Title: Physical activity and visual difficulties in 36 low- and middle-income countries

Running title: Physical activity and visual difficulties

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What was known before

- Regular and sustained participation in physical activity is beneficial for almost every facet of adult health.
- One group that has consistently been reported to have low levels of physical activity are those who are visually impaired.
- Data on the association between visual difficulty and physical activity from low- and middle-income countries are scarce.

What this study adds

- Visual difficulty was associated with a 1.53 (95%CI=1.38-1.71) times higher odds for low physical activity with strong associations being observed in males and older adults.
- Interpersonal activities, cognition, and sleep/energy explained more than 10% of the association between visual difficulties and low physical activity.
- Addressing issues such as interpersonal activities, cognition, and sleep/energy in people with visual difficulties may increase levels of physical activity.

ABSTRACT

Background: Data on the association between visual difficulty and physical activity (PA) from low- and middle-income countries (LMICs) are scarce. Thus, the aim of the study was to investigate the association between visual difficulty and PA among adults from 36 LMICs, and to assess the mediators in this association.

Methods: Cross-sectional, community-based, predominantly nationally representative data from the World Health Survey were analyzed. The final sample included 199,110 individuals aged ≥18 years [mean (SD) age 38.6 (16.1) years; 49.4% males]. Visual difficulty referred to having severe/extreme difficulties in seeing and recognizing a person that the participant knows across the road. Low PA was defined as not complying with PA recommendations of 150 minutes of moderate-vigorous PA per week. Multivariable logistic regression, meta-analysis, and mediation analysis were conducted to assess associations.

Results: Meta-analysis based on country-wise multivariable logistic regression analysis showed that overall, visual difficulty is associated with a 1.53 (95%CI=1.38-1.71) times higher odds for low physical activity. Particularly strong associations were observed in males (OR=1.72; 95%CI=1.45-2.05) and adults aged ≥ 65 years (OR=1.95; 95%CI=1.67-2.29). Interpersonal activities, cognition, and sleep/energy explained more than 10% of the association between visual difficulty and low physical activity.

Conclusions: In conclusion, we found evidence that especially in the case of males and older adults with visual difficulties in LMICs, there were low levels of engagement with PA. Addressing issues such as interpersonal activities, cognition, and sleep/energy in people with visual difficulties may increase levels of physical activity.

Keywords: Physical activity, visual difficulty, low- and middle-income countries, epidemiology

INTRODUCTION

Physical activity may be described as any bodily movement caused by contraction of skeletal muscle that results in energy expenditure and may include activities such as structured exercise and sport, active travel (walking and cycling), occupational activity and household chores/gardening.[1] Regular and sustained participation in physical activity is beneficial for almost every facet of adult health. For example, a recent systematic review of review articles found that physically active older adults are at a reduced risk of cardiovascular mortality, breast and prostate cancer, fractures, recurrent falls, functional limitation, and depression. They also experience healthier ageing trajectories, better quality of life and improved cognitive functioning.[2] Importantly, regular participation in physical activity is also associated with a reduction in all-cause mortality.[3] In light of this evidence, governments across the globe have produced recommendations for adequate levels of physical activity. One key message from the World Health Organization (WHO) guidance is that adults and older adults should achieve at least 150 minutes of moderate physical activity and/or 75 minutes of vigorous physical activity per week.[4] It is therefore important to ensure that all populations maintain adequate levels of physical activity for good health.

However, one group that has consistently been reported to have low levels of physical activity are those who are visually impaired. The authors of the present paper have shown in a sample of 6,634 UK participants (mean age 65.0±9.2 years) that those with poor vision were twice as likely to be physically inactive than those with good eyesight.[5] The present authors have also found similar associations in adults residing in the US [6] and Spain.[7] Moreover, other authors have found similar results.[8] However, all previous studies on this topic have been carried out in high-income countries (HICs) and there are no studies specifically on this topic from low- and middle-income countries (LMICs). This is an

important research gap as the association may differ between HICs and LMICs due to differences in social and political contexts. For example, people with visual difficulties in LMICs may have more difficulty in engaging in physical activity owing to lack or scarcity of disability accessible facilities. Moreover, visual difficulties are more prevalent in LMICs than HICs. One study reported that across 70 countries, 21% of adults reported any visual difficulty but that the prevalence is higher in LMICs (23-24%) as compared to HICs (13%).[9]

