Correlates of low physical activity across 46 low- and middle-income countries: A cross-sectional analysis of community-based data

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Title: Correlates of low physical activity across 46 low- and middle-income countries: a cross-sectional analysis of community-based data

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List of abbreviations

CI: Confidence interval; HICs: High-income countries; IPAQ: International physical activity questionnaire; LMICs: Low- and middle-income countries; NCD: Non-communicable diseases; OR: Odds ratio; PA: Physical activity; SD: Standard deviation; WHO: World Health Organization; WHS: World Health Survey

Abstract

Physical inactivity accounts for 5.5% of all avoidable global deaths. However, a paucity of multinational studies, particularly in low- and middle-income countries (LMICs), has investigated correlates of physical activity (PA). Thus, we assessed the correlates of PA using cross-sectional, community-based data of the World Health Survey including 46 LMICs. PA was assessed by the International Physical Activity Questionnaire (IPAQ) and participants were dichotomized into those who do (≥150 minutes moderate-vigorous PA per week) and do not (<150 minutes=low PA) comply with the World Health Organization (WHO) PA recommendations. Multivariable logistic regression was used to assess the PA correlates. The prevalence of low PA in 206,356 persons (mean age 38.4 years; 49.6% males) was 29.2% (95%CI=28.3%-30.0%). In the overall sample, female sex, not married/cohabiting, high education and wealth, unemployment, and urban setting were significant sociodemographic correlates of low PA. In terms of other correlates, inadequate fruit and vegetable intake, subsyndromal depression, worse sleep/energy and cognition, visual impairment, hearing problems and asthma were associated with not meeting the WHO recommendations. There were some variations in the correlates depending on age and sex. Interventions should be developed that operate at multiple levels of influence and take into account age- and gender-related PA patterns in order to assist people in LMICs to comply with the WHO PA recommendations. Researchers, funding bodies, practitioners and policymakers in education, mental and physical health, and urban planning have a critical role to play.

Key words: Physical activity, correlates, low- and middle-income countries

Introduction

Physical inactivity is a global health problem, responsible for more than 5 million deaths per year and is one of the primary targets of the World Health Organization (WHO) to reduce non-communicable diseases (NCD) (World Health Organization, 2010). The global WHO target is to reduce inactivity by 10% by 2025 (World Health Organization, 2010). Following this target, many countries have now adopted national policies or action plans to increase physical activity (PA) levels to meet the WHO recommendations, i.e., adults aged 18 and older should engage in at least 150 minutes of moderate-intensity aerobic PA throughout the week or at least 75 minutes of vigorous-intensity aerobic PA, or an equivalent combination of moderate- and vigorous-intensity PA (World Health Organization, 2010). However, implementation of national PA policies and action plans appears to be weak, particularly in low- and middle-income countries (LMICs) (Sallis et al., 2016a). Barriers to meet this target include insufficient workforce to implement these policies, lack of effective multisector partnerships including transport, education, sport, recreation, and urban planning sectors, and the absence of information on the actions most likely to be effective and feasible in a given context (Sallis et al., 2016a). In order to design effective and feasible interventions that target evidence-based mechanisms of change, understanding PA correlates is an essential first step (Bauman et al., 2012). Recently calls were made to explore PA correlates in LMICs (Bauman et al., 2012; Sallis et al., 2016a). Almost three-quarters of NCD deaths occur in these countries, indicating a large potential for preventive interventions (Organization, 2014). Exploring PA correlates in LMICs is also important given different levels of knowledge regarding the benefits of PA (Pengpid et al., 2015), occupational and socio-cultural structures, methods of transportation, and environmental factors (e.g., safety, climate) (Atkinson et al., 2016) compared to other contexts. Although studies exploring PA correlates from LMICs is increasing in recent years, the vast majority are from a few upper-middle income countries such as Brazil and China (Bauman et al., 2012; Sallis et al., 2016a). The lack of studies from LMICs also highlights the gap between where most correlation research is done and where the largest public health impact of physical inactivity is located (Sallis et al., 2016a). Thus, given the aforementioned gaps within the literature, we aimed to assess PA correlates (socio-demographic, health behavior, mental and physical health) among community-dwelling adults in 46 LMICs.

Methods

The World Health Survey (WHS) was a cross-sectional study undertaken from 2002 to 2004 in 70 countries worldwide. Single-stage random sampling and stratified multi-stage random cluster sampling were conducted in 10 and 60 countries respectively. The details of the survey has been provided elsewhere (World Health Organization). Briefly, all individuals aged ≥18 years with a valid home address were eligible to participate. Each member of the household had equal probability of being selected with the use of Kish tables. The data were collected in all countries using the same set of questionnaires with some countries using a shorter version. The overall individual response rate was 98.5% (Nuevo et al., 2012). Ethical approval was obtained from ethical boards at each study site. Sampling weights were generated to adjust for non-response and the population distribution reported by the United Nations Statistical Division. Informed consent was obtained from all participants.

