Association between physical activity and leisure-time sedentary behavior among 140,808 adolescents aged 12 to 15 from 47 low- and middle-income countries

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Abstract

Objectives: Data from high-income countries (HICs) indicate that sedentary behavior is negatively associated with moderate-to-vigorous physical activity (MVPA) in young people. We examined associations between leisure-time sedentary behavior (LTSB) and MVPA in adolescents from 47 low- and middle-income countries (LMICs).

Study design: Cross-sectional study.

Methods: Data from the Global school-based Student Health Survey were analyzed in 140,808 adolescents (13.8±1.0 years; 49% girls). Time spent in LTSB was a composite variable assessing time spent sitting and playing computer games, watching TV, talking with friends during a typical day. The PACE+ Adolescent Physical Activity Measure assessed MVPA levels. The association between ≥3 hours/day of LTSB and adequate physical activity levels (every day last week 60 minutes MVPA) was explored with multivariable logistic regression analyses.

Results: The prevalence of ≥3 hours/day of LTSB and 60 minutes of MVPA/day last week were 26.3% (girls 26.2%; boys 26.5%) and 15.3% (girls 12.1%; boys 18.4%), respectively. LTSB of ≥3 hours/day versus <3 hour/day was associated with a 35% increased odds for adequate levels of MVPA in boys [OR=1.35 (95%CI=1.23-1.48)] and 22% in girls [1.22 (95%CI=1.10-1.36)].

Conclusions: Our data indicate that being physically active 60 min per day every day and at moderate-to-vigorous intensity and being sedentary ≥ 3 hours/day during leisure-time might co-exist in adolescents in some LMICs.

Keywords: Exercise; Global School-based Student Health Survey; Sitting

1. Introduction

Globally more than 80% of school-going adolescents do not meet current recommendations for daily physical activity[1] while they spend almost 60% of their after-school period in sedentary behaviour[2]. Both, physical inactivity and sedentary behaviour are public health risks in all parts of the world with insufficient physical activity prevalence for example being 84.9% (95% confidence interval, CI = 82.6–88.2) in low-income countries, 79.3% (95%CI=77.2–87.5) in lower–middle-income countries, 83.9% (95%CI=79.5–89.2) in upper–middle-income countries, and 79.4% (95%CI=74.0–86.2) in high-income countries.[1]

Considering the high global prevalence of physical inactivity and leisure-time sedentary behavior (LTSB) in adolescents, relationships between sedentary behavior and physical inactivity[3], and their respective role in the development of physical and mental health conditions, including cardio-metabolic disorders and depression[4-8], are a focus of ongoing research. Physical inactivity may be defined as performing insufficient amounts of moderate-to-vigorous intensity activity (MVPA), i.e. not meeting international physical activity recommendations.[9] For example, according to the World Health Organization[10], children and youth aged 5–17 years should accumulate at least 60 minutes of MVPA daily. Sedentary behavior however, refers to any behavior during waking hours characterized by an energy expenditure less than1.5 times the metabolic equivalent (defined as the amount of oxygen consumed while sitting at rest and is equal to 3.5 ml O_2 per kg body weight x min) while in a sitting, reclining or lying posture.[9]

It has been suggested that sedentary behaviors are negatively associated with MVPA levels[11]. For example, in a multinational study conducted among 2,290 adolescents aged 15 to 17 in 2 cities in the UK and one city in Saudi Arabia, significant negative associations were found between time spent watching TV and walking in both countries, although in the UK, only in one of the two cities[12]. Another multinational study involving 200,615 youths aged 11-13 years from 39 countries in North America and Europe found that exceeding 2 hours of daily total screen-time was negatively associated with MVPA among youths overall.[13] However, also in this multinational study, findings were not consistent across all countries, and on a national level, negative associations between screen-based sedentary behaviors and MVPA were less likely to be observed in countries with relatively low levels of MVPA.[13] Data are indeed inconsistent in the literature. For example, in a study including 2,084 adolescents aged 12.5 to 17.5 years from 10 European countries, time spent in MVPA was not significantly associated with screen

time.[14] Furthermore, in another study among 2,494 adolescents aged 11–15 years from the USA and UK, a cluster of participants reported higher than average levels of screen-based sedentary behavior along with elevated levels of MVPA.[15] Taken together, these findings suggest that the association between MVPA and sedentary behavior may differ by context and that national guidelines for limiting time in sedentary behavior among children and adolescents may not be conducive to increasing levels of MVPA in all countries.[15]

To the best of our knowledge, these four studies[12-15] are the only multinational studies to date that have explored the associations between sedentary behavior, mainly screen-based behaviors, and MVPA in adolescents. Multinational studies facilitate examination of associations between sedentary behavior and MVPA independent of national policies. However, to our knowledge, there are currently no multinational studies from low- and middle-income countries (LMICs). Exploring associations between sedentary behavior and MVPA in LMICs is a priority given the varied socio-cultural attitudes towards sedentary behavior and MVPA (e.g., using motorized transport as a sign of wealth), differing access to devices (e.g., television, computers) and varied environmental factors (e.g., safety and climate issues which may prevent children from being physically active) in comparison with high-income countries.[16]

When exploring associations between sedentary behavior and MVPA in LMICs, it will be important to stratify the analyses by sex while adjusting for level of food insecurity. Sex differences in physical activity participation and sedentary behavior have been reported before in LMICs,[17-20] 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 more sedentary or low intensity domestic activities (e.g. cooking, household chores), which may involve less energy expenditure[18,19]. In contrast, boys are more likely to engage in outdoor sports activities (e.g. soccer)[18,19]. These differences suggest that culturally defined gender roles are likely to be an important factor when considering lifestyle behaviors in adolescents in LMICs. 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[21]. 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)[22]. Poorer diet has been associated with poorer mental health outcomes, also in children and adolescents[23]. Poorer mental health, in turn, might result in more inactivity and more sedentary behavior[24].

Considering the current lack of multinational studies exploring associations between sedentary behavior and MVPA in LMICs, and in order to inform public health strategies and formulate recommendations concerning sedentary behavior and MVPA among children and youths in LMICs, it is necessary to better understand the relationships between these two behaviors. Building on existing research, the aim of the current study was to assess the association between total LTSB excluding school and homework-based sitting, and MVPA in adolescents and controlling for age, sex and level of food security using data from 47 LMICs.

2. Methods

2.1 Survey details

We analyzed data from the Global school-based Student Health Survey (GSHS), which is publicly available at http://www.who.int/chp/gshs and at http://www.cdc.gov/gshs. The GSHS was developed by the United States Centers for Disease Control and Prevention, the World Health Organization and other United Nations allies. The survey assesses and quantifies the risk and protective factors linked to major non-communicable diseases. Within each participating country, the survey used a standardized two-stage probability sampling design for the selection process. For stage 1, schools were selected with probability proportional to size sampling. In stage 2, classrooms that included students aged 13-15 years were randomly selected within each school. The multiple-choice questions were translated into the local language of each country, back-translated, and pilot-tested for comprehension within every local culture. Ethical approval was granted by both a national government administration (often the Ministry of Health or Education) and an institutional review board or ethics committee. Informed consent was obtained from students, parents and/or school officials. Data were weighted for probability selection and non-response.

From the publicly available data, we selected all nationally representative datasets from LMICs, which included all variables of interest. We selected the most recent dataset if there were more than two from the same country. The survey was conducted between 2009 and 2016. The income classification of the World Bank was used to divide countries into low-income, lower middle-income, and upper middle-income countries, and this was based on a measure of national income per person, or gross national income per capita [25]. Although data on physical activity were available from surveys conducted before 2009, these data were not included to avoid inconsistency with later versions of the physical activity question. The characteristics of each country or survey are provided in **Table 1**.

2.2 Leisure-time sedentary behavior (LTSB) (exposure)

The following question was used to assess LTSB: “How much time do you spend during a typical or usual day sitting and watching television, playing computer games, talking with friends, or doing other sitting activities?” with answer options: <1, 1-2, 3-4, 5-6, 7-8, and ≥8 hours/day. This excluded time at school and when doing homework. In the current study, we dichotomized this variable (≥3 hours/day or not). A cut-off of 3 hours/day was chosen since several studies of adolescents (12-15 years) carried out

in LMICs have shown that being sedentary ≥3 hours/ day when not in school was associated with outcomes including obesity[26], fast-food consumption[27], loneliness[28] and suicide attempts[29].

2.3 moderate-to-vigorous physical activity (MVPA) (outcome)

Participation in MVPA was assessed using the PACE+ Adolescent Physical Activity measure [30]. This measure has been shown to have good reliability (interclass correlation =0.77) and validity (r with accelerometer data = 0.40, p<.001). The following definition of MVPA was given to participants: "*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 MVPA are running, fast walking, biking, dancing, football, and (country-specific examples)*." Participants were then asked during the past 7 days on how many days did you participate in MVPA for at least 60 minutes. To allow comparison with the World Health Organizations recommendations[8] on MVPA for children and young people, response options were categorized as 0-6 days (inadequate physical activity) and all 7 days (adequate physical activity). We also used the MVPA variable as a continuous variable (i.e. number of days participating in MVPA for at least 60 minutes in the past 7 days).

