**Preventive Medicine**

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

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**Abstract**

**Background**

Physical inactivity is a growing public health concern in young adolescents from low- and middle-income countries (LMICs). However, a paucity of multinational studies, particularly in LMICs, has investigated correlates of physical activity (PA) in young adolescents.

**Methods**

Data from the Global school-based Student Health Survey were analyzed in 142,118adolescents from 48 LMICs [mean (SD) age 13.8 (1.0) years; 49% girls). PA was assessed by the PACE+ Adolescent Physical Activity Measure and participants were dichotomised into those who do (60 minutes of moderate-vigorous PA every day of the week) and do not comply with the World Health Organization (WHO) PA recommendations. Multivariable logistic regression was used to assess the PA correlates.

**Findings**

The prevalence of low PA was 15.3% (95%CI=14.5%-16.1%). Boys and those who participated in physical education for ≥5 days/week were significantly more likely to meet PA guidelines, while adolescents with food insecurity, low fruit and vegetable intake, low parental support/monitoring, no friends, and who experienced bullying were significantly less likely to have adequate levels of PA. There were some variations in the correlates depending on country-income level.

**Interpretation**

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. Future longitudinal data are required to confirm/refute the findings to inform public interventions which aim to increase physical activity levels in inactive adolescents living in LMICs.

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**Introduction**

In adolescents, the relationship between low levels of physical activity and the development of chronic physical and mental health conditions, mainly cardio-metabolic disorders and depression (de Oliveira and Guedes, 2016; Farren et al., 2018; Raudsepp et al., 2019; 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., 2017). Next to an immense mental health burden, almost three-quarters of non-communicable related deaths occur in LMICs indicating a large potential for preventive interventions such as physical activity at the early stages of life in this part of the world (Organization, 2014).

 To this end, there is nowadays an awareness in LMICs that adolescents should meet the international physical activity recommendation of at least 60 minutes of moderate-to-vigorous physical activity 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 participation in physical activity in adolescents living in LMICs are an essential first step in order to devise effective physical activity interventions. 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 physical activity behavior (Stubbs et al., 2014; Stubbs et al., 2015; Vancampfort et al., 2015a; Vancampfort et al., 2012; Vancampfort et al., 2014). Socio-ecological models posit that multiple relevant attributes influence health behavior (Bauman et al., 2012). These include intrapersonal (demographic, biological, psychological, emotional and cognitive), interpersonal/cultural (e.g., social support), physical environment (e.g., distance to the facilities, financial costs, enjoyable scenery), and policy (laws, rules, regulations, codes) factors (Sallis et al., 2006). Previous research in adolescents from high income countries demonstrated that sex, age, ethnicity, parental education, family income, socioeconomic status, perceived competence, self-efficacy, goal orientation/motivation, perceived barriers, participation in community sports, parental support, support from significant others, access to sport/recreational facilities are all consistent correlates of physical activity behavior (Biddle et al., 2011; Sterdt et al., 2014).

Exploring physical activity correlates in adolescents in LMICs separately is however also important given different sociocultural attitudes towards physical inactivity (e.g., using motorized transport as a sign of wealth), 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 prevent children from being physically active) in comparison with high-income countries (Arat and Wong, 2017). To date, multinational studies exploring physical activity correlates in adolescents aged 12-15 years in LMICs are absent. Multinational studies allow exploration of physical activity correlates irrespective of national policies and available facilities, and at the same time allow comparison between countries in order to investigate the role of these policies and available facilities in different countries.

We assessed physical activity 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 behaviour related variables (e.g., smoking, alcohol use, diet pattern) and a health-related variable (the presence of obesity) among adolescents aged 12-15 years who participated in the Global school-based Student Health Survey (GSHS). Correlates of physical activity available in the GSHS dataset were selected based on past literature (Jabeen et al., 2018; Khan et al., 2017; Peltzer et al., 2016; Sallis et al., 2000; Shokrvash et al., 2013).