Reasons why people with visual difficulties have low levels of physical activity is likely to be manyfold, e.g., due to factors such as lack of access to recreational and athletic programmes, and help or encouragement in developing suitable and safe physical recreation skills and habits.[10] Moreover, people with visual difficulties may experience activity limitations in walking, and environmental barriers such as those for transport, and this can hamper a person's ability to be physically active.[10,11] In addition, it is possible that people with visual difficulties are more likely to lose jobs, develop mental health problems, or have problems with interpersonal activities, which may themselves also lead to less physical activity.[12-17]

Identifying mediating factors will allow for the development of targeted interventions to increase levels of physical activity in the visually impaired. However, there are no previous studies which have quantified the degree to which various factors may explain this association. Therefore, the aims of the present study were to (a) investigate the association between visual impairment and physical activity in 199,110 individuals aged ≥18 years from 36 LMICs; (b) identify the potential mediating role of unemployment, depression, interpersonal activities, cognition, and sleep/energy in this association.

METHODS

The World Health Survey (WHS) was a cross-sectional survey carried out in 70 countries in 2002-2004. Single-stage random sampling was undertaken in 10 countries, while stratified multi-stage random cluster sampling was conducted in 60 countries. Survey details are available elsewhere (http://www.who.int/healthinfo/survey/en/). In brief, individuals with a valid home address aged ≥18 years were eligible to participate. Kish tables were used so that all household members had an equal chance of being selected. The questionnaire was subject to standard translation procedures to ensure comparability. Information was obtained through face-to-face interviews and telephone interviews conducted by trained interviewers. Across all countries, the individual response rate was 98.5%.[18] To adjust for non-response, sampling weights were generated using the population distribution as reported by the United Nations Statistical Division. Ethical approval for the survey was provided by ethical boards at each study site. All participants gave their informed consent.

Visual difficulty

As in a previous WHS publication, we operationalized visual difficulty as having severe or extreme difficulty in seeing and recognizing a person that the participant knows across the road (i.e., from a distance about 20 meters).[9] If the participant wore glasses or contact lenses, then they were asked to answer this question taking into account glasses or contact lenses. A validity study using the exact same question in the WHS showed that this response (i.e., severe/extreme) likely corresponds to WHO definitions of visual impairment (20/60 or 0.48 logMAR).[9]

Physical activity

Items from the International Physical Activity Questionnaire [19] were used to categorize physical activity. Specifically, participants were asked how many days over the past week on average they engaged in moderate and vigorous physical activity. Secondly, participants were asked for how many minutes on average, they engage in physical activity at a moderate and vigorous level. The total amount of moderate to vigorous physical activity over the last week was calculated and those scoring ≥150 minutes were classified as meeting the recommended guidelines (coded 0), and those scoring <150 minutes (low physical activity) were classified as not meeting the recommended guidelines (coded 1).

Mediators

The mediators in the current analysis (unemployment, anxiety, depression, cognition, interpersonal activities, sleep/energy) were based on the possibility that they may be the consequence of visual impairment, while they may also be the cause of low physical activity.[20-29] Unemployment referred to not working for pay or not currently in paid employment. Anxiety was assessed by the question 'Overall in the past 30 days, how much of a problem did you have with worry or anxiety' with answer options being none, mild, moderate, severe, and extreme. In accordance with previous WHS publications, those who answered severe and extreme were considered to have anxiety.[30,31] Depression was defined using the DSM-IV algorithm and was based on duration and persistence of depressive symptoms in the past 12 months.[32,33] Cognition, interpersonal activities, and sleep/energy were assessed with two questions each that assessed health function in the past 30 days. The actual questions can be found in **Table S1** in the Supplement. Each item was scored on a five-point scale ranging from 'none' to 'extreme/cannot do'. As in previous WHS publications, 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 to 100 with higher values representing worse health function.[34]

Control variables

The control variables were selected based on past literature and included age (18-44, 45-64, ≥65 years), sex, wealth quintiles, current smoking (yes or no), obesity, and chronic physical conditions (angina, arthritis, diabetes). The wealth quintiles were created using principal component analysis based on 15-20 assets including country-specific items for some countries. Obesity was defined as body mass index ≥30kg/m^2 based on self-reported weight and height. Arthritis and diabetes were based on self-reported lifetime diagnosis. For angina, in addition to a self-reported diagnosis, a symptom-based diagnosis based on the Rose questionnaire was also used.[35] Chronic physical conditions referred to having at least one of angina, arthritis, or diabetes.