2.4 Statistical analyses

Analyses were limited to those aged 12 to 15 years owing to the majority of students in the study falling into this age range. Chi square tests were used to investigate differences in prevalence of achieving adequate physical activity levels by time spent in LTSB. Next, univariable and multivariable logistic regression analyses were carried out to investigate the association between ≥ 3 hours/day LTSB (exposure) and adequate physical activity levels (60 minutes of MVPA every day in the past 7 days) (outcome), based on individual data from each country separately. For the multivariable analysis, overall sample analyses were adjusted for all pre-specified covariates (i.e. sex, age, food insecurity), while the sex-stratified analyses were adjusted for age and food insecurity. To measure food insecurity status, participants were asked, "During the past 30 days, how often did you go hungry because there was not enough food in your home?" Answers were categorized as: never, rarely/ sometimes, and most of the time/ always. To investigate the level of between-country heterogeneity the Higgins's I^2 statistic[31] was calculated. Between-country heterogeneity 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[29]. A pooled estimate (overall and by country income level) was obtained based on country-wise estimates using meta-analysis with random effects. We also conducted multivariable analysis with the continuous MVPA variable as the outcome.

All covariates were included in the regression analysis as categorical variables with the exception of age. Less than 2.3% of data were missing for all the variables included in the analysis. Complete case analysis was performed. Taylor linearization methods were employed in all analyses to account for the sample weighting and complex study design. Results from the logistic regression and linear regression analyses are presented as odds ratios (ORs) and b-coefficients, respectively, with 95% confidence intervals (CIs). The level of statistical significance was set at $P<0.05$. Statistical analyses were performed with Stata 14.1 (Stata Corp LP, College station, Texas).

3. Results

In total, 6 low-income, 27 lower middle-income, and 14 upper middle-income countries were included in the current analyses. The final sample consisted of 140,808 adolescents aged 12-15 years with a mean (SD) age of 13.8 (1.0) years and 49.0% were girls. In country-wise samples, boys constituted between 42.9% (Namibia) and 65.6% (Benin) of the sample, while some countries had a higher proportion of older adolescents (e.g., Laos, Vietnam) (Table 1). Furthermore, the severest form of food insecurity was more prevalent in countries such as Samoa, Afghanistan, and Ghana. The overall prevalence of ≥3 hours/day of LTSB and adequate MVPA levels were 26.3% (girls 26.2%; boys 26.5%) and 15.3% (girls 12.1%; boys 18.4%), respectively. The prevalence ranged widely between countries with the ranges for LTSB and adequate MVPA levels being 8.2% (Pakistan) to 54.6% (Antigua & Barbuda) and 6.5% (Cambodia) to 41.2% (Bangladesh), respectively (Table 1). Among boys, the prevalence of ≥3 hours of LTSB ranged from 9.0% (Pakistan) to 50.2%(Thailand), while among girls, the corresponding figure was 6.9% (Pakistan) to 59.2% (Antigua & Barbuda) (**Appendix Table S1**). For adequate MVPA, this ranged from 7.8% (Philippines) to 41.3%(Bangladesh) among boys and from 4.7% (Cambodia) to 41.2% (Bangladesh) among girls. The prevalence of adequate MVPA levels by <3 or ≥3 hours/day of LTSB for the overall sample is shown in **Table 2**, while the corresponding figures for sex-stratified samples are shown in **Appendix Table S2**. There was a tendency for the prevalence of adequate physical activity to be higher in those engaging in ≥3 hours/day of LTSB in most countries, although there were some exceptions. The associations between ≥3 hours/day of LTSB and adequate MVPA levels estimated by multivariable logistic regression are shown in **Figure 1**. In 39 of the 47 countries included in our study, a positive association between LTSB and MVPA (OR>1) was observed although this was not statistically significant in all countries. The strongest positive associations were observed in countries such as the Philippines (OR=2.90; 95%CI=2.29-3.67), Egypt (OR=2.15; 95%CI=1.31-3.52), and Tuvalu (OR=2.13; 95%CI=1.19-3.80), while a significant negative association between LTSB and MVPA was only observed in Argentina (OR=0.87; 95%CI=0.76-0.99). The overall estimate (95%CI) was 1.30 (95%CI=1.19-1.42) with a high level of between-country heterogeneity being observed (I^2=72.7%). The associations for boys (**Figure 2**) and girls (**Figure 3**) were similar although the overall estimate was slightly higher among boys [OR=1.35 (95%CI=1.23-1.48) vs. 1.22 (95%CI=1.10-1.36)]. Analyses by country-income level showed that the pooled estimate by country-income level is not always significant. However, there was moderate to high level of heterogeneity within country-income levels, which means

that country-income levels are unlikely to explain the between-country heterogeneity observed in the overall sample. Furthermore, the univariable analysis showed that there was little change in the estimates between univariable and multivariable analyses, demonstrating the fact that socioeconomic status (food insecurity) and sex (only for analysis using overall sample) have little influence in the association between LTSB and adequate levels of PA (**Appendix Figures S1, S2, S3**). Finally, the multivariable analysis using the continuous MPVA variable as the outcome showed that adolescents with ≥3 hours/day of LTSB participated in MVPA for 0.41 (95%CI=0.33-0.48) more days on average in the past 7 days than those with <3 hours/day of LTSB based on the pooled estimate using the overall sample (**Appendix Figures S4**), and this positive association was statistically significant in the majority of countries although a high level of between-country-heterogeneity was observed (I^2=70.4%). Similar associations were found for boys (**Appendix Figures S5**), and girls (**Appendix Figures S6**), although the overall estimate among boys was slightly higher than in girls [b=0.47 (95%CI=0.39-0.56) vs b=0.32 (95%CI=0.23-0.42)].

4. Discussion

4.1 General findings

This is the first multinational study in LMICs to explore associations between LTSB and MVPA levels. Our study, involving 140,808 adolescents aged 12-15 years from 47 LMICs, demonstrated that in several LMICs, the prevalence of adequate MVPA levels (i.e. accumulate at least 60 minutes of MVPA daily) was higher among those who were sedentary for ≥3 hours/day during leisure-time. The overall estimate (95%CI) was 1.30 (95%CI=1.19-1.42). Similarly, MPVA as a continuous variable showed that adolescents with ≥3 hours/day of LTSB participated in MVPA for 0.41 (95%CI=0.33-0.48) more days on average in the past 7 days than those with <3 hours/day of LTSB. However, in both the dichotomous and continuous analyses, there was a high level of between-country heterogeneity and the direction was, for example, significantly opposite in Argentina, where those with higher levels of LTSB were less likely to engage in adequate MVPA levels.

We observed in our multi-national study that, overall, adolescents who spend ≥3 hours/day sedentary during leisure-time were also more likely to comply with MVPA guidelines. Higher levels of MVPA among sedentary adolescents have previously also been reported in studies from high-income countries (HICs)[15], suggesting that MVPA does not interfere with behaviors such as reading, or vice-versa. Overall, our current data argue against the assumption that MVPA and LTSB share an inverse relationship and, although longitudinal research is needed to confirm our findings, it may be hypothesized that in the vast majority of LMICs, physical inactivity might not be a consequence of adolescents spending excessive time in sedentary behaviors.

Another reason for the co-existence of MVPA and LTSB might be that in most LMICs, the majority of adolescents need to walk or cycle a long distance to go to school and back. It might be that those who actively commute spend their time at home rather sedentary. In future studies, it will be interesting to explore whether or not active commuting to school also explains the between-country differences we observed, and whether there exist differences in the associations between LTSB and MVPA between school days and weekends, and between school periods and holidays. Furthermore, as it is known that adolescents in urban centers more often use motorized transport when they commute to school[32], it will also be of interest to explore differences in the associations between LTSB and MVPA in adolescents living in rural versus urban areas.

In contrast to a previous study[15] conducted in the UK and the US, we did not find differences in the association between LTSB and MVPA between boys and girls. A possible explanation might be that our LTSB question was rather broad covering sedentary behaviors that can be endorsed by both boys and girls. For example, the LTSB question in our study included socializing with friends, which in previous research has been reported to be a sedentary behavior more endorsed by girls, while it also included sedentary behavior involving technology, which has been reported more in boys.[15]

4.2 Limitations, strengths, and future research

A clear strength of the present study includes the largest sample size to date on this topic in LMICs. Moreover, this study was performed with nationally representative samples of adolescents attending school.

There are some limitations which should be considered when interpreting the current results. First, due to the cross-sectional design, the directionality of the relationships remains uncertain. Longitudinal studies are needed to disentangle the relationships. Second, GSHS only assessed adolescents in schools. Therefore, the MVPA and sedentary behavior patterns might not be representative for all adolescents of the included countries. We did not have information on adolescents who are unable to attend school or have dropped out. Third, although some potentially confounding factors were adjusted for in the multivariate analyses, residual confounding or unmeasured factors such as household wealth[33] might have influenced our findings. Fourth, time spent sedentary in our study only referred to LTSB and excluded time at school and when doing homework. Thus, this should be taken into consideration when interpreting our study results. Relatedly, our study lacked information on specific sedentary behaviors. Future studies with more detailed information on the type of LTSB that adolescents engage in can potentially shed light on the reasons for the between-country heterogeneity that was observed in our study. Next, participants self-reported their physical activity and sedentary behavior, potentially introducing reporting bias into the analysis[34]. Besides this, the questions assessing physical activity in our study have only been tested in the United States[30]. Although they were tested in an ethnically diverse sample and country-specific examples were included in order to be able to adapt the assessment to the local context, future research should test the PACE+ Adolescent Physical Activity measure in the included countries separately. Additionally, the sedentary behavior related questions, have not been tested for validity or reliability in adolescents. Future research should use objective

devices, such as accelerometers-inclinometers or smart-phone physical activity tracker applications to measure physical activity and sedentary behavior. However, it is likely that the association between sedentary behavior and MVPA is dependent on the domain of sedentary behavior (e.g., cognitively active sedentary behavior, such as reading and internet use, versus cognitively passive TV viewing)[35], which accelerometers-inclinometers are not able to measure. Therefore, a combination of both objective and subjective methods is needed.

