Public Health Nutrition: 16(9), 1684–1692 doi:10.1017/S1368980012003990

Physical activity patterns and correlates among adults from a developing country: the Sri Lanka Diabetes and Cardiovascular Study

Prasad Katulanda[1,2,*], Ranil Jayawardana[1,3], Priyanga Ranasinghe[1,4], MH Rezvi Sheriff[1] and David R Matthews[2]

[1]Diabetes Research Unit, Department of Clinical Medicine, Faculty of Medicine, University of Colombo, Kynsey Road, Colombo, Sri Lanka: [2]Oxford Centre for Diabetes, Endocrinology and Metabolism, University of Oxford, Oxford, UK: [3]Institute of Health and Biomedical Innovation, Queensland University of Technology, Brisbane, Queensland, Australia: [4]Department of Pharmacology, Faculty of Medicine, University of Colombo, Colombo, Sri Lanka

Submitted 7 March 2012: Final revision received 6 June 2012: Accepted 16 July 2012: First published online 20 September 2012

Abstract

Objective: To evaluate patterns of physical activity (PA), the prevalence of physical inactivity and the relationships between PA and sociodemographic, clinical and biochemical parameters among Sri Lankan adults.
Design: Descriptive cross-sectional study.
Setting: Nationally representative population-based survey conducted in Sri Lanka.
Subjects: Data on PA and associated details were obtained from 5000 adults. PA was assessed using the International Physical Activity Questionnaire (short-form). A binary logistic regression analysis was performed using the dichotomous variable 'health-enhancing PA' (0 = 'active', 1 = 'inactive').
Results: Sample size was 4485. Mean age was 46·1 (SD 15·1) years, 39·5 % were males. The mean weekly total MET (metabolic equivalents of task) minutes of PA among the study population was 4703 (SD 4369). Males (5464 (SD 5452)) had a significantly higher weekly total MET minutes than females (4205 (SD 3394); $P<0·001$). Rural adults (5175 (SD 4583)) were significantly more active than urban adults (2956 (SD 2847); $P<0·001$). Tamils had the highest mean weekly total MET minutes among ethnicities. Those with tertiary education had lowest mean weekly total MET minutes. In all adults 60·0 % were in the 'highly active' category, while only 11·0 % were 'inactive' (males 14·6 %, females 8·7 %; $P<0·001$). Of the 'highly active' adults, 85·8 % were residing in rural areas. Results of the binary logistic regression analysis indicated that female gender (OR = 2·1), age >70 years (OR = 3·8), urban living (OR = 2·5), Muslim ethnicity (OR = 2·7), tertiary education (OR = 3·6), obesity (OR = 1·8), diabetes (OR = 1·6), hypertension (OR = 1·2) and metabolic syndrome (OR = 1·3) were all associated with significantly increased odds of being physically 'inactive'.
Conclusions: The majority of Sri Lankan adults were 'highly active' physically. Female gender, older age, urban living, Muslim ethnicity and tertiary education were all significant predictors of physical inactivity. Physical inactivity was associated with obesity, diabetes, hypertension and metabolic syndrome.

Keywords
Physical activity
Sri Lanka
Adults
Non-communicable diseases

Physical inactivity has been identified as the fourth leading risk factor for overall mortality (6 % of annual deaths globally) and the eleventh risk factor for percentage of disability-adjusted life years[1,2]. It is estimated that physical inactivity is responsible for approximately 3·2 million deaths and 32·1 million disability-adjusted life years globally per annum (representing about 2·1 % of overall disability-adjusted life years)[2]. Epidemiological studies suggest that physical activity (PA) reduces the risk of type 2 diabetes and CHD by about 30–50 %[3]. In addition, quantitative estimates indicate that sedentary living is responsible for about one-third of deaths due to CHD and type 2 diabetes, diseases for which physical inactivity is an established risk factor[4,5]. Furthermore, PA helps to improve musculoskeletal health, control body weight and reduce symptoms of depression[2]. Physical inactivity levels are rising in many countries with major implications for the prevalence of non-communicable diseases (NCD) and the general health of populations worldwide[1]. Studies have shown that even a small increase in

*Corresponding author: Email pkatulanda@yahoo.com

community PA practices can reduce mortality from NCD by as much as 5–6 % or 30 000–35 000 deaths per annum[6].

Sri Lanka is a middle-income developing country in South Asia with a population of over 20 million. The prevalences of NCD such as type 2 diabetes, hypertension, CHD and cerebrovascular disease have reached epidemic levels in Sri Lanka. In 2005, the prevalences of hypertension and type 2 diabetes were nearly 20 % and 11 %, respectively, while a fifth of the adult population was suffering from dysglycaemia (diabetes and pre-diabetes)[7,8]. In addition, according to South-Asian cut-off values, the prevalences of overweight (25·2 %) and obesity (9·2 %) were at very high levels among the adult population[9]. Childhood obesity and associated metabolic consequences are also rapidly growing problems in Sri Lanka[10]. CHD (10·6 %) and cerebrovascular disease (9·3 %) are two of the leading causes of death in the country (by percentage of the total mortality for 2000)[11]. In addition to increased mortality, these diseases are also associated with a host of life-threatening and potentially disabling group of complications. Hence, besides the direct excess health-care expenditure, there is also a much larger economic burden in the form of lost productivity as a result of restricted daily activity, reduced work efficiency, premature mortality and permanent disability.

NCD are caused to a large extent by four modifiable behavioural risk factors that are pervasive aspects of economic transition, rapid urbanization and 21st-century lifestyles: tobacco use, unhealthy diet, insufficient PA and the harmful use of alcohol[12]. The greatest effects of these risk factors fall increasingly on low- to middle-income countries[12]. Hence, controlling these modifiable risk factors at the population level is recognized as one of the main strategies to combat the NCD epidemic. Therefore, measuring PA levels in a population is a vital preliminary step towards NCD prevention and it is an important public health priority.