Statistical analysis

Data were publicly available for 69 countries but 10 countries with no sampling information were excluded. Of the remaining 59, a total of 10 HICs were deleted as the focus on this paper was on LMICs. Two LMICs were deleted as data on physical activity were not collected. Furthermore, 11 LMICs were deleted as >25% of data on physical activity and/or visual difficulty were missing. Thus, individuals from 36 LMICs constituted the analytical sample. The classification of country-income level was based on the World Bank classification at the time of the survey (2003). All data were nationally representative with the exception of Russia, India, China, Comoros, and Ivory Coast.

The statistical analysis was done with Stata 14.1 (Stata Corp LP, College station, Texas). The difference in sample characteristics by visual difficulty or low physical activity was tested by Chi-squared tests for categorical variables and Student's *t*-tests for continuous variables. Multivariable logistic regression analysis was conducted to assess the association between visual difficulty (exposure) and low physical activity (outcome). Analyses using the overall sample, and age- (i.e., 18-44, 45-64, ≥65 years), sex-, and country-stratified samples were done. In order to assess whether the magnitude of the association between visual difficulty and low physical activity is statistically different between age groups and sex, we conducted interaction analysis by including the product term [age group (18-44, 45-64, ≥65 years) X visual difficulty] or (sex X visual difficulty)] using the overall sample.

Furthermore, to assess whether there is between-country heterogeneity in the association between visual difficulty and low physical activity, the Higgins's I^2 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.[36] A pooled estimate was obtained by combining the estimates for each country into a random effect meta-analysis.

Next, we conducted mediational analysis to understand the extent to which various factors (unemployment, anxiety, depression, cognition, interpersonal activities, sleep/energy) may explain the association between visual difficulty and low physical activity using the overall sample. The mediational analysis was done using the *khb* (Karlson Holm Breen) command in Stata.[37] This method decomposes the total effect of a variable into direct and indirect effects, and can be used with logistic regression models. This method also allows for the calculation

of the mediated percentage, which is interpreted as the percentage of the main association that can be explained by the mediator. Each potential mediator was included in the model separately.

The regression analyses were adjusted for age, sex, wealth, smoking, obesity, chronic conditions, and country with the exception of the age-, sex-, and country-stratified analyses which were not adjusted for age, sex, and country, respectively. Adjustment for country was done by including dummy variables for each country as in previous WHS publications.[38,39] The sample weighting and the complex study design were taken into account in all analyses. Results from the logistic regression models are presented as odds ratios (ORs) with 95% confidence intervals (CIs). The level of statistical significance was set at $P<0.05$.

RESULTS

The analytical sample consisted of 199,110 individuals aged ≥18 years [mean (SD) age 38.6 (16.1) years; 49.4% males]. The overall prevalence (95%CI) of visual difficulty and low physical activity were 5.0 (4.7-5.2) and 30.5 (29.6-31.4), respectively. There was a large range in this prevalence by country with it being 1.2% (Malaysia) to 9.9% (Comoros) and 9.6% (Comoros) to 81.8% (Mauritania) for visual difficulty and low physical activity, respectively (**Table 1**). The sample characteristics are provided in **Table 2**. The prevalence of low physical activity was much higher among those with visual difficulty (vs. those without this condition) (46.3% vs. 29.8%; $P<0.001$). Also, the prevalence of older age, females, obesity, chronic physical conditions, unemployment, anxiety, and depression were higher among those with visual difficulty or low physical activity, while they had worse health status in terms of cognition, interpersonal activities, and sleep/energy. Lower levels of wealth

and smoking were more common among those with visual difficulty but these were less common among those with low levels of physical activity.

