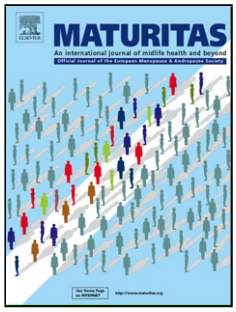

Title: Sedentary behavior and perceived stress among adults aged ≥50 years in six low- and middle-income countries

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Sedentary behavior and perceived stress among adults aged ≥50 years in six low- and middle-income countries

Running title: Sedentary behavior and stress

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Highlights

- Little is known about the relationship between sedentary behavior and perceived stress.
- Our data across 6 low- and middle-income countries suggest sedentary behavior is associated with increased perceived stress.
- A one-hour increase in sedentary behavior per day was associated with a score (on a 0-10 scale) for perceived stress that was 0.92 points higher.
- Future research is warranted to examine the types and contexts of sedentary behavior and the mechanisms underpinning this relationship.

Abstract

Background

Sedentary behavior and perceived stress are both negatively associated with physical and mental health. Little is known about the association between sedentary behavior and perceived stress, and there is a particular paucity of data on people aged ≥50 years from low- and middle-income countries (LMICs).

Methods

We analyzed cross-sectional, community-based data from 34,129 individuals aged ≥50 years [mean age 62.4 (SD=16.0) years, 52% females] from six LMICs. Perceived stress was assessed using the Perceived Stress Scale and time spent sedentary per day was self-reported.

Multivariable linear regression analyses were conducted, adjusting for important socio-economic and physical and mental health-related confounders.

Results

The mean perceived stress score increased with greater sedentary time (38.4 for 0-<4 h/day to 54.2 for ≥11 h/day). In the fully adjusted model, 4-8, 8-11, and ≥11 h/day of sedentary behavior (SB) were associated with 1.97 (95%CI=0.57-3.36), 7.11 (95%CI=4.96-9.27), and 9.02 (95%CI=5.45-12.59) times higher mean perceived stress scores, compared with 0-<4 h/day. Greater time spent sedentary was associated with higher perceived stress scores in all six countries, although the association in Mexico fell short of statistical significance.

Conclusion

This is the first multinational analysis to show that a greater amount of sedentary behavior is associated with higher levels of perceived stress among older adults in LMICs. Future research may examine the types and contexts of sedentary behavior, and explore the underlying mechanisms of the relationship.

Keywords: Sedentary behavior, perceived stress, health, mental health, low- and middle-income countries, physical activity

INTRODUCTION

Sedentary behavior (SB), defined as energy expenditure ≤1.5 metabolic equivalents of task (METs) while in a sitting or reclining posture during waking hours [1], has been associated with multiple adverse health outcomes, including type-2 diabetes, cardiovascular disease and premature mortality [2]. In addition, it has also been associated with negative mental health outcomes, such as higher incidence of depression and anxiety among adults

[3,4]. Given this, it is concerning that the amount of SB among adults is high - approximately 9.5 hours per/day in sitting time when measured objectively in the United States [3]. Even more troubling is the fact that among adults, SB seems to increase with age, and that older adults are the most sedentary proportion of society [5,6].

To date, a growing number of studies have looked at SB and mental health, but focused on conditions such as depression and anxiety [3,4,7–10]. Despite growing literature on the association between SB and mental health outcomes, there is a paucity of studies on its association with perceived stress, which is closely linked to the adverse mental health profiles that have been associated with SB. Perceived stress, can be defined as a state in which one perceives their life situations as stressful and also takes into account the uncontrollability of one's life, and the extent to which one is capable of dealing with difficulties [11]. Perceived stress has been found to be negatively associated with physical health conditions such as arthritis, asthma and diabetes [12] and has been found to predict higher levels of depression [13]. Furthermore, increased levels of perceived stress have been found to be associated with adverse health behaviors, such as lower fruit, vegetable and protein intake, higher intake of salty snacks and lower rates of physical activity in a cross-sectional American study [14]. Importantly, it has also been found that perceived stress generally increases with age [15]. However, most of the studies looking at SB and mental health have focused on children or adolescents [16–18]. One study examined SB and stress symptoms among Korean adults and found that prolonged sedentary time was significantly associated with a greater risk of stress symptoms [19]. Another study examined the longitudinal associations between SB and perceived stress [20]. This study analyzed stress as the predictor in their multinomial logistic regression, and found that stress predicted increased television watching time [20]. However, there are very few studies on SB and mental health from low and middle-income countries (LMICs). As SB is a modifiable behavior, it may be that changes in SB might affect levels of

perceived stress, through improving inflammatory marker profiles [40]. Given that the average age in LMIC countries continues to rise, the representativeness of the current research is unclear [21], particularly since perceived stress levels are significantly higher in LMICs than in developed countries [22]. In addition, some LMICs are experiencing socioeconomic changes related to urbanization and globalization, which may be causing increased levels of stress among the inhabitants of these countries [23].

