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Correlates of physical activity among 142,118 adolescents aged 12–15 years from 48 low- and middle-income countries

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ABSTRACT

Physical inactivity is a serious public health concern in adolescents from low- and middle-income countries (LMICs). Despite this, only a few multinational studies has investigated correlates of physical activity (PA) in young adolescents in this part of the world. In this study, we identified physical activity correlates using data from the Global school-based Student Health Survey. In total, 142,118 adolescents from 48 LMICs (age 13.8 ± 1.0 years; 49% girls) were included in the analyses. PA was assessed by the PACE+ Adolescent Physical Activity Measure and participants were dichotomised into those who do (60 min of moderate-vigorous PA every day of the week) and do not comply with the World Health Organization recommendations. We used multivariable logistic regression in order to assess the correlates. The prevalence of low PA was 15.3% (95%CI = 14.5%–16.1%). Boys (OR = 1.64; 95%CI = 1.47–1.83) and those who participated in physical education for ≥5 days/week (OR = 1.12; 95%CI = 1.10–1.15) were more likely to meet PA guidelines, while adolescents with food insecurity (OR = 0.85; 95%CI = 0.80–0.90), low fruit and vegetable intake (OR = 0.68; 95%CI = 0.63–0.74), low parental support/monitoring (OR = 0.68; 95%CI = 0.62–0.74), no friends (OR = 0.80; 95%CI = 0.72–0.88), and who experienced bullying (OR = 0.93; 95%CI = 0.86–0.99) were less likely to have adequate levels of PA. There were a few variations in the correlates depending on country-income level. Our data indicate that in adolescents aged 12 to 15 years living in LMICs physical activity participation is a complex and multi-dimensional behavior determined by sociocultural, socio-economic, and policy-related factors. Longitudinal research is needed to confirm/refute the present findings.

1. Introduction

In adolescents, the association between low levels of physical activity (PA) and the development of chronic physical and mental health conditions, mainly cardio-metabolic disorders and depression (Carson et al., 2014; de Oliveira and Guedes, 2016; Farren et al., 2018; Schuch et al., 2017; Wu et al., 2017), are ongoing topics of research. The burden of these chronic conditions is particularly high in low- and middle-income countries (LMICs). For example, prevalence rates of depression in adolescents in LMICs are as high as 28% (Yatham et al.,

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2017). Next to an immense mental health burden, almost three-quarters of non-communicable related deaths occur in LMICs indicating there is a need for preventive efforts such as promoting PA in adolescents in this part of the world (World Health Organization, 2014).

To this end, there is nowadays an awareness in LMICs that adolescents should meet the international PA recommendation of at least 60 min of moderate-to-vigorous PA daily (Barbosa Filho et al., 2016). However, implementation of these guidelines in low resource settings is challenging (Barbosa Filho et al., 2016). Understanding barriers and facilitators of PA in adolescents living in LMICs are an important first step in order to devise PA interventions that can effectively be implemented in these settings. Behavioral theories such as the socio-ecological model (Sallis et al., 2006) have proven to be useful in attempting to understand the factors which influence PA behavior (Stubbs et al., 2014, 2015; Vancampfort et al., 2012, 2014, 2015). Socio-ecological models posit that multiple factors influence any health behavior (Bauman et al., 2012). These include intrapersonal (demographic, psychological, cognitive and biological), interpersonal (e.g., social support), environmental (e.g., enjoyable scenery such as a green environment, distance to the facilities, financial costs), and policy (e.g., regulations laws, rules) factors (Sallis et al., 2006). Previous research in adolescents from high-income countries demonstrated that sex, age, ethnicity, family income, socioeconomic status, parental education, self-efficacy, perceived competence, goal orientation and motivation, perceived barriers, participation in community sports, parental support for PA, support from others, and access to sport and recreational facilities are all consistent correlates of PA behavior (Biddle et al., 2011; Sterdt et al., 2014).

Exploring PA correlates in adolescents in LMICs separately is however also important given different cultural attitudes towards physical inactivity (e.g., taking motorized transport as sign of economic welfare), different access to devices (e.g., access to television and computers which might stimulate more sedentary behaviors) and different environmental factors (e.g., safety and climate issues that might prevent adolescents from being physically active) compared with adolescents from high-income countries (Arat and Wong, 2017). To date, multinational studies exploring correlates of PA in adolescents aged 12–15 years in LMICs are absent. Multinational studies allow exploration of these correlates irrespective of the available facilities in each country and irrespective of any national policies. At the same time multinational studies provide a platform to investigate between-country comparisons in order to explore the role of these available facilities and policies.

