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Physical activity and depression:

A large cross-sectional, population-based study across 36 low- and middle-income countries

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Abstract(word count ~~196~~200/200)

Objective

Physical activity (PA) is good for health yet several small scale studies have suggested that depression is associated with low PA. ~~However, a~~A paucity of nationally representative studies investigating this relationship exists, particularly in low- and middle-income countries (LMICs). This study explored the global association of PA with depression and its mediating factors.

Method

Participants from 36 LMICs from the World Health Survey were included. Adjusted logistic regression analyses were undertaken exploring the relationship between PA and depression.

Results

Across 178,867 people (mean±SD age=36.2±13.5years; 49.9% male), the prevalence of depression and low PA were 6.6% and 16.8% respectively. The prevalence of low PA was significantly higher among those with depression vs. no depression (26.0% vs. 15.8%, p<0.0001). In the adjusted model, depression was associated with higher odds for low PA (OR=1.42; 95%CI=1.24-1.63). Mediation analyses demonstrated that low PA among people with depression was explained by mobility limitations (40.3%), pain and discomfort (35.8%), disruptions in sleep and energy (25.2%), cognition (19.4%), and vision (10.9%).

Conclusion

Individuals with depression engage in lower levels of PA in LMICs. ~~Given the range of benefits of PA, population level interventions to increase PA in LMICs are warranted, particularly among those with depression.~~ Future longitudinal research is warranted to better understand the relationships observed.

Significant Outcomes

- Data from the largest multinational study established that depression is associated with low physical activity among people from LMICs.
- Findings were generalizable in most of the 36 LMICs in our country wide meta-analysis adjusted for age and sex.
- Mobility limitations, cognition, vision and pain appear to mediate the relationship between depression and low physical activity.

Limitations

- The data is cross-sectional and directionality cannot be determined.
- Physical activity was captured with a self-report measure which is prone to bias.

Key words: Physical activity, depression, exercise, major depression

Introduction

Depression is estimated to affect 350 million people worldwide and was the second leading cause of global disability in 2010 (1). In particular, a confirmed diagnosis of major depressive disorder accounts for 8.2% of the total worldwide years lived with disability (1). The global prevalence of depression ranges from 6 to 20 % (2). Depressive disorders are pervasive in society, affecting people of all ages, both sexes, across the full range of socioeconomic status (3-5). Moreover, secondary co-morbidities need to be considered which add significantly to the increased disability and burden. For example, depression is an independent risk factor for type 2 diabetes (6, 7) and cardiovascular diseases (CVD) (8). Meta-analyses (9, 10) have suggested that individuals with depressive disorders have almost twice the risk of developing CVD. Moreover, CVD and metabolic diseases remain leading contributors to the increased mortality among people with depression (11).

In the general population, there is robust evidence demonstrating that physical activity is broadly as effective as pharmacological interventions in preventing and managing CVD and premature mortality (12). Moreover, there is an abundance of research demonstrating that physical activity is effective for the prevention and management of depression (13-15). Nonetheless, previous studies with modest sample sizes which were not nationally representative have suggested that people with depression often do not achieve the recommended levels of physical activity participation (16, 17). Whilst these study results have provided insights into the association between physical activity and depression, there are only a few multinational representative studies on this topic, most of which have been conducted in high-income countries. Thus, investigating this association across different populations may aid in the design and implementation of effective strategies to address physical activity in individuals with depression. In an attempt to understand the factors influencing physical

activity participation in people with depression, a number of correlates of low physical activity have been identified, including a higher body mass index, the presence of physical co-morbidity and a lower self-efficacy (18). Although progress has been made, relatively few large scale representative studies have investigated physical activity correlates in people with depression (18). Moreover, whilst correlational analyses are useful, mediation analyses can offer a further insight into factors influencing the physical activity and depression relationship. Previous studies have identified potential mediators (e.g., motivation and self-efficacy) (19, 20), but these samples have all been relatively small and were limited to single countries, thus raising questions about generalizability. Mediation analysis at a multinational level of potentially important mediators (e.g., mobility difficulties or pain) which are common in people with depression (21, 22), may provide a greater understanding of the impact of such common comorbidities in those with depression irrespective of the background health care system.

Another pertinent gap within the literature is the paucity of representative data investigating physical activity levels in people with depression in low- and middle-income countries (LMICs). Depression is common in LMICs and physical health comorbidities such as diabetes and CVD, which may benefit from physical activity are highly prevalent (23). Yet, little research is available on this subject in LMICs. Clearly, the context and culture of the research on physical activity in Western countries cannot be assumed to automatically apply to LMICs and there is a need for LMIC-specific research investigating physical activity and depression. This is deemed important as contribution to the development of policies and programs on psychical activity and mental health in LMICs.

Aims of the study

Given these aforementioned gaps within the literature (i.e., a paucity multi-national studies on physical activity and depression, absence of studies on this topic from low- and middle-income countries, scarcity of large scale mediation analyses), we set out to investigate the relationship between depression and physical activity across 36 low- and middle-income countries, and the mediators of this association.