Given the current gaps in the literature, the aim of the current study was to assess whether higher levels of SB are associated with greater levels of perceived stress among community-dwelling older adults using nationally representative data from six LMICs (China, Ghana, India, Mexico, Russia, South Africa) which broadly represent different geographical locations and levels of socio-economic and demographic transition. Given the previously reported link between SB and adverse mental health outcomes, we hypothesized that greater time spent in SB would be associated with higher perceived stress, and that this would hold true across all six countries.

METHODS

The survey

Data from the SAGE were analyzed. These data are publically available through http://www.who.int/healthinfo/sage/en/. This survey was undertaken in China, Ghana, India, Mexico, Russia, and South Africa between 2007 and 2010. These countries broadly represent different geographical locations and levels of socio-economic and demographic transition. Based on the World Bank classification at the time of the survey, Ghana was the only low-income country, and China and India were lower middle-income countries although China became an upper middle-income country in 2010. The remaining countries were upper middle-income countries. Details of the survey methodology have been published elsewhere

[24]**.** In brief, in order to obtain nationally representative samples, a multistage clustered sampling design method was used. The sample consisted of adults aged ≥18 years with oversampling of those aged ≥50 years. Trained interviewers conducted face-to-face interviews using a standard questionnaire. Standard translation procedures were undertaken to ensure comparability between countries. The survey response rates were: China 93%; Ghana 81%; India 68%; Mexico 53%; Russia 83%; and South Africa 75%. Sampling weights were constructed to adjust for the population structure as reported by the United Nations Statistical Division. Ethical approval was obtained from the WHO Ethical Review Committee and local ethics research review boards. Written informed consent was obtained from all participants.

Perceived stress (PS) (Outcome)

We assessed perceived stress in the last month using the only two questions on perceived stress that were available in the WHS. These two items were taken from the Perceived Stress Scale [25]. This validated scale has been widely used to measure perceived stress worldwide [12,26,27]. The questions asked were: "How often have you felt that you were unable to control the important things in your life?"; and "How often have you found that you could not cope with all the things that you had to do?" The answer options to these questions were: never (score=1), almost never (score=2), sometimes (score=3), fairly often (score=4), very often (score=5). As in a previous study which used the identical questions to measure perceived stress [12], we conducted factor analysis with polychoric correlations to incorporate the covariance structure of the answers provided for individual questions measuring a similar construct [28]. The principal component method was used for factor extraction, while factor scores were obtained using the regression scoring method. These

factor scores were later converted to scores ranging from 0-100 with higher values indicating higher levels of perceived stress.

Sedentary behavior (Exposure)

In order to assess SB, participants were asked to state the total time they usually spent (expressed in minutes per day) sitting or reclining including at work, at home, getting to and from places, or with friends (e.g., sitting at a desk, sitting with friends, travelling in car, bus, train, reading, playing cards or watching television). This did not include time spent sleeping. The variable on time spent sedentary was used as a continuous variable (hours/day) and as a categorical variable (<4, 4-8, 8-11, ≥11 hours/day) [29].

Confounding variables

The selection of the confounding variables was based on past literature [10,12,19,30]. These included age (years), sex, wealth quintiles based on country-specific income, education (secondary completed or not), marital status (married/cohabiting, never married, separated/divorced/widowed), employment status (engaged in paid work ≥2 days in last 7 days: Y/N), setting (urban/rural), obesity, number of chronic physical conditions, disability, depression, social cohesion, and physical activity. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Obesity was defined as BMI≥30kg/m^2 [31]. The total number of seven chronic physical conditions (angina, arthritis, asthma, chronic lung disease, diabetes, hypertension, stroke) was summed per individual. The details on how these conditions were assessed are provided in eTable 1 (Appendix). Disability was assessed by standard basic activities of daily living (ADL) questions [32–34] which included six questions with the introductory phrase "overall in the last 30 days, how much difficulty did you have" followed by: in washing your whole body?; in getting