We identified PA correlates including demographic variables (age, gender), policy related variables (e.g. provision of physical education classes), socio-environmental factors (e.g., food insecurity as a measure of proxy for socio-economic status, parental support, bullying), health behavior related variables (e.g., smoking, alcohol use, diet pattern) and health-related variables (obesity) among adolescents aged 12–15 years living in a LMIC and who participated in the Global school-based Student Health Survey (GSHS).

2. Methods

2.1. The survey

Data from the Global school-based Student Health Survey (GSHS) were analyzed. These data are publically available at http://www.who.int/chp/gshs and http://www.cdc.gov/gshs, and details on the survey can also be found in these websites. Briefly, the main aim of the survey was to examine risk and protective factors for major non-communicable diseases among school-going adolescents. The process of the selection of participants involved a standardized two-stage probability sampling design within each participating country. Probability proportional to size sampling was first used to select schools. Next, within each selected school, classrooms that included students aged 13–15 years were randomly selected. The multiple choice questionnaire was translated into the local language of each country. Questionnaires were provided in the form of computer scannable sheets. The protocol was approved by a national government administration in each country (most commonly the Ministry of Health or Education, and an institutional review board or ethics committee). Participation in the survey was voluntary and anonymity was guaranteed. The students, parents and/or school officials provided informed consent. Sampling weights that corrected for non-response and probability selection were available for analysis.

For the current analysis, all nationally representative datasets from LMICs, which included the variables pertaining to the study, were included. The most recent dataset was used in cases where more than two datasets were available from the same country. A total of 48 countries were included in the current study. For these countries, data were collected between 2009 and 2016. There were 6 low-income, 27 lower middle-income, and 15 upper middle-income countries based on the World Bank classification at the time of the survey (World Bank, 2017). The income classification of the World Bank is based on a measure of national income per person, or gross national income per capita (World Bank, 2017). Although data on PA were also available from surveys conducted before 2009, we did not include data from these surveys to ensure comparability as the question on PA was different. The characteristics of each country or survey are provided in Table 1.

2.2. PA

Levels of PA levels were assessed with The PACE+ Adolescent Physical Activity Measure (Prochaska et al., 2001). A definition of PA was first provided to the students as follows: “Physical activity is any activity that increases your heart rate and makes you breathe hard. PA can be done in sports, playing with friends, or walking to school. Some examples of PA are running, fast walking, biking, dancing, football, and (country-specific examples).” Subsequently, the student was asked about the number of days with any kind of PA of at least 60 min during the past 7 days. For the current study, responses were dichotomized as 0–6 days (inadequate PA; coded 0) and all 7 days (adequate PA; coded 1) to reflect the WHO's recommendations on PA for children and young adults (World Health Organization, 2010). This measure has been tested for validity and reliability (Prochaska et al., 2001)

2.3. Correlates

Fourteen correlates of PA were selected based on past literature (Jabeen et al., 2018; Khan et al., 2017; Peltzer and Pengpid, 2016; Sallis et al., 2000; Shokrvash et al., 2013). We included only factors that may be theoretically linked with PA. We did not include drug use as its association with PA will be reported in a separate study (unpublished data). The demographic variables included age and sex. As in previous GSHS studies (Balogun et al., 2014; Koyanagi et al., 2019), food insecurity was used as a proxy for socioeconomic status (Jones et al., 2013) as there were no variables on socioeconomic status in the GSHS. Food insecurity was assessed by the question “During the past 30 days, how often did you go hungry because there was not enough food in your home?” Answer options were categorized as ‘never’ (coded 0) and ‘rarely/sometimes/most of the time/always’ (coded 1). Smoking referred to the use of any form of tobacco on at least one day in the past 30 days. Alcohol consumption was defined as having had at least one drink containing alcohol in the past 30 days. Those who consumed fast food on at least one day in the past 7 days were considered to be consumers of fast food. Those who consumed carbonated soft drinks in the past 30 days (excluding diet soft drinks) were considered to be consumers of carbonated soft drink. Low fruit and vegetable consumption was defined as intake of fruit and vegetables less than five times per day (< 400 g of fruits and vegetables/day) during the past 30 days (Centers for Disease Control and Prevention, 2012). Trained survey staff conducted measurement of weight and height. Body mass index was

Table 1
Survey characteristics.