The country-wise association between visual difficulty and low physical activity estimated by multivariable logistic regression is shown in **Figure 1**. The overall pooled estimate based on a meta-analysis was 1.53 (95%CI=1.38-1.71) with a moderate level of heterogeneity (I^2=53.1%). The pooled estimate for low-income countries and middle-income countries were similar. There was a significant interaction in the association between visual difficulty and low physical activity by age group and sex (i.e., interaction term P<0.05). Specifically, the association was strongest among those aged ≥65 years (OR=1.95; 95%CI=1.67-2.29), compared to those aged 18-44 years (OR=1.23; 95%CI=0.97-1.58) and 45-64 years (OR=1.26; 95%CI=1.05-1.51). Furthermore, this association was stronger among males than females [males OR 1.72 (95%CI=1.45-2.05) vs. females OR 1.42 (95%CI=1.25-1.62) (**Figure 2**).

The mediation analysis showed that interpersonal activities, cognition, and sleep and energy explained more than 10% of the association between visual difficulties and low physical activity, while unemployment, anxiety, and depression explained this association to a lesser degree (**Table 3**).

DISCUSSION

In this large sample of 199,110 individuals aged ≥18 years from 36 LMICs, we found that, overall, those with visual difficulty were 1.53 (95%CI=1.38-1.71) times more likely to have low physical activity. This association was particularly pronounced among males (OR=1.72) and those aged ≥65 years (OR=1.95). Moreover, interpersonal activities, cognition, and sleep/energy explained more than 10% of the association between visual difficulties and low

physical activity, while unemployment, anxiety, and depression explained this association to a lesser degree.

Our finding that visual impairment is associated with lower levels of physical activity is in line with previous studies on this topic from HICs [5-7] but expands previous knowledge by showing that this association also exists in multiple LMICs. Previous studies have shown that the main barriers to an active lifestyle in people with difficulty seeing are lack of access to recreational and athletic programmes, lack of transport, lack of accessible exercise equipment, lack of help or encouragement in developing suitable and safe physical recreation skills and habits and activity limitations in walking.[10,11] Thus, in order to increase levels of physical activity among people in LMICs, it may be important to address these issues which are often lacking in many LMICs.

Interestingly, we found that interpersonal activities, cognition, and sleep/energy explained more than 10% of the association between visual difficulties and low physical activity. First, literature has shown that those who are visually impaired find it difficult to establish new relationships,[14,15] while social isolation and loneliness are associated with lower levels of physical activity in the general adult population.[40] Second, those who have visual impairment have worse cognitive functioning as they age. For example, one study in older adults found that good visual acuity and wearing glasses correlated with better cognitive function. Indeed, the study concluded that reading glasses can serve as a protective factor against cognitive deterioration associated with sensory (visual) deprivation in old age.[16] Moreover, lower cognitive functioning has been found to be associated with lower level of physical activity.[17] Finally, those who are visually impaired tend to report poor sleep (short and long sleep duration) compared to the general population [41] and poor sleep is associated with lower levels of physical activity possibly due to factors such as fatigue.[42]

It should be noted that the association between visual impairment and physical activity was most pronounced among those aged ≥65 years and also among males. Literature suggests that visual impairment in older people is associated with increases in the incidence of falls and hip fractures.[43] Compared to the general older population, this group is 1.7 times more likely to fall, 1.9 times more likely to have multiple falls and 1.3–1.9 times more likely to experience hip fractures.[44] Thus, the more pronounced association observed in older adults may be partly explained by fear of falling.[45] Next, the reason why the association was stronger among males is unclear. However, one can speculate that it may be owing to the difference in gender roles in LMICs. In this setting, the role of domestic duties may lay with the female regardless of visual difficulty status and these domestic duties will likely yield sufficient levels of physical activity. Further research of a qualitative nature is needed to confirm or refute this hypothesis.

Finally, a moderate level of between-country heterogeneity in the association between visual difficulty and low physical activity was observed. Although the reasons for this can only be speculated, it is possible that this may be related with differences in environmental barriers to engage in physical activity, availability of family members to help in physical activities, or the need to be physically active and work due to economic needs despite visual difficulties.

The use of a large predominantly nationally representative dataset across multiple LMICs is a clear strength of the present study. However, findings must be interpreted in light of the study limitations. First, physical activity and visual difficulty were assessed using self-reported measures, and this may have introduced some level of bias (e.g., recall bias). Future studies using objective data on visual acuity and physical activity from LMICs are warranted.

Second, the study is of a cross-sectional nature and it is not known whether lower levels of physical activity precede visual difficulty or whether visual difficulty precedes low levels of physical activity. Finally, it is important to note that our mediation analysis was based on cross-sectional data and thus, it is not possible to differentiate the factors as mediators or confounders. Mediation and confounding are identical statistically and can only be distinguished on conceptual grounds.