PA is a complex human behaviour and is relatively difficult to assess due to variations in PA types across age groups, genders and different cultures. A range of objective measures are available to evaluate PA and/or energy expenditure, including the doubly labelled water technique, physiological monitoring of heart rate or motion sensors such as accelerometers, which have several advantages over proxy methods of PA assessment, such as reducing the bias from poor memory and over- and under-reporting[13]. However, limitations such as the cost of high-quality monitors and the burden placed on participants and researchers have curtailed the widespread use of these objective measures for population-level surveillance. Hence self-reported surveys of PA based on various validated PA questionnaires are the most commonly used method worldwide for PA assessment due to their simplicity, practicality and cost-effectiveness[13]. Several PA questionnaires are available, among which the International Physical Activity Questionnaire (IPAQ) is the most widely used[14]. The IPAQ has been validated in many countries including Sri Lanka[15].

The present study aimed to evaluate patterns of PA and the prevalence of physical inactivity among Sri Lankan adults. The study also investigated the relationships between PA and sociodemographic, clinical and biochemical parameters, and additionally evaluated the relationship between PA levels and NCD prevalence.

Experimental methods

Study population and sampling

Data on PA and its associated details were obtained from the Sri Lanka Diabetes and Cardiovascular Study (SLDCS). This population-based cross-sectional study was conducted in seven of the nine provinces in Sri Lanka between August 2005 and September 2006. The war-affected Northern and Eastern provinces of the country were excluded from the study. The total sampling frame was approximately 14 million adults aged ≥18 years living in 12 018 'village officer' units (the smallest government administrative unit). The sample sizes for individual provinces and the rural and the urban sectors in each province were determined using a probability-proportional-to-size technique. Detailed sampling has been reported previously[7]. Relevant data from the nationally representative sample of 5000 non-institutionalized adults aged ≥18 years are presented here.

Measurements

Data collection was carried out by a field team of medical graduates and nurses who were trained in the research methodology prior to commencement of data collection. PA during the past week was assessed using the short version of the IPAQ administered by an interviewer[14]. The IPAQ was administered by a minimum number of trained interviewers who were competent in both Sinhalese and Tamil, the two native languages in Sri Lanka. The data collectors were initially trained by the study team on uniformly administering the questionnaire using the native languages. The data collectors were regularly trained and assessed on their IPAQ administration techniques to ensure consistency over time. The short-form IPAQ allows categorical and continuous measurements of PA. The continuous score allows the estimation of the weekly energy expenditure expressed in weekly MET minutes or MET-min/week (MET = metabolic equivalents of task)[16]. This is obtained by multiplying the value of energy expenditure for the given PA in MET by the weekly frequency (d/week) and the time in minutes (min/d). The categorical score classifies individuals into three categories: 'inactive', 'moderately active' and 'highly active'[14]. The 'inactive' category includes those who do not perform any PA and those reporting some activity, but not enough to meet other categories. The patterns of activity to be classified as 'moderately active' comprise the following criteria: (i) ≥3 d of vigorous-intensity activity of at least 20 min/d or (ii) ≥5 d of moderate-intensity activity and/or walking of at least 30 min/d or (iii) ≥5 d of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum total PA of at least 600 MET-min/week. Individuals meeting at least one of the above criteria would be defined as accumulating a minimum level of activity and therefore be classified as 'moderately active'. The two criteria for classification as 'highly active' are: (i) vigorous-intensity activity on ≥3 d achieving a minimum total PA of at least 1500 MET-min/week or (ii) ≥7 d of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum total PA of at least 3000 MET-min/week.

Details of anthropometric measurements, clinical assessment, blood sample collection and biochemical analysis are described elsewhere[7]. An interviewer-administered questionnaire was used to obtain sociodemographic details such as age, gender, area of residence, ethnicity, level of education and household income. Urban and rural sectors were defined according to the classification of the Sri Lanka Department of Census and Statistics, where the urban sector comprised all municipal and urban council areas (21% of Sri Lankans are urban)[17]. The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Ethics Review Committee of the Faculty of Medicine, University of Colombo, Sri Lanka. Written informed consent was obtained from all participants.

Definitions

Obesity was defined as BMI ≥ 25·0 kg/m^2, overweight as BMI = 23·0–24·9 kg/m^2, normal weight as BMI = 18·5–22·9 kg/m^2 and underweight as BMI < 18·5 kg/m^2, the cut-off values recommended for Asian Indians[18]. Central obesity was classified as waist circumference >90 cm for males and >80 cm for females, the cut-offs recommended by the WHO for Asians[19]. Hypertension was defined as systolic blood pressure >130 mmHg and/or diastolic blood pressure >85 mmHg and/or being on antihypertensive treatment. Hypercholestrolaemia was defined as serum total cholesterol ≥240 mg/dl. Participants were considered to have 'diagnosed diabetes' if they had been previously diagnosed at a government hospital or by a registered medical practitioner. Verification was by review of previous medical records, laboratory reports or prescriptions. New cases ('undiagnosed diabetes') were diagnosed according to the American Diabetes Association and WHO criteria, when fasting plasma glucose ≥7·0 mmol/l or 2 h post-OGTT plasma glucose ≥11·1 mmol/l. Impaired glucose tolerance was diagnosed when 2 h post-OGTT plasma glucose ≥7·8 mmol/l but <11·1 mmol/l (OGTT = oral glucose tolerance test). Impaired fasting glucose was diagnosed when fasting plasma glucose ≥5·6 mmol/l but <7·0 mmol/l. Metabolic syndrome was diagnosed according to the International Diabetes Federation criteria[20].

Statistical analyses

All data were double-entered and cross-checked for consistency. Data were analysed using SPSS version 14 and Stata/SE 10·0 statistical software packages. The significance of the differences between proportions (%) and means was tested using the Z test and Student's t test or ANOVA respectively, and Fisher's Least Significant Difference test was used for *post hoc* analysis.

