Assessment of Physical Activity among Undergraduate Students in a Local University using a Pedometer

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ABSTRACT: The objective of this study was to assess the pedometer-determined physical activity among a sample of undergraduate students. To obtain the data required, the subjects' total number of steps was assessed using pedometer readings over the course of three days. Measurements of subjects' height, weight, waist and hip circumferences, and blood pressure were also recorded. A total of 174 young adults were involved in this study. The mean age was 20.7 ± 1.3 years; 40.2% were male, and 59.8% were female. The mean body mass index (BMI) was 22.0 ± 4.0 kg/m^2 and the prevalence of overweight and obesity was 10.4% and 3.4%, respectively. Mean steps taken per day were 7587 ± 2704 for females and 8481 ± 2914 for males. Based on waist-hip ratio data, female subjects were classified as having higher risk of chronic disease than males (5.7% vs. 1.2%). Classification of the waist circumference showed similar results (10.9% vs. 6.3%).We found that the number of steps taken per day was not significantly related ($p > 0.05$) to variables such as waist circumference, hip circumference, waist-hip ratio, BMI and systolic or diastolic blood pressure. Further analysis showed that subjects with fewer than 6594 steps per day (< 33rd percentile) had a higher systolic blood pressure than those subjects who walked more steps in a day (111 ± 14 mmHg vs.106 ±11 mmHg; $t=-2.42$, $p<0.05$). Other variables, such as BMI, waist and hip circumferences, waist-hip ratio and diastolic blood pressure were not significantly different among groups with different mean steps per day. The prevalence of a sedentary lifestyle, assessed by the total number of steps taken per day, was less than 15% among the sample of young adults in this study. Further investigation is required to confirm the association between daily step count and blood pressure among young adults.

Keywords: Physical activity, pedometer, body composition

Introduction

Physical activity is defined as "bodily movement that is produced by the contraction of skeletal muscles and that substantially increases the amount of energy expend" (USDHHS, 1996). Physical activity contributes positively to health but sedentary or inactivity has been identified as the one of the leading risk factor for mortality causing an estimated 6% of deaths globally (WHO, 2009). The minimum recommendation of physical activity for adult is 30 minutes moderate intensity physical activity at least 5 times per week, but globally at least 60% of the population fails to achieve this recommendation (WHO, 2002).

In Malaysia, the prevalence of physical inactivity is 43.7%, and the national prevalence of normal body mass index (BMI) is 48.37%, with 29.10% of the population overweight and 14.01% obese, as reported in the Third National Health and Morbidity Survey, 2006 (MOH, 2008). Data gathered from the Malaysian Non-Communicable Diseases Surveillance in 2006 showed similar trends, with overall prevalence of overweight and obesity among Malaysian adults reported as 31.6% and 16.3%, respectively. In other words, 47.9% of adults were in either the overweight or obese categories. Additionally, overall prevalence for central obesity (waist circumference ≥80cm for female and ≥90cm for male) was found to be 48.6% (Disease Control Division, 2006). According to Hill and Peters (1998), the opportunities to be sedentary rather than active have increased for the current generation, and there are growing concerns that young people are more sedentary than previous generations.

Physical activity is multi-dimensional and thus complicated to measure. The variation in accuracy of this measurement may contribute to inconsistent results among studies. To date, methods of physical activity assessments have included self reported questionnaires, physical activity diary, observation, calorimetric, electronic motion sensors, heart rate and doubly labelled water (Welk, 2002). Primarily due to its practicality and cost-effectiveness, self reported technique has been used in many local studies including in the National Health and Morbidity Survey (MOH, 2008) and the Malaysian Non Communicable Diseases Surveillance (Disease Control Division, 2006). Advancement in technology has enable motion sensors such as pedometer being used by researchers as alternative to self reported methods (Tudor *et al.*, 2004b). Pedometers have been found to offer an easy-to-use and cost-effective objective measure of physical activity (Stycker *et al*., 2007). Pedometers provide inexpensive, objective, accurate and reliable measurement of ambulatory activity by counting the number of steps taken per day (Hornbuckle *et al*., 2005).