In conclusion, we found evidence that especially males and older adults with visual difficulties in LMICs engage in low levels of physical activity. Addressing issues such as interpersonal activities, cognition, and sleep/energy in people with visual difficulties may increase levels of physical activity. However, given that the influence of these factors in the association between visual difficulty and low physical activity was small, addressing other environmental factors are also likely to be important to increase physical activity levels in this population. Future studies of longitudinal design are warranted to understand the potentially complex interplay of factors assessed in this study and others to obtain a more profound understanding on why people with visual difficulties are less likely to engage in physical activity. This information is essential for the design of future policies to increase physical activity in people with visual difficulty.

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Conflicts of Interest

None.

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TABLES AND FIGURES

Table 1 Sample size and prevalence of visual difficulty and low physical activity by country

Country	N	Visual difficulty % [95%CI]	Low physical activity % [95%CI]
Low-income countries			
Bangladesh	5,942	7.1 [6.5,7.8]	22.3 [20.0,24.7]
Burkina Faso	4,948	3.6 [2.8,4.7]	14.4 [12.6,16.4]
Comoros	1,836	9.9 [8.4,11.6]	9.6 [7.5,12.2]
Ghana	4,165	3.6 [3.1,4.3]	29.5 [27.2,32.0]
India	10,687	8.1 [6.8,9.5]	18.9 [15.5,22.9]
Ivory Coast	3,251	4.6 [3.7,5.8]	36.4 [32.7,40.2]
Kenya	4,640	2.6 [2.0,3.4]	12.4 [9.8,15.5]
Laos	4,988	2.0 [1.6,2.4]	26.3 [24.3,28.4]
Malawi	5,551	5.4 [4.7,6.1]	16.6 [14.9,18.5]
Mauritania	3,902	7.6 [5.7,10.1]	81.8 [78.2,85.0]
Myanmar	6,045	2.1 [1.7,2.7]	24.1 [20.7,27.8]
Nepal	8,820	6.9 [6.4,7.6]	14.7 [13.7,15.8]
Pakistan	6,501	2.2 [1.7,2.8]	51.1 [48.9,53.3]
Zambia	4,165	3.4 [2.6,4.5]	25.6 [22.9,28.5]
Zimbabwe	4,290	5.6 [4.6,6.7]	20.4 [18.6,22.3]
Middle-income countries			
Brazil	5,000	5.4 [4.6,6.3]	33.6 [31.5,35.7]
China	3,994	1.7 [1.3,2.4]	39.3 [31.6,47.6]
Croatia	993	3.9 [2.8,5.4]	26.4 [23.3,29.7]
Czech Republic	949	2.0 [1.2,3.3]	35.6 [30.6,41.0]
Dominican Republic	5,027	4.9 [4.0,6.0]	58.9 [56.1,61.6]
Estonia	1,020	3.8 [2.5,5.9]	20.0 [16.7,23.7]

Georgia	2,950	5.9 [4.8,7.1]	32.1 [26.5,38.2]
Hungary	1,419	3.9 [3.0,5.0]	18.6 [15.9,21.6]
Kazakhstan	4,499	3.6 [2.4,5.5]	38.6 [31.0,46.8]
Malaysia	6,145	1.2 [0.9,1.6]	31.8 [30.1,33.5]
Mauritius	3,968	6.1 [5.2,7.2]	29.5 [26.0,33.3]
Mexico	38,746	3.2 [3.0,3.5]	31.5 [30.1,32.9]
Namibia	4,379	6.3 [5.1,7.8]	48.7 [46.3,51.0]
Paraguay	5,288	3.8 [3.2,4.5]	25.6 [23.9,27.3]
Philippines	10,083	5.0 [4.4,5.6]	11.9 [10.7,13.3]
Russia	4,427	7.7 [6.3,9.4]	30.6 [27.3,34.1]
South Africa	2,629	6.9 [5.0,9.3]	66.6 [62.5,70.5]
Sri Lanka	6,805	3.3 [2.7,4.0]	22.3 [19.4,25.6]
Tunisia	5,202	5.1 [4.4,5.9]	46.9 [43.4,50.5]
Ukraine	2,860	6.0 [4.8,7.6]	20.6 [17.0,24.6]
Uruguay	2,996	2.6 [2.2,3.1]	63.9 [55.6,71.3]