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Materials and methods

The data set

The current study is a cross-sectional analysis of the World Health Survey (WHS), which was conducted in 70 countries between 2002 and 2004. The primary aim of the WHS was to gather and compare data on the health and wellbeing of the adult population across the world. Data was gathered in a single stage random sampling approach in 10 countries, whilst a stratified multi-stage random cluster sampling method was used in the other 60 countries. A public record of the details of the WHS are available at http://www.who.int/healthinfo/survey/en/. Individuals with a registered home address from the 70 countries and aged 18 years or older, were eligible to participate. Kish tables were utilized to ensure that all household members had an equal chance of being selected. A standardized questionnaire to collect data for the WHS was developed and a consistent translation procedure was employed to ensure cross-country comparisons. Data was gathered via face-to-face interviews in the countries included in the current study, which were undertaken by trained interviewers. Across all countries, the response rate was very high at 98.5% (23). To adjust for non-responders, sampling weights were generated using the population distribution as reported by the United Nations Statistical Division. Ethical permissions and appropriate governance were obtained from each country state and informed consent was acquired from all participants.

Within the final dataset, data were publically available for 69 countries. The data were nationally representative for all countries with the exception of China, Comoros, the Republic of Congo, Ivory Coast, India, and Russia. Countries without any sampling information (10 countries – Austria, Belgium, Denmark, Germany, Greece, Guatemala, Italy, Netherlands, Slovenia, UK) were not included in the analysis. Of the remaining 59 countries, 10 (Finland, France, Ireland, Israel, Latvia, Luxembourg, Morocco, Norway, Portugal, Sweden) were

subsequently excluded as information on physical activity was not collected. A further 11 countries (Ukraine, Mauritania, Chad, Slovakia, Ethiopia, Swaziland, Senegal, Congo, Mali, Ecuador, Turkey) were excluded because more than 25% of the data on physical activity or depression was missing (24, 25). Finally, the only two remaining high-income countries (Spain and United Arab Emirates) were excluded as the focus of the study was on LMICs. Based on the World Bank classification in 2003, the remaining 36 countries consisted of 21 middle-income, and 15 low-income countries.

Physical activity (Outcome variable)

Physical activity was assessed using the short form of the International Physical Activity Questionnaire ~~(IPAQ)~~ (26), in which respondents are asked to report the number of days and the duration of the vigorous, moderate, and walking activities they undertook during the last 7 days. Show-cards illustrating different types of vigorous (e.g., carrying heavy loads, digging, running, strenuous sport) and moderate (e.g., cleaning, gardening, swimming, climbing stairs) physical activities were presented to the respondents in addition to brief explanations of what was meant by vigorous and moderate activity. As per previous WHS publications (27) and in accordance with the American College of Sports Medicine recommendations (28), a person who did not meet any of the following three criteria was considered to have low physical activity according to existing recommendations: (a) 3 or more days of vigorous activity during the last week, consisting of at least 20 minutes per day; or (b) 5 or more days of moderate-intensity activity or walking during the last week, consisting of at least 30 minutes per day; or (c) 5 or more days of any combination of walking, moderate- or vigorous-intensity activities during the last week, achieving a minimum of at least 600 metabolic equivalent (MET)-minutes per week in which one MET is the ratio of the work metabolic rate to the resting metabolic

rate. One MET is defined as 1 kcal/kg/hour and is more or less equivalent to the energy cost of sitting quietly (26).

Depression (Exposure variable)

Past 12-month depression was based on duration and persistence of depressive symptoms. Algorithms based on the DSM-IV (29) used in previous WHS publications were employed (30, 31). Respondents were first asked five questions. Those who answered 'Yes' to four of them were considered as possibly having depression or a major depressive episode. Specifically, respondents were asked: "During the last 12 months have you ever experienced…": (a) A period lasting several days when you felt sad, empty or depressed? (b) A period lasting several days when you lost interest in most things you usually enjoy such as hobbies, personal relationships or work? (c) A period lasting several days when you have been feeling your energy level decreased or that you were tired all the time? (d) Did you lose your appetite? (e) Did you notice any slowing down in your thinking?'. Among those with possible depression, individuals who further responded 'Yes' to both of the following questions were classified as having depression: (a) Was this period for more than 2 weeks? (b) Was this period most of the day, nearly every day?

Health status (Mediators)

Participants' health status was evaluated with 10 health-related questions pertaining to five health domains including: (a) mobility; (b) pain and discomfort; (c) cognition; (d) vision; (e) sleep and energy. Each of the five domains corresponds to those in common health related quality of life outcome measures such as the Short Form-12 (SF-12) (32), the Health Utilities Index Mark-3 (HUI) (33) and the EUROQOL-5D (34). These domains have been used as indicators of functional health status in prior studies utilizing the WHS dataset (23, 35, 36).

Each domain consisted of two questions that assessed health function in the past 30 days. The actual questions can be found in supplementary table 1. Each item was scored on a five-point scale ranging from 'none' to 'extreme/cannot do'. For each separate domain, we used factor analysis with polychoric correlations to obtain a factor score which was later converted to scores ranging from 0-100 (23, 36) with higher values representing worse health function.