Physical activity (PA)

Items from the International Physical Activity Questionnaire (IPAQ) were used to categorize PA. Specifically, participants were asked how many days over the past week on average they engaged in moderate and vigorous PA. Secondly, participants were asked for how many minutes on average, they engage in PA at a moderate and vigorous level. The total amount of moderate to vigorous PA over the last week was calculated and those scoring ≥150 minutes were classified as meeting the recommended WHO guidelines (coded 0), and those scoring <150 minutes (low PA) were classified as not meeting the recommended guidelines (coded 1) (World Health Organization, 2010).

Sociodemographic domain

Variables in this domain included sex, age, marital status [married/cohabiting, or else (never married, separated/divorced/widowed)], highest education attained (no formal, primary, secondary completed, tertiary completed), wealth quintiles, employment status (unemployed or not), living arrangement (alone or not), and setting (rural or urban). Principal component analysis based on 15-20 assets was performed to establish country-wise wealth quintiles.

Health behavior domain

Variables in this domain included current smoking, fruit and vegetable intake [≥2 and ≥3 servings/day of fruits and vegetables, respectively (adequate)] according to the WHO/FAO recommendations,(Joint FAO/WHO Expert Consultation, 2003) and alcohol consumption (lifetime abstainer, non-heavy, infrequent heavy, frequent heavy). The categorization of alcohol consumption was based on how many standard drinks of any alcoholic beverage the respondent had on each day of the past 7 days. The number of days in the past week in which 4 (female) or 5 (male) drinks were consumed was calculated, and a total of 1-2 and ≥3 days in the past 7 days were considered infrequent and frequent heavy drinking respectively. All other drinkers were considered non-heavy drinkers (Koyanagi et al., 2016).

Mental health domain

Type of depression included depressive episode, brief depressive episode, and subsyndromal depression following the ICD-10 algorithm based on duration and persistence of depressive symptoms in the previous 12 months (Ayuso-Mateos et al., 2010; Koyanagi et al., 2016). Anxiety was assessed by the question 'Overall in the past 30 days, how much of a problem did you have with worry or anxiety' with answer options being none, mild, moderate, severe, and extreme. Those who answered severe and extreme were considered to have anxiety (Koyanagi et al., 2016; Wong et al., 2013). Past-30 day sleep/energy and cognition were assessed by two questions each (Additional file 1 **Table 1**). We used factor analysis with polychoric correlations to obtain a factor score which was later converted to scores ranging from 0-10 with higher values representing worse sleep/energy or cognition (Koyanagi et al., 2016; Vancampfort et al., 2017).

Physical health domain

Visual impairment was defined as having extreme difficulty in seeing and recognizing a person that the participant knows across the road (Vancampfort et al., 2017). The participant was considered to have hearing problems if the interviewer observed this condition at the conclusion of the survey. Arthritis and asthma were based on self-reported lifetime diagnosis.

Statistical analysis

The statistical analysis was done with Stata 14.1 (Stata Corp LP, College station, Texas). Data from 69 countries were publically available. Countries lacking sampling information, data on PA and some demographic variables used in the analysis, and high-income countries (HICs) were excluded (n=23). Thus, a total of 46 countries (Africa 19, Americas 6, Asia 13, Europe 8), which were all LMICs (21 low-, and 25 middle-income countries) according to the World Bank classification at the time of the survey (2003) constituted the final analytical sample (Additional file 1 **Table 2**).

A total of 19 potential correlates of PA, which were selected based on past literature (Bauman et al., 2012), corresponding to four domains (socio-demographics, heath behavior, mental health, physical health) were examined. Multivariable logistic regression analyses were done with low PA as the outcome to assess its correlates by domains (Suetani et al., 2016). We conducted analyses using the overall sample and by four subgroups: Males aged 18-64 years; Females aged 18-64 years; Males aged ≥65 years; Females aged ≥65 years. This was done as previous studies have shown that the correlates of PA may differ by age and sex (Bauman et al., 2012; Sallis et al., 2016a). The age cut-off of 65 years was chosen *a priori* taking into account the difference in nature and availability of the scientific evidence relevant to the prevention of NCD through PA in those aged <65 years and older (World Health Organization, 2010). First, sociodemographic correlates were assessed by models which mutually adjusted for all variables in the sociodemographic domain and country. Sex was only adjusted for in the overall sample. Subsequently, the correlates in the health behavior, and mental and physical health domains were assessed by constructing models which mutually adjusted for all variables in the respective domains, in addition to all the sociodemographic variables [sex (only overall sample), age (continuous variable), marital status, education, wealth, employment status, living arrangement, setting], and country. Analyses stratified by country income level were also done.

