

Improvement of Cardiorespiratory Fitness in Young men with Cardiovascular Risks Participating in Pedometer-based Workplace Programme

Norsuhana Omara^{1,2*}, Amilia Aminuddin¹, Zaiton Zakaria¹, Raifana Rosa Mohamad Sattar³, Kalaivani Chellappan³, Mohd Alauddin Mohd Ali³, Norizam Salam¹ and Nor Anita Megat Mohd. Nordin¹

¹Department of Physiology, Hospital Canselor Tuanku Mukhriz, Faculty of Medicine, Universiti Kebangsaan Malaysia, Cheras, 50600 KL, Malaysia

²Department of Physiology, Faculty of Medicine, Universiti Sains Malaysia, Kota Bharu, Kelantan, 16150, Malaysia

³Department of Electrical, Electronic and Systems Engineering, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Selangor, Bangi, 43650, Malaysia

*Corresponding author: Norsuhana Omara, Department of Physiology, Hospital Canselor Tuanku Mukhriz, Faculty of Medicine, Universiti Kebangsaan Malaysia, Cheras, 50600 KL, Malaysia, Tel: 013-9801287; E-mail: dmorsuhana@gmail.com

Received date: Apr 06, 2016; Accepted date: May 10, 2016; Published date: May 11, 2016

Copyright: © 2016 Omara N, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Abstract

Lack of exercise among Malaysians and the increasing cardiovascular disease morbidity and mortality among young men are of concern. In response to the wide use of pedometers, daily targets of 10,000 steps/day have been recommended. In Malaysia, data on workplace exercise intervention is scarce. A programme was designed to enable subjects to increase their level of walking as part of their daily work routine and self-monitored by using pedometers. 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 (20-40 years old) who were sedentary, achieving less than 5,000 steps/day in casual walking with 2 or more cardiovascular risk factors were recruited in IKBN Hulu Langat. 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 CG step counts were similar (4983 ± 366 vs 5697 ± 407 steps/day). The PG increased step count from 4996 ± 805 to 10,128 ± 511 steps/day (P<0.001). 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 VO₂ peak 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; Pedometer-based workplace programme and Young men

Introduction

Cardiovascular disease (CVD) is still the main cause of mortality in Malaysia [1]. According to the Health Indicator 2012, the MOH 2011 Hospitals' survey noted that there were 8,150 deaths due to heart diseases and diseases of pulmonary circulation followed by 5,590 cancer-related deaths and 4,162 deaths due to cerebrovascular disease. Among the CVD, more than 50% were due to ischemic heart disease (IHD). Twenty three per cent of these patients were less than 50 years. Most of the ACS cases involved men [2]. The increased in IHD prevalence may be due to increase in CVD risk factors such as dyslipidemia, obesity, smoking, hypertension, diabetes mellitus and physical inactivity [3].

Cardiorespiratory fitness (CRF) is also known as aerobic fitness or aerobic capacity and an important component of physical fitness as it reflects cardiovascular health [4]. The level of CRF is broadly associated with physical activity, lifestyle, sociodemography and health [5]. For instance, physical activity is a form of behaviour that results in increased CRF. Overall fitness, physical activity and health in turn, are influenced by heredity or genetic factors [6].

Assessment of CRF or aerobic fitness as measured by maximal or peak oxygen consumption (VO_{2max} or VO_{2peak}) would indicate 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 [7-9]. The gold standard for assessing CRF is direct measurement of maximal oxygen consumption during maximal exercise. By definition, maximal oxygen consumption (VO_{2max}) is the maximum amount of oxygen an individual can take in and utilise 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 [10]. 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 [11,12]; b) a heart rate ± 12 b/min of predicted maximal heart rate of 220-age [13]; c) a respiratory exchange ratio (RER) of 1.0 or 1.1, depending on the age of the subject [14]; and d) a plateau in oxygen consumption [15]. 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 VO₂ peak to describe the highest value attained is the more appropriate term [16,17].

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 [18]. For adults, one MET is approximately 3.5 ml oxygen (O₂) used per kilogram of body weight per minute.

