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Norsuhana Omar

Rozaziana Ahmad

Mohd Shahrulsalam Mohd Shah,

Department of Surgery, School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia.

Amilia Aminuddin

Department of Physiology, Faculty of Medicine, Universiti Kebangsaan Malaysia Medical Centre, Cheras, Kuala Lumpur, Malaysia

Kalaivani Chellappan

Department of Electrical, Electronic and Systems Engineering, Faculty of Engineering, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia

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Corresponding Author

Norsuhana Omar
E-mail: suhanakk@usm.my
Department of Physiology
School of Medical Sciences,
Universiti Sains Malaysia, Kubang Kerian,
Kelantan, Malaysia.
Telephone: +6097673000; +0139801287

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Norsuhana Omar[1], Rozaziana Ahmad[2], Mohd Shahrulsalam Mohd Shah[3], Amilia Aminuddin[4], & Kalaivani Chellappan[5]

[123]Department of Surgery, School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian, Kelantan, Malaysia.

[4]Department of Physiology, Faculty of Medicine, Universiti Kebangsaan Malaysia Medical Centre, Cheras, Kuala Lumpur, Malaysia

[5]Department of Electrical, Electronic and Systems Engineering, Faculty of Engineering, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia

ABSTRACT

Community-based health programmes at workplace involves planning, implementation and evaluation with the aim of empowering employees to gain control over their health. Brisk walking was a form of exercise that was acceptable to most people and may be integrated easily into daily routine. The aim of this study was to evaluate the improvement of cardiorespiratory fitness (CRF) through a pedometer-based walking programme at the workplace. A total of 70 young men who were sedentary, achieving less than 5,000 steps/day in casual walking with 2 or more cardiovascular risk factors were recruited. Subjects were randomly assigned to a control (CG) (n=34; no change in walking) and pedometer group (PG) (n=36; minimum target: 8,000 steps/day). Blood lipid profile, anthropometric and CRF were measured at baseline and after 12 weeks. At post intervention, the PG increased step count and results for lipid and anthropometrics variables were significantly improved for time and group effect ($p<0.001$). In PG, the CRF was significantly increased for time and effect ($p<0.01$) for VO_2peak from 31.54 ± 9.66 to 40.15 ± 9.55(ml/kg/min but no change in CG (31.46 ± 6.15 vs 31.60 ± 8.99 ml/kg/min). The walking programme improved health status in terms of improving biophysical profiles and cardiorespiratory fitness.

Keywords: *cardiorespiratory fitness, brisk walking, workplace programme, cardiovascular risks*

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INTRODUCTION

Cardiovascular disease (CVD) is the number one killer worldwide. CVD included two major categories which were vascular and heart diseases. Examples of vascular diseases: coronary artery disease, cerebrovascular disease, peripheral vascular disease and disease of aorta. Congenital heart disease, rheumatic heart disease, cardiomyopathy and cardiac arrhythmia are heart diseases (Khoo et al., 1991). Among the CVD, more than 50% are due to ischemic heart disease (IHD). Twenty-three per cent of these patients are less than 50 years. Most of the ACS cases involved men (Wan Ahmad & Sim, 2010). The increased in IHD prevalence may be due to increase in CVD risk factors such as dyslipidaemia, obesity, smoking, hypertension, diabetes mellitus and physical inactivity (Haskell et al., 2007).

Cardiorespiratory fitness (CRF) is also known as aerobic fitness or aerobic capacity and an important component of physical fitness as it reflects cardiovascular health (ACSM, 1995). The level of CRF was broadly associated with physical activity, lifestyle, sociodemography and health (Mahler, 1995). For instance, physical activity is a form of behaviour that results in increased CRF. Overall fitness, physical activity and health in turn, were influenced by heredity or genetic factors (Bouchard et al., 1994).