**Methods**

***The survey***

Publically available data from the Global school-based Student Health Survey (GSHS) were analyzed. Details on this survey can be found at <http://www.who.int/chp/gshs> and <http://www.cdc.gov/gshs>. Briefly, the GSHS was jointly developed by the World Health Organization and the United States Centers for Disease Control and Prevention and other United Nations allies. The core aim of this survey was to assess and quantify risk and protective factors of major non-communicable diseases. The survey used a standardized two-stage probability sampling design for the selection process within each participating country. For the first stage, schools were selected with probability proportional to size sampling. The second stage involved the random selection of classrooms which included students aged 13-15 years within each selected school. All students in the selected classrooms were eligible to participate in the survey regardless of age. Data collection was performed during one regular class period. The questionnaire was translated into the local language in each country, and consisted of multiple choice response options. Students recorded their response on computer scannable sheets. All GSHS surveys were approved, in each country, by both a national government administration (most often the Ministry of Health or Education) and an institutional review board or ethics committee. Student privacy was protected through anonymous and voluntary participation, and informed consent was obtained from the students, parents and/or school officials. Data were weighted for non-response and probability selection.

 From all publicly available data, we selected all nationally representative datasets from LMICs that included the variables used in the current analysis. If there were more than two datasets from the same country, we chose the most recent dataset. A total of 48 countries were included in the current study. The characteristics of each country or survey are provided in Table 1. For the included countries, the survey was conducted between 2009 and 2016, and consisted of 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. Although data on physical activity were also available from surveys conducted before 2009, we did not include data from these surveys to ensure comparability as the question on physical activity was different.

***Physical activity***

The PACE+ Adolescent Physical Activity Measure (Prochaska et al., 2001) was used to assess physical activity levels. This measure has been tested for validity and reliability (Prochaska et al., 2001). The student was first provided with a definition of physical activity as follows: “Physical activity is any activity that increases your heart rate and makes you breathe hard. Physical activity can be done in sports, playing with friends, or walking to school. Some examples of physical activity 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 physical activity of at least 60 minutes during the past 7 days. For the current study, responses were dichotomized as 0-6 days (inadequate physical activity; coded 0) and all 7 days (adequate physical activity; coded 1) to reflect the WHO’s recommendations on physical activity for children and young adults (World Health Organization, 2010).

***Correlates***

A total of 13 potential correlates of PA were selected based on past literature (Jabeen et al., 2018; Khan et al., 2017; Peltzer et al., 2016; Sallis et al., 2000; Shokrvash et al., 2013). The demographic variables included age and sex. Food insecurity was used as a proxy for socioeconomic status as there were no variables on socioeconomic status in the GSHS, and this 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 (< 400g of fruits and vegetables/day) during the past 30 days [20]. Trained survey staff conducted measurement of weight and height. Body mass index was 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 [15]. 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). Finally, bullying victimization was defined as being bullied on at least one day in the past 30 days.

***Statistical analysis***

Statistical analyses were performed with Stata 14.1 (Stata Corp LP, College station, Texas). The analysis was restricted to those aged 12-15 years as most students were within this age range and data on the exact age outside of this age range was not provided. Multivariable logistic regression analysis was conducted to assess the association each correlate (exposure) and adequate physical activity (outcome) based on data from each country. 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 physical activity was assessed with a model that mutually adjusted for these three variables. Only countries with less than 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 *I2*statistic was calculated. This represents the degree of heterogeneity that is not explained by sampling error with a value of <40% often considered as negligible and 40-60% as moderate 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).

 All variables were included in the regression analysis as categorical variables with the exception of age. Taylor linearization methods were used in all analyses to account for the sample weighting and complex study design. Results from the logistic regression analyses are presented as odds ratios (ORs) with 95% confidence intervals (CIs). The level of statistical significance was set at p<0.05.

**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 physical activity 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 physical activity estimated by meta-analysis is shown in Table 3. In the overall sample, boys and those who participated in physical education for ≥5 days/week were significantly more likely to meet recommended physical activity guidelines, while adolescents with food insecurity (proxy of low socioeconomic status), low fruit and vegetable intake, low parental support/monitoring, no friends, and who experienced bullying were significantly less likely to have adequate levels of physical activity. There were some correlates which were significantly associated with adequate physical activity for certain country-income levels. Specifically, older age, carbonated soft drink consumption, and obesity were significantly associated with lower likelihood of complying with the recommended amount of physical activity, and alcohol consumption with greater odds for meeting the physical activity recommendations only in upper middle-income countries. Furthermore, smoking was associated with significantly lower odds for adequate levels of physical activity only in lower middle-income countries. The country-wise estimates are shown in Figure S1 to Figure S13 of the Appendix.