Lifestyle modifications that include habitual physical activity have been shown to reduce CVD risk factors especially the modifiable risk factors. The National Institute for Health and Clinical Excellence (NICE), 2006 [19] recommended that every adult accumulates the recommended 30 minutes of moderate physical activity on five days of the week or to accumulate 150 minutes per week in at least ten minute bouts of sustained physical activity. Besides that the Centers 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 for CAD [20]. A 6 month moderate-intensity exercise, 30 minutes per day 3 times per week has been shown to sustain lowered LDL and triglyceride levels for up to 15 days post exercise training, and 30 minutes per day of vigorous exercise can increase plasma HDL cholesterol [21]. Leon and colleagues (2000) [22] found that an acute bout of aerobic exercise can significantly reduce plasma triglycerides for 24 to 48 hours, consistent with the previous research. In addition, those who are fit and yet have other risk factors for cardiovascular disease may be at lower risk of premature death than those who are sedentary with no risk factors [23].

Walking is a type of exercise that is well 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. Pedometers are simple to use, low-cost needed, and demand less staff resources rather than previous traditional face-to-face approaches. Pedometers also give immediate feedback to the users and this self-monitoring may help individuals to develop self-regulatory skills for behavior change and be a powerful behavior change technique. It does not require specialist equipment or any formal training and can be undertaken in an individual's own locality and time. It may involve variable levels of exercise. However, NICE indicates that there is currently insufficient evidence to recommend the promotion of organised walking schemes, and that the effects of low levels of exercise are poorly documented.

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 [24,25]. 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, 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 cardiorespiratory fitness (CRF) through a pedometer based walking programme at the workplace among young men.

Methodology

Subjects

This was a randomized controlled trial study. Subjects were recruited from Institute of Vocational Skills for Youth (IKBN Hulu Langat). 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. 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 adults 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 is equivalent to coronary artery disease (CAD), and subjects may have advanced vascular damage compared to other CV risk factors [16]. Criteria for young Malaysian males for various CV risk factors was 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 ≥ 7 mmol/L [17]. 3) Smokers: a habit of daily smoking continued at the time of recruitment for study [26]. 4) Abdominal obesity: waist circumference >90 cm [27]. 5) Family history (FH) of premature CAD: when parents had CAD at <55 (father) or <65 (mother) of age [28]. 6) Dyslipidemia: when TC >6.2 mmol/L, TG >1.7 mmol/L, LDL >4.2 mmol/L, or HDL <1.04 mmol/L [18]. 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.

Pedometer-based workplace 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 program, 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 will be 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 is used as the baseline for the further step goals. Subjects with less than 5000 steps per day will be 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 is needed before the start of the actual intervention phase.

Subsequently, those subjects assigned to the PG followed a 12 week pedometer-based walking programme [29]. The number of steps initiated by them from wake-up to bed time every day (five days per week) were recorded in a standardised diary book provided to all PG

members. Daily diet intakes was 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 (m²). 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 [18].

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 (VO₂ peak)

Measurement of peak oxygen consumption (VO₂) was performed in the laboratory exercise, Department of Physiology, PPUKM. The tests were conducted from 9.00 am to 11.00 am. The test requires 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) [30,31].

Subjects were informed to avoid any strenuous physical activity 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 [32]. 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 [33] 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 VO₂ 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 VO₂ peak 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. O₂ and CO₂ 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 [32].

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).

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. 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 2).

Table 3 depicts the mean VO₂ changes that was significantly improved in PG for time and group interaction (p<0.05). No changes were seen in CG.

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/m ²)	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
Triglyceride level (TG) (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
Fasting Blood Glucose (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.			

Table 1: Subjects characteristics.

	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	5.01 ± 0.80	4.62 ± 1.08*	5.10 ± 1.26	5.29 ± 1.08
TG	1.81 ± 0.90	1.16 ± 0.59**#	1.82 ± 1.24	1.77 ± 1.31
HDL	1.17 ± 0.17	1.29 ± 0.24**#	1.18 ± 0.19	1.16 ± 0.16
LDL	3.07 ± 0.76	2.87 ± 0.85*	3.28 ± 1.04	3.6 ± 1.35
FBS	4.94 ± 0.85	4.84 ± 0.83	4.77 ± 0.42	4.68 ± 0.53
*P value<0.05 (Time*group interaction); ** P value<0.01 (Time*group interaction); # P value <0.05(time effect).				

Table 2: Changes in characteristics of the subjects following intervention.