The selection of assessment method to be used for physical activity in related studies is of importance. An appropriate method can decrease misclassification of data and may enhance the understanding of the association between physical activity and health. To our knowledge, data on physical activity assessments using objective methods (such as pedometer and accelerometer) is still very limited in Malaysia. Therefore the objectives of this study were to determine the level of physical activity among undergraduate students in Universiti Putra Malaysia using pedometers and to describe the relationship between the body composition variables and pedometer-determined physical activity.

Materials and Methods

Study design and location

This research involved a cross-sectional study design, including a total of 174 undergraduate students enrolled in Universiti Putra Malaysia. Those included were aged 18 to 24 years and enrolled in bachelor's degree programmes. Exclusion criteria included students in diploma, master's or doctoral programmes as well as students with any physical disability. To select subjects, researchers randomly sampled names from lists of students in four programmes within the university. Those sampled were invited to participate, and written informed consent forms were collected prior to data collection.

Sample size calculation

The formula used for calculating sample size was: $n = Z_{(1-\alpha/2)}^2 \times p \times (1-p) / d^2$ (WHO, 2006) where $Z_{(1-\alpha/2)}$ indicates 95% confidence level, *p* is the prevalence of physical inactivity among Malaysian adults (according to the Third National Health and Morbidity Survey 2006; Ministry of Health Malaysia, 2006; 43.7%), and *d* is the desired accuracy level for estimating physical inactivity prevalence (set at ± 0.10). Given these parameters, we required a sample size of at least 95 subjects for this study.

Study protocol

A digital scale (Tanita, Japan) was used to assess weight to the nearest 0.1 kg. Two measurements were taken in immediate succession. The average reading from the measurements was calculated and recorded. The Seca body meter 206 (Germany) was used to assess height to the nearest 0.1 cm after removal of shoes, socks, slippers and any head gear. Again, two measurements were taken in immediate succession, after which the Body Mass Index (BMI) of each participant was calculated and classified according to the formulation outlined by the World Health Organization (1995).

For the waist circumference, the inferior margin (lowest point) of the last rib and the crest of the ilium (top of the hip bone) were located, and the circumference of the midpoint between these points was measured to the nearest 0.1 cm. According to the International Diabetes Federation (2006), there is an increased risk of metabolic complications for Asian men with a waist circumference of ≥ 90 cm and for Asian women with a waist circumference of ≥ 80 cm.

The subjects' hip circumference was measured to the nearest 0.1 cm using a measuring tape. For this purpose, the measuring tape was positioned around the maximum circumference of the buttocks. The waist-hip ratio was calculated using a simple method (waist-hip formula) to describe the distribution of both subcutaneous and intra-abdominal adipose tissues. A waist-hip ratio of ≤ 1.0 for an adult male and ≤ 0.85 for adult female are the established cut-off points for risks of chronic diseases (WHO, 2006).

An Automatic Blood Pressure Monitor measured blood pressure of the subjects. A pedometer (Yamasa Allness 200S, Japan) was used to assess the steps per day. The subjects were required to wear the pedometer for two weekdays and one weekend. To ensure that accuracy was achieved, the subjects were taught to use the pedometer and were then asked to demonstrate their understanding. The pedometer was worn (at the waist) from the time that subjects woke up in the morning until they retired for the night.Subject were asked to remove the pedometer when bathing or swimming. They were asked not to alter their usual physical activities. During these three days, the subjects were required to record steps per day from the pedometer each night before sleeping.

In addition, a set of questionnaires was used to collect necessary data on subjects' socio-demographic background. The data collection was carried out for two months, from December 2007 until the end of January 2008. Prior to data collection, ethical approval was obtained from the Research Ethics Committee of the Faculty of Medical and Health Sciences, Universiti Putra Malaysia.

Data Analysis

The data were analysed using the Statistical Package for Social Sciences (SPSS), Version 15.0. The descriptive analyses included means, frequencies and standard deviations. Pearson's correlation coefficient was used to determine the relationship between the independent variable (pedometer-determined physical activity) and each dependent variable (BMI, waist circumference, waist-hip ratio and blood pressure). The significance level for these tests was set at $p < 0.05$.