A binary logistic regression analysis was performed using the dichotomous variable 'health-enhancing PA' (0 = 'active', 1 = 'inactive'). The 'active' group included those who were 'moderately active' and 'highly active' in the IPAQ categorical scoring system, while the remaining participants were classified into the 'inactive' group. A stepwise forward entry method was used to enter the variables. The independent covariables (reference category) included in the binary logistic regression analysis were: gender (0 = 'male'), age category (0 = '<30 years'), area of residence (0 = 'rural'), ethnicity (0 = 'Tamil'), level of education (0 = 'no formal education'), BMI category (0 = '<18·5 kg/m^2'), central obesity (0 = 'no central obesity'), cholesterol (0 = 'normal total cholesterol'), pre-diabetes (0 = 'no pre-diabetes'), diabetes (0 = 'no diabetes'), hypertension (0 = 'no hypertension') and metabolic syndrome (0 = 'no metabolic syndrome'). For each independent variable with more than two categories, dummy variables were created. The first category was taken as the reference category. A similar binary logistic regression analysis with the above dependent and independent variables was also performed separately for both males and females. In all statistical analyses P values <0·05 were considered significant.

Results

Sample size was 4485 (response rate of 89·7%), 39·5% (*n* 1772) were males and 17·6% (*n* 789) were residing in urban areas. Mean age was 46·1 (SD 15·1) years. The majority of the study population were Sinhalese in ethnicity (*n* 3877, 86·4%), educated up to grade 6–11 in school (*n* 1665, 37·1%), unemployed (*n* 2359, 52·6%) and had household income <7000 Sri Lankan rupees/month (*n* 2453, 54·7%). The age- and sex-adjusted prevalences of diabetes, impaired glucose tolerance and impaired fasting glucose were 10·3% (males 9·8%, females 10·9%), 5·4% (males 4·2%, females 6·5%) and 4·4% (males 5·6%, females 3·1%), respectively. Central obesity was present in 26·2% (males 16·5%, females 36·3%), while 25·2% (males 22·6%, females 28·0%) were obese according to BMI cut-off values.

The mean weekly total MET minutes of PA in the study population was 4703 (SD 4369). Males (5464 (SD 5452)) had a significantly higher mean weekly total MET minutes than females (4205 (SD 3394); $P<0{\cdot}001$). As shown in Table 1, rural adults were significantly more physically active than their urban counterparts ($P<0{\cdot}001$). Rural males had significantly higher mean weekly total MET minutes than rural females; however, there was no significant difference observed between urban males and females (Table 1). The highest weekly mean total MET minutes in all adults, males and females were observed in the age category 40–49 years; this was significantly higher than in other age categories in all adults, males and females ($P<0{\cdot}001$), except for age category 30–39 years. Except in those >70 years old, in all age categories males had a significantly higher weekly mean total MET minutes than their female counterparts (Table 1). In all adults, males and females, Tamils had a significantly higher mean weekly total MET minutes than other ethnicities ($P<0{\cdot}001$; Table 1). Among different levels of education, those with tertiary education (graduate/postgraduate) had the lowest mean weekly total MET minutes, which was significantly lower than for all other levels of education ($P<0{\cdot}001$; Table 1). Patients with diabetes and hypertension had significantly lower mean weekly total MET minutes in comparison to others in all adults as well as both genders ($P<0{\cdot}001$; Table 1). Similarly, those with central obesity and in higher BMI categories had lower levels of PA as measured by weekly mean total MET minutes (Table 1).

There was a significant negative correlation between weekly total MET minutes and clinical parameters such as weight, BMI, waist circumference, hip circumference, waist-to-hip ratio, systolic blood pressure and diastolic blood pressure in all adults, males and females (all $P<0{\cdot}001$; Table 2). A similar negative correlation was also observed for biochemical parameters such as fasting blood glucose, 2 h postprandial blood glucose, total cholesterol, LDL cholesterol and TAG (all $P<0{\cdot}001$; Table 2). A significant positive correlation between weekly

Table 1 Mean weekly total MET minutes of PA and its associations in all adults, males and females: Sri Lanka Diabetes and Cardiovascular Study (SLDCS), 2005–2006

	Mean weekly total MET minutes						
	All		Males		Females		
	Mean	SD	Mean	SD	Mean	SD	*P* value†
Area of residence							
Urban (*n* 3696)	2956[a]	2847	3152[a]	3328	2835[a]	2502	NS
Rural (*n* 789)	5175[a]	4583	6060[a]	5727	4588[a]	3511	<0·001
Age category							
<30 years (*n* 740)	4594	4199	5571	5427	3881	2802	<0·001
30–39 years (*n* 887)	5164	4518	6059	5772	4626	3454	<0·001
40–49 years (*n* 1090)	5392	4785	6170	5880	4908	3880	<0·001
50–59 years (*n* 896)	4856	4109	5658	5008	4348	3329	<0·001
60–69 years (*n* 537)	3998	3954	4886	5024	3418	2929	<0·001
>70 years (*n* 335)	2199	2966	2323	3751	2099	2133	NS
Ethnicity							
Sinhalese (*n* 3877)	4730[a]	4306	5446[a]	5414	4268[a]	3325	<0·001
Tamil (*n* 299)	6279[a]	5423	7476[a]	6003	5307[a]	4700	<0·01
Muslim (*n* 298)	2874[a]	3224	3453[a]	4438	2515[a]	2090	<0·05
Level of education							
No formal education (*n* 267)	5279	5376	5940	6094	5103[a,b]	5170	NS
Primary education (*n* 809)	5284[a]	5004	6844[a]	6246	4335[a]	3770	<0·001
Secondary education (*n* 3379)	4608[a]	4127	5309[a]	5252	4128[b]	3038	<0·001
Tertiary education (*n* 129)	2248[a]	2297	2284[a]	2655	2197[a]	1678	NS
Diabetes							
Absent (*n* 3949)	4929[a]	4467	5808[a]	5579	4347[a]	3424	<0·001
Present (*n* 536)	3037[a]	3095	2766[a]	3240	3198[a]	2998	NS
Hypertension							
Absent (*n* 3266)	5107[a]	4555	6021[a]	5647	4507[a]	3540	<0·001
Present (*n* 1219)	3627[a]	3600	3969[a]	4572	3407[a]	2784	<0·01
Central obesity							
Absent (*n* 3127)	5213[a]	4652	5885[a]	5549	4608[a]	3555	<0·001
Present (*n* 1358)	3527[a]	3350	3313[a]	4331	3585[a]	3029	NS
BMI category							
<18·5 kg/m^2 (*n* 852)	5466[a]	4903	6479[a]	5772	4671[a]	3921	<0·001
18·5–22·9 kg/m^2 (*n* 2043)	4934[a]	4453	5701[b]	5406	4331[b]	3413	<0·001
23·0–24·9 kg/m^2 (*n* 1142)	4453[a]	3935	4967[a,b]	5247	4156[a]	2887	<0·05
≥25·0 kg/m^2 (*n* 4475)	3606[a]	3569	3438[a,b]	4623	3668[a,b]	3072	NS