	Pedometer group (N=12)		Control Group (N=12)	
	Week 1	Week 12	Week 1	Week 12
VO₂ peak (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).				

Table 3: Changes in CRF of the subjects following intervention.

Discussion

The pedometer is a validated instrument to measure steps, and it encourages increased physical activity effecting health-related quality of life [34]. 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, we 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% [22]. Our study showed a much larger 10% overall increase in HDL for PG. The higher HDL increase in the current study, may be attributed to: the 5 days exercise vs. 3 times per week in the Leon et al. 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 our 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 [35]. Hypertension is 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 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 VO₂ peak values were similar in both studies despite ethnic and other differences [36]. 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 [37].

Limitation of the study

The findings were restricted to young men, and not applicable to females or older aged groups.

Conclusion

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

Acknowledgment

We would like to thank the Ministry of Higher Education and UKM for providing financial aid in terms of KTP Grants (PHUM-2013) and Ethical approval (FF-2014-139), En. Abdul Ghani b. Mansur, subjects who generously participated in this study and staff of Physiology Department PPUKM.

References

1. Khoo KL, Tan H, Khoo TH (1991) Cardiovascular mortality in Peninsular Malaysia: 1950-1989. *Med J Malaysia* 46: 7-20.
2. Wan Ahmad WA, Sim KH (2010) Annual Report of the NCVD-ACS Registry, Year 2007 and 2008. Kuala Lumpur, Malaysia: National Cardiovascular Disease Database.
3. Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, et al. (2007) Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation* 116: 1081-1093.
4. ACSM (1995) American College of Sports Medicine. Guidelines for Exercise Testing and Prescription. (5th edn.) Philadelphia, Pa: Lea and Febiger.
5. ACSM (2005) American College of Sports Medicine. Guidelines for Exercise Testing and Prescription. (7th edn.) Philadelphia, Pa: Lippincott, Williams & Wilkins.
6. Bouchard C, Shephard RJ (1994) Physical activity, fitness and health: the model and key concepts. In: Bouchard C, Shepard R and Stephens T (edn) *Physical Activity, Fitness and Health. International proceedings and consensus statement.* Champaign, IL: Human Kinetics, pp. 77-88.
7. Bouchard C, Daw EW, Rice T, Pérusse L, Gagnon J, et al. (1998) Familial resemblance for VO₂max in the sedentary state: the HERITAGE family study. *Med Sci Sports Exerc* 30: 252-258.
8. Laukkanen JA, Lakka TA, Rauramaa R, Kuhanen R, Venäläinen JM, et al. (2001) Cardiovascular fitness as a predictor of mortality in men. *Arch Intern Med* 161: 825-831.
9. Blair SN, Ellsworth NM, Haskell WL, Stern MP, Farquhar JW, et al. (1981) Comparison of nutrient intake in middle-aged men and women runners and controls. *Med Sci Sports Exerc* 13: 310-315.
10. Talbot LA, Morrell CH, Metter EJ, Fleg JL (2002) Comparison of cardiorespiratory fitness versus leisure time physical activity as predictors of coronary events in men aged <or = 65 years and >65 years. *Am J Cardiol* 89: 1187-1192.
11. Johnson RE, Brouha L, Darling RC (1942) A test of physical fitness for strenuous exertion. *Rev Canad Biol* 1: 491-504.
12. Astrand PO (1956) Human physical fitness with special reference to sex and age. *Physiol Rev* 36: 307-335.
13. Astrand PO, Rodahl K (1977) *Textbook of work physiology: Physiological of exercise.* McGraw-Hill, New York, USA.
14. Durstine JL, Pate RR (1988) Cardiorespiratory responses to acute exercise. In: Blair SN, Palmer P, Pate RR, Smith LK, Taylor CB (edn.) *Resource manual for guidelines for exercise testing and prescription,* Philadelphia: Lea and Febiger pp. 38-54.