For all regression analyses, variables were included in the models as categorical variables with the exception of age, sleep/energy, and cognition (continuous variables). Mexico was not included in the analyses including fruit and vegetable intake as this information was not collected. Adjustment for country was done by including dummy variables for each country as in previous WHS publications (Koyanagi et al., 2016; Vancampfort et al., 2017). In order to assess the influence of multicolinearity, we calculated the variance inflation factor (VIF) value for each independent variable. The highest VIF was 2.14, which is much lower than the commonly used-cut off of 10 (O'brien, 2007), indicating that multicolinearity was unlikely to be a problem. Under 10% of the values were missing for all variables used in the analysis with the exception of PA (12.9%), fruit and vegetable intake (14.3%), and unemployment (15.7%). In order to assess whether missing values lead to biased estimates, we repeated the analysis by conducting multiple imputation of missing values using the *mi* commands in Stata using chained equations (10 imputations). Since the results of the analysis with and without

imputed data were similar, we only present the non-imputed results.

The sample weighting and the complex study design were taken into account in all analyses, with the exception of the Ns which are provided as unweighted estimates. Results from the logistic regression models are presented as odds ratios (ORs) with 95% confidence intervals (CIs). The level of statistical significance was set at $P<0.05$.

Results

The sample characteristics are provided in **Table 1**. The mean (SD) age of the sample was 38.4 (16.0) years and 49.2% were males.

Table 1 Sample characteristics (overall and by sex and age) of individuals from 46 countries who participated in the World Health Survey 2002-2003

Characteristic		Overall	Age 18-64 years		Age ≥65 years	
			Male	Female	Male	Female
Physical activity[a]	Low	29.2 (63254/206356)	23.3 (21012/82572)	30.6 (30728/102205)	49.6 (4947/9455)	56.2 (6472/11932)
Sociodemographic domain						
Sex	Male	49.2 (102106/228213)				
Age (years)	Mean (SD)	38.4 (16.0)	34.9 (11.8)	35.5 (13.2)	71.8 (6.6)	72.5 (7.2)
Marital status	Married/cohabiting	66.3 (151620/227227)	65.4 (62566/90901)	69.4 (76961/112332)	80.4 (7848/10609)	34.1 (4098/13103)
Education	No formal	26.1 (49478/227323)	18.8 (14846/90899)	30.7 (26061/112357)	36.1 (3479/10612)	43.2 (4884/13116)
	Primary	31.0 (75025/227323)	32.8 (31009/90899)	29.4 (35524/112357)	33.5 (3996/10612)	28.5 (4421/13116)
	Secondary completed	33.7 (85366/227323)	38.3 (37155/90899)	31.1 (42378/112357)	23.6 (2597/10612)	22.4 (3189/13116)
	Tertiary completed	9.2 (17454/227323)	10.2 (7889/90899)	8.8 (8394/112357)	6.8 (540/10612)	5.9 (622/13116)
Wealth	Poorest	20.1 (50829/214938)	19.0 (18894/84895)	19.9 (23946/105153)	24.3 (3035/9919)	29.6 (4417/12381)
	Poorer	20.0 (45452/214938)	19.5 (17479/84895)	20.0 (22214/105153)	23.0 (2331/9919)	22.1 (2875/12381)
	Middle	19.9 (41850/214938)	19.9 (16643/84895)	20.0 (20761/105153)	19.8 (1846/9919)	19.2 (2113/12381)
	Richer	20.0 (39581/214938)	20.6 (16277/84895)	20.1 (19663/105153)	17.7 (1502/9919)	14.8 (1683/12381)
	Richest	20.0 (37226/214938)	21.1 (15602/84895)	20.0 (18569/105153)	15.2 (1205/9919)	14.2 (1293/12381)
Unemployed	Yes	42.5 (77280/199752)	19.1 (15374/86306)	60.6 (48542/94130)	59.6 (4919/8846)	87.3 (8298/10198)
Living arrangement	Alone	3.5 (16629/236666)	2.9 (6246/91222)	2.1 (4724/112618)	7.2 (1582/10637)	20.3 (3700/13153)
Setting	Urban	43.1 (115946/235750)	41.7 (43862/90865)	44.1 (55885/112200)	41.6 (4945/10588)	50.0 (6880/13089)
Health behavior domain						
Current smoking	Yes	26.7 (53792/223966)	41.0 (35786/89374)	12.7 (12612/110887)	40.4 (3626/10438)	14.1 (1718/12931)
Fruit & vegetable intake[b]	Adequate	16.3 (18872/170032)	16.5 (7816/68593)	16.7 (9453/83868)	13.7 (684/7562)	13.4 (888/9769)
Alcohol consumption	Lifetime abstainer	66.1 (137886/221926)	58.0 (44548/88495)	74.6 (78595/109937)	55.4 (5308/10331)	69.3 (9156/12837)
	Non-heavy	29.1 (72904/221926)	33.8 (35889/88495)	23.3 (28828/109937)	40.4 (4601/10331)	29.9 (3545/12837)
	Infrequent heavy	3.8 (8743/221926)	6.4 (6344/88495)	1.7 (2017/109937)	2.6 (281/10331)	0.5 (97/12837)
	Frequent heavy	1.1 (2393/221926)	1.8 (1714/88495)	0.4 (497/109937)	1.5 (141/10331)	0.3 (39/12837)
Mental health domain						
Depression type	No depression	88.2 (210553/234783)	91.8 (83912/90521)	85.6 (97937/111605)	84.0 (9134/10570)	77.8 (10538/13016)
	Subsyndromal depression	2.5 (5011/234783)	1.9 (1475/90521)	2.8 (2655/111605)	3.8 (366/10570)	5.1 (509/13016)
	Brief depressive episode	2.7 (6167/234783)	1.9 (1797/90521)	3.5 (3654/111605)	2.5 (235/10570)	4.3 (468/13016)
	Depressive episode	6.5 (13052/234783)	4.4 (3337/90521)	8.1 (7359/111605)	9.7 (835/10570)	12.8 (1501/13016)
Anxiety	Yes	11.5 (24850/224507)	8.8 (7556/89573)	12.8 (13466/111153)	14.8 (1397/10480)	21.2 (2410/12974)
Sleep/energy[c]	Mean (SD)	2.12 (2.63)	1.65 (2.22)	2.25 (2.77)	3.36 (3.16)	4.34 (3.14)
Cognition[c]	Mean (SD)	1.98 (2.60)	1.47 (2.12)	2.07 (2.69)	3.64 (3.34)	4.63 (3.34)
Physical health domain						
Visual impairment	Yes	1.3 (2282/213950)	0.5 (450/84893)	1.2 (753/106075)	4.8 (438/10107)	7.7 (628/12616)
Hearing problem	Yes	3.4 (7385/223069)	1.8 (1465/89036)	1.8 (1809/110369)	19.3 (1782/10410)	20.7 (2315/12920)
Arthritis	Yes	13.0 (27956/222210)	8.9 (7529/88853)	13.4 (13600/110055)	28.8 (2491/10298)	36.9 (4269/12664)
Asthma	Yes	5.2 (10254/222599)	4.2 (3260/88861)	5.3 (5228/110239)	11.2 (828/10364)	8.4 (924/12809)