Other variables

Information on age (18-34, 35-59, ≥60 years), sex, wealth, and education were also collected. Principal component analysis based on 15-20 assets was conducted to establish country-wise wealth quintiles. Specifically, based on information on whether the participant owns items such as a bicycle, refrigerator, washing machine, computer etc, we calculated a wealth score for each individual by weighting each asset by the coefficient of the first principal component (37). Education was categorized as: no formal education, primary education, secondary or high school completed, or tertiary education completed.

Statistical analysis

The statistical analysis was done with Stata 14.1 (Stata Corp LP, College station, Texas). All analyses were restricted to those aged 18-69 years since the ~~IPAQ~~ International physical activity questionnaire is considered to be valid for this age range (38). Country-wise age-sex adjusted prevalence estimates were calculated using the United Nations population pyramids for the year 2010 (http://esa.un.org/wpp/Excel-Data/population.htm) as the standard population. The difference in sample characteristics by the presence of depression was examined with Chi-squared tests in the pooled sample including all countries.

Using the pooled sample, multivariable logistic regression analysis was done to assess the association between depression and low physical activity while adjusting for age, sex,

education, wealth, and country. Body mass index was also considered to be a potential confounder but was not included in the models as preliminary analyses showed that its influence on the association between depression and physical activity is limited. Analyses were conducted using the overall sample including all countries, and by income level of the country (low-income or middle-income). Adjustment for country was done by including dummy variables in the models, as in previous WHS publications (23, 36).

Next, in order to gain an understanding on the extent to which various health related factors may explain the relation between depression and low physical activity, we conducted mediation analysis using the overall sample. Specifically, we focused on mobility, pain and discomfort, cognition, vision, as well as sleep and energy as potential mediators for their previously reported association with the exposure (depression) and the outcome (low physical activity) (38). We used the *khb* (Karlson Holm Breen) command in Stata (39) for this purpose. This method can be applied in logistic regression models and decomposes the total effect of a variable (i.e., unadjusted for mediators) into direct effects (i.e., the effect of depression on low physical activity adjusted for the mediator), and indirect effects (i.e., the mediational effect). Using this method, the percentage of the main association explained by the mediator can also be calculated (mediated percentage). Each potential mediator was included in the model individually. The mediation analysis controlled for age, sex, education, wealth, and country.

Finally, country-wise multivariable logistic regression models were constructed to assess the association between depression and low physical activity, adjusting for age (18-34, 35-59, ≥60 years) and sex. The estimates for each country were also combined into a random-effect meta-analysis with the Higgins' I^2 statistic being calculated. The Higgins' I^2 represents the degree of heterogeneity between countries not explained by sampling error with a value of <40% often considered as negligible and 40-60% moderate heterogeneity (40). The country-

wise analyses were done to: 1) test the robustness of our findings based on a different statistical approach; and 2) illustrate country-wise associations to assess the generalizability of our findings across nations.

For all analyses, complete-case analysis was done. The sample weighting and the complex study design were taken into account with the use of the *svy* command in Stata which uses the Taylor linearization method for robust variance estimation. Results from the logistic regression models are presented as odds ratios (ORs) with 95% confidence intervals (CIs). The level of statistical significance was set at $P<0.05$.

Results

Sample characteristics

After restricting the sample to those aged 18-69 years, the final sample size included in the current study was 178,867. The country specific sample size ranged from 784 (Czech Republic) to 35,772 (Mexico). The mean (SD) age of the overall sample was 36.2 (13.5) years and 49.9 % were men.

Prevalence of depression and physical activity

Overall, the prevalence of depression and low physical activity were 6.6% and 16.8% respectively. The prevalence of low physical activity was higher among those with depression vs. no depression (26.0% vs. 15.8%; Chi-squared test p<0.0001). Likewise, the proportion of those with depression was higher among those with low physical activity vs. higher levels of physical activity (10.4% vs. 5.8%; Chi-squared test p<0.0001). Full details of the age-sex adjusted country-wise prevalence of depression and physical activity is presented in **Table 1**. The prevalence of depression ranged from 0.4% (Myanmar) to 16.4% (Brazil), while the corresponding figures for low physical activity were 3.0% (Comoros) to 47.6% (South Africa).

Table 1 here

Relationship between depression and physical activity

In the overall sample, those with depression were significantly more likely to be of older age, female sex, as well as lower education and wealth (**Table 2**). In the adjusted model using the pooled sample of all countries, depression was associated with a 1.42 times higher odds for low physical activity across all LMICs (OR=1.42; 95%CI=1.24-1.63) (**Table 3**). Older people were at a particularly increased risk of low physical activity. Physical activity was lower in the

richest participants in both low-income and middle-income countries compared to the poorest (Table 3).