15. Holly RG (1988) Measurement of the maximal rate of oxygen uptake. In: Blair SN, Palmer P, Pate RR, Smith LK, Taylor CB (edn.). *Resource manual for guidelines for exercise testing and prescription,* Philadelphia: Lea & Febiger, pp. 171-177.
16. ACSM (2000) American College of Sports Medicine. *Guidelines for graded exercise testing and exercise prescription,* (6th edn.) Baltimore: Williams & Wilkins.
17. Howley ET, Bassett DR Jr, Welch HG (1995) Criteria for maximal oxygen uptake: review and commentary. *Med Sci Sports Exerc* 27: 1292-1301.
18. MacDougall JD, Wenger HA, Green HJ (1982) *Physiological testing for the elite athlete* (1st edn.). Hamilton, Ontario Canadian Association of sport sciences, Mutual Press Limited.
19. Ainsworth BE, Haskell WL, Leon AS, Jacobs DR Jr, Montoye HJ, et al. (1993) Compendium of physical activities: classification of energy costs of human physical activities. *Med Sci Sports Exerc* 25: 71-80.
20. (2006) A rapid review of the effectiveness of pedometer interventions to promote physical activity in adults. National Institute for Health and Clinical Excellence (NICE), London, UK.
21. Slentz CA, Houmard JA, Johnson JL, Bateman LA, Tanner CJ, et al. (2007) Inactivity, exercise training and detraining, and plasma lipoproteins. STRRIDE: a randomized, controlled study of exercise intensity and amount. *J Appl Physiol* 103: 432-442.
22. Leon AS, Rice T, Mandel S, Després JP, Bergeron J, et al. (2000) Blood Lipid Response to 20 Weeks of Supervised Exercise in a Large Biracial Population: The HERITAGE Family Study. *Metabolism* 49: 513-520.
23. Blair SN, Horton E, Leon AS, Lee IM, Drinkwater BL, et al. (1996) Physical activity, nutrition, and chronic disease. *Med Sci Sports Exerc* 28: 335-349.
24. Singh R, Singh HJ, Sirisinghe RG (1995) Physical and physiological profiles of Malaysian dragon boat rowers. *Br J Sports Med* 29: 13-15.
25. Zawawi AZ (1999) The construction of a human calorimeter for the metabolic predisposition to obesity among adults: an initial study. Masters thesis. Universiti Kebangsaan Malaysia
26. Stone NJ, Bilek S, Rosenbaum S (2005) Recent National Cholesterol Education Program Adult Treatment Panel III update: adjustments and options. *Am J Cardiol* 96: 53E-59E.
27. Alberti KG, Zimmet PZ (1998) Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus provisional report of a WHO consultation. *Diabet Med* 15: 539-553.
28. Alberti KG, Zimmet P, Shaw J (2006) Metabolic syndrome--a new worldwide definition. A Consensus Statement from the International Diabetes Federation. *Diabet Med* 23: 469-480.
29. Tudor-Locke C, Williams JE, Reis JP, Pluto D (2004) Utility of Pedometers for Assessing Physical Activity. *Sports Med* 34: 281-291.
30. Garrard CS, Emmons C (1986) The reproducibility of the respiratory responses to maximum exercise. *Respiration* 49: 94-100.
31. Powell KE, Thompson PD, Caspersen CJ, Kendrick JS (1987) Physical activity and the incidence of coronary heart disease. *Annu Rev Public Health* 8: 253-287.
32. Dean E (1996) Mobilization and exercise. In: Frownfelter D, Dean E (3rd edn.) *Principles and Practice of Cardiopulmonary Physical Therapy,* Mosby pp. 265-298.

-
33. Bruce RA (1971) Exercise testing of patients with coronary heart disease. Principles and normal standards for evaluation. *Ann Clin Res* 3: 323-332.
 34. Tudor-Locke CE, Myers AM (2001) Challenges and opportunities for measuring physical activity in sedentary adults. *Sports Med* 31: 91-100.
 35. Blumenthal JA, Sherwood A, Gullette EC, Babyak M, Waugh R, et al. (2000) Exercise and weight loss reduce blood pressure in men and women with mild hypertension: effects on cardiovascular, metabolic, and hemodynamic functioning. *Arch Intern Med* 160: 1947-1958.
 36. Sallis JF, Haskell WL, Fortmann SP, Vranizan KM, Taylor CB, et al. (1986) Predictors of adoption and maintenance of physical activity in a community sample. *Prev Med* 15: 331-341.
 37. Collins K (1982) Energy expenditure, productivity and endemic disease. In: Harrison GA (edn.) *Energy and effort*, London: Taylor and Francis pp. 65-84.