Abbreviation SD Standard Deviation.

Data are weighted column percentage (unweighted n/N) unless otherwise stated.

[a] The total amount of moderate to vigorous physical activity over the last week was calculated and those scoring <150 min were considered to have low physical activity.
[b] Mexico is not included as data on fruit and vegetable consumption were not collected.
[c] Sleep/energy and cognition were based on scores ranging from 0-10 with higher scores representing worse conditions.

The prevalence of low PA overall was 29.2% (95%CI=28.3%-30.0%), while this figure was much higher among those aged ≥65 years (males 49.6%; females 56.2%). Based on unadjusted estimates, older age, female sex, not married/cohabiting, low and high education, greater levels of wealth, not being employed, living alone, and urban setting were the characteristics of the sociodemographic domain associated with higher prevalence of low PA (**Figure 1**). Factors in other domains such as inadequate fruit and vegetable intake, depression, anxiety, worse sleep/energy and cognition, and chronic physical conditions were also associated with higher prevalence of low PA (**Figure 2**).

In the adjusted model using the overall sample, female sex, older age, not married/cohabiting, high education and wealth, unemployment, and urban setting were significant sociodemographic correlates of low PA (**Table 2**). Being older or unemployed were factors consistently associated with low PA across all subgroups. The education and wealth gradients were most obvious among younger males. Living alone was significantly associated with low PA among younger males but with high PA among older males. Urbanicity was not associated with PA among older women.

Table 2 Association between sociodemographic factors and low physical activity (outcome) among individuals from 46 countries who participated in the World Health Survey 2002-2003 estimated with multivariable logistic regression

Characteristic	Overall OR (95%CI)	Male (Age 18-64 years) OR (95%CI)	Female (Age 18-64 years) OR (95%CI)	Male (Age ≥65 years) OR (95%CI)	Female (Age ≥65 years) OR (95%CI)
Sex					
Female	1.00				
Male	0.84 (0.79-0.89)				
Age (per increase in one year)	1.03 (1.02-1.03)	1.02 (1.02-1.03)	1.01 (1.01-1.02)	1.07 (1.05-1.09)	1.08 (1.06-1.10)
Marital status					
Married/cohabiting	1.00	1.00	1.00	1.00	1.00
Else[a]	1.34 (1.27-1.42)	1.16 (1.03-1.30)	1.33 (1.23-1.44)	1.02 (0.76-1.37)	1.39 (1.10-1.75)
Education					
No formal	1.00	1.00	1.00	1.00	1.00
Primary	0.94 (0.87-1.01)	1.14 (1.00-1.30)	0.93 (0.83-1.04)	0.76 (0.56-1.02)	0.84 (0.65-1.09)
Secondary completed	1.05 (0.95-1.15)	1.23 (1.06-1.43)	1.04 (0.90-1.21)	0.99 (0.66-1.51)	0.75 (0.52-1.08)
Tertiary completed	1.28 (1.11-1.46)	1.56 (1.27-1.91)	1.16 (0.95-1.42)	1.12 (0.65-1.93)	0.91 (0.57-1.48)
Wealth					
Poorest	1.00	1.00	1.00	1.00	1.00
Poorer	1.05 (0.98-1.14)	1.14 (1.01-1.28)	0.98 (0.88-1.10)	1.14 (0.82-1.58)	1.09 (0.85-1.40)
Middle	1.06 (0.96-1.16)	1.12 (0.96-1.30)	1.01 (0.89-1.15)	0.90 (0.62-1.29)	1.10 (0.80-1.51)
Richer	1.13 (1.03-1.23)	1.32 (1.16-1.50)	0.95 (0.82-1.10)	1.22 (0.84-1.76)	1.40 (1.00-1.95)
Richest	1.32 (1.19-1.47)	1.49 (1.29-1.73)	1.23 (1.05-1.44)	0.84 (0.56-1.24)	1.42 (0.96-2.10)
Unemployed					
No	1.00	1.00	1.00	1.00	1.00
Yes	1.81 (1.70-1.94)	1.96 (1.74-2.21)	1.45 (1.32-1.58)	2.96 (2.26-3.88)	1.92 (1.44-2.57)
Living arrangement					
Not alone	1.00	1.00	1.00	1.00	1.00
Alone	0.98 (0.87-1.12)	1.34 (1.09-1.64)	1.08 (0.89-1.32)	0.53 (0.31-0.90)	0.79 (0.61-1.03)
Setting					
Rural	1.00	1.00	1.00	1.00	1.00
Urban	1.56 (1.43-1.71)	1.62 (1.45-1.80)	1.60 (1.39-1.84)	1.72 (1.31-2.25)	1.00 (0.73-1.36)

