditure (kcal)	2113±252	1729±235	1897±309	0.00

**t*-test

as measured by the accelerometer was higher among men compared to women ($p<0.05$).

Table 2 shows the distribution and descriptions of the lipid profiles of the respondents. For total cholesterol (TC), almost 90% of the respondents were in the desirable range, with a higher proportion of men having desirable TC levels than women (95.4% vs. 84.9%). The majority (97%) of the respondents had optimal triglyceride (TG) level. Approximately half of the respondents (49.3%) were classified as having an optimal LDL level, and all of the respondents had a low HDL level.

Almost 65% of the respondents had sedentary physical activity and the percentage of women who were categorised as sedentary was higher than the percentage of men (70.3% vs. 57.6%) (Figure 1). Less than 2.5% of the respondents were vigorously active. The relationships between physical activity levels and anthropometric characteristics, blood pressure, and lipid profiles are presented in Table 3. There were significant but weak relationships between physical activity level and BMI ($r=-0.353$, $p<0.05$), percentage of body fat ($r=-0.394$, $p<0.05$), waist circumference ($r=-0.198$, $p<0.05$), and systolic blood pressure ($r=0.149$, $p<0.05$). These findings indicate that a higher level of physical activity is significantly associated with a lower BMI, waist circumference and body fat percentage. Among the men, physical activity level was associated negatively with body fat percentage ($r=-0.237$, $p<0.05$) and positively with glucose level ($r=0.306$, $p<0.05$). Among the women, physical activity level was significantly associated with BMI (-0.486, $p<0.05$) body fat percentage (-0.416, $p<0.05$) waist-hip ratio (-0.417, $p<0.05$) and HDL level (0.255, $p<0.05$). The calculated odds ratio showed that there were significant associations between physical activity levels and BMI, waist circumference, and body fat percentage. The risk of having a BMI equal to or more than 25 kg/m^2, an at-risk classified waist circumference, and body fat percentage classified as unhealthy is higher among sedentary than moderate to active individuals.

DISCUSSION

In the Malaysian Adult Nutrition Survey (MANS) conducted in 2003, the percentage of respondents who were categorised as physically inactive was 39.7% (Poh *et al.*, 2010). The percentage of adults who were categorised as sedentary in the 2006 Third

Table 2. Distribution of lipid profiles and glucose levels of respondents

	Men (n=65) *n (%)*	*Women (n=73)* *n (%)*	*Total (n=138)* *n (%)*
Total cholesterol (mmol/L)			
Desirable (<5.1)	62 (95.4)	62 (84.9)	124 (89.9)
Borderline high (5.1-6.1)	2 (3.1)	8 (11.0)	10 (7.2)
High (>6.1)	1 (1.5)	3 (4.1)	4 (2.9)
Triglyceride (mmol/L)			
Optimal(<1.69)	61 (93.8)	73 (100)	134 (97.1)
Borderline high (1.69-2.25)	4 (6.2)	0 (0)	4 (2.9)
HDL (mmol/L)			
Low (<1.01)	65 (100)	73 (100)	138 (100)
Borderline & desirable (≥1.01)	0 (0.0)	0 (0.0)	0 (0.0)
LDL (mmol/L)			
Optimal (<2.56)	32 (49.2)	36 (49.3)	68 (49.3)
Near optimal (2.56-3.30)	28 (43.1)	18 (24.7)	46 (33.3)
Borderline high (3.31-4.00)	2 (3.1)	14 (19.2)	16 (11.6)
High (4.01-4.85)	3 (4.6)	3 (4.1)	6 (4.3)
Very high (>4.85)	0 (0.0)	2 (2.7)	2 (1.5)
Glucose (mmol/L)			
Normal (≤5.5)	53(79.1)	58(78.4)	111(78.7)
Impaired (5.6-6.9)	11(16.4)	12(16.2)	23(16.3)
Provisional (≥7.0)	3(4.5)	4(5.4)	7(5.0)

HDL - High Density Lipoprotein Cholesterol
LDL – Low Density Lipoprotein Cholesterol

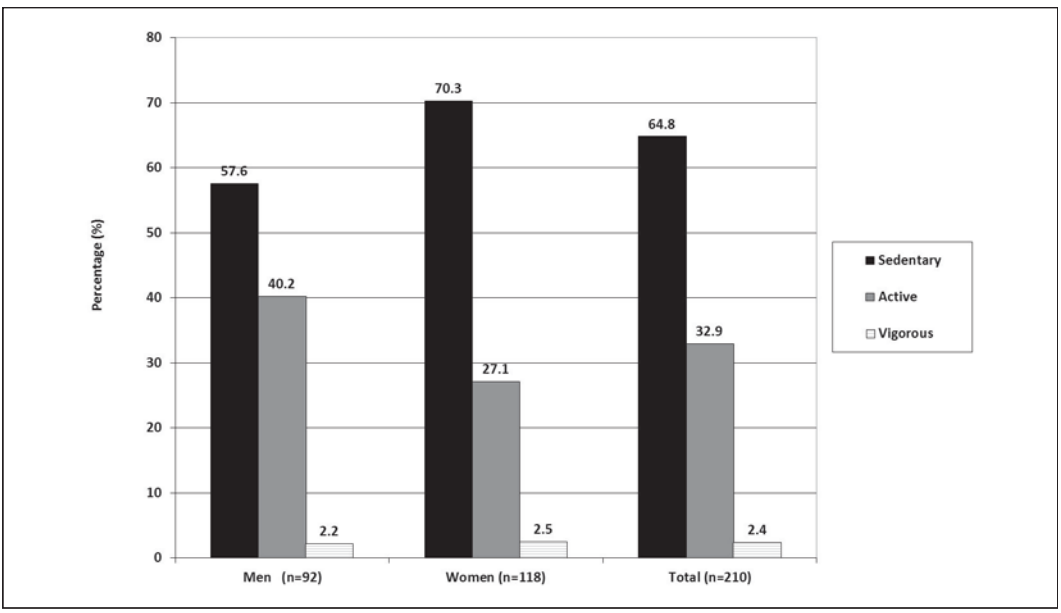

Figure 1. Distribution of respondents based on classification of physical activity levels