Results

In total, 174 Universiti Putra Malaysia (UPM) undergraduate students participated in this study. The data on subjects' age, sex, ethnicity, programmes of study and monthly household income of parents are presented in **TABLE 1.**

Mean age was 20.7 $\pm$ 1.3 years old, and the majority (75.3%) of subjects were between 20 and 22 years old. Female subjects accounted for 59.8% of the sample. Malay participants made up 59.8% of the sample, followed by Chinese (37.9%) and Indian (2.3%) students. About 45% of the subjects were from the Faculty of Engineering, 12.6% from the Faculty of Design and Architecture, and 42% from Faculty of Medicine and Health Sciences. The mean household income of their parents was RM2517.7 $\pm$ 2258.5 per month.

Anthropometric measurements and blood pressure

Descriptive statistics for the anthropometric measurement and blood pressure are shown in **TABLE 2**. The mean Body Mass Index (BMI) was 22.0 $\pm$ 4.0 kg/m^2, and male subjects (23.0 $\pm$ 5.1 kg/m^2) had a higher mean BMI than females (21.3 $\pm$ 2.9 kg/m^2). Mean waist circumferences for male and female subjects were 81.9 $\pm$ 12.5 cm and 73.3 $\pm$ 8.0 cm, respectively, while mean waist-hip ratios for male and female subjects were 0.85 $\pm$ 0.05 cm and 0.77 $\pm$ 0.06 cm. The mean systolic blood pressure was 120 $\pm$ 11 mm/Hg (male) vs. 103 $\pm$ 9 mm/Hg (female), and the diastolic blood pressure was 72 $\pm$ 10 mm/Hg (male) vs. 67 $\pm$ 9 mm/Hg (female, difference $p<0.05$).

The classification of BMI was based on World Health Organization (1995) guidelines. In this study, a majority of the subjects (73.0%) had a normal BMI, followed by underweight (13.2%), overweight (10.4%) and obese (3.4%). By gender, a similar proportion of overweight was shown, although it was found that a higher percentage of males (2.8%) were classified as obese, as compared to females (0.6%).

The waist-hip ratio was used as an indicator of abdominal fat distribution. Most of the subjects (93.1%) were in the low risk group, while 6.9% of the subjects showed increased risk of chronic diseases such as cardiovascular disease (Gu *et al.*, 2008). Based on this ratio, 10 out of the 12 subjects with increased risk were female. Based on risk associated with waist circumferences, 17.2% of the subjects overall were at increased risk, and 6.3% of the male subjects and 10.3% of female subjects had increased risk of co morbidities.

TABLE 1- Socio-demographic characteristics of the subjects (n=174)

Characteristics	n	Percentage (%)	Mean ± Standard Deviation
Age (Years)			
18 – 19	26	14.9	20.7 ± 1.3
20 – 22	131	75.3	
23 – 24	17	9.8	
Gender			
Male	70	40.2	
Female	104	59.8	
Ethnicity			
Malays	104	59.8	
Chinese	66	37.9	
Indians	4	2.3	
Program of Study			
Engineering	79	45.4	
Design and Architecture	22	12.6	
Nutrition and Community Health	53	30.5	
Dietetics	20	11.5	
Monthly Household Income (RM*)			
< 1000	42	24.1	2517.7±2258.5
1000 – 2000	67	38.5	
2001 – 3000	28	16.1	
3001 – 4000	14	8.1	
> 4000	23	13.2	

* 1 USD = RM3.2
RM = Ringgit Malaysia
USD = United States Dollar

TABLE 2- Anthropometric measurements and blood pressure of the subjects

Anthropometric measurements	**Male** (Mean ± SD)	**Female** (Mean ± SD)	**Total** (Mean ± SD)	**p**
Height (cm)	170.5 ± 7.4	158.9 ± 5.9	162.9 ± 9.0	0.00
Weight (kg)	67.0 ± 15.2	53.2 ± 8.5	58.8 ± 13.5	0.00
Body Mass Index (kg/m²)	23.0 ± 5.1	21.3 ± 2.9	22.0 ± 4.0	0.01
Waist circumference (cm)	81.9 ± 12.5	73.3 ± 8.0	76.7 ± 10.1	0.00
Hip circumference (cm)	96.1 ± 9.4	94.5 ± 6.5	95.1 ± 7.8	0.20
Waist-hip ratio	0.85 ± 0.05	0.77 ± 0.06	0.80 ± 0.07	0.00
Systolic blood pressure (mm/Hg)	120 ± 11	103 ± 9	110 ± 13	0.00
Diastolic blood pressure (mm/Hg)	72 ± 10	67 ± 9	69 ± 10	0.00
Classification	**n (%)**	**n (%)**	**n (%)**	
Body Mass Index				
Underweight < 18.5 kg/m²	6 (3.4)	17 (9.8)	23 (13.2)	
Normal 18.5 – 24.9 kg/m²	50 (28.7)	77 (44.3)	127 (73.0)	
Overweight 25.0 – 29.9 kg/m²	9 (5.2)	9 (5.2)	18 (10.4)	