Abbreviation OR Odds Ratio CI Confidence Interval
Models are adjusted for all variables in the respective columns and country.
The total amount of moderate to vigorous physical activity over the last week was calculated and those scoring <150 min were considered to have low physical activity.
[a] Never married/separated/divorced/widow.

In terms of correlates in other domains, in the overall sample, inadequate fruit and vegetable intake, subsyndromal depression, worse sleep/energy and cognition, visual impairment, hearing problems and asthma were significant correlates of low PA (**Table 3**). Non-heavy alcohol consumption was significantly associated with lower odds for low PA compared to lifetime abstinence. In the subsamples, the findings on alcohol consumption were significant only among females. Subsyndromal depression was the depression subtype most consistently associated with low PA. Depressive episode was only associated with low PA among younger males.

Table 3 Association of health behavior, and mental and physical health factors with low physical activity (outcome) among individuals from 46 countries who participated in the World Health Survey 2002-2003 estimated with multivariable logistic regression

Characteristic		Overall OR (95%CI)	Male (Age 18-64 years) OR (95%CI)	Female (Age 18-64 years) OR (95%CI)	Male (Age ≥65 years) OR (95%CI)	Female (Age ≥65 years) OR (95%CI)
Health behavior domain[a]						
Current smoking	Yes vs No	0.96 (0.89-1.03)	0.94 (0.85-1.05)	1.00 (0.87-1.15)	1.05 (0.79-1.40)	0.98 (0.74-1.30)
Fruit & vegetable	Inadequate	1.00	1.00	1.00	1.00	1.00
intake	Adequate	0.79 (0.71-0.88)	0.76 (0.64-0.90)	0.82 (0.72-0.95)	0.71 (0.49-1.01)	0.79 (0.58-1.09)
Alcohol	Lifetime abstainer	1.00	1.00	1.00	1.00	1.00
consumption	Non-heavy	0.91 (0.84-0.99)	1.01 (0.89-1.14)	0.88 (0.77-0.99)	0.95 (0.72-1.26)	0.69 (0.53-0.91)
	Infrequent heavy	0.95 (0.82-1.10)	0.94 (0.78-1.14)	0.96 (0.73-1.25)	0.90 (0.42-1.93)	0.49 (0.22-1.09)
	Frequent heavy	0.87 (0.67-1.14)	0.94 (0.68-1.29)	0.63 (0.35-1.14)	0.77 (0.32-1.86)	2.73 (0.53-14.13)
Mental health domain						
Depression type	No depression	1.00	1.00	1.00	1.00	1.00
	Subsyndromal depression	1.40 (1.17-1.68)	1.51 (1.07-2.14)	1.30 (1.03-1.64)	0.96 (0.48-1.91)	2.18 (1.33-3.59)
	Brief depressive episode	1.07 (0.92-1.24)	1.10 (0.86-1.41)	1.02 (0.84-1.25)	1.88 (0.94-3.76)	1.02 (0.65-1.60)
	Depressive episode	1.12 (0.98-1.28)	1.49 (1.18-1.89)	0.94 (0.81-1.09)	1.32 (0.84-2.08)	1.36 (0.93-1.99)
Anxiety	Yes vs. No	1.01 (0.91-1.11)	1.03 (0.87-1.22)	1.02 (0.89-1.16)	0.90 (0.64-1.25)	1.11 (0.84-1.47)
Sleep/energy[b]	per unit increase	1.01 (1.00-1.02)	1.00 (0.98-1.02)	1.02 (1.00-1.04)	1.07 (1.03-1.12)	1.02 (0.97-1.08)
Cognition[b]	per unit increase	1.02 (1.01-1.03)	1.03 (1.01-1.06)	0.99 (0.97-1.01)	1.08 (1.03-1.13)	1.03 (0.98-1.07)
Physical health domain						
Visual impairment	Yes vs. No	1.95 (1.54-2.46)	1.70 (0.99-2.92)	1.68 (1.21-2.33)	2.42 (1.57-3.73)	1.44 (0.86-2.44)
Hearing problems	Yes vs. No	1.61 (1.38-1.88)	1.54 (1.14-2.09)	1.63 (1.26-2.10)	1.17 (0.86-1.60)	1.39 (1.01-1.92)
Arthritis	Yes vs. No	1.07 (0.97-1.19)	1.13 (0.96-1.33)	1.09 (0.97-1.22)	1.30 (0.99-1.71)	0.96 (0.78-1.20)
Asthma	Yes vs. No	1.13 (1.01-1.27)	1.15 (0.95-1.40)	1.03 (0.85-1.25)	1.42 (0.96-2.10)	1.20 (0.86-1.69)

