PJN
ISSN 1680-5194

Pakistan Journal of Nutrition

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
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E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 11 (6): 523-528, 2012
ISSN 1680-5194

Objective Assessment of Physical Activity in the Workplace Setting

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Abstract: This study was conducted to assess the Physical Activity Level (PAL) of government employees at government agencies in Kangar Perlis, Malaysia, by using an accelerometer as an objective measurement. Respondents were chosen randomly and required to wear the accelerometer for three days. Socio-demographic data were obtained by questionnaire and anthropometric measurements, Body Fat Percentage (BF%) and blood pressure were assessed using standard procedures. A 8-12 h fasting venous blood sample was taken for analysis of plasma glucose, lipid profile and 2 h Oral Glucose Tolerance Test (OGTT). A total of 272 respondents were recruited for this study (151 males and 121 females), with a mean age of 39±11 years. About 44.9% of the respondents were categorized as active to vigorously active based on PAL, whereas 55.1% were sedentary. Statistical analysis showed significant differences in age ($p<0.0001$), Body Mass Index (BMI) ($p<0.0001$), WC ($p<0.0001$), BF% ($p<0.0001$), diastolic blood pressure ($p<0.05$), 2 h plasma glucose and HDLC between the active and sedentary PAL groups. Logistic regression analyses of accelerometer-determined PAL showed that increasing BMI (OR = 0.841, 95% CI = 0.714, 0.990), WC (OR = 0.969, 95% CI = 0.944, 0.995), BF% (OR = 0.907, 95% CI = 0.875, 0.940) and diastolic blood pressure (OR = 0.953, 95% CI = 0.921, 0.987) were related to lower levels of PAL. In contrast, increasing HDLC levels (OR = 7.814, 95% CI = 2.603, 23.456) were related to higher levels of PAL. This study shows the significant contribution of physical activity to health status. HDLC levels increased as PAL increased and PAL was inversely associated with BMI, WC, BF% and diastolic blood pressure.

Key words: Physical activity, accelerometer, body composition

INTRODUCTION

Objective physical activity measures, specifically accelerometry, have been increasingly applied to assess Physical Activity Level (PAL). This method overcomes the limitations of subjective methods (Murphy, 2009), as it provides data on the amount, frequency and duration of Physical Activity (PA) (Plasqui and Westerterp, 2007). According to Trost *et al.* (2005), within a given day or over several days, the accelerometer provides a more objective estimate of PAL by measuring the acceleration of the body at the hip. This method enables real-time data storage, which has a significant advantage over the subjective methods.

Although the accelerometer is limited in its ability to capture the full energy cost of certain activities, such as walking while carrying a load, walking uphill and swimming, it can be used to approximate energy expenditure and is a valid measure of PAL (Plasqui and Westerterp, 2007; Matthews, 2005). It can also complement the data on studies of PAL using the subjective method to understand the prevalence and potential correlates of PA (Peters *et al.*, 2010).

In Malaysia, data on accelerometer-determined physical activity is very limited as compared to other countries. While the association between questionnaire-assessed PAL and chronic risk factors is somewhat established. Therefore, the assessment of PAL using objective methods requires further exploration. Thus, the purpose of the current study was to determine the PAL of a sample of Malaysian subjects and to determine the association of accelerometer-determined PA with Body Mass Index (BMI), Waist Circumference (WC), Body Fat Percentage (BF%) and blood profile.

MATERIALS AND METHODS

Respondents: A list of 98 government agencies in Perlis was obtained and agencies located in Kangar City were short-listed for sampling purposes. The sample size required for the study was calculated based on the formula provided by Margetts and Nelson (1997). Ten government agencies were randomly chosen and all staff members (n = 327) at these agencies were invited to participate in the study. The inclusion criteria for the study were individuals with no physical disability and not

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pregnant. Of the 327 employees, 272 employees agreed to participate in the study, resulting in a response rate of 83.2%. Only 225 of the respondents agreed to participate in the blood sample collection process and 210 were eligible for the 2 h oral glucose tolerance test.