5. Conclusion

Findings from the present study show that school going adolescents aged 12 to 15 years can be at the same time physically active enough (i.e. complying with the physical activity guidelines) and too sedentary (≥3 hours/ day when not in school). The wider literature suggests that LTSB has a deleterious impact on multiple health outcomes. Taken together, the current multinational study provides indications that also in LMICs, preventive public health interventions should focus on reducing LTSB also in those adolescents who comply with the MVPA guidelines.

Conflicts of interest

None.

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Tables and Figures

Table 1 Survey characteristics

Country	Country-income	Years	Response rate (%)	N[a]	Sedentary behavior (%)[b]	Adequate MVPA (%)[c]	Boys (%)	Age (years) (%)				Food insecurity (%)		
								12	13	14	15	Never	Rarely/ sometimes	Most of the time/always
Afghanistan	L	2014	79	1,493	23.3	9.6	53.4	5.3	21.2	37.0	36.5	49.8	33.1	17.1
Algeria	UM	2011	98	3,484	26.8	14.9	45.8	22.2	23.7	23.7	30.5	55.7	36.2	8.1
Antigua & Barbuda	UM	2009	67	1,235	54.6	22.4	51.4	2.9	32.1	33.3	31.8	56.0	36.8	7.2
Argentina	UM	2012	71	21,528	49.9	16.8	47.7	6.2	25.6	36.6	31.5	65.0	31.5	3.5
Bangladesh	LM	2014	91	2,753	14.9	41.2	63.4	2.7	27.5	41.6	28.3	38.3	48.4	13.3
Belize	LM	2011	88	1,600	36.3	20	48.4	21.9	25.2	28.1	24.7	62.3	30.5	7.1
Benin	L	2016	78	717	25.2	28.1	65.6	3.8	16.8	31.7	47.7	50.8	36.7	12.5
Bolivia	LM	2012	88	2,804	24.3	13.7	49.7	4.6	23.5	34.9	37.1	39.1	52.8	8.2
Cambodia	L	2013	85	1,812	10.2	6.5	48.4	4.0	23.0	36.6	36.4	49.1	43.1	7.7
Costa Rica	UM	2009	72	2,265	44.2	18.1	49.6	1.7	31.9	34.0	32.4	80.8	18.1	1.1
East Timor	LM	2015	79	1,631	15.6	8.2	46.3	8.2	17.0	33.7	41.0	50.8	38.2	11.0
Egypt	LM	2011	85	2,364	27.5	13	49.2	13.9	38.3	30.2	17.5	54.4	41.1	4.5
El Salvador	LM	2013	88	1,615	35.2	12.5	50.6	3.9	26.7	36.6	32.8	65.4	30.7	3.9
Fiji	UM	2016	79	1,537	28.9	19.2	49.0	0.7	8.1	41.4	49.8	40.4	48.1	11.6
Ghana	LM	2012	82	1,110	18.4	8.9	49.1	14.1	23.8	32.0	30.0	38.8	46.3	14.8
Guatemala	LM	2015	82	3,611	22.9	11.1	50.9	7.6	26.6	34.1	31.7	63.5	33.8	2.7
Guyana	LM	2010	76	1,973	35.7	14.8	48.6	1.0	27.6	36.8	34.6	54.7	37.3	8.0
Honduras	LM	2012	79	1,486	30.3	15.2	46.1	17.3	30.1	30.4	22.2	64.2	32.1	3.7
Indonesia	LM	2015	94	8,806	24.5	12	49.2	21.5	30.1	30.1	18.3	46.1	49.7	4.2
Iraq	UM	2012	88	1,533	25.6	14.8	54.7	7.9	28.4	30.4	33.3	67.2	24.0	8.8
Kiribati	LM	2011	85	1,340	14.4	17.4	45.5	3.6	25.1	35.6	35.7	32.9	54.3	12.8
Laos	LM	2015	70	1,644	19.2	16.3	47.8	0.3	11.0	29.4	59.3	53.2	45.8	1.0
Lebanon	UM	2011	87	1,982	47.2	23.3	46.6	13.3	28.9	32.3	25.4	66.5	29.9	3.6
Malaysia	UM	2012	89	16,273	42.7	13.8	49.5	1.2	32.9	33.2	32.7	39.3	56.3	4.5
Maldives	LM	2009	80	1,981	42.4	21.6	47.9	0.6	12.1	39.0	48.3	65.8	28.1	6.1
Mauritania	LM	2010	70	1,285	38.9	11.2	53.2	7.1	15.1	31.9	46.0	41.8	48.8	9.4
Mauritius	UM	2011	82	2,074	39.2	19.4	49.2	9.1	29.7	30.4	30.8	75.0	21.5	3.5
Mongolia	LM	2013	88	3,707	39.6	26.9	49.4	14.8	29.7	28.6	26.9	64.0	34.1	1.9
Morocco	LM	2010	92	2,405	25.7	12.6	52.9	16.2	26.7	32.2	24.9	69.3	21.0	9.7
Mozambique	L	2015	80	668	41	11.3	49.6	6.0	21.0	27.8	45.2	55.5	32.5	12.0
Namibia	UM	2013	89	1,936	37.2	14	42.9	3.3	25.2	31.4	40.1	46.1	43.7	10.2
Nepal	L	2015	69	4,616	9.8	14.4	47.3	12.8	26.6	33.3	27.3	67.8	27.8	4.4
Pakistan	LM	2009	76	4,998	8.2	11.6	60.8	1.7	21.5	40.3	36.5	74.8	19.6	5.6
Peru	UM	2010	85	2,359	28.6	15	49.9	1.9	23.5	36.4	38.2	48.8	48.0	3.2
Philippines	LM	2015	79	6,162	30.7	7.3	48.1	8.8	26.6	32.6	32.0	30.6	62.2	7.2

Samoa	LM	2011	79	2,200	38.1	12.1	47.4	3.6	21.1	44.2	31.0	18.8	45.2	36.0
Solomon Islands	LM	2011	85	925	26.4	16.5	52.1	5.9	21.1	32.3	40.6	16.8	72.9	10.3
Sudan	LM	2012	77	1,401	19.7	7.6	51.9	1.6	22.0	34.6	41.8	60.4	30.5	9.2
Suriname	UM	2009	89	1,046	40.3	19.6	45.4	8.4	22.4	33.1	36.1	67.0	24.8	8.1
Syria	LM	2010	97	2,929	25.3	11.3	51.2	16.3	30.2	31.6	21.9	47.1	41.9	11.1
Tanzania	L	2014	87	2,615	20.1	21.1	46.8	18.5	27.1	27.4	27.0	75.5	18.1	6.4
Thailand	UM	2015	89	4,132	50.7	12.2	49.6	14.2	29.9	30.8	25.1	46.4	49.4	4.3
Tonga	LM	2010	80	1,946	29.2	13.8	50.3	5.0	22.6	34.2	38.2	25.9	60.3	13.7
Tuvalu	UM	2013	90	679	15.3	11.9	48.9	28.6	28.3	23.9	19.2	47.4	44.6	8.0
Vanuatu	LM	2011	72	852	19	10.5	49.5	22.0	30.3	28.1	19.6	50.3	44.7	4.9
Vietnam	LM	2013	96	1,743	34.9	13	46.6	0.1	1.0	47.8	51.2	50.9	48.2	0.9
Yemen	LM	2014	75	1,553	19.4	12.9	56.3	10.7	27.4	30.5	31.4	41.7	47.2	11.1

Abbreviation: L = Low-income; LM = Lower middle-income; UM = Upper middle-income; MVPA = moderate-to-vigorous physical activity

[a] Based on sample aged 12-15 years

[b] ≥3 hours/day of leisure-time sedentary behavior per day

[c] Adequate moderate-to-vigorous physical activity (MVPA) referred to physical activity of at least 60 minutes everyday in the past 7 days.