Country income	Country	Year	Response rate (%)	N[a]	Adequate PA (%)
Low-income	Afghanistan	2014	79	1493	9.6
	Benin	2016	78	717	28.1
	Cambodia	2013	85	1812	6.5
	Mozambique	2015	80	668	11.3
	Nepal	2015	69	4616	14.4
	Tanzania	2014	87	2615	21.1
Lower middle-income	Bangladesh	2014	91	2753	41.2
	Belize	2011	88	1600	20.0
	Bolivia	2012	88	2804	13.7
	East Timor	2015	79	1631	8.2
	Egypt	2011	85	2364	13.0
	El Salvador	2013	88	1615	12.5
	Ghana	2012	82	1110	8.9
	Guatemala	2015	82	3611	11.1
	Guyana	2010	76	1973	14.8
	Honduras	2012	79	1486	15.2
	Indonesia	2015	94	8806	12.0
	Kiribati	2011	85	1340	17.4
	Laos	2015	70	1644	16.3
	Maldives	2009	80	1981	21.6
	Mauritania	2010	70	1285	11.2
	Mongolia	2013	88	3707	26.9
	Morocco	2010	92	2405	12.6
	Pakistan	2009	76	4998	11.6
	Philippines	2015	79	6162	7.3
	Samoa	2011	79	2200	12.1
	Solomon Islands	2011	85	925	16.5
	Sudan	2012	77	1401	7.6
	Syria	2010	97	2929	11.3
	Tonga	2010	80	1946	13.8
	Vanuatu	2011	72	852	10.5
	Vietnam	2013	96	1743	13.0
	Yemen	2014	75	1553	12.9
Upper middle-income	Algeria	2011	98	3484	14.9
	Antigua & Barbuda	2009	67	1235	22.4
	Argentina	2012	71	21,528	16.8
	Costa Rica	2009	72	2265	18.1
	Dominica	2009	84	1310	16.6
	Fiji	2016	79	1537	19.2
	Iraq	2012	88	1533	14.8
	Lebanon	2011	87	1982	23.3
	Malaysia	2012	89	16,273	13.8
	Mauritius	2011	82	2074	19.4
	Namibia	2013	89	1936	14.0
	Peru	2010	85	2359	15.0
	Suriname	2009	89	1046	19.6
	Thailand	2015	89	4132	12.2
	Tuvalu	2013	90	679	11.9

Abbreviation: PA = Physical activity.
Adequate PA was defined as at least 60 min of moderate-to-vigorous physical activity daily.
[a] Based on students aged 12–15 years.

calculated as weight in kilograms divided by height in meters squared. Obesity was defined as > 2 SDs above the median for age and sex based on the 2007 WHO Child Growth reference (World Health Organization, 2019). Physical education referred to the number of days the student went to physical education class each week during the current school year. This variable was dichotomized into < 5 (coded 0) and ≥5 days (coded 1) (Sharma et al., 2018). Low parental involvement was defined as answering 'rarely' or 'never' to all of the following three questions: (a) 'during the past 30 days, how often did your parents or guardians check to see if your homework was done?'; (b) 'during the past 30 days, how often did your parents or guardians understand your problems and worries?'; and (c) 'during the past 30 days, how often did your parents or guardians really know what you were doing with your free time?' (Romo et al., 2016). Close friends referred to the number of close friends a student has. This variable was dichotomized into at least one (coded 0) and none (coded 1). Bullying victimization was defined as being bullied on at least one day in the past 30 days.

2.4. Statistical analysis

We restricted the analysis to adolescents aged 12–15 years as the exact age outside of this age range was not available in the dataset and because the majority of the students were within this age range.

We applied a multivariable logistic regression analysis in order to assess the association between each correlate (exposure) and adequate PA (outcome). The analysis was adjusted for age, sex, and food insecurity (proxy of low socioeconomic status). The association of age, sex, and food security with adequate PA was assessed with a model that mutually adjusted for these three variables. Only countries with < 20% of data on obesity missing were included in the analysis on obesity as many countries had a high proportion of missing values for this variable. Furthermore, not all countries could be included in the analysis for some analyses since data on some variables were not collected from certain countries (see Table 2 for availability of data for each country). To assess the level of between-country heterogeneity, the Higgins's I^2 statistic was calculated. A value of < 40% is often considered as low, while 40–60% indicates a moderate level of heterogeneity (Higgins and Thompson, 2002). Pooled estimates were obtained by combining the estimates for each country into a random effect meta-analysis (overall and by country-income level) as the level of between-country heterogeneity was at least moderate for most of the analyses. As the correlates of PA may differ by sex (Sallis et al., 2000), we also conducted sex-stratified analyses with the same methodology mentioned above with the only difference being that the sex-stratified analysis was only adjusted for age and food insecurity.

All variables, with the exception of age, were included in the regression analysis as categorical variables. We used Taylor linearization methods in all analyses in order to be able to account for the sample weighting and complex study design (Wolter, 2007). The findings are presented as odds ratios (ORs) with 95% confidence intervals (CIs). Statistical analyses were performed with Stata 14.1 (Stata Corp LP, College station, Texas).