dressed?; with moving around inside your home?; with eating (including cutting up your food)?; with getting up from lying down?; with getting to and using the toilet? Answer options were none, mild, moderate, severe, extreme/cannot do. ADL disability was a dichotomous variable where those who answered severe or extreme/cannot do to any of the six questions were considered to have limitations in ADL[35]. Questions based on the World Mental Health Survey version of the Composite International Diagnostic Interview [36,37] were used for the endorsement of past 12-month DSM-IV depression. As in a previous SAGE publication [38], a social cohesion index was created based on 9 questions on the participant's involvement in community activities in the past 12 months (e.g., attended religious services, club, society, union etc) with answer options 'never (coded=1)', 'once or twice per year (coded=2)', 'once or twice per month (coded=3)', 'once or twice per week (coded=4)', and 'daily (coded=5)'. The answers to these questions were summed and converted to a scale ranging from 0 to 100 with higher scores representing higher levels of social cohesion. Pain was assessed with the question "Overall in the last 30 days, how much of bodily aches or pains did you have?" with answer options 'none', 'mild', 'moderate', 'severe', and 'extreme'. Those who answered at least 'mild' were considered to have pain. The Global Physical Activity Questionnaire was used to assess the level of physical activity using conventional cut-offs and categorized as low, moderate, and high (http://www.who.int/chp/steps/GPAQ/en/).

Statistical analysis

The analyses were done with Stata statistical software version 14.1 (Stata Corp LP, College Station, Texas). The analysis was restricted to those aged ≥50 years. Multivariable linear regression analyses were used to estimate the association between time spent sedentary (exposure) and perceived stress (outcome). Using the categorical SB variable (i.e., 0-<4, 4-

<8, 8-<11, ≥11 hours/day), five models were constructed to assess the effect of the inclusion of different variables in the models using the overall sample: Model 1 - Adjusted for sociodemographic variables (age, sex, wealth, education, marital status, unemployment, setting, country); Model 2 - Adjusted for factors in Model 1 and obesity, number of chronic physical conditions, and disability; Model 3 - Adjusted for factors in Model 2 and depression; Model 4 - Adjusted for factors in Model 3 and social cohesion; Model 5 - Adjusted for factors in Model 4 and pain; Model 6 - Adjusted for factors in Model 5 and physical activity. Analyses stratified by age (50-64, ≥65 years) were also conducted, as middle-aged and older age may differ due to factors such as work and retirement, while adjusting for all potential confounders (i.e., all variables in Model 6). The continuous SB variable (i.e., sedentary time per day in hours) was also used in a secondary analysis which used the overall and country-wise sample. This analysis was also adjusted for all potential confounders with the exception of the country-wise analysis which was not adjusted for country. Adjustment for country was conducted by including dummy variables for each country as in previous SAGE publications [9, 18]. All variables were included in the models as categorical variables with the exception of age, number of chronic physical conditions, social cohesion, and the SB variable when used as a continuous variable. In order to assess the influence of multicollinearity, we calculated the variance inflation factor (VIF) value for each independent variable. The highest VIF was 2.04, which is much lower than the commonly used cut-off of 10, indicating that multicollinearity was unlikely to be a problem in our analyses. Under 3.2% of the values for all variables used in the analysis were missing with the exception of obesity (6.2%). Complete case analysis was done. The sample weighting and the complex study design were taken into account in all analyses with Taylor linearization methods. Results from the linear regression models are presented as b-coefficients with 95% confidence intervals (95%CIs). The level of statistical significance was set at $P<0.05$.

RESULTS

A total 34,129 individuals aged ≥50 years (China = 13,175; Ghana = 43,05; India = 6,560; Mexico = 2,313; Russia = 3,938; South Africa = 3,838) were included in the analysis. The mean age was 62.4 (16.0) years and 52.1% were females (**Table 1**). The mean sedentary time (hours/day) was 3.9 hours and the proportions of those engaged in 0-4, 4-8, 8-11, and ≥11 hours of SB per day were 52.9%, 36.3%, 8.4%, and 2.4%, respectively. The mean perceived stress score increased linearly with increasing hours spent sedentary per day (**Figure 1**). After adjustment for sociodemographic factors, compared to those who engage in 0-4 hours of SB/day, 4-8, 8-11, and ≥11 hours/day were associated with 2.40 (95%CI=1.01-3.78), 8.87 (95%CI=6.73-11.00), and 11.34 (95%CI=7.55-15.13) times higher mean perceived stress scores (range 0-100), respectively (Model 1) (**Table 2**). The inclusion of various factors in the model gradually attenuated the b-coefficients but even in the fully-adjusted model (Model 6), the b-coefficients remained significant with the corresponding figures being 1.97 (95%CI=0.57-3.36), 7.11 (95%CI=4.96-9.27), and 9.02 (95%CI=5.45-12.59), respectively. The results by age groups of 50-64 years and ≥65 years were similar (**Table 3**). Overall, after adjustment for potential confounders, a one-hour increase in SB per day was associated with on average a 0.88 (95%CI=0.63-1.13) points higher perceived stress score overall (**Figure 2**). A higher amount of time spent in SB was associated with higher perceived stress scores in all individual countries although this did not reach statistical significance in Mexico. The increase in stress scores was most notable in India and South Africa.