Abbreviation: CI Confidence interval

Table 2 Sample characteristics (overall and by visual difficulty and low physical activity)

			Visual difficulty			Low physical activity		
Characteristic	Category	Overall	No	Yes	P-value[a]	No	Yes	P-value[a]
Low physical activity	No	69.5	70.2	53.7	<0.001			
	Yes	30.5	29.8	46.3				
Visual difficulty	No	95.0				96.2	92.7	<0.001
	Yes	5.0				3.8	7.3	
Age (years)	18-44	67.0	69.3	24.5	<0.001	71.6	58.5	<0.001
	45-64	24.0	23.3	37.1		22.7	26.3	
	≥65	8.9	7.4	38.5		5.7	15.3	
Sex	Female	50.6	49.8	65.5	<0.001	47.9	56.8	<0.001
	Male	49.4	50.2	34.5		52.1	43.2	
Wealth quintile	Poorest	20.3	19.7	30.2	<0.001	21.0	18.4	<0.001
	Poorer	20.0	19.8	23.4		20.4	19.0	
	Middle	19.9	19.9	18.5		20.4	19.1	
	Richer	19.9	20.1	15.2		19.9	20.3	
	Richest	20.0	20.3	12.7		18.4	23.2	
Smoking	No	71.8	72.1	65.8	<0.001	69.9	76.0	<0.001
	Yes	28.2	27.9	34.2		30.1	24.0	

Obesity	No	90.8	90.9	89.2	0.035	92.6	86.6	<0.001
	Yes	9.2	9.1	10.8		7.4	13.4	
Chronic physical conditions	No	76.2	77.7	47.2	<0.001	77.8	72.8	<0.001
	Yes	23.8	22.3	52.8		22.2	27.2	
Unemployed	No	57.2	58.5	32.7	<0.001	62.1	44.1	<0.001
	Yes	42.8	41.5	67.3		37.9	55.9	
Anxiety	No	87.8	89.1	63.5	<0.001	88.5	86.6	<0.001
	Yes	12.2	10.9	36.5		11.5	13.4	
Depression	No	92.8	93.5	80.1	<0.001	93.6	91.5	<0.001
	Yes	7.2	6.5	19.9		6.4	8.5	
Cognition[b]	Mean (SD)	20.1 (26.0)	18.5 (24.8)	49.6 (30.5)	<0.001	18.9 (24.8)	22.5 (28.1)	<0.001
Interpersonal activities[b]	Mean (SD)	14.8 (24.4)	13.6 (23.2)	34.7 (32.4)	<0.001	13.7 (23.2)	16.6 (26.1)	<0.001
Sleep and energy[b]	Mean (SD)	21.0 (26.1)	19.6 (24.9)	48.7 (30.3)	<0.001	20.1 (25.2)	23.2 (27.8)	<0.001

Abbreviation: SD Standard deviation

Data are column % unless otherwise specified.

[a] P-value was based on Chi-squared tests for categorical variables and Student's *t*-tests for continuous variables.

[b] Scores ranged from 0 to 100 with higher scores representing worse health status.

Table 3 Mediators in the association between visual difficulty and low physical activity

Mediator	Effect	OR [95%CI]	P-value	% Mediated
Unemployment	Total	1.53 [1.35,1.72]	<0.001	7.6
	Direct	1.48 [1.31,1.66]	<0.001	
	Indirect	1.03 [1.02,1.04]	<0.001	
Anxiety	Total	1.53 [1.36,1.71]	<0.001	2.9
	Direct	1.51 [1.34,1.70]	<0.001	
	Indirect	1.01 [1.00,1.02]	0.016	
Depression	Total	1.54 [1.37,1.72]	<0.001	5.3
	Direct	1.50 [1.34,1.68]	<0.001	
	Indirect	1.02 [1.01,1.04]	0.011	
Cognition	Total	1.53 [1.36,1.71]	<0.001	10.7
	Direct	1.46 [1.30,1.64]	<0.001	
	Indirect	1.05 [1.02,1.07]	<0.001	
Interpersonal activities	Total	1.54 [1.38,1.72]	<0.001	12.3
	Direct	1.46 [1.30,1.63]	<0.001	
	Indirect	1.05 [1.04,1.07]	<0.001	
Sleep and energy	Total	1.54 [1.37,1.72]	<0.001	10.4
	Direct	1.47 [1.31,1.65]	<0.001	
	Indirect	1.05 [1.02,1.07]	<0.001	

Abbreviation: OR Odds ratio; CI Confidence interval

Models are adjusted for age, sex, wealth, smoking, obesity, chronic conditions, and country.