Obese 30.0 – 34.9 kg/m²	2 (1.1)	1 (0.6)	3 (1.7)
Extremely obese>40.0kg/m²	3 (1.7)	0 (0)	3 (1.7)
Waist-hip ratio			
Low risk	68 (39.0)	94 (54.0)	162 (93.1)
Increased risk	2 (1.2)	10 (5.7)	12 (6.9)
Waist circumference			
Low risk	59 (33.9)	85 (48.9)	144 (82.8)
Increased risk	11 (6.3)	19 (10.9)	30 (17.2)

* Low risk means WC < 90cm for male and WC < 80cm for female, respectively.
** Increased risk means WC ≥ 90cm for male and WC ≥ 80 cm for female, respectively.
* Low risk means WHR ≤ 1.0 for male and WHR ≤ 0.85 for female, respectively.
** Increased risk means WHR > 1.0 for male and WHR > 0.85 for female, respectively.

Hypertension is an important risk factor for cardiovascular and renal diseases. As systolic or diastolic pressure increases, there is a greater risk of death from cardiovascular disease (Welborn *et al*., 2003). **TABLE 3** shows that 75.9% and 85.1% of the subjects had normal systolic and diastolic blood pressure, respectively. About 24.1% had elevated systolic, and 14.9% had elevated diastolic blood pressure.

TABLE 3: Distribution of subjects according to the classification of blood pressure

Category	Blood pressure	Male(n=70) n(%)	Female(n=104) n(%)	Total(n=174) n(%)
Systolic blood pressure				
Normal	< 120 mmHg	32 (18.4)	100 (57.5)	132 (75.9)
Elevated blood pressure	≥ 120 mmHg	38 (21.8)	4 (2.3)	42 (24.1)
Diastolic blood pressure				
Normal	< 80 mmHg	53 (30.5)	95 (54.6)	148 (85.1)
Elevated blood pressure	≥ 80 mmHg	17 (9.8)	9 (5.2)	26 (14.9)
Diastolic and systolic blood pressure				
Normal	<120/80 mmHg	29 (16.7)	93 (53.4)	122 (70.1)
Elevated blood pressure	≥ 120/80 mmHg	41 (23.6)	11 (6.3)	52 (29.9)

Pedometer-determined physical activity

Mean daily steps overall was 7947 ± 2817, and mean steps for males (8481 ± 2914 steps per day) was higher than females (7587 ± 2704 steps per day) (**TABLE 4**). (As shown by Tudor and Bassett (2004a), the pedometer-determined physical activity can be classified into sedentary, low active, somewhat active and active categories. Most of the subjects (65.6%) in this study could be classified as low active and somewhat active, followed by active (19.5%), while less than 15% were categorised as sedentary. The percentage of the female subjects classified as sedentary was two times higher than for males, whereas the percentage of subjects classified as active was comparable for both genders.

TABLE 4- Mean ± SD steps per day and subject classification by pedometer determined physical activity category

		Male	Female	Total
Total average (Mean ± SD)				
Steps per day		8481 ± 2914	7587 ± 2704	7947 ± 2817
	Steps per day	n (%)	n (%)	n (%)
Sedentary	< 5000	9 (5.2)	17 (9.7)	26 (14.9)
Low active	5000 – 7499	18 (10.4)	39 (22.4)	57 (32.8)
Somewhat active	7500 – 9999	28 (16.1)	29 (16.7)	57 (32.8)
Active	≥ 10000	15 (8.6)	19 (10.9)	34 (19.5)

Classification based on Tudor-Locke *et al*. (2004a)

Pearson's correlation coefficient was used to determine association between the independent and dependent variables. The analysis indicated that the number of steps taken was not significantly related to the variables of the subjects' body composition ($p>0.05$). There was also no significant relationship between the pedometer-determined physical activity and systolic or diastolic blood pressure ($p>0.05$).