Procedures: Height was measured using the SECA 206 (Germany), whereas body weight and BF% were measured in light clothing without shoes using the Tanita Body Composition Analyzer TBF-306 (Japan). Waist and hip circumference and blood pressure were measured using non-stretchable measuring tape and the Omron digital blood pressure monitor HEM-780 (Japan), respectively. Socio-demographic data were obtained by questionnaire and all respondents were required to wear an accelerometer (Lifecorder e-Step, Suzuken Company Limited, Japan). Details of the accelerometer used and its validity have been described elsewhere (Kumahara *et al.*, 2004; Rafamantanantsoa *et al.*, 2002). All participants were provided an explanation and demonstration on how to wear the accelerometer. The respondents were required to wear the accelerometer for three days, two weekdays and once during the weekend. PAL was calculated as the ratio of Total Energy Expenditure (TEE) to Basal Metabolic Rate (BMR). TEE was determined using the accelerometer and BMR was calculated using the predictive equations of Ismail *et al.* (1998), which are based on sex- and age-specific body weight for Malaysians. The accelerometer-determined PAL was categorized using the classification of FAO/WHO/UNU (2001). A PAL of 1.40-1.69 was categorized as sedentary, PAL of 1.70-1.99 as active and PAL of 2.00-2.40 as vigorous.

Blood collection was conducted by an accredited medical laboratory (B.P. Clinical Lab Sdn. Bhd Kangar branch) after 8-12 h of fasting (except water) throughout the night. Four ml of blood samples were transferred to fluoride oxalate blood collection tubes for the Fasting Blood Glucose Test (FBG). For the lipid profiles, 6 ml of the blood samples were transferred into Potassium Ethylene Diamine Tetra Acetate (K_2EDTA) BD vacutainers. All blood samples were stored in an ice box before being centrifuged at 3000 rpm at 4^oC for 15 min. The samples were then analyzed using ARCHITECT ci8200 integrated system (clinical chemistry and immunoassay) and Hitachi Automatic Analyzer 902, respectively. LDLC level for each respondent was obtained using Friedewald's formula (LDLC (mmol/L) = TC-HDLC-(TG/2.2)). For the 2 h Oral Glucose Tolerance Test (OGTT), the blood sample was collected two hours after the respondents drank 75 grams of a glucose-rich beverage.

The study protocol was approved by the Medical Research Ethics Committee of Faculty of Medicine and Health Sciences, Universiti Putra Malaysia. Permission to conduct the study was also obtained from the director of all agencies involved. All respondents signed an informed consent form before the data collection.

Statistical analysis: Data were analyzed using SPSS version 18.0 for windows. Descriptive data are expressed as mean±s.d. and percentage. PAL was dichotomised to create a binary outcome variable. Differences in age, anthropometric and blood profile data between the PAL groups were assessed by the independent-samples t-test, while the relationships between the categorical variables were assessed using the chi-squared test. Logistic regression models were used to determine the associations of the respondents' characteristics with PAL.

RESULTS AND DISCUSSION

A total of 272 respondents were involved in the study, including 151 males and 121 females. Based on PAL, 44.9% of the respondents were categorized as active to vigorous while 55.1% were sedentary. The distribution of respondents based on socio-demographic, anthropometric and blood profile characteristics are shown in Table 1. A majority of active respondents were male (62.3%) and equal proportion of the male and female respondents were in the sedentary group. A total of 46.7% of the respondents earned RM1500-RM2500 monthly and 34.6% were diploma/degree holders. Most of the sedentary respondents (65.1%) worked in an administrative position. The mean age of the respondents was 39±11 years and the mean Body Mass Index (BMI) was 26.52±5.27 kg/m^2. Based on the blood profile data, those who were sedentary had higher levels of fasting and 2 h plasma glucose and LDLC and had lower levels of TC, TG and HDLC as compared to the active to vigorous group. In addition, the chi-squared test showed a significant relationship between sex and PAL ($p = 0.042$) and independent sample t-tests showed significant differences in BMI ($p<0.0001$), WC ($p<0.0001$), BF% ($p<0.0001$), diastolic blood pressure ($p<0.05$), 2 h plasma glucose ($p<0.05$) and HDLC ($p<0.0001$) between the sedentary and active to vigorous groups.