3. Results

The final sample consisted of 142,118 adolescents aged 12–15 years with a mean (SD) age of 13.8 (1.0) years and 49.0% were girls. The overall prevalence of adequate PA was 15.3% (95%CI = 14.5%–16.1%), which ranged widely between countries (Table 1). Specifically, the lowest and highest prevalence was found in Cambodia (6.5%) and Bangladesh (41.2%), respectively. The country-wise prevalence of each of the correlates are illustrated in Table 2. Overall, the prevalence of fast food and carbonated soft drink consumption was high, while the vast majority of adolescents had low fruit and vegetable intake. The association between each correlate and adequate PA estimated by meta-analysis is shown in Table 3. In the overall sample, male sex (OR = 1.64; 95%CI = 1.47–1.83; I^2 = 82.8%), participation in physical education for ≥5 days/week (OR = 1.12; 95%CI = 1.10–1.15; I^2 = 87.0%), and alcohol consumption (OR = 1.10; 95%CI = 0.99–1.22; I^2 = 60.8%) were positively associated with meeting recommended PA guidelines, although for alcohol consumption, the associations was largely driven by the more pronounced association observed in upper middle-income countries. On the other hand, overall, food insecurity (proxy of low socioeconomic status) (OR = 0.85; 95%CI = 0.80–0.90; I^2 = 44.0%), low fruit and vegetable intake (OR = 0.68; 95%CI = 0.63–0.74; I^2 = 64.5%), low parental support/monitoring (OR = 0.68; 95%CI = 0.62–0.74; I^2 = 42.9%), no friends (OR = 0.80; 95%CI = 0.72–0.88; I^2 = 21.2%), and bullying victimization (OR = 0.93; 95%CI = 0.86–0.99; I^2 = 48.6%) were the factors which were associated with the most

Table 2
Prevalence or mean of the correlates by country.