TABLE 5- Pearson's correlation coefficients (r) between the number of steps per day and body composition variables and blood pressure

	Body Mass Index	Waist Circumference	Hip Circumference	Waist Hip Ratio	Systolic Blood Pressure	Diastolic Blood Pressure
Steps per day	r=-0.02	r=0.02	r=-0.08	r=-0.11	r=0.13	r=0.04
	p=0.76	p=0.84	p=0.31	p=0.14	p=0.09	p=0.63

For this study, a further analysis was done, and the total number of steps was divided into percentiles. Subjects with fewer than 6594 steps per day (< 33rd percentile) had a higher systolic blood pressure than those participants in the higher percentiles (111 ± 14 mmHg vs. 106 ±11 mmHg; t=-2.42, p<0.05). Other variables such as BMI (t=-2.42, p>0.05), waist (t=2.58, p>0.05) and hip circumferences (t=1.06, p>0.05), waist-hip ratio (t=-0.72, p>0.05), and diastolic blood pressure (t=-0.72, p>0.05) were not significantly different across different activity levels.

Discussion

To overcome certain limitations of the self reported methods, there has been increasing interest in the objective monitoring of physical activity using motion sensors such as pedometers. To date, research published using this objective method is limited, in particular research involving Malaysian subjects. Previous national survey (MOH, 2008; Disease Control Division, 2006) carried out to assess the level of physical activity in Malaysia has been dependent upon the use of questionnaires and self-report methods. It is important to note that these methods sometimes produce imprecise results and that some activities, particularly walking, are unreliably recalled (Basset *et al*., 2000; Richardson *et al*., 1994). The current study used an objective method to determine the level of physical activity among undergraduate students in Universiti Putra Malaysia.

The composition of the sample for this study represented the ethnic distribution in Malaysia. In particular, Malays and other Bumiputera groups comprise 65.1% of the total Malaysian population, followed by Chinese (26.0%) and Indians (7.7%) (Department of Statistics Malaysia, 2001). The mean pedometer-determined physical activity recorded for the present study (7947± 2817 steps per day) is comparable to other studies. Thompson *et al*. (2004) conducted a study among middle-aged women in the United States and found that their mean steps per day were 8354 + 3249. Similarly, Tudor-Locke *et al*. (2004a) found that the males residing in Sumter County, United States had a higher mean steps per day compared to females (7192+3596 vs. 5210+3518, p<0.0001). Studies by Sequeira *et al*. (1995) of residents of Switzerland aged 25 to 74 years showed that the average number of steps per day was higher among younger age groups (from 11,900 to 6,700 for men and from 9,300 to 7,300 for women), in the youngest to the oldest age groups. Findings in this study are consistent with those published in which males took more steps per day than females (8481 ± 2914 vs. 7587 ± 2704).

Results from the 2006 Malaysian Non-Communicable Disease Surveillance report showed that the prevalence of physical inactivity among those aged 25 to 34 years in Malaysia was 52.9% (Disease Control Division, 2006). In our study among a sample of undergraduate university students, 14.9% of the subjects were classified as sedentary (based on the mean number of steps taken per day). In the Malaysian Adults Nutrition Survey, the prevalence of adequate exercise was 15.6% overall and 21% in males vs. 10% in females (MOH, 2007), and results from the Third Malaysian National Health and Morbidity Survey, 2006 showed that 41.4% of men and women aged 20-24 years were inactive (MOH, 2008). The results of these questionnaire studies suggest that many Malaysians are inactive.

Based on pedometer-determined physical activity, the proportion of sedentary (less than 5000 steps per day) young adults involved in this study was less than 15%.

Using pedometers to quantify activity may contribute to bias in assessment since pedometers can be motivational tools to encourage individuals to increase walking and thus their level of physical activity (Yamanouchi *et al*., 1995). Additionally, results from this research may not generalise to other age groups, as other studies have shown an inverse and significant relationship between the number of steps taken per day and age (Sequeira *et al*., 1995; Tudor-Locke *et al*., 2004a).