Assessment of CRF or aerobic fitness as measured by maximal or peak oxygen consumption (VO_{2max} or VO_{2peak}) would indicated one's physiological limitations and health status in terms of the risk of developing chronic diseases. A low level of CRF is associated with an increased risk of cardiovascular diseases and mortality in men (Bouchard et al., 1998; Laukkanen et al., 2001; Blair et al., 1981). The gold standard for assessing CRF is direct measurement of maximal oxygen consumption during maximal exercise. By definition, maximal oxygen consumption (VO_{2max}) was the maximum amount of oxygen an individual could take in and utilized to produce ATP aerobically while breathing air during heavy exercise. This procedure is important because exercise performed at a lower intensity would not differentiate between the fit and unfit (Talbot et al., 2002). Several physiological criteria can be used to decide whether results represent a maximal effort or VO_{2max}: a) lactate value greater than 8 mmol/L (Johnson et al., 1942; Aåstrand, 1956); b) a heart rate ± 12 b/min of

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predicted maximal heart rate of 220 – age (Hignett et al., 2000); c) a respiratory exchange ratio (RER) of 1.0 or 1.1, depending on the age of the subject (Durstine and Pate, 1988); and d) a plateau in oxygen consumption (Wilson, 1995). However, the plateau is not always evident especially among the sedentary, children and the elderly and hence in these cases the term *peak oxygen consumption* or VO_{2peak} to describe the highest value attained was the more appropriate term (Pollock et al., 2000; Howley et al., 1995).

The measurement of metabolic equivalents (MET) is another way to evaluate the energy consumption of an activity. Definition of MET is the energy consumption in units of ml/kg/min while sitting comfortably (McQuillan, 2007). For adults, one MET is approximately 3.5 ml oxygen (O_2) used per kilogram of body weight per minute.

Community-based health promotion programmes at workplace requires programme planning, implementation and evaluation with the aim of empowering employers to gain control over the determinants of health. Walking is a form of exercise that is very acceptable to many people and may be integrated easily into daily routine. In recent years, pedometers have been used widely in campaigns at national, community and worksite level to promote walking (Petersen et al., 2012; Ogilvie et al., 2007) Pedometers are simple to use, low-cost and demand less resources rather than previous traditional face-to-face approaches. Pedometers also give immediate feedback to the users and this self-monitoring method may help individuals to develop self-regulatory skills for behaviour change. It does not require specialized equipment or any formal training and can be undertaken in an individual's own locality and time. It may involve varying levels of exercise. The Centre for Disease Control and Prevention (CDC) and the American College of Sports Medicine (ACSM) also recommended adults 10,000 steps/day on most days of the week. These recommendations have been shown to promote and maintain health and significantly reduce the risk of coronary artery disease (CAD) (Haskell et al., 2007; Baker et al., 2008; O'Donovan et al., 2005).

Up to now, there is limited data on CRF among Malaysians with even less information on young men. Studies in Malaysia have reported aerobic fitness mainly among athletes (World Health Organization, 1999). There are gaps in evidence in relation to the effects of varying doses of exercise using pedometers as an adjunct to other interventions. In addition,

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pedometer-based health promotion is gaining in popularity but data on its role in intervention for health is lacking. Thus, the aim of the present study is to evaluate the improvement of blood lipid levels and CRF through a pedometer based walking programme at the workplace among young men.

METHODOLOGY

Subjects

This was an randomized controlled trial study. Subjects were recruited from Institute of Vocational Skills for Youth (IKBN Hulu Langat, Malaysia). Subjects were randomly assigned to two groups either a control (CG) or pedometer group (PG). The research was approved by the Research and Ethics Committee of Universiti Kebangsaan Malaysia (Ethical approval (FF-2014-139)). All measurements were done in Universiti Kebangsaan Malaysia Medical Center, Cheras and Physiology Department, Universiti Kebangsaan Malaysia Medical, Kuala Lumpur.