Results from logistic regression analyses of accelerometer-determined PAL showed that increasing BMI (OR = 0.841, 95% CI = 0.714, 0.990), WC (OR = 0.969, 95% CI = 0.944, 0.995), BF% (OR = 0.907, 95% CI = 0.875, 0.940) and diastolic blood pressure (OR = 0.953, 95% CI = 0.921, 0.987) were related to lower levels of PAL (Table 2). Female respondents were more likely to be categorized into the lower PAL group (OR = 0.727, 95% CI = 0.438, 1.207); however, the association was not significant. For the blood profile, HDLC was the only variable that showed a significant result, with increasing HDLC related to higher levels of PAL (OR = 7.814, 95% CI = 2.603, 23.456).

Table 1: Socio-demographic, anthropometric and blood profile characteristics of the respondents

Variables	Sedentary PAL (n = 150) (%)	Active to vigorous PAL (n = 122) (%)	Total (n = 272) (%)	
Sex				
Male	50.0	62.3	55.5	Chi^2 = 4.118
Female	50.0	37.7	44.5	p = 0.042
Income level				
<RM1500	38.0	30.3	34.6	Chi^2 = 6.446
RM1500-RM2500	44.0	50.0	46.7	p = 0.092
RM2501-RM3500	10.7	5.7	8.4	
>RM3500	7.3	14.0	10.3	
Educational level				
Primary school	2.6	1.3	4.0	Chi^2 = 4.579
Lower secondary school	16.1	14.0	18.9	p = 0.333
Upper secondary school	28.3	28.7	27.9	
Matriculation/Form 6	18.4	21.3	14.8	
College/University	34.6	34.7	34.4	
Occupation				
Professional	12.9	12.6	13.1	Chi^2 = 6.026
Administrative/clerical	65.1	70.7	58.2	p = 0.049
General assistant	22.0	16.7	28.7	
	M±SD	M±SD	M±SD	p-value
BMI (kg/m^2)	26.52±5.27	28.63±5.08	23.92±4.26	<0.0001
Waist circumference (cm)	86.98±12.15	90.60±11.34	82.52±11.66	<0.0001
Body fat percentage (%)	31.36±10.36	35.50±10.26	26.27±7.96	<0.0001
Systolic blood pressure (mmHg)	130.23±16.96	131.01±16.10	129.27±17.98	NS
Diastolic blood pressure (mmHg)	80.12±11.14	81.60±10.61	78.30±11.55	<0.05
Fasting plasma glucose (mmol/L)	5.19±1.61	5.33±2.02	5.01±0.86	NS
After 2 h OGTT (mmol/L) (n = 210)	6.20±3.33	6.66±3.98	5.66±2.24	<0.05
Total Cholesterol (mmol/L)	4.20±1.10	4.19±0.97	4.22±1.24	NS
Triglyceride (TG) (mmol/L)	1.22±0.92	1.22±0.70	1.22±1.14	NS
High Density Lipoprotein Cholesterol (HDLC) (mmol/L)	0.71±0.28	0.64±0.25	0.79±0.29	<0.0001
Low Density Lipoprotein Cholesterol (LDLC) (mmol/L)	2.94±0.87	3.00±0.82	2.88±0.92	NS

Note: n = 272 respondents; p-values for continuous variables evaluate the difference between those with active to vigorous PAL and those who were sedentary. PAL: Physical Activity Level, NS: Not Significant, M: Mean, SD: Standard Deviation

Table 2: Odd Ratio (OR) (95% CI) for predicting likelihood in accelerometer-determined physical activity level