Table 2 Prevalence of adequate levels of MVPA (%) by time spent in leisure-time sedentary behaviour

Country	Leisure-time sedentary behavior <3 hours/day	≥3 hours/day	P-value[a]
Afghanistan	9.7	10.1	0.814
Algeria	13.1	19.7	<0.001
Antigua & Barbuda	18.8	25.9	0.030
Argentina	18.1	15.4	0.004
Bangladesh	41.2	42.0	0.877
Belize	18.6	22.4	0.311
Benin	26.4	32.8	0.261
Bolivia	13.7	14.1	0.838
Cambodia	6.3	7.4	0.682
Costa Rica	18.8	17.2	0.341
East Timor	7.4	11.5	0.002
Egypt	9.6	21.4	0.001
El Salvador	11.3	14.7	0.090
Fiji	18.9	21.2	0.460
Ghana	8.2	12.2	0.080
Guatemala	10.3	14.3	0.129
Guyana	12.3	19.3	0.005
Honduras	13.6	18.7	0.007
Indonesia	11.2	14.2	0.021
Iraq	14.0	16.9	0.319
Kiribati	16.5	21.1	0.176
Laos	15.2	20.8	0.012
Lebanon	23.9	22.9	0.761
Malaysia	13.6	14.0	0.538
Maldives	17.7	27.7	<0.001
Mauritania	9.9	12.2	0.347
Mauritius	19.4	18.9	0.748
Mongolia	25.9	28.3	0.295
Morocco	11.4	16.2	0.002
Mozambique	10.9	12.0	0.703
Namibia	12.1	17.8	0.014
Nepal	14.8	11.2	0.141
Pakistan	11.2	16.2	0.171
Peru	15.4	14.2	0.376
Philippines	4.9	12.9	<0.001
Samoa	12.7	12.0	0.738
Solomon Islands	14.9	20.6	0.107
Sudan	6.9	11.4	0.076
Suriname	17.7	23.0	0.046
Syria	10.8	12.8	0.319
Tanzania	19.7	25.6	0.006
Thailand	12.0	11.9	0.971
Tonga	12.5	16.7	0.011
Tuvalu	10.2	20.6	0.004
Vanuatu	9.2	15.7	0.041
Vietnam	13.2	12.4	0.666
Yemen	13.3	11.9	0.508

[a] P-value was calculated by Chi-squared tests.

Abbreviation: MVPA = moderate-to-vigorous physical activity. Adequate moderate-to-vigorous physical activity (MVPA) referred to physical activity of at least 60 minutes everyday in the past 7 days.

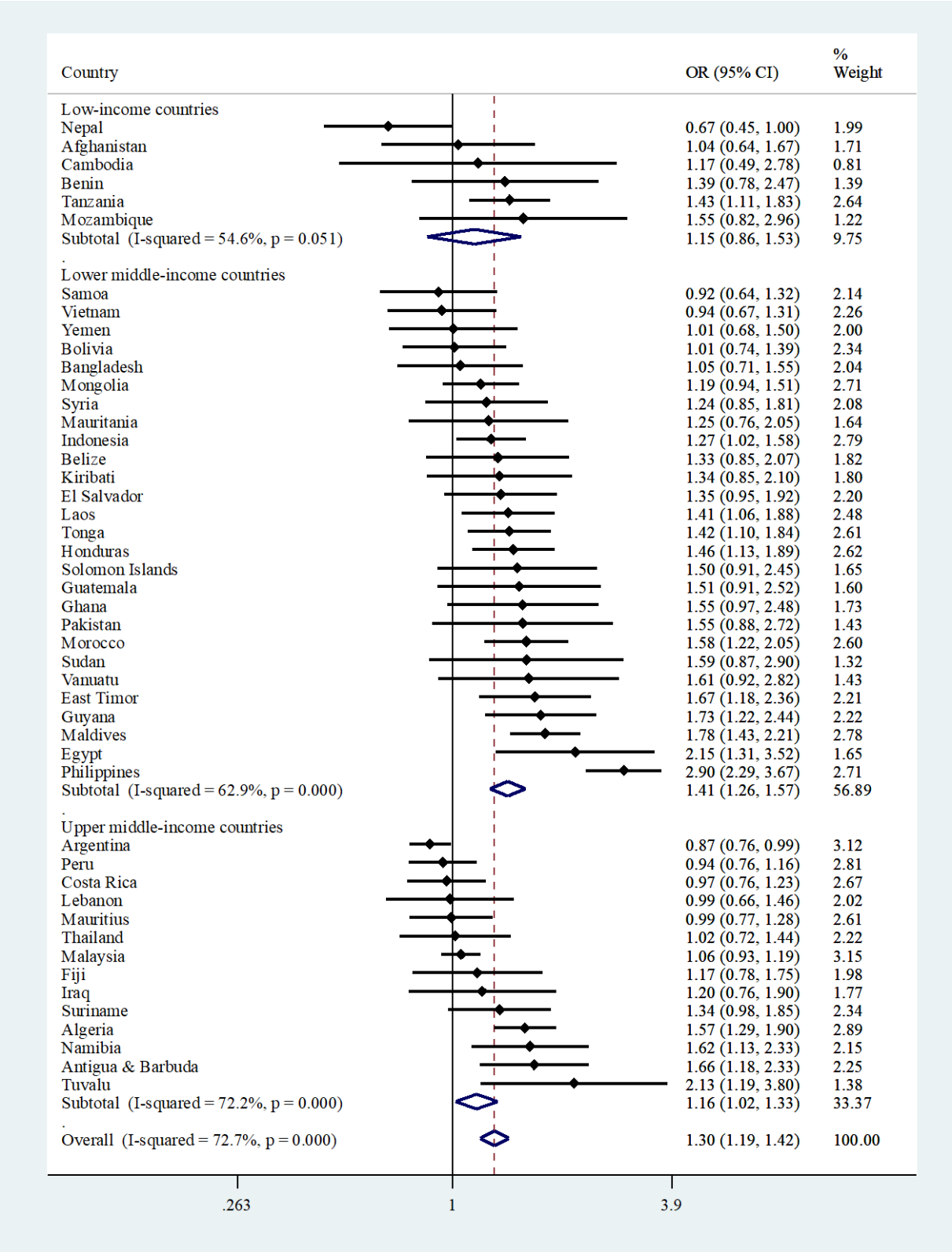

Figure 1 Association between ≥3 hours of leisure-time sedentary behavior per day (exposure) and adequate levels of MVPA (outcome) estimated by multivariable logistic regression

Abbreviation: OR = Odds ratio; CI = Confidence interval; MVPA = moderate-to-vigorous physical activity

Adequate moderate-to-vigorous physical activity (MVPA) referred to physical activity of at least 60 minutes everyday in the past 7 days.

Models are adjusted for age, sex, and socioeconomic status (food insecurity).

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

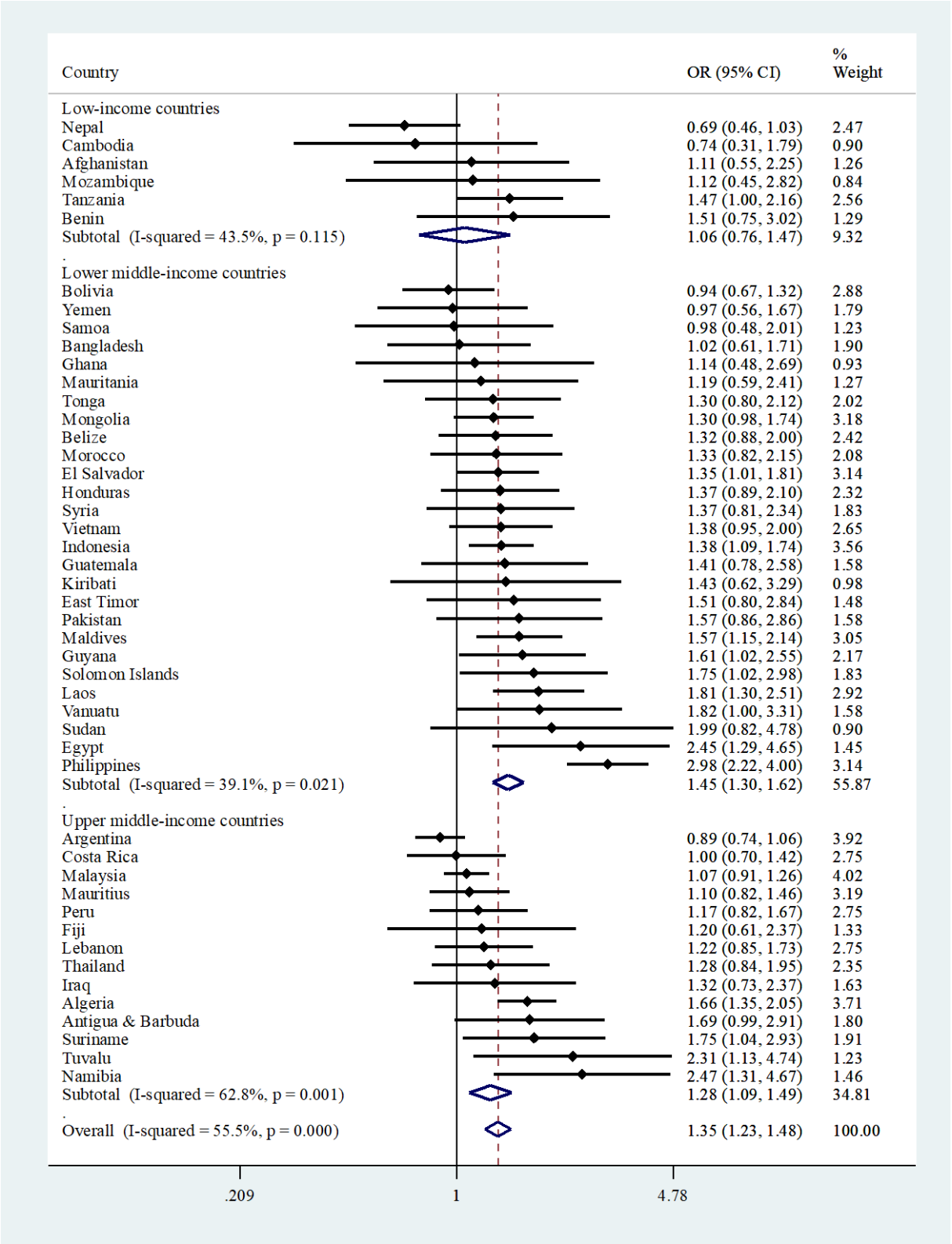

Figure 2 Association between ≥3 hours of leisure-time sedentary behavior per day (exposure) and adequate levels of MVPA (outcome) among boys estimated by multivariable logistic regression

Abbreviation: OR = Odds ratio; CI = Confidence interval; MVPA = moderate-to-vigorous physical activity

Adequate moderate-to-vigorous physical activity (MVPA) referred to physical activity of at least 60 minutes everyday in the past 7 days.