MET, metabolic equivalents of task; PA, physical activity.
[a,b]Mean values within a column with the same superscript letter under each variable were significantly different ($P<0{\cdot}01$).
†*P* values for males *v.* females.

Table 2 Correlation between mean weekly total MET minutes of PA and clinical/biochemical parameters in all adults, males and females: Sri Lanka Diabetes and Cardiovascular Study (SLDCS), 2005–2006

	Correlation coefficient		
	All adults	Males	Females
Clinical parameter			
Weight	−0·092***	−0·177***	−0·088***
BMI	−0·159***	−0·191***	−0·117***
Waist circumference	−0·195***	−0·247***	−0·182***
Hip circumference	−0·202***	−0·240***	−0·162***
Waist-to-hip ratio	−0·095***	−0·161***	−0·114***
Systolic blood pressure	−0·120***	−0·145***	−0·127***
Diastolic blood pressure	−0·101***	−0·122***	−0·087***
Biochemical parameter			
Fasting blood glucose	−0·085***	−0·118***	−0·061***
2 h Postprandial blood glucose	−0·118***	−0·163***	−0·043***
Total cholesterol	−0·087***	−0·107***	−0·049***
LDL cholesterol	−0·074***	−0·100***	−0·026***
HDL cholesterol	0·004	0·051***	0·005
TAG	−0·075***	−0·097***	−0·096***

MET, metabolic equivalents of task; PA, physical activity.
***$P < 0·001$.

Table 3 Mean values of clinical and biochemical parameters according to PA level: Sri Lanka Diabetes and Cardiovascular Study (SLDCS), 2005–2006

	'Inactive' (*n* 495)		'Moderately active' (*n* 1297)		'Highly active' (*n* 2693)	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	50·9[a]	18·7	47·6[a]	16·1	44·6[a]	13·6
Weight (kg)	55·7[a]	14·0	54·2[a]	12·1	52·2[a]	10·7
BMI (kg/m^2)	22·4[a]	4·8	22·4[b]	4·3	21·3[a,b]	4·0
Waist circumference (cm)	81·3[a]	13·0	79·5[a]	12·0	75·4[a]	11·0
Hip circumference (cm)	90·8[a]	9·9	90·7[b]	9·3	87·8[a,b]	8·6
Waist-to-hip ratio	0·89[a]	0·08	0·87[a]	0·08	0·86[a]	0·08
Systolic blood pressure (mmHg)	132·2[a]	22·4	129·4[a]	21·3	125·1[a]	18·2
Diastolic blood pressure (mmHg)	77·0[a]	12·0	76·4[b]	11·3	74·6[a,b]	11·0
Fasting blood glucose (mg/dl)	96·9[a]	39·8	92·8[a]	29·7	89·7[a]	25·3
2 h Postprandial blood glucose (mg/dl)	118·6[a]	60·7	115·2[b]	52·2	107·0[a,b]	49·4
Total cholesterol (mg/dl)	210·2[a]	43·4	208·1	43·9	205·4[a]	43·4
LDL cholesterol (mg/dl)	137·3	36·8	136·2	37·7	134·8	37·7
HDL cholesterol (mg/dl)	45·1[a,b]	9·6	46·8[a]	10·5	47·1[b]	10·9
TAG (mg/dl)	139·2[a]	81·0	124·1[a]	65·2	117·3[a]	64·1

PA, physical activity.
[a,b]Mean values within a row with the same superscript letter were significantly different ($P < 0·01$).

total MET minutes and HDL cholesterol was observed only in males ($P < 0·001$). The correlation coefficients for all of the clinical and biochemical parameters just mentioned were higher for males than females (Table 2). The correlation coefficients for parameters such as TAG, LDL cholesterol and HDL cholesterol in males were very low compared with other parameters; however, the association is significant possibly due to the larger sample sizes.

In all adults, those who were physically active were significantly younger than the physically inactive ($P < 0·01$; Table 3). Similarly, adults who were physically active had significantly lower body weight, BMI, waist and hip circumferences, WHR, systolic and diastolic blood pressures, fasting blood glucose, 2 h postprandial blood glucose, total cholesterol, HDL cholesterol and TAG than physically inactive adults (all $P < 0·01$; Table 3).