The classification of level of physical activity using pedometer-determined physical activity should be interpreted carefully. Pedometers have limitations and therefore can contribute to differences in results. According to Welk *et al*. (2002), a pedometer cannot detect arm movements and external work done in pushing, lifting and carrying objects, so it cannot provide specific or detailed information on patterns of physical activity. Furthermore, pedometers cannot differentiate intensity of activity, and certain activities (such as cycling) are undetectable by this device. The overweight and obesity prevalence in this study was lower than those obtained from a national sample. According to the Third National Health and Morbidity Survey 2006, about 29.10% and 14.01% of the Malaysian adult populations, aged 18 years or older were overweight and obese, respectively. Upon comparison of the different age groups, the results of this study were found to be in line with the national data, which showed that the prevalence of obesity (BMI $\geq$ 30 kg/m^2) and overweight (BMI between 25 to 29.9 kg/m^2) was lower among the younger age group compared to the older group (MOH, 2008). According to the Malaysian Adults Nutrition Survey (2003), the prevalence of obesity among those aged 18 and19 years was 15.5%.

The results of this study show that females had a higher prevalence of abdominal obesity (10.9%) than males (6.3%). This trend was similar to the results gathered in the Third National Health and Morbidity Survey, 2006 which found overall prevalence of abdominal obesity to be 17.4%, with women higher (26.0%) than men (7.3%) (MOH,2008). This pattern was also similar to the 2006 Malaysian Non-Communicable Disease Surveillance report, which showed that 57.1% and 40.7% of the female and male population, respectively, were at risk for chronic diseases (Disease Control Division, 2006).

Analysis (Pearson's correlation coefficient) indicated that the number of steps taken was not significantly related to variables of subjects' body composition such as waist circumference, hip circumference, waist-hip ratio and BMI. There was no significant relationship between the pedometer-determined physical activity and systolic or diastolic blood pressure. However, several studies have shown contrasting results, in which the total number of steps taken per day was shown to be significantly related to the variables of body composition. According to Tudor *et al*. (2001), steps per day had an inverse relationship with BMI and body fat percentage. Similarly, Chan *et al*. (2003) found that there was a correlation between steps taken per day and BMI and blood pressure and that steps taken per day was inversely associated with waist circumference among female subjects. Moreau *et al*. (2001) found that walking was not significantly related to diastolic blood pressure; however, a walking program that met physical activity recommendations was proven to be effective in lowering systolic blood pressure. A meta-analysis of prospective cohort studies confirms that walking is inversely associated with a lower risk of cardiovascular disease and that a dose-response relationship exits, but the mechanism that mediates this relationship remains unknown (Hamer *et al*., 2008).

We found that subjects with fewer than 6594 steps per day (< 33rd percentile) had a higher systolic blood pressure than those who walked more or equal to 6594 steps per day (111 ± 14 mmHg vs.106 ±11 mmHg; t=-2.42, p<0.05). Other variables such as BMI, waist and hip circumferences, waist-hip ratio and diastolic blood pressure were not significantly different (p>0.05) among different categories of physical activity. In a randomised control trial, Murphy *et al*. (2006) found that by walking twice per week for 45 minutes at a 62% maximum heart rate, participants could reduce systolic blood pressure and prevent an increase in the amount of body fat. Murphy's study also showed that at this level of activity, there is no improvement of other markers of cardiovascular disease. The results of our study showed that the difference in mean systolic blood pressure was small (111 ± 14 mmHg vs.106 ±11 mmHg; t=-2.42, p<0.05) but important, since the subjects involved in this study were between age 18 to 24 years old. As age increases, the difference in blood pressure between these two groups may be higher and important from a clinical perspective.

This research is a cross-sectional study in nature, and therefore the results are limited in predicting a causal relationship. Since the research involved only young adults, the findings cannot be used to draw conclusions for men or women of other ages. To further investigate the relationship between the number of steps taken and body composition, a larger, randomised study is needed. Moreover, the use of an objective method of physical activity assessment should be further explored in research involving different age and ethnic groups in Malaysia. The effects of walking on body composition, blood pressure and health outcomes among different ethnic groups could also be further explored.