The inclusion criteria were young men aged 20-40 years old, sedentary lifestyle with less than 5000 steps per day and have 2 or more cardiovascular risk factors (cardiovascular high risk group) such as dyslipidemia, smoking, hypertension, abdominal obesity, and family history (FH) of CVD. Exclusion criteria were those with established diabetes mellitus and other chronic disease such as CVD, inflammatory disease, peripheral vascular disease, lung disease and liver disease. Women and adult subjects were excluded to prevent from get bias results since the body changes may differ either between men and women or young and adults people. Diabetes mellitus was excluded since this disease was equivalent to coronary artery disease (CAD), and subjects may have advanced vascular damage compared to other CV risk factors (Pollock et al., 2000). Criteria for young Malaysian males for various CV risk factors were observed as per reference given with each of the following: 1) Hypertension: systolic blood pressure ≥140 and / or diastolic ≥90 or on antihypertensive medication. 2) Diabetes mellitus: fasting plasma glucose ≥7mmol/L (Howley et al., 1995) 3). Smokers: a habit of daily smoking continued at the time of recruitment for study (Alberti et al., 2006). 4) Abdominal obesity: waist circumference >90 cm (Tudor-Locke et al., 2004). 5) Family history (FH) of premature CAD: when parents had CAD at <55 (father) or <65 (mother) of age (Sallis et al., 1986). 6) Dyslipidemia: when TC >6.2mmol/L, TG >1.7mmol/L, LDL >4.2mmol/L, or HDL <1.04mmol/L (McQuillan, 2007). In this study, a total of eligible 70 young men (20 - 40 years) who were sedentary, achieving less than 5,000 steps/day in casual walking with 2 or more cardiovascular risk factors were recruited.

Walking Workplace Intervention Programme

The protocol as well as the potential risks and benefits of participating in this programme were explained to each subject before written consent was given.

Once enrolled in the programme, subjects underwent a complete medical history and physical examination to ensure that they were deemed safe for the exercise intervention. During the initial phase, each subject was exposed to the self-monitoring pedometer programme which needs a full commitment from each subject. The subjects were informed that the programme involved a self-monitoring based pedometer intervention, and they were expected to give full commitment and must be mentally and physically prepared to go through the next phases.

In the first week of trial, the subjects were instructed to assess their average number of daily steps with a pedometer (Yamax Digi-Walker SW-200) for five days including four working and one non-working day. The average number of daily steps were used as the baseline for the further step goals. Subjects with less than 5000 steps per day would recruited in this programme. Subjects were divided randomly (Excel Microsoft 2007) into pedometer group (PG) and control group (CG).

The PG underwent a 4-week trial whereby subjects were required to gradually increase their walking by 1000 steps/day over 4 weeks. At the end of the trial phase, they should achieve a mean daily step count of 3000 steps/day above their baseline on at least 5 days of the week, so that a total minimum number of 8000 steps/day were needed before the start of the actual intervention phase.

Subsequently, those subjects assigned to the PG followed a 12-weeks pedometer-based walking programme (Bruce, 1971). The number of steps initiated by them from wake-up to bedtime every day (five days per week) were recorded in a standardised diary book provided to all PG members. Daily diet intakes were not recorded as dietary habits was not focussed in this study.

Subjects assigned to the CG were instructed to maintain their habitual lifestyle and not to change their activity throughout this programme.

There were two sessions of cardiovascular markers assessments: at baseline, and at 12-weeks intervention (post intervention).

Measurement of Body Anthropometry.

Height was measured by a wall-mounted stadiometer (SECA, Hamburg, Germany) and weight was measured by using a digital scale (SECA, Hamburg, Germany). Body mass index was then calculated as weight (kg)/height (m^2). Waist circumference was measured by a measuring tape on the horizontal plane, midway between the anterior superior iliac spine and lower rib after normal expiration (McQuillan, 2007).

Measurement of Blood Parameters.

About 5 ml of blood was withdrawn from the antecubital vein after fasting for a minimum of 8 hours. Blood samples were then sent to Gribbles pathology laboratory (Selangor, Malaysia) for further analysis of lipid profiles and glucose. The serum TG, HDL cholesterol, and TC were measured using enzymatic methods (Advia 2400 Chemistry Analyzer, Siemens, Tokyo, Japan). The blood glucose was measured by enzymatic method using hexokinase and glucose-6-phosphate dehydrogenase enzymes (Advia 2400 Chemistry Analyzer, Siemens, Tokyo, Japan). For lipids profile, the inter-assay coefficient of variant (CV) ranged from 1.4-3.5%. This laboratory obtained International Organization of Standardization (ISO: MS ISO 15189) in compliance with the standard quality.