Insert table 2 and 3 here

Mediation analysis

The results of the mediation analysis that assessed the degree to which the association between depression and low physical activity can be explained by various health conditions are illustrated in **Table 4**. All indirect effects were highly significant. The greatest proportion of the total effect was explained by mobility limitations (40.3%), pain and discomfort (35.8%), disruptions in sleep and energy (25.2%), cognition (19.4%), and vision (10.9%).

Table 4 here

Meta-analysis of low physical activity among people with depression

The OR (95%CI) from the country wide analysis investigating the relationship between depression and low physical activity ranged from 0.20 (0.04-2.27) in Myanmar to 6.02 (1.99-18.20) in Czech Republic. The overall pooled OR (95%CI) based on a meta-analysis was 1.44 (1.26-1.63) with a moderate level of heterogeneity being observed (I^2 54.0%) (**Figure 1**).

Figure 1 here

Discussion

To the best of our knowledge, the current data are the first large scale data to suggest on a multi-national level that depression is associated with low physical activity. There was a wide variation in the prevalence of depression and low physical activity across nations. As for depression, this may be related with the varying levels of availability of treatment, or differences in cultures in terms of the conceptualization and expression of depression (41-44), while the variability in the level of physical activity may be related to macro-level environmental factors such as the climate, economic development, and cultural factors (45). The prevalence of low physical activity was higher among those with depression versus no depression (26.0% vs. 15.8%; Chi-squared test $p<0.0001$) equating to a higher odds for low physical activity (OR=1.42; 95%CI=1.24-1.63) in people with depression. Second, our data investigated mediators of low physical activity in people with depression suggesting that mobility limitations, pain and discomfort, disruptions in sleep and energy, and cognitive problems are key factors that influence physical activity participation in people with depression. In particular, our age and sex adjusted meta-analysis established a multi-national trend in low physical activity across LMICs. Our country wide meta-analysis demonstrated the relationship between depression and low physical activity was evident across most countries (see Figure 1).

Previous literature among relatively small samples has demonstrated that lower levels of physical activity are associated with an increased risk of depression (46). Moreover, physical activity is an established treatment for depressive symptoms in those with confirmed depression (47) and can improve quality of life in this group (14). However, our data is the first large multinational dataset to determine the inverse relationship between physical activity and depression across such a large sample of people from LMICs. Importantly, our data offer a

large scale attempt to understand the mediators underlying the relationship between depression and low physical activity and showed that in particular female sex, older age and a higher socio-economic status were significantly associated with low physical activity. Older age and female gender are also important moderators of low physical activity in general population studies in Western countries (48).

Our mediation analyses of health status factors identified that mobility limitations and pain mediate the relationship between physical activity and depression. People with depression may be more likely to have chronic pain (49), which impacts upon mobility (50) and is associated with sedentary behaviour (51). Whilst previous correlational studies have identified pain as a potential correlate of low physical activity (52), our data is the first large study to confirm this. Given these findings, interventions that address mobility limitations and pain might be important to increase physical activity in people from LMICs Cognitive impairment also appears to influence physical activity participation among people with depression (53), and increasing physical activity might help improve both of these conditions (54, 55). Since cognitive impairment and depression often coexist (56), additional support may be required to encourage people with coexisting depression and cognitive impairment to become more active. Overcoming all of these potential barriers may be important for increasing physical activity in LMICs among people with depression. ~~This will however require developing the necessary infrastructure at the health units at hospitals/health facilities (where they are largely missing in LMICs), including physical activity in the training of public health cadres and integrating physical activity in the current programs running on control and management of non-communicable diseases at all levels including primary health care in LMICs.~~

Our data suggest that in contrast with Western societies where a lower socio-economic status is associated with low physical activity in people with mental health problems (57), in LMICs, a higher socio-economic status is associated with low physical activity. It might be that due to a more "Western" lifestyle, mainly observed in urban centers of LMICs and including the use of motorized transport, less labor-demanding jobs, and physically undemanding, mostly screen-based leisure, are responsible for higher levels of sedentarity in those who can afford such a lifestyle. This observation points to the need to integrate the importance of physical activity into the existing Information, Education and Communication (IEC especially on mental health and lifestyle diseases) public health awareness campaigns (58). When one considers the multiple benefits of physical activity for health and wellbeing and the fact that organizations such as the World Health Organization recommends the promotion of physical activity as a priority (59), our data also add further importance for promoting physical activity. ~~Taken together with the wider literature, targeted and regular messages about the importance of physical activity for prevention and treatment of depression should be developed in order to make this campaign affordable. The benefits of engaging in physical activity should be properly outlined; education is required in order to overcome cultural barriers to physical activity such as fear of adverse events, advice with regards to starting at a low intensity, and information on ways to maintain an active lifestyle should all be included in the awareness programs across communities and policy makers. Continuous medical education (CME), which is commonly conducted in medical settings including Africa, can be used to equip medical professionals with the necessary knowledge to manage physical health and promote physical activity in people with depression.~~