Models are adjusted for age and socioeconomic status (food insecurity).

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

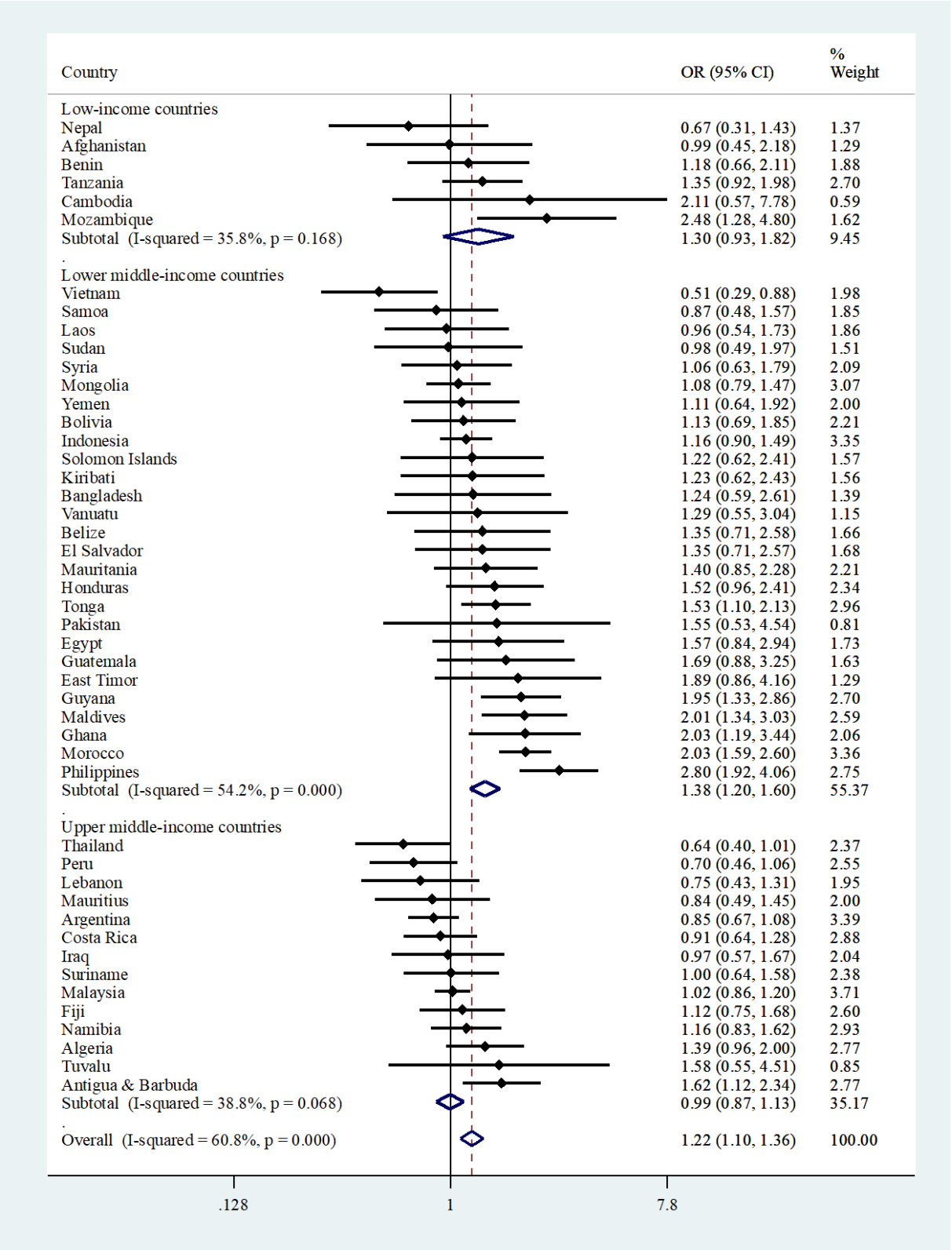

Figure 3 Association between ≥3 hours of leisure-time sedentary behavior per day (exposure) and adequate levels of MVPA (outcome) among girls estimated by multivariable logistic regression

Abbreviation: OR = Odds ratio; CI = Confidence interval; MVPA = moderate-to-vigorous physical activity

Adequate moderate-to-vigorous physical activity (MVPA) referred to physical activity of at least 60 minutes everyday in the past 7 days.

Models are adjusted for age and socioeconomic status (food insecurity).

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

Appendix

Table S1 Prevalence of sedentary behavior and adequate MVPA by sex

	Sedentary behavior (%)[a]		Adequate MVPA (%)[b]	
Country	Male	Female	Male	Female
Afghanistan	20.3	26.8	9.5	10.4
Algeria	29.7	24.1	23.7	7.6
Antigua & Barbuda	50.2	59.2	28.2	16.7
Argentina	46.7	53.0	21.6	12.2
Bangladesh	16.8	11.5	41.3	41.2
Belize	32.5	40.0	23.6	16.5
Benin	24.3	26.7	32.6	20.2
Bolivia	24.9	24.2	16.5	11.3
Cambodia	10.9	9.7	8.3	4.7
Costa Rica	40.5	47.6	24.6	11.7
East Timor	16.0	15.4	11.0	5.7
Egypt	35.6	19.6	19.3	7.1
El Salvador	33.2	37.7	15.8	9.2
Fiji	27.9	29.3	21.3	17.4
Ghana	18.0	18.8	8.9	9.1
Guatemala	21.5	24.5	12.7	9.3
Guyana	35.0	36.0	17.7	12.2
Honduras	30.2	30.4	18.2	12.6
Indonesia	25.0	23.9	12.7	11.3
Iraq	27.6	23.3	19.9	8.8
Kiribati	15.6	13.3	20.7	14.6
Laos	18.9	19.3	24.6	8.8
Lebanon	45.3	48.9	30.6	17.0
Malaysia	41.8	43.6	19.4	8.3
Maldives	43.2	41.6	24.2	19.2
Mauritania	38.5	39.8	15.1	7.1
Mauritius	37.7	40.5	25.8	13.2
Mongolia	36.9	42.3	31.4	22.4
Morocco	25.3	26.0	15.0	10.1
Mozambique	34.3	48.8	13.5	8.1
Namibia	35.1	38.4	14.5	13.6
Nepal	11.0	8.8	15.9	13.4
Pakistan	9.0	6.9	12.8	9.5
Peru	28.3	29.3	16.8	13.3
Philippines	30.4	31.0	7.8	6.9
Samoa	43.6	31.7	10.9	13.3
Solomon Islands	26.9	27.2	18.8	14.8
Sudan	21.9	17.5	7.9	7.4
Suriname	40.0	40.3	24.1	15.9
Syria	23.9	26.8	14.6	7.8
Tanzania	19.9	20.4	24.2	18.4
Thailand	50.2	50.9	17.5	7.0
Tonga	28.4	30.0	12.0	15.7
Tuvalu	20.1	10.8	13.8	9.9
Vanuatu	22.1	15.8	12.3	9.1
Vietnam	33.8	36.0	16.8	9.5
Yemen	16.9	22.3	16.3	8.9

Abbreviation: MVPA = moderate-to-vigorous physical activity

[a] ≥3 hours/day of leisure-time sedentary behavior per day

[b] Adequate moderate-to-vigorous physical activity (MVPA) referred to physical activity of at least 60 minutes everyday in the past 7 days.