Abbreviation OR Odds Ratio CI Confidence Interval
Models are adjusted for all variables in the respective domains in addition to sex (only overall sample), age (continuous variable), marital status, education, wealth, employment status, living arrangement, setting, and country.
The total amount of moderate to vigorous physical activity over the last week was calculated and those scoring <150 min were considered to have low physical activity.
[a] Mexico was omitted from the analysis as it lacked information on fruit and vegetable consumption.
[b] Sleep/energy and cognition were based on scores ranging from 0-10 with higher scores representing worse conditions.

Some differences in correlates between country income levels were also evident (Additional file 1 **Tables 3** and **4**).

Discussion

This is the first general population multinational study exploring a multitude of PA correlates across different domains among community-dwelling adults in LMICs across the globe. In terms of the sociodemographic PA correlates, our study results confirm findings from previous smaller studies from mainly upper-MICs on PA correlates (Allen et al., 2017; Bauman et al., 2012; Sallis et al., 2016a) that older age, female sex, higher wealth, unemployment, and urban setting are significant correlates of low PA.

However, in contrast to previous findings in LMICs (mainly studies from upper-MICs such as China and Brazil) (Bauman et al., 2012; Sallis et al., 2016a) but in line with the PA correlates literature in HICs (Trost et al., 2002), not being married/cohabiting was associated with physical inactivity. It might be hypothesized that loneliness, lack of social connectivity, and lack of social control mediate associations between marital status and PA behavior. A similar reason might explain associations between being employed and more PA as employment may offer not only opportunities for people to be physically active but also to connect socially, which enhances social functioning. Previous research in LMICs demonstrated that social support, in particular from friends but not from family members or a spouse, enhances PA (Sallis et al., 2016a).

In contrast with the current PA correlates literature in LMICs (Bauman et al., 2012; Sallis et al., 2016a) and HICs (Trost et al., 2002), our study is the first to demonstrate that higher education is associated with being more physically inactive in young males but not females. It might be hypothesized that young males with higher education levels are employed in less labor-demanding service-based jobs while young females, even when highly educated remain responsible for the daily household chores and errands and reach recommended levels of PA through these household chores such as fetching water or wood etc. Educational levels were not associated with PA levels in the elderly.

Of interest, and also in contrast with literature in HICs (Trost et al., 2002) is that those in the richest quintile were less physically active. A more Western lifestyle, mainly observed in urban centers of LMICs and including the use of more motorized transport, less labor-demanding jobs, and physically undemanding, mostly screen-based leisure might be responsible for lower levels of PA in those who can afford it. It may be that lower wealth corresponds more strongly to labor-demanding jobs in LMICs than in HICs making it more of a stronger marker of work-related PA. In HICs, the prevalence of sedentary jobs among the poor and the rich may be more similar than in LMICs. This may be reflected in our findings where higher wealth and education were particularly strongly associated with low PA in low-income countries compared to middle-income countries. Next to this, it might be hypothesized that those in the richest quintile do not necessarily need to leave their homes or engage in outdoor activities for subsistence.

Urbanicity was associated with low PA in young people and older males, but not among older females. It might be speculated that in young males and females, more access to motorized transport

and less labor-demanding jobs in cities are the major determinants of low PA, while for the elderly, lack of leisure-time PA facilities might be a more important barrier for being physically active. Generally, women have hobbies that tend to keep them at home while men tend to engage in more outdoor physical recreational activities (Walter and Du Randt, 2011) indicating that lack of access to open space and the lack of outdoor PA facilities might be of more influence on PA patterns in older males. The fact that older females were also less physically active than older males seems to confirm this hypothesis. Our findings strengthens the recent calls (Sallis et al., 2016b) to invest in activity-friendly urban design.

While previous studies did not find any associations between dietary and PA habits, we observed in our study that unhealthy dietary habits (inadequate fruit and vegetable consumption) are associated with physical inactivity. Low PA and less consumption of fruit and vegetables may be reflecting a clustering of unhealthy lifestyles and behavior which is increasing in LMICs.