Conclusion

In summary, the prevalence of a sedentary lifestyle, measured by the total number of steps taken per day, was less than 15% among a sample of undergraduate students in this study. This study provides link between daily step counts and blood pressure among young adults. The association between blood pressure and steps taken per day needs to be investigated further to confirm the relationship.

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References

1. Bassett, D.R., Jr., Ainsworth, B.E., Swartz, A.M., Strath, S.J., O’Brien, W.L. and King, G.A. (2000). Validity of four motion sensors in measuring moderate intensity physical activity. *Medicine and Science in Sports and Exercise* 32 (9): S471–S480.

2. Blair, S.N., LaMonte, M.J. and Nichaman, M.Z. (2004). The evolution of physical activity recommendations: how much is enough? *American Journal of Clinical Nutrition* 79 (5): 913S-920S.

3. Centers for Disease Control and Prevention. (2004). *Promoting Better Health for Young People through*

Physical Activity and Sports: A Report to the President. Department of Health and Human Services, Centers for Disease Control and Prevention, National Centre for Chronic Disease Prevention and Health Promotion, USA.

4. Chan, C.B., Spangler, E., Valcour, J. and Tudor-Locke, C. (2003). Cross-sectional Relationship of Pedometer-Determined Ambulatory Activity to Indicators of Health. *Obesity Research* 11 (12): 1563-1570.

5. Department of Statistic Malaysia. (2001). *Population Distribution and Basic Demographic Characteristics Report 2001*. Available from: http://www.statistics.gov.my/english/census/ pressdemo.htm?file=pressdemo *Retreived on 29 March, 2008*.

6. Diseases Control Division. (2006). *Non Communicable Diseases Surveillance-1*. Noncommunicable Diseases Section, Diseases Control Division, Ministry of Health Malaysia, Putrajaya.

7. Ekelund, U., Yngve, A., Brage, S., Westerterp, K. and Sjostrom, M. (2004). Body movement and physical activity related energy expenditure in children and adolescents: How to adjust for differences in body size and age. *American Journal of Clinical Nutrition* 79 (5): 851-856.

8. Gu, D., Kelly, T.N., Wu, X., Chen, J., Duan, X., Huang, J.F., Chen, J.C., Whelton, P.K. and He, J. (2008). Blood pressure and risk of cardiovascular disease in Chinese men and women. *American Journal of Hypertension* 21 (3): 247-272.

9. Hamer, M. and Chida, Y. (2008). Walking and primary prevention: a meta-analysis of prospective cohort studies. *British Journal of Sports Medicine* 42: 238-243.

10. Hill, J.O. and Peters, J.C. (1988). Environmental contributions to the obesity epidemic. *Science* 280 (5368):1371– 1374.

11. Hoos, M.B., Gerver, W.J.M., Kester, A.D. and Westerterp, K.R. Physical activity levels in children and adolescents. *International Journal of Obesity* 2003: 27 (5):605-609.

12. Hornbuckle, L.M., Bassett, Jr D.R. and Thompson, D.L. (2005). Pedometer determined walking and body composition variables in African-American women. *Medicine and Science in Sports and Exercise* 37(6): 1069-1074.

13. International Diabetes Federation. (2006). *The IDF consensus worldwide definition of the metabolic syndrome*. IDF Communications, Belgium.

14. Lagerros, Y.T. and Lagiou, P. (2007). Assessment of physical activity and energy expenditure in epidemiological research of chronic diseases. *European Journal of Epidemiology* 22 (6): 353-362.

15. Ministry of Health Malaysia. (2008).*The third National Health and Morbidity Survey 2006*. National Institute of Health, Kuala Lumpur.

16. Ministry of Health Malaysia. (2007).*The Malaysian Adult Nutrition Survey 2003*. Nutrition, Family Health Development Division, Ministry of Health Malaysia, Kuala Lumpur.

17. Moreau, K.L., Degarmo, R., Langley, J., Mcmahon, C., Howley, E.T., Bassett,

Enough? Preliminary Pedometer Indices for Public Health. *Sport Medicine* 34 (1): 1-8.