In all adults 60·0 % were in the 'highly active' category (males 59·5 %, females 60·4 %; NS), while only 11·0 % were 'inactive' (males 14·6 %, females 8·7 %; $P < 0·001$). Among those who were 'highly active', 85·8 % were residing in rural areas while only 14·2 % were from urban areas ($P < 0·001$). Diabetes prevalence in physically 'inactive', 'moderately active' and 'highly active' adults was 19·4 %, 15·8 % and 8·4 %, respectively ($P < 0·001$). A similar pattern was observed for the prevalence of hypertension ('inactive' 41·3 %, 'moderately active' 31·9 %, 'highly active' 22·7 %; $P < 0·001$). However, there was no significant difference in the prevalence of pre-diabetes across PA categories ('inactive' 13·9 %, 'moderately active' 14·0 %, 'highly active' 12·1 %; NS). The prevalence of metabolic syndrome showed a significant variation between different PA levels, being highest in those who

Table 4 Binary logistic regression analysis comparing 'health-enhancing PA' ('active' and 'inactive') groups in all adults, males and females: Sri Lanka Diabetes and Cardiovascular Study (SLDCS), 2005–2006

	All		Male		Female	
Covariables (reference category)	OR	95 % CI	OR	95 % CI	OR	95 % CI
Female gender	2·1***	1·9, 2·2				
Age category (<30 years)						
30–39 years	0·7***	0·5, 0·9	0·7*	0·5, 1·0	0·7*	0·5, 0·9
40–49 years	0·6***	0·5, 0·8	0·6**	0·4, 0·8	0·7**	0·5, 0·9
50–59 years	0·8**	0·6, 1·0	0·6**	0·4, 0·8	0·9	0·7, 1·2
60–69 years	1·3*	1·2, 1·4	0·7	0·5, 1·1	1·4*	1·0, 2·0
>70 years	3·8***	2·8, 5·3	4·6***	2·7, 7·6	3·6***	2·3, 5·5
Urban residence	2·5***	2·1, 2·9	2·3***	1·8, 3·0	2·7***	2·2, 3·4
Ethnicity (Tamil)						
Sinhalese	1·1	0·8, 1·4	1·7*	1·1, 2·6	0·8	0·6, 1·2
Muslim	2·7***	1·9, 3·9	3·1***	1·7, 5·4	2·5***	1·5, 3·9
Level of education (No formal education)						
Primary education	0·9	0·7, 1·3	0·8	0·4, 1·5	1·1	0·8, 1·5
Secondary education	1·1	0·8, 1·5	1·1	0·6, 2·1	1·1	0·8, 1·6
Tertiary education	3·6***	2·2, 6·0	2·8***	1·2, 6·6	4·4***	2·2, 8·9
BMI category (<18·5 kg/m^2)						
18·5–22·9 kg/m^2	1·1	0·9, 1·3	1·3	1·0, 1·7	1·0	0·8, 1·2
23·0–24·9 kg/m^2	0·8	0·6, 1·1	1·2	0·8, 1·8	0·6	0·4, 0·8
≥25·0 kg/m^2	1·8*	1·6, 2·0	1·8*	1·1, 2·9	1·7*	1·5, 1·9
Central obesity	1·5**	1·2, 1·9	1·5**	1·1, 1·9	1·8***	1·4, 2·3
High total cholesterol	1·1	0·9, 1·3	1·4*	1·1, 1·8	0·9	0·7, 1·1
Pre-diabetes	1·0	0·8, 1·2	1·2	1·0, 1·4	0·9	0·8, 1·0
Diabetes	1·6***	1·2, 1·9	1·9***	1·4, 2·1	1·7***	1·0, 2·8
Hypertension	1·2*	1·0, 1·4	1·4*	1·1, 1·8	1·1*	1·0, 1·3
Metabolic syndrome	1·3*	1·0, 1·6	1·4*	1·0, 1·8	1·3*	1·0, 1·7

*$P<0·05$, **$P<0·01$, ***$P<0·001$.

were 'inactive' ('inactive' 38·8 %, 'moderately active' 33·5 %, 'highly active' 21·1 %; $P<0·001$).

The results of the binary logistic regression analysis using the dichotomous variable 'health-enhancing PA' (0 = 'active', 1 = 'inactive') as the dependent factor and other independent variables mentioned above are shown in Table 4. The overall model was statistically significant as determined by the likelihood ratio test ($\chi^2 = 38·22$, $P<0·05$). The Cox and Snell R^2 and Nagelkerke R^2 values were 0·124 and 0·168, respectively. The results indicate that female gender (OR = 2·1), age >70 years (OR = 3·8), urban living (OR = 2·5), Muslim ethnicity (OR = 2·7), tertiary level of education (OR = 3·6), obesity (OR = 1·8), central obesity (OR = 1·5), presence of diabetes (OR = 1·6), hypertension (OR = 1·2) and metabolic syndrome (OR = 1·3) were all associated with significantly increased odds of being physically 'inactive' (Table 4). Similar results were seen in both males and females (Table 4).

Discussion

PA is one of the most important facets to improve the health of individuals and communities. Regular PA helps to control weight, reduce cardiovascular risk, reduce the risk of diabetes and metabolic syndrome, strengthen muscles and bones, improve mental health and increase longevity[21]. The present paper reports results from the first survey of PA among ethnic South Asian adults based on a nationally representative sample. Previous studies from India, Pakistan and Bangladesh have been either on community-based samples[22,23] or confined to a specific locality only[24]. In addition, previous studies have also explored the patterns of PA among migrant South Asians residing in the UK[25]. South Asia is home to almost a quarter of the world's population and comprises many diverse ethnic, linguistic and religious groups. NCD including diabetes, hypertension, cerebrovascular disease and CHD have become important health concerns in the South Asian region[26]. Studies have consistently shown that South Asians are ethnically predisposed towards NCD such as diabetes, hypertension and CHD[27,28]. PA is one of the important risk factors common to this group of NCD. Hence, it is important to critically evaluate PA patterns and their correlates among Sri Lankans and in other South Asian populations.