Country	Age	Male	FI	Smoke	Alcohol	Fast food	Soft drink	Low FV	Obesity	PE[a]	Low PS/M	No friend	Bullied	PI
Low-income														
Afghanistan	14.0 (0.9)	53.4	50.2	9.1	NA	63.3	70.8	84.3	2.2	18.0	12.8	13.7	43.8	46.2
Benin	14.2 (0.9)	65.6	49.2	5.2	38.6	46.3	72.1	69.2	2.4	10.0	14.9	11.8	48.4	45.7
Cambodia	14.1 (0.8)	48.4	50.9	4.0	5.2	25.5	84.1	89.7	0.4	6.3	NA	5.7	22.1	19.8
Mozambique	14.1 (0.8)	49.6	44.5	4.8	9.4	65.5	87.2	75.5	NA	9.6	10.2	10.3	45.7	58.4
Nepal	13.8 (1.0)	47.3	32.2	7.0	4.6	75.3	76.0	90.6	0.5	28.7	12.3	4.4	50.3	64.0
Tanzania	13.6 (1.0)	46.8	24.5	6.7	4.2	35.6	63.8	65.3	NA	25.0	17.6	8.7	26.9	40.1
Lower middle-income														
Bangladesh	14.0 (0.8)	63.4	61.7	9.0	1.4	53.3	83.7	83.5	1.3	27.5	9.1	8.8	23.7	43.2
Belize	13.6 (1.1)	48.4	37.7	NA	25.2	66.2	87.8	70.3	13.5	13.2	10.6	7.8	30.7	44.8
Bolivia	14.0 (0.9)	49.7	60.9	14.1	14.7	56.9	88.3	68.5	4.7	26.0	19.8	8.2	30.4	48.8
East Timor	14.1 (1.0)	46.3	49.2	22.8	12.3	67.0	88.0	84.0	1.2	18.9	26.5	4.9	31.3	72.2
Egypt	13.5 (0.9)	49.2	45.6	6.2	NA	49.3	82.5	75.1	7.7	13.5	12.6	8.2	70.1	33.0
El Salvador	14.0 (0.9)	50.6	34.6	NA	16.7	57.4	90.4	79.1	10.3	33.2	12.6	5.2	22.5	35.5
Ghana	13.8 (1.0)	49.1	61.2	16.7	15.3	69.9	71.6	63.1	1.9	18.1	11.3	10.0	62.8	72.2
Guatemala	13.9 (0.9)	50.9	36.5	NA	16.6	56.8	88.8	71.2	7.7	28.8	NA	6.5	23.0	32.2
Guyana	14.1 (0.8)	48.6	45.3	15.4	39.3	56.0	91.2	68.3	4.1	11.7	11.5	10.3	38.4	37.7
Honduras	13.6 (1.0)	46.1	35.8	13.3	14.8	48.0	91.9	73.7	6.0	27.5	14.8	6.8	32.3	35.9
Indonesia	13.5 (1.0)	49.2	53.9	11.5	3.7	54.7	61.9	75.2	5.3	8.8	8.0	3.1	21.0	30.1
Kiribati	14.0 (0.9)	45.5	67.1	31.3	29.8	43.9	47.4	85.3	8.0	24.5	24.6	2.6	36.8	57.7
Laos	14.5 (0.8)	47.8	46.8	3.9	19.8	44.8	88.4	81.9	2.2	9.5	19.3	5.1	13.2	18.6
Maldives	14.4 (0.7)	47.9	34.2	12.1	5.0	34.9	75.6	87.7	NA	NA	12.6	9.6	37.0	40.3
Mauritania	14.2 (0.9)	53.2	58.2	24.1	23.5	63.2	76.8	71.1	NA	20.8	19.9	7.6	47.5	54.4
Mongolia	13.7 (1.0)	49.4	36.0	8.3	4.1	55.2	73.2	78.7	1.8	3.7	14.6	6.0	31.4	36.3
Morocco	13.7 (1.0)	52.9	30.7	8.9	NA	44.2	76.2	53.3	2.8	26.4	20.1	8.8	18.5	29.3
Pakistan	14.1 (0.8)	60.8	25.2	10.1	NA	21.0	59.1	89.9	1.0	7.9	9.3	8.1	41.1	36.3
Philippines	13.9 (0.9)	48.1	69.4	13.8	17.5	51.9	87.8	74.4	2.8	34.0	22.8	4.2	51.5	49.5
Samoa	14.0 (0.8)	47.4	81.2	45.3	34.5	78.9	80.7	52.0	NA	14.0	9.7	15.9	74.1	83.4
Solomon Islands	14.1 (0.9)	52.1	83.2	28.5	17.6	65.9	74.7	55.0	NA	28.0	8.3	13.4	65.7	68.1
Sudan	14.2 (0.8)	51.9	39.6	10.2	NA	41.5	65.8	76.9	3.6	9.1	14.6	NA	NA	NA
Syria	13.6 (1.0)	51.2	52.9	19.2	7.2	42.8	78.8	84.7	6.1	20.9	22.4	5.1	NA	44.8
Tonga	14.1 (0.9)	50.3	74.1	26.0	16.2	70.0	87.8	60.9	21.9	16.8	15.8	9.3	50.6	61.9
Vanuatu	13.5 (1.0)	49.5	49.7	12.5	7.6	56.4	71.1	48.6	NA	15.1	11.5	15.9	67.9	62.9
Vietnam	14.5 (0.6)	46.6	49.1	3.0	15.5	29.7	75.4	77.1	0.6	3.3	14.5	4.4	26.1	28.9
Yemen	13.8 (1.0)	56.3	58.3	15.7	NA	34.5	66.3	78.7	2.4	21.2	27.1	5.9	42.0	46.9
Upper middle-income														
Algeria	13.6 (1.1)	45.8	44.3	9.5	NA	51.9	93.2	65.4	3.7	16.2	NA	NA	51.0	31.9
Antigua & Barbuda	13.9 (0.9)	51.4	44.0	11.8	44.3	56.6	86.3	73.2	NA	21.3	16.5	8.4	25.1	50.7
Argentina	13.9 (0.9)	47.7	35.0	19.9	48.1	31.5	90.1	82.5	NA	20.5	14.0	5.5	24.4	33.3
Costa Rica	14.0 (0.9)	49.6	19.2	10.3	23.3	54.4	87.5	80.6	8.9	31.2	15.4	5.6	19.1	22.2
Dominica	13.6 (1.1)	50.4	34.2	NA	50.8	47.1	84.1	73.6	NA	20.0	NA	9.8	27.0	42.6
Fiji	14.4 (0.6)	49.0	59.6	11.7	13.2	64.2	90.7	62.3	8.2	11.3	7.7	7.9	30.0	47.7
Iraq	13.9 (1.0)	54.7	32.8	12.4	NA	55.7	87.2	73.0	7.9	25.2	18.0	6.5	28.3	34.8
Lebanon	13.7 (1.0)	46.6	33.5	NA	28.5	64.6	93.4	72.3	NA	28.6	12.5	3.6	24.9	38.7
Malaysia	14.0 (0.9)	49.5	60.7	10.9	7.5	48.3	73.3	69.8	9.7	21.0	18.7	3.2	21.0	35.9
Mauritius	13.8 (1.0)	49.2	25.0	16.1	NA	54.2	79.2	73.0	6.2	21.3	NA	NA	35.2	38.7
Namibia	14.1 (0.9)	42.9	53.9	11.6	23.0	53.9	75.2	71.5	1.9	23.8	11.8	13.2	45.9	58.3
Peru	14.1 (0.8)	49.9	51.2	17.7	26.9	50.0	86.9	90.1	2.9	1.7	16.4	5.5	47.2	48.9
Suriname	14.0 (1.0)	45.4	33.0	10.0	31.2	62.4	94.9	69.1	7.2	16.2	12.7	15.8	26.2	29.5
Thailand	13.7 (1.0)	49.6	53.6	13.1	17.6	80.1	88.2	70.1	6.6	7.1	16.8	5.9	32.7	40.6
Tuvalu	13.3 (1.1)	48.9	52.6	18.6	10.9	44.4	72.1	64.4	NA	26.8	37.2	16.2	30.1	51.7