18. Murphy, M.H., Murtagh, E.M., Boreham, C.A.G., Hare, L.G. and Nevill, A.M.(2006). The effect of a worksite based walking programme on cardiovascular risk in previously sedentary civil servants BMC Public Health 6:136.[doi:10.1186/1471-2458-6-136].

19. Popkin, B.M. (2001). Nutrition in transition: the changing global nutrition challenge. *Asia Pacific Journal of Clinical Nutrition,* 10:S13-S18.

20. Richardson, M.T., Leon, A.S., Jacobs, D.R., Ainsworth, B.E. and Serfass, R. (1994). Comprehensive evaluation of the Minnessota Leisure Time Physical Activity Questionnaire. *Journal of Clinical Epidemiology* 47:271-281.

21. Sequeira, M.M., Rickenbach, M., Wietlisbach, V., Tullen, B. and Schutz, Y.(1995). Physical Activity Assessment Using a Pedometer and Its comparison with a Questionnaire in a Large Population Survey. *American Journal of Epidemiology* 142(9):989-999.

22. Stryker, L.A., Duncan, S.C., Chaumeton, N.R., Duncan, T.E. and Toobert, D.J.(2007). Reliability of pedometer data in samples of youth and older women. *International Journal of Behavioral Nutrition and Physical Activity* 4 art. No.4.

23. Thompson, D.L., Rakow, J. and Perdue, S.M. (2004). Relationship between accumulated walking and body composition in middle-aged women. *Medicine and Science in Sport and Exercise* 36(5):911-914.

24. Tudor-Locke, C. and Bassett, Jr. D.R. (2004a). How many steps/day are enough? Preliminary Pedometer Indices for Public Health. *Sport Medicine* 34 (1): 1-8.

25. Tudor-Locke, C., Ainsworth, B.E., Whitt, M.C., Thompson, R.W., Addy, C.L. and Jones, D.A. (2001).The relationship between pedometer-determined ambulatory activity and body composition variables. *International Journal of Obesity* 25 (11): 1571-1578.

26. Tudor-Locke, C., Ham, S.A., Macera, C.A., Ainsworth, B.E., Kirtland, K.A., Reis, J.P., Kimsey, C.D. Jr. (2004b).Descriptive epidemiology of pedometer-determined physical activity. *Medicine and Science in Sports Exercise* 36 (9):1567-73.

27. U.S. Department of Health and Human Services. (1996). *Physical Activity and Health: A Report of the Surgeon General* Atlanta, GA: U.S.

28. Welborn, T.A., Dhaliwal, S.S. and Bennett. (2003). Waist –hip ratio is the dominant risk factor predicting cardiovascular death in Australia. *Medical Journal of Australia* 179:580-585.

29. Welk, G.J. (Ed.). (2002). *Physical Activity Assessments for Health-Related Research*, Human Kinetics.Champaign, IL.

30. World Health Organisation. (1995). Physical status: The Use and Interpretation of Anthropometry. World Health Organisation Technical Report Series. World Health Organisation, Geneva.

31. World Health Organization (2002). *The world health report 2002. Reducing risks, promoting healthy life.* World Health Organisation, Geneva.

32. World Health Organization (2009). Global health risks: mortality and burden of disease attributable to selected major risks. World Health Organisation, Geneva.

33. World Health Organization. (2000). Director General Report, Fifty third World Health Assembly: Global Strategy for the prevention and control of Non-communicable diseases. World Health Organisation, Geneva.

34. World Health Organization. (2003). *World Health Report: Shaping the Future*. World Health Organization, Geneva.

35. World Health Organization. (2005). *Preventing Chronic Diseases: a Vital Investment*. World Health Organisation, Geneva.

36. World Health Organization.(2006).*The WHO STEPS wise approach to chronic disease risk factor surveillance*. World Health Organization, Geneva.

37. Yamanouchi, K., Shinozaki, T., Chikada, K., Nishikawa, T., Ito, K., Shimizu, S., Ozawa, N., Suzuki, Y., Maeno, H., Kato, K., Oshida, Y. and Sato, Y.(1995). Daily walking combined with diet therapy is a useful means for obese NIDDM patients not only to reduce body weight but also to improve insulin sensitivity. *Diabetes Care* 18: 775–778.