In all Sri Lankan adults, 60·0 % of the study population was in the 'highly active' category, while only 11·0 % were 'inactive'. These results are comparable to previous reports from nationally representative samples based on the short-form IPAQ from developed countries such as Australia, New Zealand, Canada and the USA[29]. In contrast, other Asian countries such India, Japan, Hong Kong and Taiwan reported much lower PA levels and a higher prevalence of physical inactivity[29]. This high level of PA among adults in the present study could also be due to majority of the study population being from rural areas (82·4 % were rural), where agriculture and plantation-based lifestyles promote PA[30]. A survey conducted using the WHO STEPwise approach in the urban Western province of Sri Lanka found that only 15·5 % of Sri Lankan adults were physically inactive[31], which is comparable to the finding of 11 % of physical inactivity in the present study. Similarly, the World Health Survey conducted by the WHO in 2002–2003 using the short-form IPAQ showed that the prevalence of physical inactivity among Sri Lankan males and females was 7·3 % and 13·8 %, respectively[32]. It is also important to note that the relative contributions of walking, moderate-intensity and vigorous-intensity PA to total MET-min/week for Sri Lankan adults in the present study were 16 %, 72 % and 12 %, respectively. By contrast, the contribution of vigorous-intensity activity to total MET-min/week was very high among other populations from developed countries with comparable levels of 'high' PA such as Australia (>50 %), New Zealand (>45 %), Canada (>45 %) and the USA (>50 %)[29]. This could be due to the fact that these countries have relatively well-developed facilities for recreational activities and a history of long-term promotion of exercise. Studies have shown that the health benefits of vigorous-intensity activity are different from those of moderate-intensity PA[33,34]. According to our analysis we found that a large portion of Sri Lankan adults are physically active despite high prevalences of diabetes, obesity and cardiovascular disease[35]; thus it is clear that these NCD may be associated with several other risk factors such as diet, smoking and physical fitness level in addition to PA. Studies have shown that physical fitness exerts a greater effect on cardiovascular disease than PA alone[36].

In addition, our results also show that urban residency is significantly associated with physical inactivity. The level of urbanization in Sri Lanka has been increasing steadily during the last few decades; with further improvements expected in the economy in future, urbanization rates are projected to rise dramatically[37]. However, much of the urbanization is unplanned and many urban areas of the country are experiencing serious environmental and urban development problems[37]. People's participation in PA is influenced by the built and natural environment in which they live. Design elements in the built environment, such as street layout, land use, the location of recreation facilities, parks and public buildings and the transport system, can either encourage or discourage PA[38]. Studies have shown that certain factors in urban design – such as lack of parks, high-speed traffic and automobile-focused transport – tend to discourage PA[39]. Planned future urbanization encouraging PA could be a feasible intervention to combat the growing national NCD epidemic. Hence, local governments and national policy makers have a crucial role to play in creating environments and opportunities for PA and active living[38].

There was also considerable ethnic variation in PA levels among Sri Lankan adults. Tamils were the most active ethnicity followed by Sinhalese and Muslims. In addition, being of Muslim ethnicity significantly increased the probability of being physically inactive. Furthermore, the relative contributions of walking, moderate-intensity and vigorous-intensity PA to total MET-min/week also varied among the different Sri Lankan ethnicities; Tamils (14·4 %, 64·8 %, 20·8 %), Sinhalese (11·9 %, 72·1 %, 16·0 %) and Muslims (10·7 %, 74·3 %, 14·9 %). The war-affected North and East provinces were excluded during data collection and a majority of Tamils in the present study were from the tea estate sector; hence it is understandable that the levels of PA among Tamils are much higher than in other ethnicities. It is also important to note that studies have shown an association of aspects of the social and cultural context with health behaviours[40]. Hence, it is important that behavioural interventions aimed at increasing PA at population level respond to these social and cultural contextual realities of people's day-to-day lives, especially in multi-ethnic South Asian countries like Sri Lanka and India.

PA levels in Sri Lankan adults were closely associated with educational status, being lowest in those with tertiary education. These findings are in contrast to developed countries where people with higher educational levels have the highest levels of PA[41,42]. It is probable that in Sri Lanka people with higher levels of education work in office environments located within urban localities, while people with lower educational background engage in farming and other forms of manual labour which encourage PA. In the present study 89·7 % and 86·7 % of those with no formal education and primary education were from rural areas, while 45·7 % of those with tertiary education were residing in urban areas. Healthy behaviours have been ranked as one of the main explanations for socio-economic differences in health indices, as many unhealthy behaviours tend to be more prevalent in lower socio-economic and educational groups[43]. Although physical inactivity was common among Sri Lankan adults with higher levels of education, our data show that their engagement in other unhealthy behaviours like smoking (2·3 %) and heavy alcohol consumption (1·2 %) was at very low levels. Hence, it is unlikely that lack of awareness regarding the health benefits of PA is the obstacle creating low levels of PA in this group.

The presence of NCD such as diabetes, hypertension, metabolic syndrome and obesity was significantly associated with physical inactivity in Sri Lankan adults. It is important to note that although we found Sri Lankan adults with diabetes and hypertension had low PA levels, due to the cross-sectional nature of the study it is not possible to extrapolate our finding to a direct cause-and-effect relationship. Physical inactivity in those with NCD could also be due to restrictions in lifestyle caused by the disease. However, since the causal relationship between physical inactivity and NCD is well established, it is reasonable to assume a similar cause-and-effect relationship within the present study population[3]. Since physical inactivity is a common risk factor to a host of

NCD that have reached epidemic levels in Sri Lanka and the South Asian region, public health interventions aimed at encouraging PA could be an amicable solution.