**Discussion**

To the best of our knowledge, this is the first multinational study exploring a multitude of physical activity correlates across different domains among adolescents aged 12 to 15 years in LMICs. In terms of the demographic physical activity correlates, boys were significantly more likely to meet recommended physical activity guidelines. Sex differences in physical activity participation have been reported before (Jabeen et al., 2018; Khan et al., 2017; Peltzer et al., 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 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. Those who participated in physical education during school hours for ≥5 days/week were significantly more likely to meet recommended physical activity guidelines. Our data are in line with a recent systematic review demonstrating that attending physical education classes is associated with a higher level of physical activity 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.

With regards to socio-environmental correlates, food insecurity was associated with less physical activity. 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 physical activity facilities (O’Donoghue et al., 2018). Second, it is possible that inadequate nutrition may lead to less energy to perform daily life activities. Third, when food becomes scarce, families tend to shift to less nutritious food (e.g., high fat and carbohydrates, low vitamins and micronutrients) (Pilgrim et al., 2012). Poorer diet has been associated with worse mental health outcomes in children and adolescents (O'Neil et al., 2014), which in turn might result in more inactivity (Bélair et al., 2018). Fourth, food insecurity may increase risk for parental depression for inadequate nutritional intake of the parents themselves or for concerns and worries about adequacy of food in the household (Li et al., 2017), which in turn may negatively affect parenting practices (e.g., unresponsive caregiving).

Our data show that low parental support/monitoring is an important social correlate and associated with less physical activity in adolescents aged 12 to 15. With regards to physical activity participation, parental support can consist of providing encouragement, transportation to physical activity opportunities, watching adolescents participate in activities, and engaging with children in physical activity (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 physical activity participation was having friends. Friends have a social influence on adolescents' level of physical activity through behavior modeling or through social support (Cheng et al., 2014). A third interpersonal, social factor that was associated with lower physical activity participation was bullying victimization. Based on our results, it might be suggested that reduced levels of physical activity should very likely be added to the growing list of health issues associated with bullying victimization. It also 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 physical activity 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 behaviour domain, we observed that unhealthy dietary habits (inadequate fruit and vegetable consumption) were overall associated with physical inactivity in LMICs. Low physical activity and less consumption of fruit and vegetables may reflect a clustering of unhealthy behaviours, the prevalence of which 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 low-income and middle-income countries. For example, carbonated soft drink consumption was negatively associated and alcohol consumption positively associated with physical activity levels in upper-middle income countries, while smoking was negatively associated with physical activity only in lower-middle income countries. A possible explanation might be that adolescents in upper-middle income countries have greater access to carbonated soft drinks (Yang et al., 2017), alcohol (Ma et al., 2018) and cigarettes (Xi et al., 2016). A rather counterintuitive finding was the association between higher physical activity levels and alcohol consumption in upper-middle income countries. Research from high-income countries suggest that until a certain level of alcohol consumption or until a ‘ceiling effect’ is reached, higher consumption of alcohol is associated with higher levels of physical activity (French et al., 2009; Vancampfort et al., 2015b). It might be that adolescents who frequently drink have an increased affinity for physical activity, perhaps because of its reward-related reinforcing effects (Leasure et al., 2014). Alternatively, some forms of physical activity (e.g., team sports participation) may be linked to post-game alcohol consumption. However, more research is needed to understand this relationship within the context of each particular country.