Given the protective effects of physical activity from depression in Western societies (46), the established efficacy of exercise as an intervention for reducing symptoms and improving

quality of life among people with depression (14, 47), ~~there is a need for~~ the development of effective physical activity interventions in LMICs might be important. Particularly since more than three quarters of the global disease burden due to mental and substance disorders affects LMICs (60), and this burden is still increasing in this part of the world (61). Despite this evidence, less than 1% of development assistance for health and government spending on health in LMICs is allocated to the care of people with these disorders (62). As a consequence, mental health services are poorly resourced with ~~treatment gaps over~~as many as 90% of people not receiving adequate treatment (63). Currently, the treatment of depression in most LMICs is mainly focused on pharmacotherapy (64), although also evidence for psychotherapy is available (65). Some countries have disparate psychiatric and psychological resources, therefore, in such instances low cost population wide physical activity interventions to promote positive mental health may offer a unique window of opportunity as a novel interventions strategy with established efficacy. In addition, such interventions could help prevent some of the established chronic conditions that may develop (e.g., diabetes). However, much of this is speculation at this stage, and clearly more research is required to consider such options of using physical activity to improve health of people in LMICs experiencing depression. ~~Nonetheless, given the large number of people affected by depression, and the increased associated morbidity, investment in trained professionals and resources to increase physical activity in daily life for people with depression may offer value, both economically and from a mental and physical health perspective, although economic data is required to clarify this.~~ Finally, our country wide age and sex adjusted meta-analysis demonstrated that our results of low levels of physical activity and depression were evident across most LMICs.

Limitations and strengths

First, the study is cross-sectional, therefore cause and effect cannot be deduced. For example, it remains unclear whether lack of physical activity was caused by depression or vice versa and whether for example chronic pain, lack of sleep and energy were consequence of or a cause for depression and / or low physical activity. Moreover, some of the mediators that we considered (e.g. sleep disturbances or cognitive impairment) are also symptoms of major depression. Therefore, future prospective research is required to disentangle the directionality of the relationships we observed in particular to confirm or refute our mediation analyses. In addition, the diagnosis of depression was not assessed by a clinical interview. Thirdly, physical activity was captured with a self-report measure and their accuracy have been questioned (66, 67). To this end, across the entire sample only 16.8% were classified as being insufficiently active, which is lower than expected based on previous research. Therefore, the relationship between depression and low physical activity in our study may have been underestimated. Moreover, the International physical activity questionnaire ~~PAQ~~ captures physical activity over the past 7 days, and thus, future research may wish to consider physical activity over a typical 7 day period. Fourth, the current study only included non-institutionalized people. Therefore, our data are not generalizable to non-community settings (e.g., inpatient/ institutional settings). Fifth, the data are over a decade old and may not accurately reflect the current situation of the countries studied. For example, there has been a considerable increase in the availability of mobile devices since the survey was conducted and this may have had an effect on physical activity levels. Finally, our country wide meta-analysis had moderate heterogeneity. Future studies would benefit from assessing the potential influence of factors such as food insecurity, civil conflicts, extreme weather conditions, and other macro-level environmental factors (52) in the association between depression and physical activity.

In conclusion, people with depression in LMICs are at increased odds of engaging in low levels of physical activity. ~~should be screened for their physical activity behavior and health care providers should be trained to promote physical activity in order to avoid chronic co-morbidities associated with low physical activity.~~ Those with mobility and vision limitations, cognitive impairment and pain may need additional interventions to help support physical activity initiation. Future prospective studies are warranted to disentangle the potentially complex interplay of depression, low physical activity, and the mediators assessed in this study.

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Declaration of interest

None to declare from any author.

Table 1 Age-sex adjusted prevalence of depression and low physical activity by country