The strengths of the present study are its national representativeness, random selection of participants out of a well-defined and homogeneous target population and the sizes of the sample population groups. Strengths of the study instrument (IPAQ short-form) include its measurement of multiple domains and the separate assessment of walking behaviour, compared with other PA questionnaires[44]. The limitations of the study are closely related to the limitations of the IPAQ. It is well known that self-reported measures can overestimate PA, and the IPAQ may do this more than other PA questionnaires[45,46]. There is also the possibility of differential measurement error between countries when using IPAQ, with some countries or populations giving relatively accurate estimates while other populations over- or underestimate their PA[32]. Another limitation is that the MET values of some activities are not derived from actual oxygen consumption[47]. Hall and co-workers demonstrated that, compared with Europeans, South Asians exhibited significantly lower fat oxidation and the same level of fat oxidation at the same relative intensities of exercise, but higher carbohydrate oxidation at the same absolute exercise intensities after adjusting for age, BMI and fat mass[48]. Therefore using MET values which were originally developed from Caucasians to estimate energy expenditure in South Asians may be erroneous. Furthermore, the coding of PA by type and intensity for South Asians is an aspect that has not been thoroughly studied at present. While self-reporting still remains the simplest, most feasible and affordable method for large-scale global PA surveillance, the use of objective population measures of PA such as pedometers or accelerometers on selected sub-populations can supplement these findings by verifying whether variations identified via self-reporting represent true differences in PA behaviour. The results of the present study can serve as a useful baseline on PA among Sri Lankan adults and could be repeated to ascertain PA trends at population level. Although surveillance data alone are not sufficient to guide the implementation of national policy, consistent trend data is an essential requirement to identify the need for public health actions and interventions.

Conclusions

The present results, from the first comprehensive nationwide survey on PA in a South Asian country, demonstrated that a majority of adults were 'highly active'. Female gender, older age, urban living, Muslim ethnicity and tertiary level of education were all significant predictors of physical inactivity. Physical inactivity increased the risk of central obesity, diabetes, hypertension and metabolic syndrome. Although with certain limitations due to the study instrument used, the present results can serve as a useful baseline on PA among Sri Lankan adults and could be repeated to ascertain PA trends at population level.

Acknowledgements

Sources of funding: The National Science Foundation of Sri Lanka was the primary source of funding for the study. Additional support provided from the Oxford Centre for Diabetes Endocrinology and Metabolism, UK and the National Institute for Health Research (NIHR, UK) Biomedical Research Centre Programme is gratefully acknowledged. *Conflicts of interest:* The authors declare that they have no competing interests. *Authors' contributions:* All authors were involved in study design, data collection and analysis. P.R. and R.J. drafted the initial manuscript. The manuscript was critically reviewed by R.J. and P.K. All authors read and approved the final manuscript. *Acknowledgement:* The authors thank the Diabetes Association of Sri Lanka and the WHO Office in Colombo for the support for lipid assays; and all individuals and institutions who helped and worked for the study.

References

1. World Health Organization (2010) *Global Recommendations on Physical Activity for Health*. Geneva: WHO.
2. World Health Organization (2009) *Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks*. Geneva: WHO.
3. Bassuk SS & Manson JE (2005) Epidemiological evidence for the role of physical activity in reducing risk of type 2 diabetes and cardiovascular disease. *J Appl Physiol* **99**, 1193–1204.
4. Barengo NC, Hu G, Lakka TA *et al.* (2004) Low physical activity as a predictor for total and cardiovascular disease mortality in middle-aged men and women in Finland. *Eur Heart J* **25**, 2204–2211.
5. Tanasescu M, Leitzmann MF, Rimm EB *et al.* (2003) Physical activity in relation to cardiovascular disease and total mortality among men with type 2 diabetes. *Circulation* **107**, 2435–2439.
6. Powell KE & Blair SN (1994) The public health burdens of sedentary living habits: theoretical but realistic estimates. *Med Sci Sports Exerc* **26**, 851–856.
7. Katulanda P, Constantine GR, Mahesh JG *et al.* (2008) Prevalence and projections of diabetes and pre-diabetes in adults in Sri Lanka – Sri Lanka Diabetes, Cardiovascular Study (SLDCS). *Diabet Med* **25**, 1062–1069.
8. Wijewardene K, Mohideen MR, Mendis S *et al.* (2005) Prevalence of hypertension, diabetes and obesity: baseline findings of a population based survey in four provinces in Sri Lanka. *Ceylon Med J* **50**, 62–70.
9. Katulanda P, Jayawardena MA, Sheriff MH *et al.* (2010) Prevalence of overweight and obesity in Sri Lankan adults. *Obes Rev* **11**, 751–756.
10. de Silva KS, Wickramasinghe VP & Gooneratne IN (2006) Metabolic consequences of childhood obesity – a preliminary report. *Ceylon Med J* **51**, 105–109.
11. Jayasekara R & Schultz T (2007) Health status, trends, and issues in Sri Lanka. *Nurs Health Sci* **9**, 228–233.
12. World Health Organization (2010) *Global Status Report on Noncommunicable Diseases*. Geneva: WHO.