Abbreviation: FI Food insecurity, FV Fruit and vegetable; PE Physical education; PS/M Parental support/monitoring; PI Physical injury; NA Not available.
All data are percentage apart from age [mean (standard deviation)].
For obesity, only countries with < 20% of data missing were included.
[a] Physical education of at least 5 days per week.

pronounced negative association with adequate levels of PA. Although the overall estimates for carbonated soft drink consumption and obesity were not notable, the associations in upper middle-income countries for these factors were OR = 0.84; 95%CI = 0.78–0.91 and OR = 0.76; 95%CI = 0.67–0.87, respectively. The country-wise estimates are shown in Figs. S1 to S14 of the Appendix. The sex-stratified analysis showed that the association between each correlate and PA is similar between both genders although the negative association with physical activity was more pronounced among boys for food insecurity, no close friends, and bullying victimization (Table 4).

4. Discussion

To the best of our knowledge, this is the first multinational study exploring a multitude of PA correlates across different domains among adolescents aged 12 to 15 years in LMICs. In terms of the demographic PA correlates, boys were more likely to meet recommended PA guidelines than girls. Sex differences in PA participation have been reported before (Jabeen et al., 2018; Khan et al., 2017; Peltzer and Pengpid, 2016; Sallis et al., 2000; Shokrvash et al., 2013) and might be reflecting traditional gender roles. For example, in many LMICs, parents are less likely to allow girls to be physically active outdoor, and therefore, girls often engage only in domestic activities (e.g. cooking, household chores), which may involve less energy expenditure. In contrast, boys

Table 3
Association between each correlate and adequate physical activity estimated by meta-analysis based on country-wise estimates.

Correlate		Overall		Low-income		Lower middle-income		Upper middle-income	
		OR (95%CI)	I^2	OR (95%CI)	I^2	OR (95%CI)	I^2	OR (95%CI)	I^2
Age (year)	Per one year increase	0.99 (0.96–1.02)	41.8	0.99 (0.91–1.09)	0.0	1.03 (0.98–1.08)	48.9	0.94 (0.91–0.97)	6.6
Sex	Male vs. Female	1.64 (1.47–1.83)	82.8	1.42 (1.17–1.73)	5.9	1.52 (1.34–1.73)	77.3	1.93 (1.61–2.30)	85.2
Food insecurity	Yes vs. No	0.85 (0.80–0.90)	44.0	0.72 (0.60–0.85)	0.0	0.83 (0.76–0.90)	47.5	0.91 (0.83–1.00)	42.7
Smoking	Yes vs. No	0.96 (0.87–1.06)	51.7	0.83 (0.35–1.98)	86.4	0.89 (0.80–0.99)	27.3	1.10 (1.00–1.21)	6.4
Alcohol consumption	Yes vs. No	1.10 (0.99–1.22)	60.8	0.68 (0.28–1.63)	81.5	1.04 (0.88–1.22)	60.8	1.21 (1.09–1.34)	35.0
Fast food consumption	Yes vs. No	0.98 (0.92–1.05)	56.9	1.04 (0.87–1.24)	0.0	1.00 (0.90–1.12)	64.8	0.93 (0.86–1.01)	42.5
Carbonated soft drink consumption	Yes vs. No	0.95 (0.89–1.02)	30.9	1.01 (0.73–1.40)	61.3	1.00 (0.91–1.09)	28.9	0.84 (0.78–0.91)	0.0
Low fruit/vegetable consumption	Yes vs. No	0.68 (0.63–0.74)	64.5	0.67 (0.46–0.98)	75.9	0.67 (0.60–0.76)	71.2	0.67 (0.61–0.73)	31.0
Obesity	Yes vs. No	0.95 (0.83–1.08)	36.4	1.21 (0.53–2.76)	57.6	1.08 (0.91–1.29)	26.2	0.76 (0.67–0.87)	0.0
Physical education (days/week)	≥5 vs. < 5	1.12 (1.10–1.15)	87.0	1.19 (1.08–1.32)	90.7	1.11 (1.07–1.14)	84.3	1.11 (1.08–1.14)	77.2
Low parental support/monitoring	Yes vs. No	0.68 (0.62–0.74)	42.9	0.70 (0.52–0.94)	9.9	0.65 (0.57–0.74)	49.6	0.73 (0.64–0.83)	33.4
Close friends	None vs. At least one	0.80 (0.72–0.88)	21.2	0.82 (0.66–1.02)	0.0	0.75 (0.65–0.87)	27.5	0.86 (0.74–1.01)	23.2
Bullying victimization	Yes vs. No	0.93 (0.86–0.99)	48.6	1.01 (0.68–1.51)	72.1	0.89 (0.80–0.98)	50.3	0.97 (0.88–1.06)	28.2