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, physical activity 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 physical activity levels (Ainsworth et al., 2006). Future research should utilize objective measures of physical activity. Accelerometers-inclinometers are available that allow for valid and reliable assessment. 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 physical activity on a population-scale, very likely shedding new light on variables that might be associated with physical activity 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 12–15 years old adolescents from most of the countries in our study do attend school (UNICEF, 2015). Finally, future studies in LMICs may wish to assess how societal changes in LMICs, civil conflicts, and extreme weather conditions are linked to physical inactivity in this population. For example, with regards to societal changes in particular economic growth and urbanization, which may offer many opportunities in LMICs, including potential better access to mental and physical health care, can also introduce new hazards such as a sedentary lifestyle due to the increasing availability of motorized transport.

**Conclusion**

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 modifiable sociocultural, socio-economic, and policy-related factors. Future longitudinal data are required to confirm/refute the findings to inform public interventions which aim to increase physical activity levels in inactive adolescents living in LMICs.

**Conflicts of interest**

None.

**Funding**

None.

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| **Table 1** Survey characteristics |
| Country income | Country | Year | Response rate (%) | Na | Adequate PA (%) |
| Low-income | Afghanistan | 2014 | 79 | 1,493 | 9.6 |
|  | Benin | 2016 | 78 | 717 | 28.1 |
|  | Cambodia | 2013 | 85 | 1,812 | 6.5 |
|  | Mozambique | 2015 | 80 | 668 | 11.3 |
|  | Nepal | 2015 | 69 | 4,616 | 14.4 |
|  | Tanzania | 2014 | 87 | 2,615 | 21.1 |
| Lower middle-income | Bangladesh | 2014 | 91 | 2,753 | 41.2 |
|  | Belize | 2011 | 88 | 1,600 | 20.0 |
|  | Bolivia | 2012 | 88 | 2,804 | 13.7 |
|  | East Timor | 2015 | 79 | 1,631 | 8.2 |
|  | Egypt | 2011 | 85 | 2,364 | 13.0 |
|  | El Salvador | 2013 | 88 | 1,615 | 12.5 |
|  | Ghana | 2012 | 82 | 1,110 | 8.9 |
|  | Guatemala | 2015 | 82 | 3,611 | 11.1 |
|  | Guyana | 2010 | 76 | 1,973 | 14.8 |
|  | Honduras | 2012 | 79 | 1,486 | 15.2 |
|  | Indonesia | 2015 | 94 | 8,806 | 12.0 |
|  | Kiribati | 2011 | 85 | 1,340 | 17.4 |
|  | Laos | 2015 | 70 | 1,644 | 16.3 |
|  | Maldives | 2009 | 80 | 1,981 | 21.6 |
|  | Mauritania | 2010 | 70 | 1,285 | 11.2 |
|  | Mongolia | 2013 | 88 | 3,707 | 26.9 |
|  | Morocco | 2010 | 92 | 2,405 | 12.6 |
|  | Pakistan | 2009 | 76 | 4,998 | 11.6 |
|  | Philippines | 2015 | 79 | 6,162 | 7.3 |
|  | Samoa | 2011 | 79 | 2,200 | 12.1 |
|  | Solomon Islands | 2011 | 85 | 925 | 16.5 |
|  | Sudan | 2012 | 77 | 1,401 | 7.6 |
|  | Syria | 2010 | 97 | 2,929 | 11.3 |
|  | Tonga | 2010 | 80 | 1,946 | 13.8 |
|  | Vanuatu | 2011 | 72 | 852 | 10.5 |
|  | Vietnam | 2013 | 96 | 1,743 | 13.0 |
|  | Yemen | 2014 | 75 | 1,553 | 12.9 |
| Upper middle-income | Algeria | 2011 | 98 | 3,484 | 14.9 |
|  | Antigua & Barbuda | 2009 | 67 | 1,235 | 22.4 |
|  | Argentina | 2012 | 71 | 21,528 | 16.8 |
|  | Costa Rica | 2009 | 72 | 2,265 | 18.1 |
|  | Dominica | 2009 | 84 | 1,310 | 16.6 |
|  | Fiji | 2016 | 79 | 1,537 | 19.2 |
|  | Iraq | 2012 | 88 | 1,533 | 14.8 |
|  | Lebanon | 2011 | 87 | 1,982 | 23.3 |
|  | Malaysia | 2012 | 89 | 16,273 | 13.8 |
|  | Mauritius | 2011 | 82 | 2,074 | 19.4 |
|  | Namibia | 2013 | 89 | 1,936 | 14.0 |
|  | Peru | 2010 | 85 | 2,359 | 15.0 |
|  | Suriname | 2009 | 89 | 1,046 | 19.6 |
|  | Thailand | 2015 | 89 | 4,132 | 12.2 |
|   | Tuvalu | 2013 | 90 | 679 | 11.9 |

Abbreviation: PA Physical activity

a Based on students aged 12-15 years.