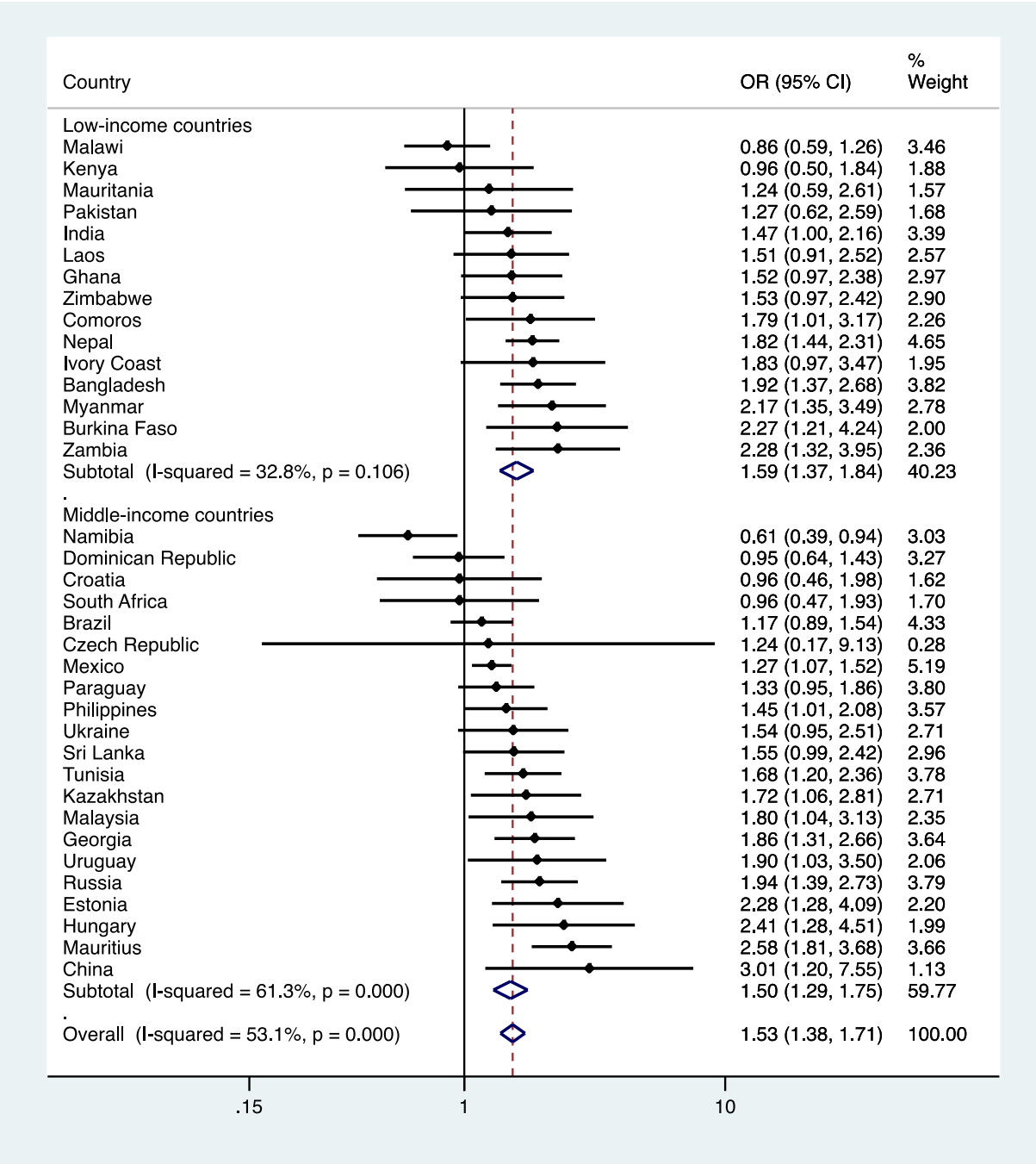

Figure 1 Country-wise association between visual difficulty and low physical activity estimated by multivariable logistic regression

Abbreviation: OR Odds ratio; CI Confidence interval

Models were adjusted for age, sex, wealth, smoking, obesity, and chronic conditions.