Country	Unweighted N	Depression	Low physical activity	Depression among those with low physical activity	Low physical activity among those with depression
Low-income countries					
Burkina Faso	4,613	7.3 (5.7-9.4)	9.1 (7.5-10.9)	14.8 (10.8-20.1)	18.8 (13.2-26.2)
Bangladesh	5,297	11.4 (9.8-13.1)	18.0 (16.1-20.1)	18.7 (14.3-24.1)	25.3 (20.0-31.3)
Ivory Coast	3,081	5.2 (3.8-6.9)	15.2 (12.7-18.1)	11.6 (6.1-21.2)	35.2 (21.3-52.2)
Comoros	1,575	5.0 (3.7-6.7)	3.0 (2.0-4.7)	5.9 (2.0-15.9)	4.3 (1.3-12.9)
Ghana	3,615	6.2 (5.1-7.6)	13.1 (11.3-15.1)	6.2 (4.0-9.4)	13.3 (8.2-21.0)
India	9,508	9.5 (8.3-10.9)	14.3 (11.3-17.9)	18.3 (12.5-26.0)	27.1 (18.4-38.0)
Kenya	4,149	9.1 (7.6-10.8)	10.4 (7.9-13.5)	14.0 (8.8-21.6)	15.0 (9.7-22.4)
Laos	4,707	1.2 (0.8-1.7)	13.0 (11.5-14.6)	1.6 (0.9-3.1)	21.7 (11.3-37.6)
Myanmar	5,543	0.4 (0.3-0.7)	11.3 (8.9-14.2)	0.1 (0.0-0.9)	1.6 (0.2-10.4)
Malawi	4,967	4.9 (4.1-5.8)	11.4 (9.5-13.6)	2.7 (1.5-4.8)	5.9 (3.8-9.1)
Nepal	8,219	9.0 (8.2-9.9)	9.5 (8.7-10.4)	10.3 (7.9-13.3)	11.0 (8.4-14.1)
Pakistan	6,097	6.4 (5.4-7.7)	21.7 (19.7-23.8)	7.6 (5.7-10.1)	26.8 (21.4-33.0)
Vietnam	3,342	0.5 (0.2-1.2)	8.7 (6.3-11.9)	NA	NA
Zambia	3,658	6.1 (4.9-7.6)	11.6 (10.0-13.4)	5.2 (2.7-9.9)	9.5 (5.3-16.6)
Zimbabwe	3,890	3.3 (2.4-4.5)	19.7 (17.8-21.6)	5.2 (2.8-9.4)	36.8 (23.2-52.9)
Middle-income countries					
Bosnia Herzegovina	907	3.0 (2.0-4.5)	15.5 (8.7-26.2)	3.7 (1.6-8.3)	17.8 (9.4-31.0)
Brazil	4,636	16.4 (14.9-18.0)	28.4 (26.4-30.5)	20.0 (17.2-23.0)	34.2 (29.6-39.2)
China	3,657	1.0 (0.5-2.0)	10.6 (7.3-15.1)	2.7 (1.1-6.3)	24.4 (12.9-41.3)
Czech Republic	784	3.6 (2.3-5.5)	9.3 (6.6-12.9)	14.9 (7.1-28.8)	26.3 (13.9-44.2)
Dominican Republic	4,171	7.2 (6.0-8.7)	42.4 (40.0-44.9)	8.0 (6.4-10.0)	45.3 (37.2-53.6)
Estonia	859	5.7 (4.5-7.1)	4.8 (3.0-7.6)	13.1 (5.6-27.5)	10.7 (4.3-24.2)
Georgia	2,270	3.9 (2.9-5.4)	8.6 (6.4-11.4)	7.2 (4.5-11.4)	18.1 (10.4-29.5)
Croatia	808	3.8 (2.6-5.4)	8.5 (6.5-11.0)	3.8 (1.4-9.8)	6.7 (2.3-17.7)
Hungary	1,182	3.8 (2.8-5.1)	8.4 (6.4-10.9)	7.4 (3.9-13.6)	31.9 (24.7-40)

Kazakhstan	4,349	3.2 (2.3-4.4)	13.2 (9.7-17.7)	4.9 (2.2-10.4)	20.0 (8.1-41.4)
Sri Lanka	6,355	1.6 (1.2-2.2)	10.6 (8.6-12.9)	2.8 (1.4-5.8)	18.1 (9.1-32.8)
Mexico	35,772	6.1 (5.6-6.5)	17.7 (16.8-18.8)	7.4 (6.4-8.5)	22.0 (18.9-25.6)
Mauritius	3,642	7.6 (6.3-9.0)	18.3 (15.4-21.5)	12.8 (9.7-16.8)	34.1 (26.8-42.3)
Malaysia	5,754	1.4 (1.1-1.9)	20.2 (18.8-21.6)	1.7 (1.1-2.6)	25.8 (16.9-37.4)
Namibia	3,982	4.8 (3.9-6.0)	40.5 (37.6-43.5)	4.0 (2.7-5.9)	37.1 (27.3-48.0)
Philippines	9,695	2.4 (2.0-3.0)	7.4 (6.3-8.7)	4.5 (2.7-7.2)	10.3 (6.5-16.0)
Paraguay	4,799	5.3 (4.5-6.1)	20.5 (18.8-22.3)	6.9 (5.2-9.1)	26.8 (20.2-34.5)
Russia	3,486	3.1 (2.4-4.1)	5.8 (4.3-7.9)	6.1 (3.2-11.4)	14.2 (7.0-26.6)
Tunisia	4,586	7.4 (6.1-8.9)	15.8 (13.9-18.0)	9.3 (6.8-12.6)	22.2 (16.5-29.2)
Uruguay	2,635	4.4 (3.4-5.7)	26.9 (22.4-31.9)	5.3 (3.4-8.2)	32.8 (20.9-47.2)
South Africa	2,277	4.2 (3.1-5.7)	47.6 (43.1-52.2)	4.9 (3.1-7.5)	55.7 (42.7-68.0)

Data are % (95% confidence interval) unless otherwise stated. All age-sex adjusted weighted estimates were calculated using the United Nations population pyramids for the year 2010. Income level was based on the World Bank classification in 2003.
Estimates for Vietnam could not be calculated because the prevalence of depression was low and there were no cases of low physical activity among those with depression.