Finally, our data confirm that chronic mental and physical conditions should be considered as correlates of low PA in LMICs (Vancampfort et al., 2017). The particularly strong association of visual impairment and hearing problems with low PA may be explained by the stigma and discrimination associated with these conditions while fear of going out due to unsafe traffic conditions and crime may further complicate physical activity participation in these populations, especially in LMICs (Gispen et al., 2014; Marmeleira et al., 2014; Oyeyemi et al., 2012).

Physical co-morbidities might be direct barriers for PA or associations might be mediated by associated feelings of depression, cognitive problems and sleep/energy problems. Our data also illustrates that depression is an important factor which is negatively associated with PA participation among males aged 18-64 years. This is a relationship that has been demonstrated in people with major depression in middle- and high-income countries, with a recent meta-analysis of 24 studies finding that this group is significantly less likely to meet WHO recommended PA levels (Schuch et al., 2017). However, helping people with depression to become physically active is important, since research in middle- and high-income countries has demonstrated that PA can actually reduce symptoms of mild, moderate and severe depression (Schuch et al., 2016a and 2016b). Moreover, a previous systematic review almost exclusively in high-income countries identified that 25 from 30 studies found that higher levels of PA offer a protective effect against the development of depression (Mammen and Faulkner, 2013). Thus, promoting PA to prevent the onset of depression and improve symptoms, may be an important public health strategy in LMICs to address this growing burden of depression in this region.

The current data should be considered in the light of some limitations. First, the study is cross-sectional, therefore cause and effect cannot be deduced. Future prospective research is required to disentangle the directionality of the relationships observed. Second, PA was captured with a self-report measure which has been prone to bias. It is well recognized that self-reported measures, especially the IPAQ, can overestimate PA (Ainsworth et al., 2006). Finally, future studies in LMICs may wish to assess how food insecurity, civil conflicts, and extreme weather conditions are linked to physical inactivity in this population.

Conclusions

Our data provides some guidance that health policy makers in LMICs should focus on higher educated, more wealthy persons living in urban centers. Also a strong emphasis on age- and gender-specific PA patterns is needed when adopting PA policies in LMICs. Our data confirm previous concerns that economic growth and urbanization, which may offer many opportunities in LMICs, including potentially better access to mental and physical health care, can introduce new hazards such as a sedentary lifestyle and consequently a higher risk for NCD. Today's urban environments in many LMICs and the unfortunate global shift toward a Western lifestyle with physical inactivity can concentrate health risks. As indicated previously, design of active urban environments has the potential to contribute nearly 90 min/week of PA, which is 60% of the 150 min/week recommended in PA guidelines (Sallis et al., 2016b). Finally, national health policies focusing on an active and healthy lifestyle should consider mental health barriers.

Conflict of interests

None.

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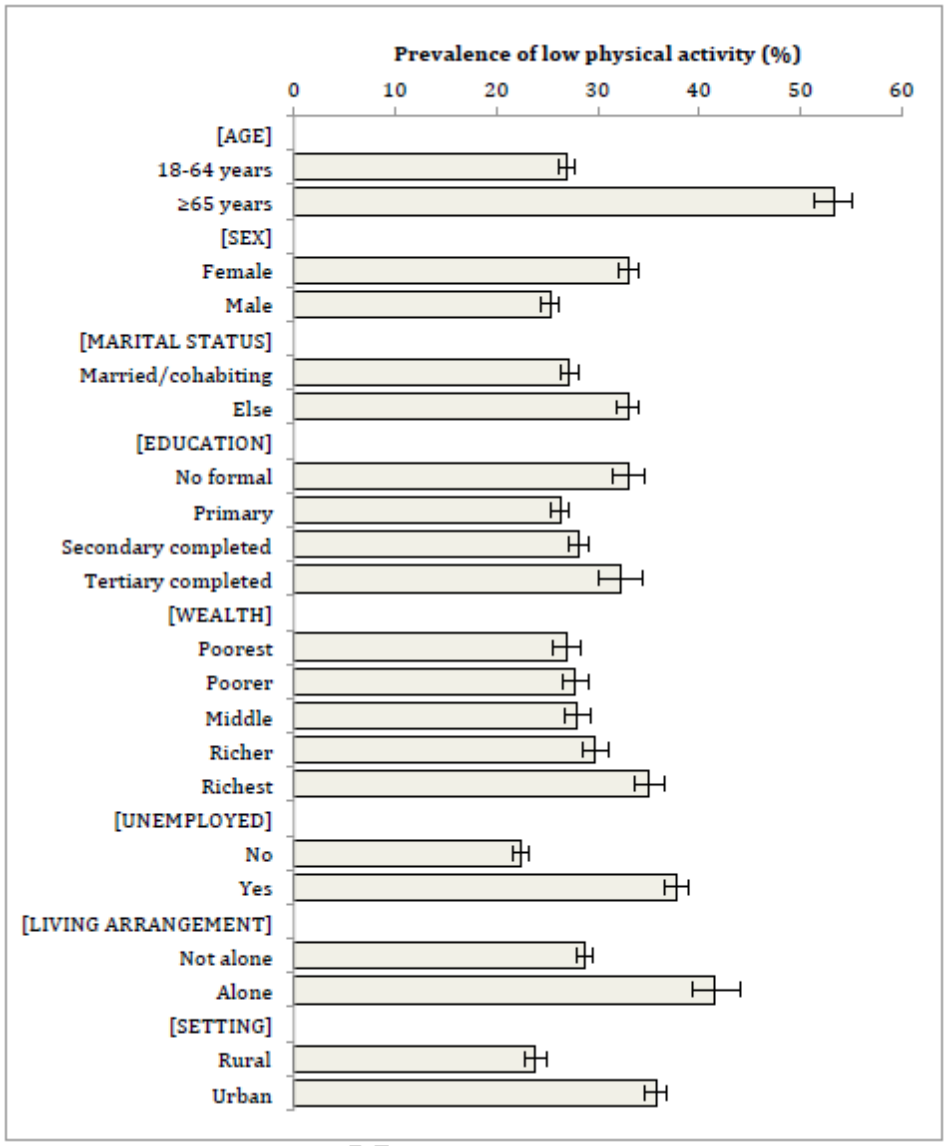