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| **Table 2** Prevalence or mean of the correlates by country |
| Country | Age | Male | FI | Smoke | Alcohol | Fast food | Soft drink | Low FV | Obesity | PEa | LowPS/M | Nofriend | Bullied |
| **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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| **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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| **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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 |

Abbreviation: FI Food insecurity, FV Fruit and vegetable; PE Physical education; PS/M Parental support/monitoring; 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.

|  |
| --- |
| **Table 3** Association between each correlate and adequate physical activity estimated by meta-analysis based on country-wise estimates |
|   |   | Overall | Low-income | Lower middle-income | Upper middle-income |
| Correlate |   | OR (95%CI) | *I2* | OR (95%CI) | *I2* | OR (95%CI) | *I2* | OR (95%CI) | *I2* |
| 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

Statistically significant associations (P<0.05) are highlighted in bold font.

Estimates were obtained by combining country-wise estimates adjusted for age, sex, and food insecurity into a meta-analysis with random effects.

**APPENDIX**



**Figure S1** Country-wise association between age (exposure) and adequate physical activity (outcome) estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Age in years was included as a continuous variable in the model.

Models are adjusted for sex and food insecurity.

Overall estimate was obtained by meta-analysis with random effects.



**Figure S2** Country-wise association between sex (male vs. female) (exposure) and adequate physical activity (outcome) estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age and food insecurity.

Overall estimate was obtained by meta-analysis with random effects.



**Figure S3** Country-wise association between food insecurity (exposure) and adequate physical activity (outcome) estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age and sex.

Overall estimate was obtained by meta-analysis with random effects.



**Figure S4** Country-wise association between smoking (exposure) and adequate physical activity (outcome) estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, and food insecurity.

Estimates for Mozambique could not be obtained because there were no smokers among those with adequate levels of physical activity.

Overall estimate was obtained by meta-analysis with random effects.



**Figure S5** Country-wise association between alcohol consumption (exposure) and adequate physical activity (outcome) estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, and food insecurity.

Overall estimate was obtained by meta-analysis with random effects.



**Figure S6** Country-wise association between fast food consumption (exposure) and adequate physical activity (outcome) estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, and food insecurity.

Overall estimate was obtained by meta-analysis with random effects.



**Figure S7** Country-wise association between carbonated soft drink consumption (exposure) and adequate physical activity (outcome) estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, and food insecurity.

Overall estimate was obtained by meta-analysis with random effects.



**Figure S8** Country-wise association between low vegetable and fruit consumption (exposure) and adequate physical activity (outcome) estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, and food insecurity.

Overall estimate was obtained by meta-analysis with random effects.



**Figure S9** Country-wise association between obesity (exposure) and adequate physical activity (outcome) estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, and food insecurity.

Estimates for Vietnam could not be obtained due to the low prevalence of obesity.

Overall estimate was obtained by meta-analysis with random effects.



**Figure S10** Country-wise association between physical education (≥5 vs. <5 days/week) (exposure) and adequate physical activity (outcome) estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, and food insecurity.

Overall estimate was obtained by meta-analysis with random effects.



**Figure S11** Country-wise association between low parental support/monitoring (exposure) and adequate physical activity (outcome) estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, and food insecurity.

Overall estimate was obtained by meta-analysis with random effects.



**Figure S12** Country-wise association between close friends (none vs. at least one) (exposure) and adequate physical activity (outcome) estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, and food insecurity.

Overall estimate was obtained by meta-analysis with random effects.



**Figure S13** Country-wise association between bullying victimization (exposure) and adequate physical activity (outcome) estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, and food insecurity.

Overall estimate was obtained by meta-analysis with random effects.

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