Variables	B	Odds Ratio (95% CI)	p-value
Sex	-0.319	0.727 (0.438, 1.207)	0.218
BMI (kg/m^2)	-0.173	0.841 (0.714, 0.990)	0.037
Waist circumference (cm)	-0.031	0.969 (0.944, 0.995)	0.018
Body fat percentage (%)	-0.098	0.907 (0.875, 0.940)	0.0001
Systolic blood pressure (mmHg)	0.017	1.017 (0.995, 1.040)	0.124
Diastolic blood pressure (mmHg)	-0.048	0.953 (0.921, 0.987)	0.007
Fasting plasma glucose (mmol/L)	0.003	1.003 (0.979, 1.026)	0.830
After 2 h OGTT (mmol/L)	-0.008	0.992 (0.983, 1.001)	0.088
Total Cholesterol (mmol/L)	0.042	1.043 (0.770, 1.414)	0.784
Triglyceride (TG) (mmol/L)	-0.034	0.966 (0.672, 1.389)	0.852
High Density Lipoprotein Cholesterol (HDLC) (mmol/L)	2.056	7.814 (2.603, 23.456)	0.0001
Low Density Lipoprotein Cholesterol (LDLC) (mmol/L)	-0.150	0.861 (0.627, 1.182)	0.354

In the present study, accelerometers were used to determine PAL and its relationship with socio-demographic, anthropometric and blood profile characteristics in government employees in Kangar, Perlis. Data from the Third National Health and Morbidity Surveys (NHMS III) showed that the prevalence of physical inactivity among Malaysian adults was 43.7%, with an estimation of 5,545,891 inactive Malaysian adults (National Institute of Health of Malaysia, 2006). However, the present study showed that 55.1% were sedentary. The higher prevalence of inactivity in the present study may be due to differences in the studies' respondents and the methods used. PA assessment in NHMS III was conducted through face-to-face interviews with "last week" recall using the WHO-stepwise questionnaire (National Institute of Health of Malaysia, 2006). In the present study, an objective measure was used to determine PAL. The NHMS III used a subjective method and required respondent to recall. Recall and measurement bias (Sallis and Saelens, 2000) misreporting and cognitive issues of recall could have affected the survey results (Peters *et al*., 2010). Thus, the results of the present study may show that the percentage of inactivity was higher than NHMS III. While the NHMS III investigated a representative of the Malaysian population, the current study only examined a sample of adults in the workplace setting.

The comparison by sex showed that the prevalence of a sedentary lifestyle was similar for females and males; however, more males were active as compared to females. Most studies (Poh *et al*., 2010; Cameron *et al*., 2002) revealed that the prevalence of physical inactivity was higher among females. Satariano *et al*. (2000) reported that women above the age of 55 years reported more obstacles to PA practice in their free time than men. This may be due to medical reasons as well as non-medical reasons such as living arrangement difficulties. In the present study, it was observed that higher levels of education were associated with more sedentary PAL and this was supported by Graff-Iversen *et al*. (2007). However, income and occupational level showed a different pattern, higher levels of income and occupation was related to a sedentary PAL. However, this may be due to the unequal distribution of the number of respondents in each income and occupation category. Crespo *et al*. (2000) showed that among adults, those who earned a low income were most at risk for physical inactivity, specifically during leisure time.

The relationships between questionnaire-assessed PAL and health indicators were well documented, but data using objective methods remain limited. The present study used the accelerometer to determined PAL and found that respondents with greater BMI, WC and BF% were more sedentary than those with lower BMI, WC and BF%. The results are similar to those reported by Peters *et al*. (2010), who used the accelerometer as a PA assessment tool. The respondents with higher BMI were more inactive overall (OR = 1.87) and spent less time in moderate-to-vigorous and light activity as compared to those with normal BMI (Peters *et al*., 2010). The OR value of the present study (OR = 0.841), compared to the study by Peters *et al*. (2010) showed a stronger contribution of BMI to PAL. In addition, Kylea *et al*. (2004) found higher BMI and BF% in sedentary subjects who did not perform exercise as recommended, which was at least 3 h per week. The highest body weight gain was found in respondents who decreased PA involvement. Yao *et al*. (2003) reported similar results, with physical activity (expressed as the PAL index) inversely associated with BF% ($r = -0.307$, $p = 0.001$). However, a stronger correlation was observed between the objectively assessed PAL and health indicators, compared to subjectively assessed PAL. Hagstromer *et al*. (2006), showed a weak correlation between PAL that was assessed by IPAQ and BMI ($r = 0.25$, $p<0.01$) and no correlation was observed between PAL and BF%. In contrast, studies that used an objective method to assess PAL showed stronger correlations ($r = -0.45$, $p = 0.001$; $r = -0.43$, $p = 0.002$, respectively) between the variables (Den Hoed and Westerterp, 2008; Abbott and Davies, 2004).