Table S2 Prevalence of adequate levels of MVPA (%) by time spent in leisure-time sedentary behavior by sex

	Boys			Girls		
	Leisure-time sedentary behavior			Leisure-time sedentary behavior		
Country	<3 hours/day	≥3 hours/day	P-value[a]	<3 hours/day	≥3 hours/day	P-value[a]
Afghanistan	9.1	10.8	0.539	10.9	10.0	0.806
Algeria	20.9	30.1	<0.001	7.1	9.1	0.155
Antigua & Barbuda	23.0	34.0	0.049	13.2	19.2	0.011
Argentina	22.7	20.3	0.121	13.1	11.5	0.189
Bangladesh	41.2	41.1	0.984	41.1	45.4	0.614
Belize	21.7	26.9	0.200	15.3	19.0	0.394
Benin	30.2	39.9	0.208	19.5	21.5	0.655
Bolivia	16.8	15.9	0.712	11.1	12.3	0.630
Cambodia	8.7	6.5	0.463	4.2	8.4	0.259
Costa Rica	24.9	24.4	0.887	11.9	11.2	0.724
East Timor	10.1	14.1	0.253	5.2	9.1	0.112
Egypt	13.8	28.1	0.013	6.4	9.8	0.133
El Salvador	14.4	18.7	0.034	8.0	11.1	0.282
Fiji	20.8	24.2	0.544	17.2	18.6	0.659
Ghana	8.8	9.6	0.824	7.8	14.7	0.011
Guatemala	12.4	15.4	0.352	8.2	13.3	0.128
Guyana	15.3	22.7	0.038	9.6	16.7	0.002
Honduras	16.5	21.9	0.093	11.1	15.9	0.082
Indonesia	11.6	15.8	0.006	10.9	12.7	0.177
Iraq	18.6	22.6	0.405	9.0	8.8	0.960
Kiribati	19.5	25.7	0.376	14.1	16.7	0.554
Laos	22.2	34.4	<0.001	8.9	8.4	0.827
Lebanon	29.3	33.2	0.269	18.9	14.6	0.280
Malaysia	18.9	20.1	0.347	8.2	8.3	0.853
Maldives	20.6	29.8	0.002	14.8	26.1	0.001
Mauritania	13.4	15.9	0.564	6.2	8.2	0.208
Mauritius	25.1	26.5	0.612	13.8	12.3	0.610
Mongolia	29.4	34.6	0.095	22.0	23.0	0.705
Morocco	14.0	17.7	0.219	8.5	15.0	<0.001
Mozambique	13.6	13.1	0.911	5.1	11.3	0.006
Namibia	10.5	22.6	0.005	13.0	14.8	0.349
Nepal	16.5	11.6	0.060	13.8	10.1	0.355
Pakistan	12.4	17.7	0.164	9.3	12.4	0.583
Peru	16.3	18.3	0.431	14.6	10.3	0.062
Philippines	5.2	13.9	<0.001	4.6	12.0	<0.001
Samoa	11.3	10.9	0.926	13.8	13.8	0.998
Solomon Islands	16.2	24.9	0.044	14.3	16.4	0.623
Sudan	6.3	14.2	0.036	7.5	7.4	0.951
Suriname	20.2	30.5	0.035	15.7	16.7	0.755

Syria	13.7	17.9	0.235	7.7	8.1	0.795
Tanzania	22.8	30.3	0.037	16.9	21.7	0.109
Thailand	15.5	18.8	0.261	8.6	5.5	0.045
Tonga	11.2	13.8	0.321	13.9	19.7	0.013
Vanuatu	10.3	18.3	0.050	8.5	12.8	0.222
Vietnam	15.0	20.0	0.072	11.5	6.1	0.021
Yemen	16.6	15.7	0.787	9.0	8.8	0.908

[a] P-value was calculated by Chi-squared tests.
Abbreviation: MVPA = moderate-to-vigorous physical activity. Adequate moderate-to-vigorous physical activity (MVPA) referred to physical activity of at least 60 minutes everyday in the past 7 days.

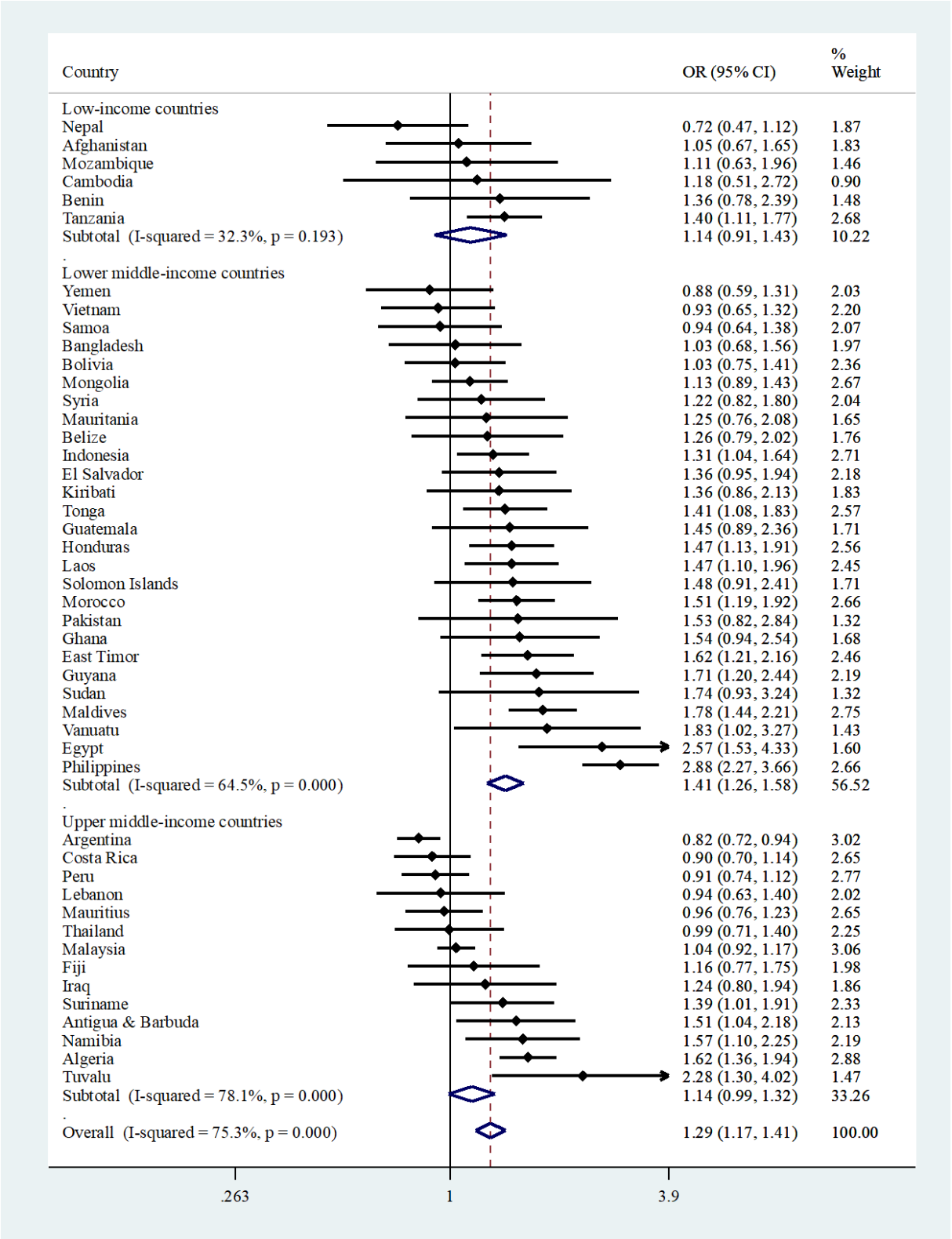

Figure S1 Association between ≥3 hours of leisure-time sedentary behavior per day (exposure) and adequate levels of MVPA (outcome) estimated by univariable logistic regression

Abbreviation: OR = Odds ratio; CI = Confidence interval; MVPA = moderate-to-vigorous physical activity

Adequate moderate-to-vigorous physical activity (MVPA) referred to physical activity of at least 60 minutes everyday in the past 7 days.