Abbreviation: OR Odds ratio; CI Confidence interval.
Estimates were obtained by combining country-wise estimates adjusted for age, sex, and food insecurity into a meta-analysis with random effects.

Table 4
Association between each correlate and adequate physical activity estimated by meta-analysis among boys and girls.

Correlate		Boys		Girls	
		OR (95%CI)	I^2	OR (95%CI)	I^2
Age (year)	Per one year increase	1.00 (0.96–1.04)	41.0	0.98 (0.94–1.02)	25.7
Food insecurity	Yes vs. No	0.79 (0.74–0.85)	34.7	0.95 (0.89–1.02)	15.7
Smoking	Yes vs. No	0.93 (0.84–1.04)	41.9	1.06 (0.94–1.19)	12.5
Alcohol consumption	Yes vs. No	1.10 (0.98–1.23)	47.4	1.12 (0.98–1.29)	48.3
Fast food consumption	Yes vs. No	0.99 (0.92–1.07)	39.9	0.97 (0.89–1.06)	45.5
Carbonated soft drink consumption	Yes vs. No	0.97 (0.90–1.04)	12.1	0.90 (0.83–0.98)	12.4
Low fruit/vegetable consumption	Yes vs. No	0.69 (0.64–0.74)	29.5	0.66 (0.60–0.73)	46.9
Obesity	Yes vs. No	0.92 (0.79–1.08)	31.0	1.09 (0.92–1.30)	17.3
Physical education (days/week)	≥5 vs. < 5	1.12 (1.10–1.15)	74.9	1.12 (1.09–1.15)	80.2
Low parental support/monitoring	Yes vs. No	0.65 (0.60–0.71)	2.2	0.73 (0.64–0.83)	45.3
Close friends	None vs. At least one	0.77 (0.69–0.86)	0.0	0.97 (0.86–1.09)	0.0
Bullying victimization	Yes vs. No	0.86 (0.77–0.95)	55.8	1.04 (0.96–1.13)	18.3

Abbreviation: OR Odds ratio; CI Confidence interval.
Estimates were obtained by combining country-wise estimates adjusted for age and food insecurity into a meta-analysis with random effects.

are more likely to engage in outdoor sports activities (e.g. soccer) (Khan et al., 2017; Shokrvash et al., 2013).

A school (policy) related correlate was participation in physical education classes. Our data are in line with a recent systematic review demonstrating that attending physical education classes is associated with a higher level of PA in and out of school during weekdays in children and adolescents from countries at various levels of development (Silva et al., 2018). A practical implication is that ministries of public health in LMICs should work closely together with ministries of education in promoting an active lifestyle among adolescents, for example through provision of daily physical education classes during school days, or potentially through after school programs. We however did not have data on any after school PA programs, which can also increase PA levels. Our finding confirms previous recommendations that public policies to promote PA in adolescents from LMIC should focus on the school environment (Barbosa Filho et al., 2016).

With regard to socio-environmental correlates, food insecurity was associated with less PA. Although the exact mechanisms linking food insecurity and physical inactivity are unclear, several hypotheses may be proposed. First, food insecurity can be considered a proxy for lower socio-economic status. Previous research indicated that a lower socio-economic status is associated with living in less safe environments and less access to PA facilities (O'Donoghue et al., 2018). Second, inadequate nutrition may result in less energy to perform daily life activities. Third, when there is a lack of food, families tend to choose less nutritious food (e.g., rich in carbohydrates and fats and poor in micronutrients and vitamins) (Pilgrim et al., 2012). Poorer diet has been associated with poorer mental health outcomes, also in children and adolescents (O'Neil et al., 2014). Poorer mental health on it turn might result in more inactivity (Bélair et al., 2018). Fourth, food insecurity may increase risk for parental depression. This might be due to the inadequate nutritional intake of the parents themselves or related to worries about the lack of food for their children (Li et al., 2017). Parental depression may lead to unresponsive caregiving.