Table 2 Characteristics of the study sample (overall and by depression)

	Overall		No depression		Depression	
Characteristic	Unweighted N	%	Unweighted N	%	Unweighted N	%
Age (years)						
18-34	81,351	50.7	76,407	51.8	3,192	37.0
35-59	81,329	41.5	74,588	40.7	4,939	50.7
≥60	16,187	7.9	14,498	7.5	1,298	12.3
Missing	0		0		0	
Sex						
Male	79,790	49.9	75,256	50.9	2,844	34.7
Female	99,077	50.1	90,237	49.1	6,585	65.3
Missing	0		0		0	
Education						
No formal	30,105	23.7	26,623	23.2	2,569	35.5
≤Primary	60,518	32.5	55,685	32.1	3,345	34.7
Secondary completed	73,785	34.7	69,508	35.4	3,081	23.8
Tertiary completed	14,284	9.1	13,540	9.3	428	6.0
Missing	175		137		6	
Wealth						
Poorest	38,801	19.6	35,423	19.4	2,464	22.2
Poorer	35,471	19.8	32,752	19.6	1,966	21.4
Middle	33,388	20.0	30,941	20.0	1,791	21.5
Richer	31,984	20.3	29,757	20.4	1,613	19.6
Richest	30,480	20.4	28,704	20.7	1,157	15.3
Missing	8,743		7,916		438	

Column percentages are based on weighted sample.
The difference between depression (no vs. yes) was statistically significant for all characteristics ($p<0.0001$) (Chi-squared test).

Table 3 Variables associated with low physical activity estimated by multivariable logistic regression

	Overall		Low-income countries		Middle-income countries	
Characteristic	OR	95%CI	OR	95%CI	OR	95%CI
Depression	1.42***	[1.24,1.63]	1.47***	[1.18,1.83]	1.39***	[1.20,1.61]
Age (years)						
18-34	1.00		1.00		1.00	
35-59	1.08*	[1.00,1.16]	1.10	[0.98,1.23]	1.08	[0.99,1.17]
≥60	1.96***	[1.76,2.17]	2.36***	[2.00,2.77]	1.61***	[1.42,1.83]
Sex						
Male	1.00		1.00		1.00	
Female	1.74***	[1.61,1.88]	2.45***	[2.12,2.82]	1.23***	[1.14,1.33]
Education						
No formal	1.00		1.00		1.00	
≤Primary	0.92	[0.83,1.02]	0.98	[0.86,1.12]	0.89	[0.74,1.06]
Secondary completed	0.92	[0.82,1.04]	1.04	[0.88,1.24]	0.86	[0.71,1.05]
Tertiary completed	1.01	[0.85,1.19]	1.27	[0.99,1.64]	0.88	[0.69,1.11]
Wealth						
Poorest	1.00		1.00		1.00	
Poorer	1.07	[0.96,1.18]	1.08	[0.93,1.26]	1.06	[0.93,1.20]
Middle	1.14*	[1.02,1.28]	1.14	[0.94,1.38]	1.14*	[1.00,1.30]
Richer	1.19**	[1.06,1.33]	1.22*	[1.03,1.46]	1.12	[0.98,1.29]
Richest	1.46***	[1.29,1.65]	1.52***	[1.25,1.85]	1.35***	[1.17,1.55]

Abbreviation: OR Odds Ratio; CI Confidence Interval
Models are adjusted for all covariates in the respective columns and country.
* p<0.05, ** p<0.01, *** p<0.001

Table 4 Health status as mediators in the association between depression and low physical activity

Mediator	Effect	OR (95%CI)	P-value	% Mediated
Mobility	Total	1.41 (1.22-1.63)	<0.0001	40.3
	Direct	1.23 (1.06-1.43)	0.0068	
	Indirect	1.15 (1.12-1.18)	<0.0001	
Pain and discomfort	Total	1.43 (1.24-1.64)	<0.0001	35.8
	Direct	1.26 (1.09-1.45)	0.0019	
	Indirect	1.14 (1.1-1.17)	<0.0001	
Cognition	Total	1.45 (1.26-1.67)	<0.0001	19.4
	Direct	1.35 (1.16-1.56)	0.0001	
	Indirect	1.07 (1.04-1.11)	<0.0001	
Vision	Total	1.41 (1.23-1.63)	<0.0001	10.9
	Direct	1.36 (1.18-1.56)	<0.0001	
	Indirect	1.04 (1.02-1.06)	<0.0001	
Sleep and energy	Total	1.42 (1.23-1.64)	<0.0001	25.2
	Direct	1.30 (1.12-1.5)	0.0004	
	Indirect	1.09 (1.06-1.13)	<0.0001	

Abbreviation: OR Odds Ratio; CI Confidence Interval
Models are adjusted for age, sex, education, wealth, and country.