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

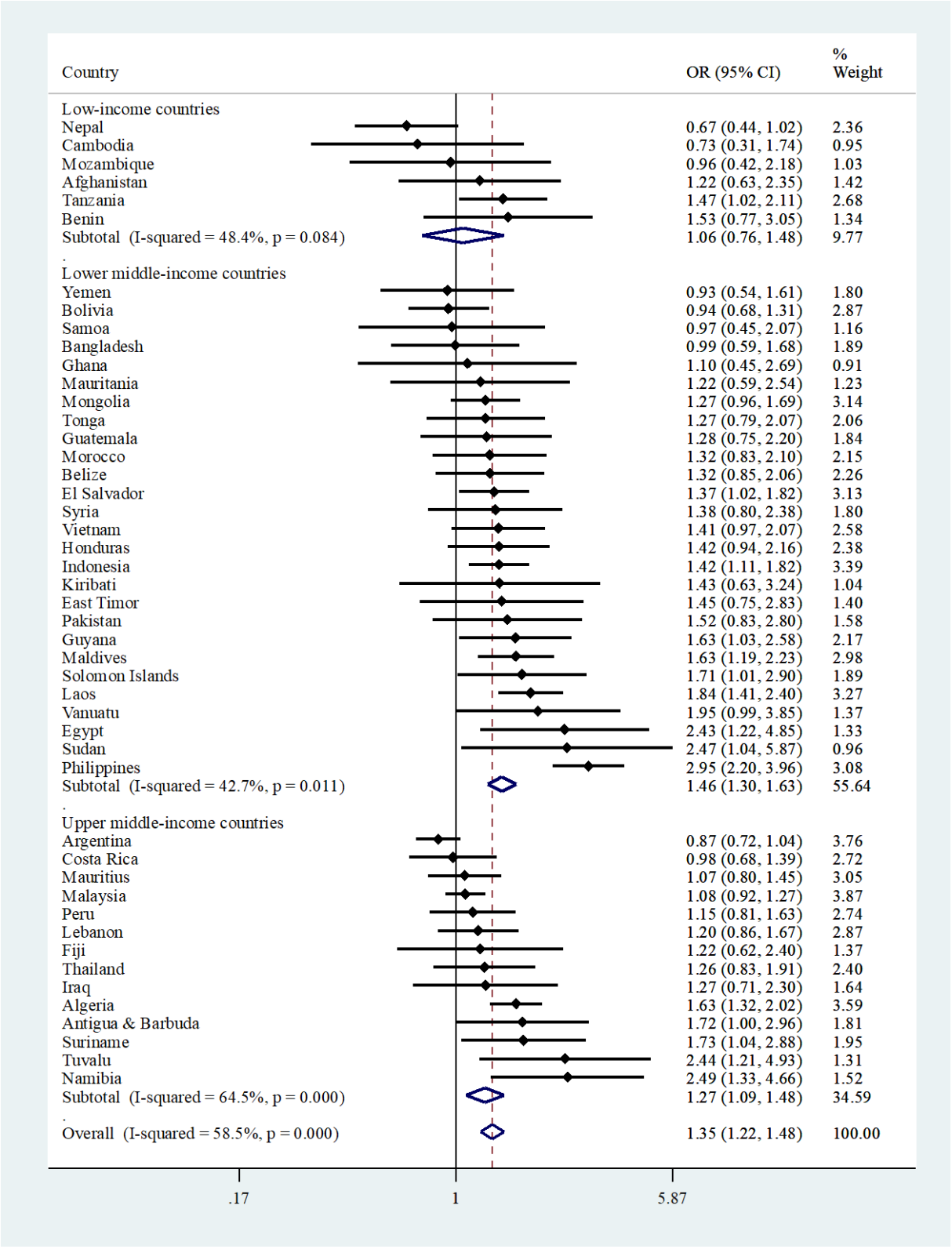

Figure S2 Association between ≥3 hours of leisure-time sedentary behavior per day (exposure) and adequate levels of MVPA (outcome) among boys estimated by univariable logistic regression

Abbreviation: OR = Odds ratio; CI = Confidence interval; MVPA = moderate-to-vigorous physical activity

Adequate moderate-to-vigorous physical activity (MVPA) referred to physical activity of at least 60 minutes everyday in the past 7 days.

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

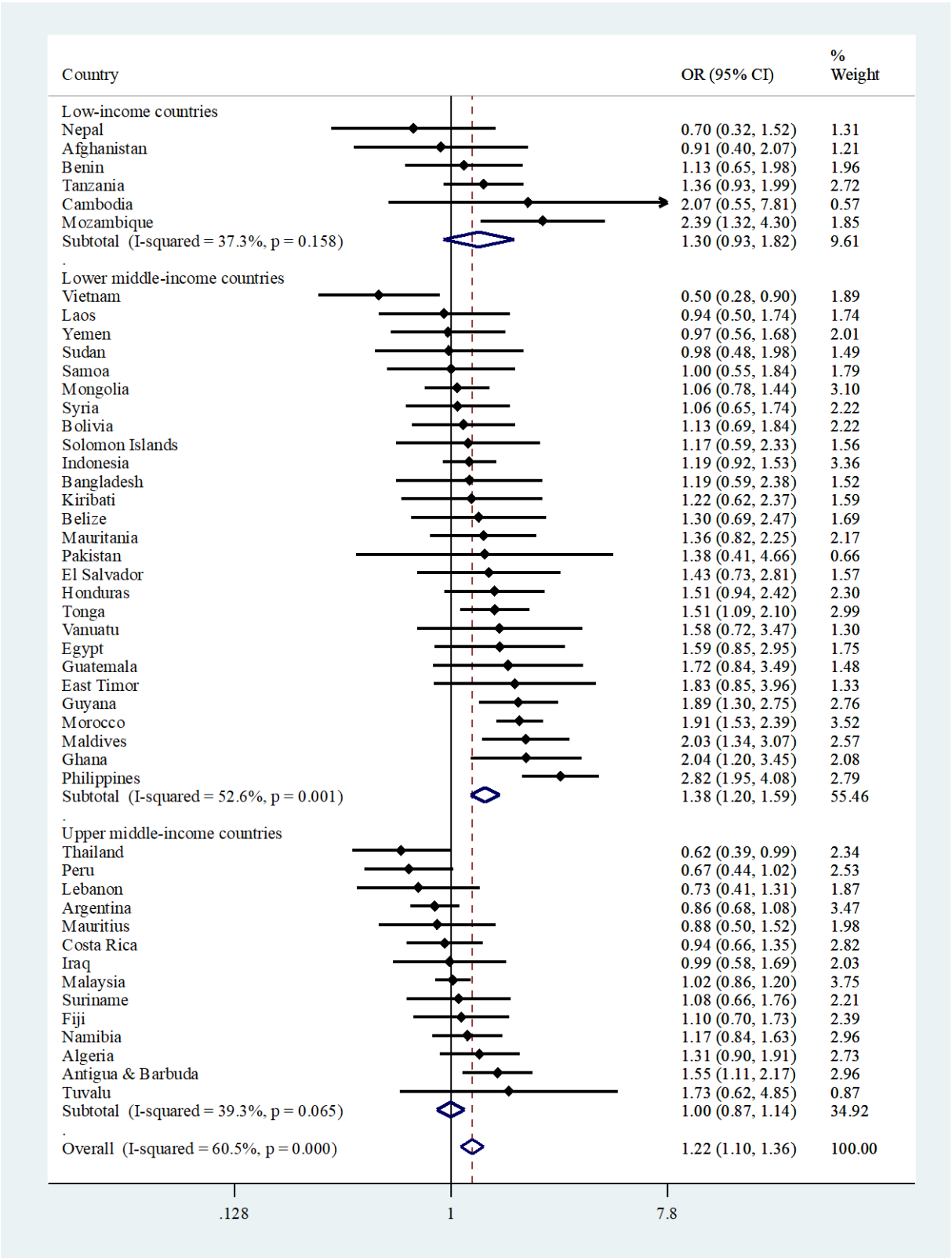

Figure S3 Association between ≥3 hours of leisure-time sedentary behavior per day (exposure) and adequate levels of MVPA (outcome) among girls estimated by univariable logistic regression

Abbreviation: OR = Odds ratio; CI = Confidence interval; MVPA = moderate-to-vigorous physical activity

Adequate moderate-to-vigorous physical activity (MVPA) referred to physical activity of at least 60 minutes everyday in the past 7 days.

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

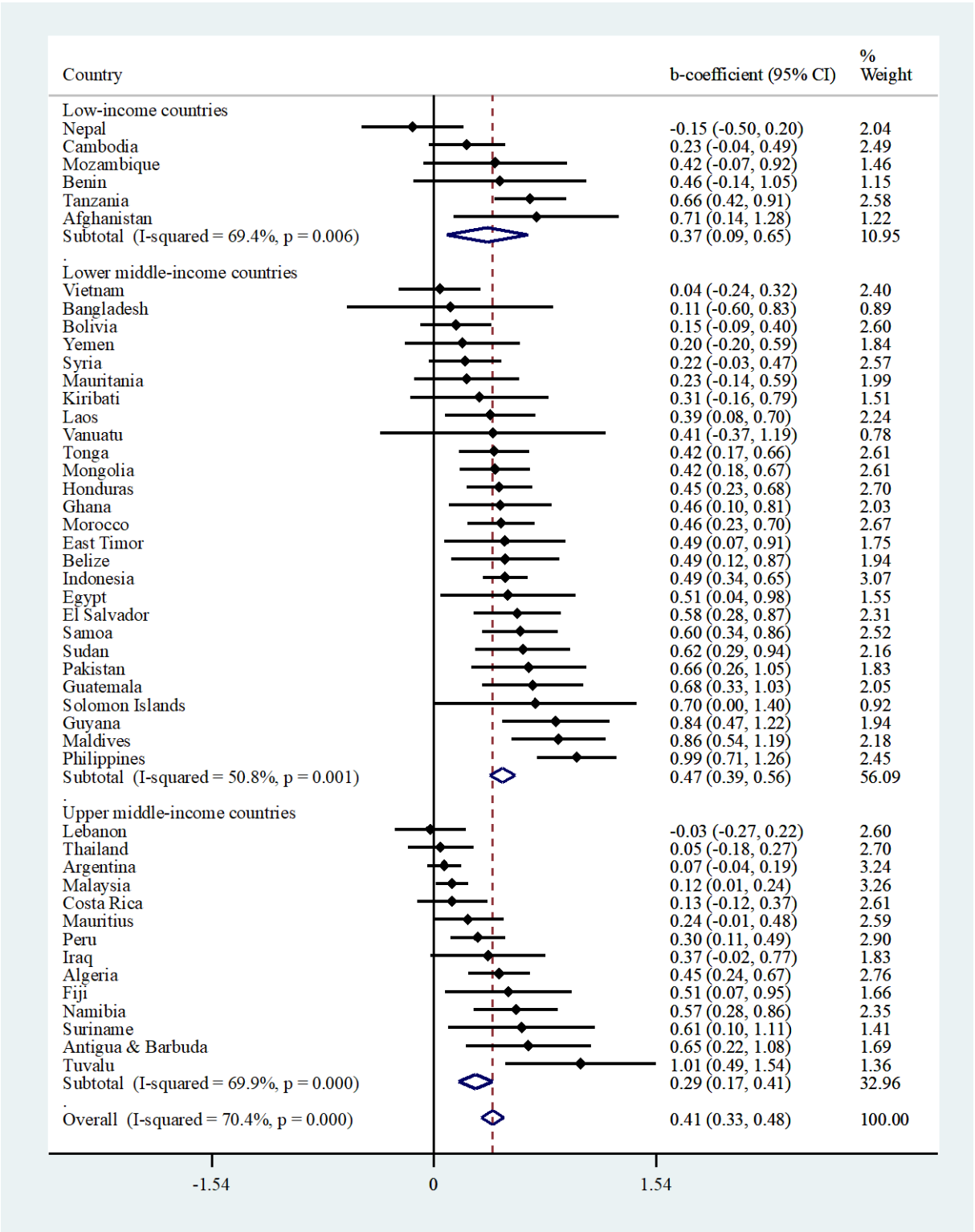

Figure S4 Association between ≥3 hours of leisure-time sedentary behavior per day (exposure) and days engaged in MVPA per week (outcome) estimated by multivariable linear regression

Abbreviation: CI = Confidence interval; MVPA = moderate-to-vigorous physical activity

Adequate moderate-to-vigorous physical activity (MVPA) referred to physical activity of at least 60 minutes everyday in the past 7 days.