Measurement of Aerobic Capacity ($VO_{2\ peak}$)

Measurement of peak oxygen consumption (VO_2) was performed in the laboratory exercise, Department of Physiology, PPUKM. The tests were conducted from 9.00am to 11.00am. The test required subjects walking or running on a treadmill Trackmaster ® TMX425C (Full Vision Inc. USA) while wearing a respiratory mask (Hans Rudolph Inc. USA), emitting X12 + ambulatory ECG (Mortara Instrument USA), heart rate transmitter Polar ® (Polar Electro Oy Finland) and KUF Tango ® BP (SunTech Medical Inc. USA). Blood pressure was monitored electronically every 3 minutes (Suntech 4240 Exercise BP monitor, USA). Arterial oxygen saturation was also monitored throughout the test (Nonin Pulse Oximeter 8600, USA) (Tudor-Locke & Myers, 2001).

Subjects were informed to avoid any strenuous physical activities for 24 hours prior to testing and to abstain from caffeine containing drinks and other drugs, 12 hours before the test and not to eat for at least 2 hours before testing to avoid the effects of food on myocardial oxygen demand and cardiac output. They were told to eat a light breakfast of 2 pieces of bread with jam and non-caffeinated drinks.

Prior to the test, subjects did 5 minutes of standardised stretching followed by 5 minutes of warm-up on the treadmill at the speed of 1.6 km/hr and 0% elevation or until he felt confident to proceed with the exercise protocol. Subjects then proceeded to perform a submaximal test using the Modified Bruce Protocol (Bruce, 1971) where speed and grade was increased every 3 minutes until they reached the stage whereby 85 % of their maximal heart rate (220-age) was attained (ACSM, 1995). Steady-state heart rate and the corresponding VO_2 of the subjects were taken at 3 levels of exercise including the last level at 85% of maximal heart rate. Once the targeted heart rate was achieved, the subjects were encouraged to maintain at this level for at least 1 minute before going into the recovery phase which was at the same speed and elevation as during the warm-up phase for 3 minutes. A linear regression equation was computed and used to extrapolate to 100% maximal heart rate to obtain VO_{2peak}e values. Subjects were monitored by a medical doctor throughout the test.

Oxygen consumption was determined using a metabolic cart (Parvomedic Trueone® 2400 Metabolic System-ousw 4.2cx) with an on-line computer assisted open circuit spirometry system. While the subjects performed an exercise test as described above, breath by breath respiratory gas analysis was monitored. O_2 and CO_2 analysers were calibrated prior to each test against known gas concentrations and the ventilation meter was calibrated at least once per day against a 3.0 L syringe.

Subjects are only allowed to leave the testing area when HR and BP returned to within 10% of baseline values (Bruce, 1971).

Statistical Analysis

A visual inspection of the histogram (plotted as the distribution frequencies) and acceptable level of skewness (-1 to 1) and kurtosis (-1 to 1) were used to determine the normality of the data. All the data were normally distributed. The differences in cardiovascular parameters between groups were compared by general linear model (GLM) repeated measures. The significant results were accepted as *p value* <0.05. All the data were analyzed using the Statistical Package for Social Sciences Version 20 (SPSS Inc., Chicago, IL, USA).

RESULTS

The subjects' characteristics for the whole and each group are summarized in Table 1. They were young males (n=70), with mean BP, WC, lipid profile, blood sugar and PWV within normal range except for Triglycerides level showed above normal. The prevalence of hypertension was 4.0%, abdominal obesity 51%, dyslipidemia 67%, smoker 74%, and FH of CAD 10%. None of them had diabetes mellitus or pre diabetes (6.1 mmol/L, <FBS <7mmol/L).