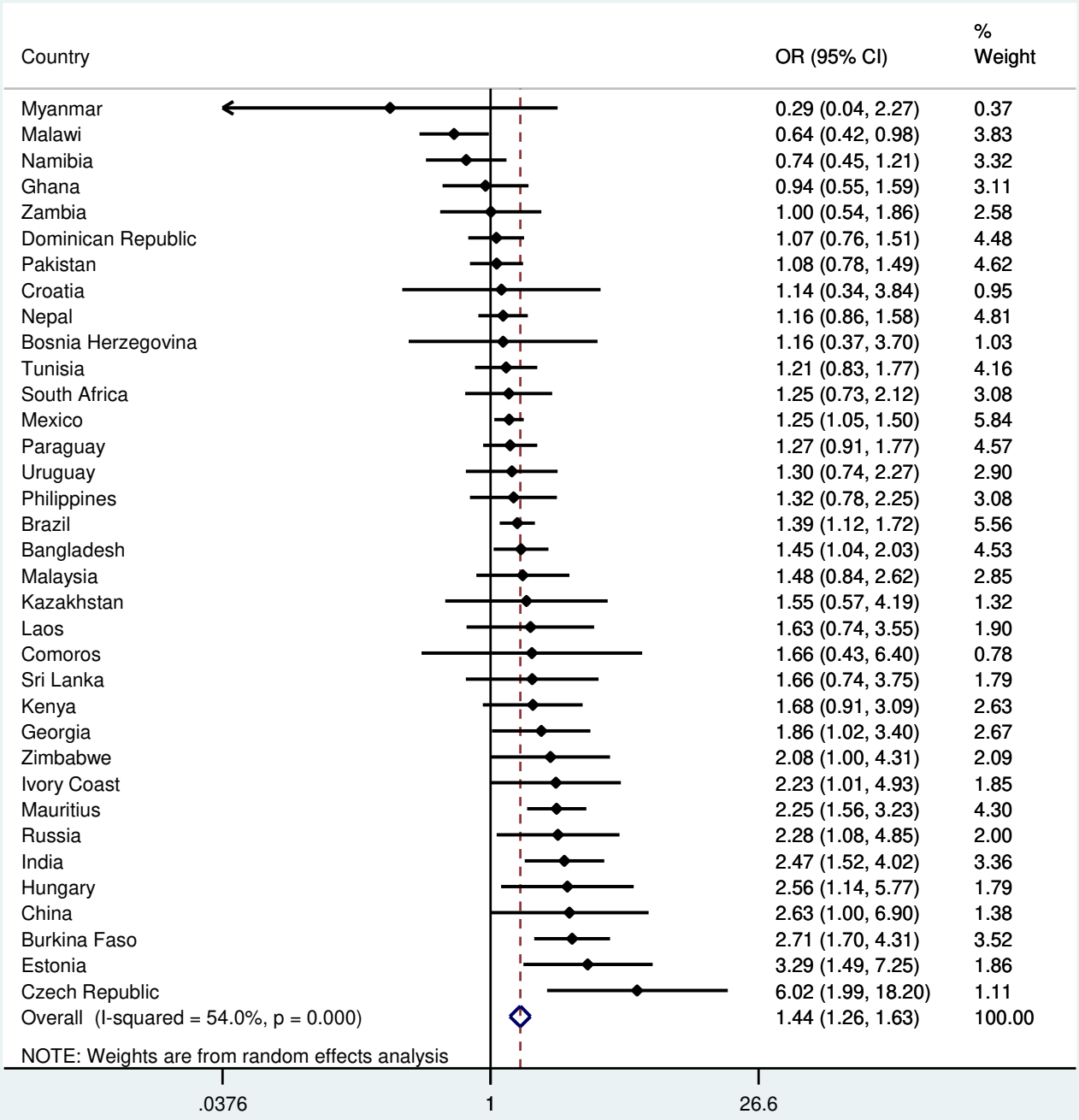

Figure 1 Country-wise association between depression (independent variable) and low physical activity (dependent variable) estimated by logistic regression adjusted for sex and age

Estimates for Vietnam could not be calculated because the prevalence of depression was low and there were no cases of low physical activity among those with depression.

Supplementary Table 1 Questions used to assess health status

Mobility	(1) Overall in the last 30 days, how much difficulty did you have with moving around? (2) In the last 30 days, how much difficulty did you have in vigorous activities, such as running 3 km (or equivalent) or cycling?
Pain and discomfort	(1) Overall in the last 30 days, how much of bodily aches or pains did you have? (2) In the last 30 days, how much bodily discomfort did you have?
Cognition	(1) Overall in the last 30 days, how much difficulty did you have with concentrating or remembering things? (2) In the last 30 days, how much difficulty did you have in learning a new task (for example, learning how to get to a new place, learning a new game, learning a new recipe etc.)?
Vision	(1) In the last 30 days, how much difficulty did you have in seeing and recognizing a person you know across the road (i.e., from a distance of about 20 meters)? (2) In the last 30 days, how much difficulty did you have in seeing and recognizing an object at arm's length or in reading?
Sleep and energy	(1) Overall in the last 30 days, how much of a problem did you have with sleeping, such as falling asleep, waking up frequently during the night or waking up too early in the morning? (2) In the last 30 days, how much of a problem did you have due to not feeling rested and refreshed during the day (e.g., feeling tired, not having energy)?

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