Models are adjusted for age, sex, and socioeconomic status (food insecurity).

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

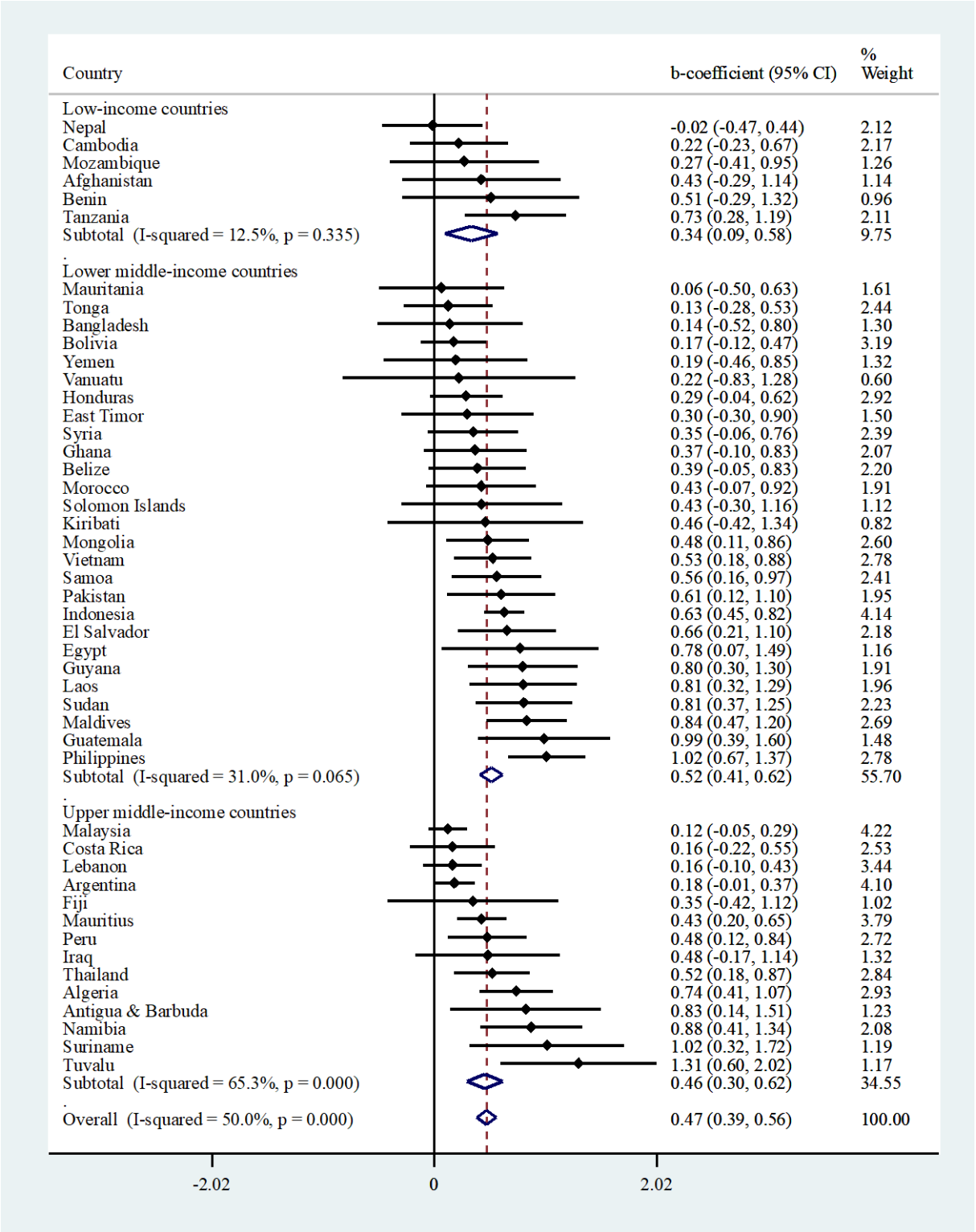

Figure S5 Association between ≥3 hours of leisure-time sedentary behavior per day (exposure) and days engaged in MVPA per week (outcome) among boys estimated by multivariable linear regression

Abbreviation: CI = Confidence interval; MVPA = moderate-to-vigorous physical activity

Adequate moderate-to-vigorous physical activity (MVPA) referred to physical activity of at least 60 minutes everyday in the past 7 days.

Models are adjusted for age and socioeconomic status (food insecurity).

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

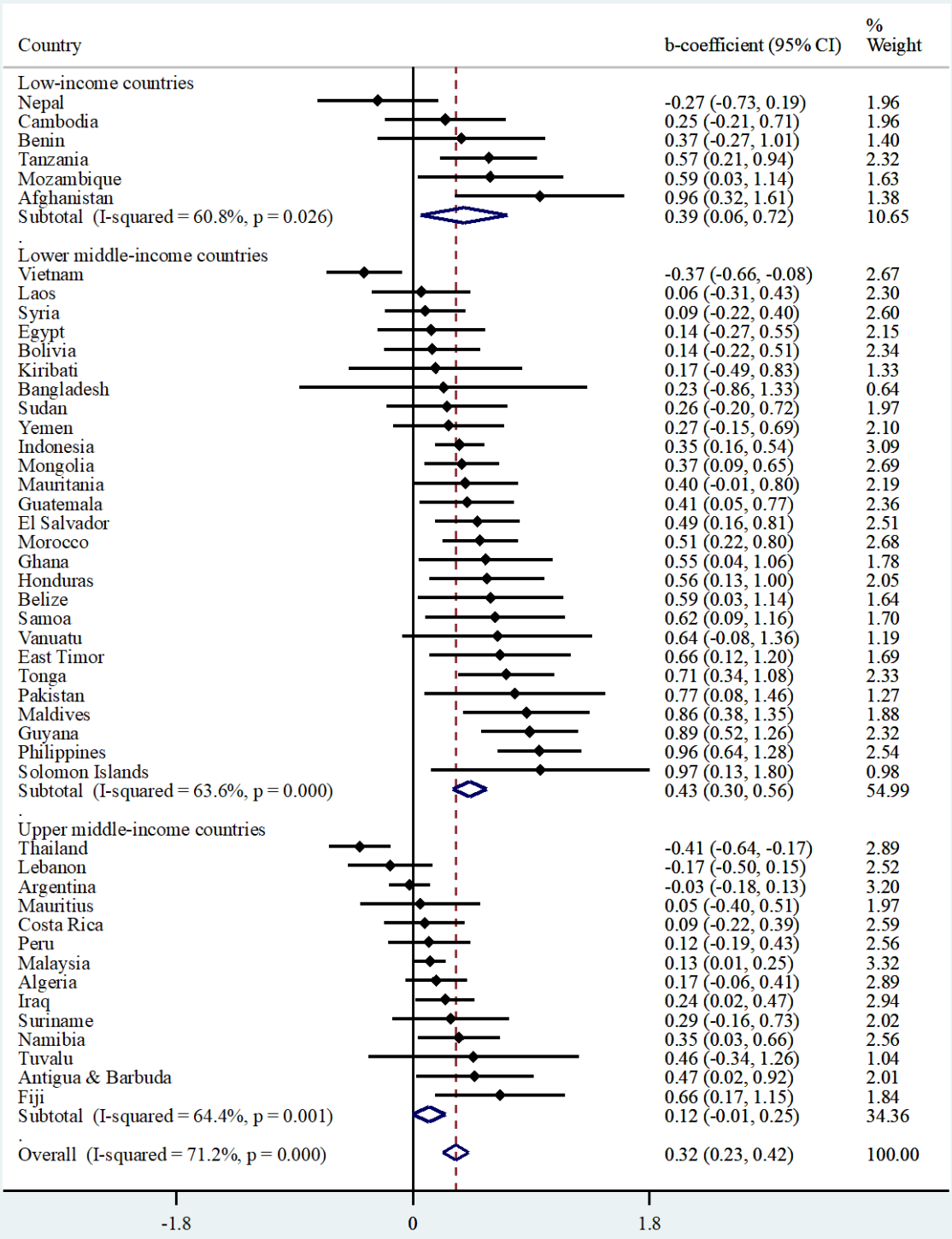

Figure S6 Association between ≥3 hours of leisure-time sedentary behavior per day (exposure) and days engaged in MVPA per week (outcome) among girls estimated by multivariable linear regression

Abbreviation: CI = Confidence interval; MVPA = moderate-to-vigorous physical activity

Adequate moderate-to-vigorous physical activity (MVPA) referred to physical activity of at least 60 minutes everyday in the past 7 days.

Models are adjusted for age and socioeconomic status (food insecurity).

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