13. Haskell WL & Kiernan M (2000) Methodologic issues in measuring physical activity and physical fitness when evaluating the role of dietary supplements for physically active people. *Am J Clin Nutr* **72**, 2 Suppl., 541S–550S.
14. IPAQ Data Management Group (2010) International Physical Activity Questionnaire. https://sites.google.com/site/theipaq/home (accessed February 2012).
15. Arambepola C, Fernando D & Ekanayake R (2008) A simple valid tool for measuring obesity-related-CHD risk in Sri Lankan adults. *Prev Control* **3**, 11–19.
16. American College of Sports Medicine Position Stand (1998) The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. *Med Sci Sports Exerc* **30**, 975–991.
17. Department of Census and Statistics Sri Lanka (2001) Census of population and housing. Population, intercensal growth and average annual rate of growth by district, 1981 and 2001. http://www.statistics.gov.lk/PopHouSat/PDF/Population/p9p1%20Growth.pdf (accessed June 2012).
18. Misra A, Chowbey P, Makkar BM *et al.* (2009) Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. *J Assoc Physicians India* **57**, 163–170.
19. World Health Organization (2000) *Obesity: Preventing and Managing the Global Epidemic, Report of a WHO Consultation. WHO Technical Report Series* no. 894. Geneva: WHO.
20. Alberti KG, Zimmet P & Shaw J (2006) Metabolic syndrome – a new world-wide definition. A Consensus Statement from the International Diabetes Federation. *Diabet Med* **23**, 469–480.
21. Centers for Disease Control and Prevention (2011) The benefits of physical activity. http://www.cdc.gov/physicalactivity/everyone/health/index.html (accessed February 2012).
22. Rastogi T, Vaz M, Spiegelman D *et al.* (2004) Physical activity and risk of coronary heart disease in India. *Int J Epidemiol* **33**, 759–767.
23. Samir N, Mahmud S & Khuwaja AK (2011) Prevalence of physical inactivity and barriers to physical activity among obese attendants at a community health-care center in Karachi, Pakistan. *BMC Res Notes* **4**, 174.
24. Khuwaja AK & Kadir MM (2010) Gender differences and clustering pattern of behavioural risk factors for chronic non-communicable diseases: community-based study from a developing country. *Chronic Illn* **6**, 163–170.
25. Hayes L, White M, Unwin N *et al.* (2002) Patterns of physical activity and relationship with risk markers for cardiovascular disease and diabetes in Indian, Pakistani, Bangladeshi and European adults in a UK population. *J Public Health Med* **24**, 170–178.
26. Ghaffar A, Reddy KS & Singhi M (2004) Burden of non-communicable diseases in South Asia. *BMJ* **328**, 807–810.
27. Mather HM & Keen H (1985) The Southall Diabetes Survey: prevalence of known diabetes in Asians and Europeans. *Br Med J (Clin Res Ed)* **291**, 1081–1084.
28. Chaturvedi N (2003) Ethnic differences in cardiovascular disease. *Heart* **89**, 681–686.
29. Bauman A, Bull F, Chey T *et al.* (2009) The International Prevalence Study on Physical Activity: results from 20 countries. *Int J Behav Nutr Phys Act* **6**, 21.
30. Ministry of Finance and Planning (2005) *Sri Lanka New Development Strategy*. Colombo: Department of National Planning.
31. Somatunga LC (2004) *NCD Risk Factor Survey in Sri Lanka: STEP Survey*. Colombo: Ministry of Health Care & Nutrition.
32. Guthold R, Ono T, Strong KL *et al.* (2008) Worldwide variability in physical inactivity a 51-country survey. *Am J Prev Med* **34**, 486–494.
33. Boutcher SH (2011) High-intensity intermittent exercise and fat loss. *J Obes* **2011**, 868305.
34. Hawley JA & Gibala MJ (2009) Exercise intensity and insulin sensitivity: how low can you go? *Diabetologia* **52**, 1709–1713.
35. Abeywardena MY (2003) Dietary fats, carbohydrates and vascular disease: Sri Lankan perspectives. *Atherosclerosis* **171**, 157–161.
36. Sassen B, Cornelissen VA, Kiers H *et al.* (2009) Physical fitness matters more than physical activity in controlling cardiovascular disease risk factors. *Eur J Cardiovasc Prev Rehabil* **16**, 677–683.
37. van Horen B & Pinnawala S (2006) Sri Lanka. In *Urbanization and Sustainability in Asia: Good Practice Approaches in Urban Region Development*, pp. 310–340 [B Roberts and T Kanaley, editors]. Manila: Asian Development Bank.
38. Edwards P & Tsouros A (2006) *Promoting Physical Activity and Active Living in Urban Environments: The Role of Local Governments*. Copenhagen: WHO Regional Office for Europe.
39. Berrigan D & Troiano RP (2002) The association between urban form and physical activity in US adults. *Am J Prev Med* **23**, 74–79.
40. Emmons KM, Barbeau EM, Gutheil C *et al.* (2007) Social influences, social context, and health behaviors among working-class, multi-ethnic adults. *Health Educ Behav* **34**, 315–334.
41. Schnohr C, Hojbjerre L, Riegels M *et al.* (2004) Does educational level influence the effects of smoking, alcohol, physical activity, and obesity on mortality? A prospective population study. *Scand J Public Health* **32**, 250–256.
42. Vaz de Almeida MD, Graca P, Afonso C *et al.* (1999) Physical activity levels and body weight in a nationally representative sample in the European Union. *Public Health Nutr* **2**, 105–113.
43. Laaksonen M, Talala K, Martelin T *et al.* (2008) Health behaviours as explanations for educational level differences in cardiovascular and all-cause mortality: a follow-up of 60 000 men and women over 23 years. *Eur J Public Health* **18**, 38–43.
44. Centers for Disease Control and Prevention (2007) Prevalence of regular physical activity among adults – United States, 2001 and 2005. *MMWR Morb Mortal Wkly Rep* **56**, 1209–1212.
45. Rzewnicki R, Vanden Auweele Y & De Bourdeaudhuij I (2003) Addressing overreporting on the International Physical Activity Questionnaire (IPAQ) telephone survey with a population sample. *Public Health Nutr* **6**, 299–305.
46. Ainsworth BE, Macera CA, Jones DA *et al.* (2006) Comparison of the 2001 BRFSS and the IPAQ Physical Activity Questionnaires. *Med Sci Sports Exerc* **38**, 1584–1592.
47. Ainsworth BE, Haskell WL, Herrmann SD *et al.* (2011) 2011 Compendium of physical activities: a second update of codes and MET values. *Med Sci Sports Exerc* **43**, 1575–1581.
48. Hall LM, Moran CN, Milne GR *et al.* (2010) Fat oxidation, fitness and skeletal muscle expression of oxidative/lipid metabolism genes in South Asians: implications for insulin resistance? *PLoS One* **5**, e14197.