In terms of blood pressure, data from this study showed that respondents with lower diastolic blood pressure were more active than those with higher diastolic blood pressure. However, there was no association between systolic blood pressure and PAL. Several studies (Hu *et al*., 2004; Hagberg *et al*., 2000; Moreau *et al*., 2001) on PA engagement and hypertension showed similar associations between the two variables. According to Bacon *et al*. (2004), current leisure-time PAL was not correlated with hypertension; however, the benefits of PA may play a role in the prevention and treatment of high blood pressure. The association between PA and blood pressure could be influenced by age, as stronger associations were found among respondents younger than 40 years old (Kvaavik *et al*., 2009).

The association between blood profile and PAL showed that only HDLC had a significant relationship with PAL; those with higher HDLC levels were more likely to have higher PAL. Similar findings were reported by Byrd *et al*. (2008), who showed that HDLC levels increased significantly with during a three-year worksite wellness program ($p<0.05$). The present result for LDLC was also similar to Byrd *et al*. (2008) study, in which LDLC decreased with increasing PAL ($p<0.01$); however, the relationship was not significant in the present study. The study results for total cholesterol and triglyceride differed, which may be due to the smaller amount of data available in the present study as compared to the study by Byrd *et al*. (2008). Although the plasma glucose results from the present study were not significant, the trend was similar to that of several previous studies (Healy *et al*., 2007; Jeon *et al*., 2007). These studies found that an increase in inactivity was significantly correlated with higher 2 h plasma glucose level, while an increase in moderate-to-vigorous and light intensity physical activity was significantly correlated with lower 2 hr plasma glucose level.

According to Aadahl *et al*. (2007), PAL was inversely correlated with all-cause mortality, specifically cardiovascular morbidity and mortality; however, the relationship between PAL and other cardiovascular disease risk factors was not fully understood in terms of the dose-response relationship. In contrast, Weinsier *et al*. (2002) suggested that a PAL of 1.7 might be required to overcome weight regain problems in post-obese females, while Brooks *et al*. (2004) suggested that a PAL of more than 1.6 was required by most adults to maintain a BMI in the healthful range. The prevalence of inactivity detected in the present study was 55.1% and there were inverse associations between PAL and body composition and blood pressure. Therefore, health promotion and activities that encourage Malaysians to be active should be targeted, especially in the workplace setting.

The current study used an objective measure (accelerometer-determined) of PAL, which is more accurate than subjective measures. However, the result could be affected if the respondents changed their daily activities intentionally. Accelerometers do not provide qualitative data on the type of exercise or PA performed. Furthermore, the accuracy of the accelerometer is dependent on the type of exercise or PA performed. Studies have shown little concordance between accelerometry and energy expenditure during activities with static hip position, while the best concordance between accelerometry and energy expenditure was during walking and running activities (Jakicic *et al*., 1999; Trost *et al*., 1998).

A limitation of the study is the use of a convenience sampling of place (Kangar, Perlis), which did not represent all government employees in Malaysia. However, random sampling was used to select government agencies in Kangar Perlis. In addition, more respondents are needed in future studies to confirm the advantages of objective measures of PAL as compared to the subjective measures.

Conclusion: The assessment method for PAL should be addressed, as it contributes to the accuracy of the result obtained. The prevalence of inactivity in the present study was higher than available national data and stronger correlations were observed between the objectively assessed PAL and health indicators. A study with a larger sample size that uses objective methods of PA assessment should be carried out to confirm the results.

Competing interests: The authors declare that they have no competing interests.

ACKNOWLEDGEMENT

This study was funded by the National Institute of Health and Nutrition, Japan (NIHN) and the Ministry of Science, Technology and Innovations, Malaysia (MOSTI).

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