Table 3. Relationship between physical activity levels and anthropometric characteristics, blood pressure and lipid profiles

	Physical activity level (r-value) [a]			*Odds Ratio*	*95% confidence interval*	
	Men	*Women*	*Total*		*Lower*	*Upper*
Body mass index		-0.486*	-0.353*	2.800*	1.551	5.054
Fat percentage	-0.237*	-0.416*	-0.394*	3.010*	1.408	6.438
Waist circumference		-0.417*	-0.198*	1.795*	1.007	3.198
Waist-hip ratio		-0.242*		0.86	0.486	1.524
Systolic BP			0.149*	0.762	0.352	1.646
Diastolic BP				0.798	0.311	2.050
Lipid profiles						
Total cholesterol				2.462	0.664	7.720
Triglyceride				0.608	0.38	4.456
HDL		0.255*				
LDL				2.095	0.770	5.701
Glucose	0.306*			1.242	0.510	3.026

* $p<0.05$, significant difference (2-tailed)
[a] Pearson coefficient

National Health and Morbidity Survey (NHMS III) was 43.7% (Institute of Public Health, 2008). The prevalence of physical inactivity in the Malaysian NCD Surveillance 2005 / 2006 was 60.1% (Disease Control Division, 2006).

In this study, more than half of the respondents (64.8% total; 57.6% men vs. 70.3% women) were classified as sedentary. Compared to the national data, this study showed the highest percentage of sedentary respondents. This may be because the aforementioned national surveys used subjective measurement methods (questionnaires) to access the physical activity level of their respondents. We used an accelerometer to quantify the level of physical activity. According to Timperio, Salmon & Crawford (2003), the accuracy of the self-report technique depends on the "recall capabilities of the respondent, respondents' perceptions of the intensity of activity match objective definitions, and the ability of the questions to capture these perceptions." The differences in the prevalence reported may also be due to the differences in the study populations; a sample of government employees in Penang compared to a nationally representative sample.

This study found significant associations between the physical activity levels assessed by an accelerometer and the indices of obesity including BMI, waist circumference and body fat percentage. The systolic blood pressure levels showed a significant association in the correlation analysis but not in the odds ratio calculations. Lohman *et al.* (2006) reported independent associations between physical activity levels and fat mass and fat-free mass. The results from a systematic review by Wilks *et al.* (2011) concluded that the association between the objectively measured physical activity levels and the body weights of adults based on observational studies had mixed results; three out of the six studies showed no association, and another three showed a negative but significant relationship. The interpretations of those results highlight the limitations of observational and non-prospective studies.

Physical activity has been shown to play a significant role in weight loss and preventing or minimising weight gain among overweight and obese adults (Jakicic, 2002). Mora *et al*. (2006) reported a significant inverse correlation between physical activity and BMI among their study population. Increasing physical activity or fitness was positively associated with body composition (O'Neil & Nicklas, 2007).

This study showed that lipid profiles and glucose were not significantly associated with the accelerometer-determined physical activity levels. A systematic review carried out by Dencker & Anderson (2008) concluded that the association between physical activity measured by an accelerometer and levels of insulin resistance had divergent results. A study by Sisson *et al*. (2010) demonstrated that the accelerometer-determined steps per day was significantly associated with the cholesterol level and lower levels of triglycerides and was significantly associated with higher high-density lipoprotein (HDL). However, Sisson *et al*. (2010) demonstrated in their study that there were no significant associations between physical activity level and glucose levels or blood pressure.

No significant correlation between energy expenditure and a reduction in blood pressure was found in a study by Padilla, Wallace & Saejong (2005); Fagard (2001) reported no significant correlation between energy expenditure and a reduction in diastolic or systolic blood pressure. According to Dencker & Anderson (2008), there are several studies that demonstrate an association between accelerometer-determined physical activity and some of the risk factors for cardiovascular disease but not all.

One of the limitations of our study is that this was a cross-sectional study where the sequence of events and causes and effects cannot be identified. Future research should be done to provide further evidence as to the benefits of physical activity. A relationship between physical activity level and obesity was inconclusive since there were no dietary intake data collected in this study. One of the strengths of our study is that the use of the accelerometer to assess physical activity levels overcomes the limitations of self-reported physical activity assessments in many of the other studies done in Malaysia. However, this study is specific to the selected respondents (a sample population of government employees in Penang, Malaysia), and the results of this study should not be generalised to other population samples.

CONCLUSION

Approximately 65% of the respondents in this study were categorised as sedentary, and approximately 50.2% of respondents were classified as either overweight or obese. A significant relationship existed between the accelerometer-determined physical activity level and the indices of obesity. The results indicate an urgent need for the implementation of intervention programmes to address the problem of sedentary lifestyles and obesity among Malaysian office-bound adults.

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