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Table 1: Subjects characteristics

Parameter	Pedometer Group (N=36)	Control Group (N=34)	p-value
Age (years)	26.17 ± 6.68	26.62 ± 7.39	0.94
Weight (kg)	73.32 ±18.47	68.94 ± 14.15	0.27
Height (m)	1.67± 0. 056	1.68 ± 0. 056	0.82
BMI (kg/m2)	26.13± 5.99	24.49± 4.54	0.20
Waist circumference (cm)	86.56± 15.09	83.75±14.01	0.42
SBP rest (mmHg)	120.22± 8.97	122.12±8.23	0.36
DBP rest (mmHg)	64.70± 8.84	67.52± 8.31	0.17
HR rest (bpm)	70.81±12.09	70.32± 14.20	0.88
Cholesterol level (mmol/L)	5.01± 0.80	5.10 ± 1.26	0.73
TG level (mmol/L)	1.81 ± 0.90	1.82±1.24	0.93
HDL level (mmol/L)	1.17± 0.17	1.18± 0.19	0.72
LDL level (mmol/L)	3.07±0.76	3.28± 1.04	0.31
FBG level (mmol/L)	4.94± 0.85	4.77± 0.42	0.29

*Data is presented as mean± SD
*P value < 0.05 is considered significant

Following intervention, the number of steps for PG significantly increased for time and group effect ($p<0.05$) for PG group from 4996 ± 805 steps/day to 10128 ± 511 steps/day. No change was seen in CG (pre; 4983 ± 366 : post; 5697 ± 407) steps/day (Table 2).

Table 2: Number of Steps Per Day Following Intervention

	Pedometer group (N=36)		Control group (N=34)	
	Week 1	Week 12	Week 1	Week 12
STEPS/DAY	4996 ± 805	10128 ± 511$^{**\#}$	4983 ± 366	5697 ± 407

*** $p < 0.01$ (Time*group interaction) # $p<0.05$ (time effect)*

In term of the physical parameters, after pedometer-based interventions for 12 weeks, the body weight and waist circumference were significantly decreased for PG (time and group effect, $p<0.05$). In addition, there was significant improvement in lipid profile in the PG (Table 3).

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Table 3: Changes in Characteristics of the Subjects Following Intervention

	Pedometer group (N=36)		Control group (N=34)	
	Week 1	Week 12	Week 1	Week 12
Weight (kg)	73.32± 18.47	71.35± 16.47**#	68.94± 14.15	69.69± 13.69
BMI (kg/m2)	26.13± 5.99	25.43± 5.27**#	24.49± 4.54	24.54± 4.57
Waist circumference (cm)	86.56± 15.09	83.62± 13.53**#	83.75±14.01	84.01± 13.11
SBP rest (mmHg)	120.22± 8.97	116.33± 9.62**#	122.12±8.23	118.71± 10.63
DBP rest (mmHg)	64.70± 8.84	63.83± 8.73*	67.52± 8.31	67.82± 6.68
HR rest (bpm)	70.81±12.09	66.89±10.83*	70.32± 14.20	71.23± 12.87
Total cholesterol (mmol/L)	5.01± 0.80	4.62± 1.08*	5.10 ± 1.26	5.29± 1.08
TG (mmol/L)	1.81 ± 0.90	1.16± 0.59**#	1.82±1.24	1.77± 1.31
HDL (mmol/L)	1.17± 0.17	1.29± 0.24**#	1.18± 0.19	1.16 ± 0.16
LDL (mmol/L)	3.07±0.76	2.87± 0.85*	3.28± 1.04	3.6± 1.35
FBG (mmol/L)	4.94± 0.85	4.84 ± 0.83	4.77± 0.42	4.68± 0.53

*p< 0.05 (Time*group interaction)
** p< 0.01 (Time*group interaction)
# p<0.05(time effect)

Table 4 depicts the mean VO_2 changes that was significantly improved in PG for time and group interaction (p<0.05). No changes were seen in CG.