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

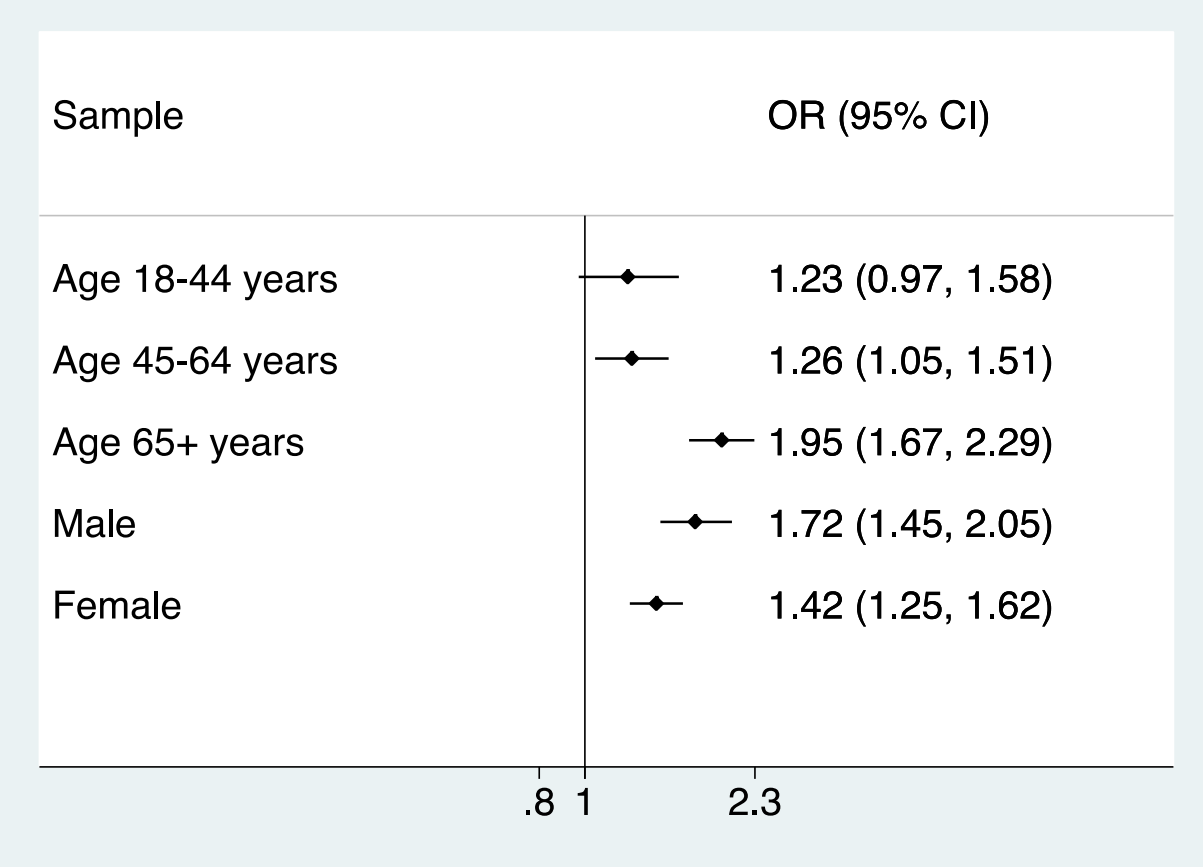

Figure 2 Association between visual difficulty and low physical activity estimated by multivariable logistic regression by age group and sex

Abbreviation: OR Odds ratio; CI Confidence interval

Age-stratified analysis is adjusted for sex, wealth, smoking, obesity, chronic conditions, and country.

Sex-stratified analysis is adjusted for age, wealth, smoking, obesity, chronic conditions, and country.

APPENDIX

Table S1 Questions used to assess cognition, interpersonal activities, and sleep and energy

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.)?
Interpersonal activities	(1) Overall in the last 30 days, how much difficulty did you have with personal relationship or participation in the community? (2) In the last 30 days, how much difficulty did you have in dealing with conflicts and tensions with others?
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)?