Figure 1 Prevalence of low physical activity by sociodemographic characteristics
Error bars denote 95% confidence intervals.
The total amount of moderate to vigorous physical activity over the last week was calculated and those scoring <150 min were considered to have low physical activity.

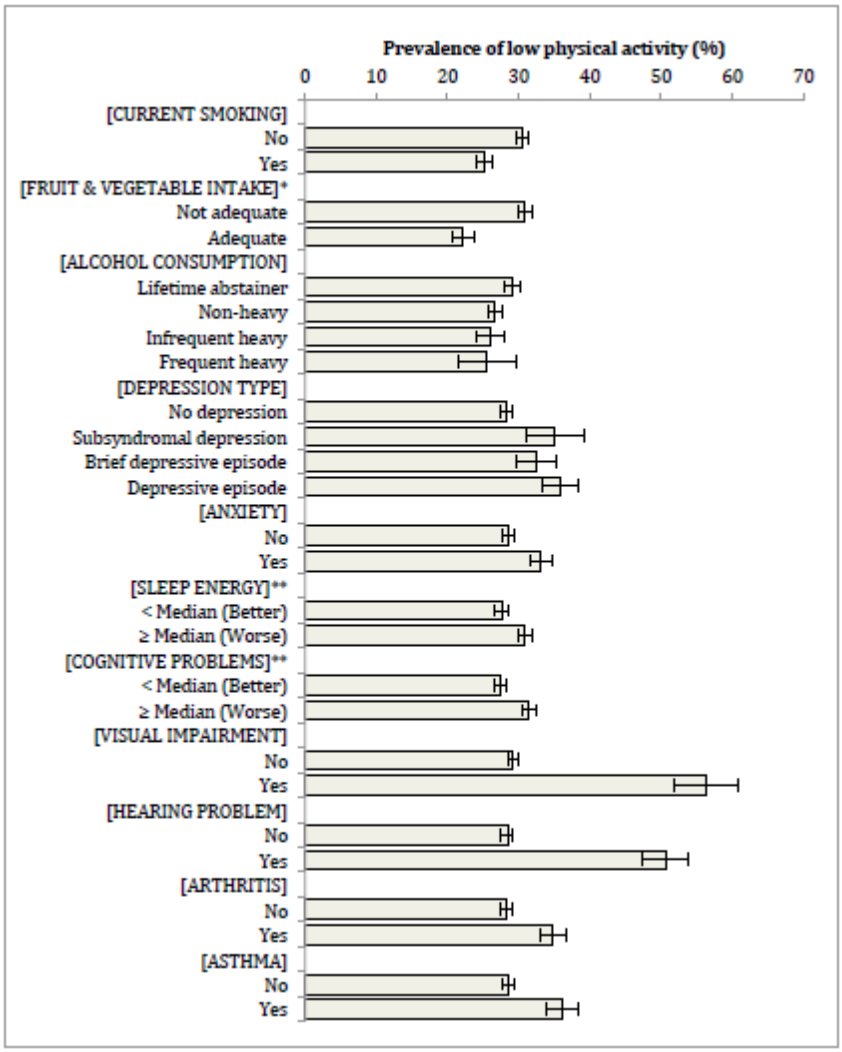

Figure 2 Prevalence of low physical activity by health behavior, and mental and physical health factors

Error bars denote 95% confidence intervals.

The total amount of moderate to vigorous physical activity over the last week was calculated and those scoring <150 min were considered to have low physical activity.

* Mexico is not included as it lacked information on fruit and vegetable consumption.

** Sleep/energy was based on scores ranging from 0-10 with higher scores representing worse conditions. Individuals were divided into those who scored < or ≥ the median value.

Highlights

- Physical activity correlates in low- and middle-income countries were investigated.
- Correlates identified include factors related with mental and physical health.
- Our data provide a platform for future physical activity interventions.