Our data show that low parental support/monitoring is an important social correlate associated with less PA in adolescents aged 12 to 15 years. With regard to PA participation, parental support can consist of providing encouragement, transportation to PA opportunities, watching adolescents participate in activities, and engaging with children in PA (Trost and Loprinzi, 2011). Interpersonal or social factors may be the most important and modifiable variables, therefore, health campaigns should focus on the importance of these interpersonal and social factors (Gustafson and Rhodes, 2006). Another social factor associated with more PA participation was having friends. Friends have a social influence on adolescents' health behavior via social support or via behavior modeling (Cheng et al., 2014). A third interpersonal, social factor that was associated with lower PA participation was bullying victimization. This finding stresses the importance of bullying prevention efforts in conjunction with health promotion programs targeting school going adolescents. Of interest is that in the overall analysis, obesity was not a PA correlate. Therefore, obesity does not seem to mediate the relationship between being bullied and physical inactivity.

A factor that might mediate the relation is low mood (Klomek et al., 2007), for which data were not available in the current study.

Within the health behavior domain, inadequate fruit and vegetable consumption was associated with physical inactivity in LMICs. Low PA and inadequate fruit and vegetable consumption may reflect a clustering of unhealthy behaviors. The prevalence of these clustered unhealthy behaviors is increasing in LMICs (Matias et al., 2018). Longitudinal research is essential to establish how different clustering patterns evolve over time in adolescents in LMICs and their influence on the development of chronic non-communicable diseases. Of interest is that differences were found between country-income levels. For example, the negative association between PA and carbonated soft drink consumption and the positive association between PA and alcohol consumption were particularly pronounced in upper-middle income countries. It may be that those who engage in PA in upper middle-income countries are more health-conscious and prefer not to consume carbonated soft drinks. A rather counterintuitive finding was the association between higher PA levels and alcohol consumption in upper-middle income countries. This may be related with wider availability of alcohol in this setting (Ma et al., 2018) but research from high-income countries suggests that until a certain level of alcohol consumption is reached, more alcohol intake is associated with more PA participation (French et al., 2009; Vancampfort et al., 2015). It might be that adolescents who consume alcohol have an increased affinity for exercise and sports because of its reward-related reinforcing effects (Leasure et al., 2014). Alternatively, joining a sports team may results in more alcohol consumption after the game. However, more research is needed explore this relationship within the context of each particular country.

The current data should be considered in the light of some limitations. First, due to the cross-sectional design, cause and effect cannot be deduced. Prospective research needs to disentangle the directionality of the relationships observed in the current study. Second, PA was assessed with a self-report measure in the current study, which is prone to bias. It is well recognized that self-reported measures can overestimate PA levels (Ainsworth et al., 2006). Future research should utilize objective measures of PA such as accelerometers. Additionally, given the recent mass-scale adoption and regular usage of smartphones among young people (Firth et al., 2019), the data collected from these devices and associated 'wearable' activity trackers may present novel and feasible methods for collecting objective measures of PA on a population-scale, very likely shedding new light on variables that might be associated with PA levels in adolescents in LMICs. Third, varying degrees of bias may have been introduced by interviewing only school going adolescents who might be more (as they do have physical education) or less (compared to those who do intensive child labor) physically active than those who are not attending school. However, the majority of adolescents aged 12 to 15 years from most of the countries in our study do attend school (UNICEF, 2015). Finally, future studies in LMICs may wish to assess the moderate to high heterogeneity observed, which is likely due to differences between countries and how different societal changes in LMICs (such as economic growth, urbanization), civil conflicts, and extreme weather conditions are linked to physical inactivity in this population. For example, urbanization may, on one hand, potentially lead to better access to mental and physical health care, on the other hand, it also introduces new hazards including a sedentary lifestyle due to the increasing availability of motorized transport.

5. Conclusion

Our data indicate that in adolescents aged 12 to 15 years living in LMICs PA participation is a complex and multi-dimensional behavior. Longitudinal research is needed to confirm/refute the findings to inform public interventions which aim to increase PA levels in inactive adolescents living in LMICs.

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Declaration of competing interest

None.

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Appendix A. Supplementary data

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