Table 4: Changes in CRF of the Subjects Following Intervention

	Pedometer group (N=36)		Control Group (N=34)	
	Week 1	Week 12	Week 1	Week 12
VO2peak (ml/kg/min)	31.54± 9.67	40.15± 9.56**#	31.46± 6.15	31.60± 8.99
METs(min)	8.70± 2.57	11.44± 2.79**#	7.81± 1.43	7.96± 1.72
RER(min)	1.20± 0.09	1.42± 0.08**#	1.15±0.06	1.26± 0.09
Maximal HR (bpm)	169.83± 7.96	162.50± 11.49**#	166.83± 5.31	166.17± 7.06

** P value< 0.01 (Time*group interaction) # P value<0.05(time effect)

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DISCUSSION

The pedometer was a validated instrument to measure steps, and it encourages increased physical activity effecting health-related quality of life (O'Donovan et al., 2005). Pedometers allow ambulatory populations to track their steps, which influences motivation through goal-setting. The current study noted better compliance and more accumulated steps in the subjects treated with pedometers and a daily step-recording log. This study also provided additional data on these values among the urban men with cardiovascular risks working in an area near Kuala Lumpur.

In the present study, this study evaluated the efficacy of pedometer-based walking in reducing CVD risk factors. The results of our study suggest that exercise interventions decrease body weight, BMI, WC, total cholesterol, increase high-density lipoproteins (HDL), decrease low-density lipoproteins (LDL) and lower blood pressure. The current study did not produce significant changes in fasting blood glucose (FBG). The lack of changes in FBG in the current study may have been attributed due to baseline values that were in normal range. The blood lipid results from our study compliment prior studies that have shown that physical activity effectively increases HDL and decreases both LDL and total cholesterol. Leon and colleagues (2000) reported that 20 weeks (5 months) of supervised exercise significantly improved HDL by 3.6% (O'Donovan et al., 2005). This study showed a much larger 10% overall increase in HDL for PG. The higher HDL increased in the current study, may be attributed to: the 5 days' exercise vs. 3 times per week in the Leon et al (2000) study, to the self-selected exercise intensity in the current study, higher self-selected volume of exercise, gender or ethnicity. As opposed to this study, both genders were involved in Leon et al study.

Resting systolic blood pressure (SBP) decreased by 4 mmHg in this study that involved 3 months duration. Blumenthal and colleagues (2000) found a 4 mmHg SBP reduction after an aerobic exercise intervention for 6 months in 133 sedentary and overweight men and women (Tudor-Locke and Myers, 2001). Hypertension was a common CVD risk factor, and our results suggest that both exercise prescription and exercise prescription with pedometer-based interventions effectively lowered overall blood pressure which is consistent with prior studies. It is possible that our study observed greater changes in resting SBP due

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to the pedometer daily log, as the participants were asked to report their steps each day with a minimum report five days of the week. Therefore, the physical activity may have been increased in our study comparatively to other studies that only included fewer than five days per week of physical activity.

Association between Physical Activity Variables and CRF

The present study showed significant improvement of CRF in PG. Similar result was found for the same age group with similar activity profile, the mean BMI and VO_{2peak} values were similar in both studies despite ethnic and other differences. Sallis et.al (1986) reported that approximately 50 work-site programme have been evaluated in the past decade. Many of these seem to have an effective in achieving at least short-term improvements in various lifestyle and risk factors profiles, especially among risk factors individuals. Exercise usually has positive health outcomes for most people. Furthermore, if the physical activity is strenuous, done frequently and long enough in duration it may improve fitness as seen in people involved in hard labour (Sallis et.al., 1986).

CONCLUSION

A pedometer-based walking programme may be an effective strategy for promoting increased daily physical activity which improved CRF and lipid profile after 12 weeks and thus improve cardiovascular health. Findings from this study would provide future direction for community based physical activity. Physical health and work performance of the employee were directly related. Healthy work environment to help in improving productivity.

Authors' Contributions

NSO, MSMS, ROZ, AM, and KC draft data and wrote the article. All authors read and approved the final manuscript. All authors contributed to the manuscript.

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