DISCUSSION

To the best of our knowledge, this study is the first large scale study to explore the multi-country relationship between SB and perceived stress across LMICs and contains a number of novel results. Our data suggest that SB is significantly and linearly associated with

increased perceived stress even after adjustment for important potential confounders. Specifically, the mean stress score (range 0-100) was 9.47 points higher among those who engage in ≥11h/day of SB compared to 0-4 h/day. This association was significant in Ghana, India, China, Russia, South Africa, with a particularly strong association being observed in India and South Africa. Finally, these results were consistent across all age groups (i.e. 50-64 years, and ≥65).

To the best of our knowledge, only one previous study has examined the association between SB and perceived stress among old adults (mean age=84 years) in one American city (n=307) [39]. However, they did not find any significant associations between SB (objectively or subjectively) and perceived stress. The discrepant results between our study are mostly likely due to sampling, as the previous smaller study may have lacked statistical power to detect a difference. The differences could also be due to the fact that the American study asked about 9 specific sedentary behaviors, while this study asked about any behaviors that were done while sitting or reclining. As such, it may be that this study captured more variation in sedentary behaviors and thus more sedentariness. Alternatively, the relationship between SB and perceived stress may differ by age, socioeconomic status, or setting. It is possible for example that the better economic situation in the American study had a buffering effect on perceived stress. Among Korean adults, sedentary time of more than 420 minutes a day was significantly associated with increased risk of stress symptoms [19]. Clearly, more studies from diverse settings are warranted in order to assess whether our results are context-specific.

Future research is required to confirm the directionality of our findings. However, previous randomized controlled studies have indicated a causal relationship in younger adults between SB and increased stress and reduced mood via increased inflammation [40] which is a key risk factor for psychological stress [41]. Despite this, the mechanisms potentially

linking SB and perceived stress in older adults in LMICs, as bidirectionality and/or third-factor causality cannot yet be established. Wealth, education and unemployment may also play a role in the relationship between SB and perceived stress. Future research should aim to clarify these mechanisms. Indeed, if it is found that SB increases stress, this provides a foundation on which to base an important public health message and future interventions.

The relationship between increasing SB and increasing perceived stress was significant for all countries with the exception of Mexico (OR=0.45; 95% CI= 0.15 - 1.05). Interestingly, the relationships were significant and strongest in India (OR=1.26; 95% CI= 0.87 - 1.66) and South Africa (OR=1.20; 95% CI= 0.45 - 1.96). It is unclear why there may be such differences between countries, however some explanations may be hypothesized by drawing from the wider literature. Past cross-cultural research has looked into the relationship between perceived stress and mental and physical health, and whether culture may play a moderating role [42]. Shavitt et al. (2016) found that among Mexican-Americans, Korean Americans, African Americans and non-Hispanic Whites, a buffering effect of social support on the relationship between perceived stress and mental and physical health was found only for Mexican Americans, but not for any of the other groups [42]. This may partially account for this different but clearly further work is required.

Indeed, it may be that the type of SB may explain the relationship between SB and perceived stress. For example, socializing with friends and family vs. sitting down and watching television vs. sitting at a computer at work may all exert different influences on perceived stress. It may be that different countries tend to have different types or contexts of SB, and these exert differing effects on perceived stress. For instance, in a study on adolescent girls [43] it was suggested that it may not be the amount of SB, but rather the type of it, that explains its association with mental health. Nihill and colleagues [43] found significant inverse associations in this population between time spent watching DVDs and

using a computer for non-school reasons and self-esteem, however there were no significant associations between TV watching, which is a cognitively passive SB, and self-esteem. It may be that different types of SB are more educational, more stimulating or more social, and thus do not exert a negative effect on perceived stress.

In a sample more closely age-related to this study, Leask et al., 2015 [44] objectively examined the context of SB among older adults in Glasgow, Scotland (Mean age= 72) and found that most of their sedentary time was spent at home (70%), that most of it was spent on their own (56%) and that screen sitting was common (36%). The authors suggested that perhaps loneliness could play a role in SB and mental health in this population if they are spending most of their sedentary time alone. However, given that this study was conducted in a high-income setting, it would be of interest to investigate the specific context of SB among the six LMICs included in our study, and assess if the types of sedentary activities might explain the differences in the relationship between SB and perceived stress observed. Furthermore, Gibson et al. (2017, [3]) objectively examined weekday vs. weekend sitting time and its effect on mental wellbeing. They found that weekday sitting had an effect on symptoms of anxiety and depression, while there was no association between weekend sitting and these outcomes. This suggests that it may be workplace SB, but not leisure SB, that exerts a negative effect on mental health. As the above studies show, it is important to understand the context of SB and how different types of SB differentially affect mental health, specifically perceived stress.

Taken together, our data, along with the wider literature, suggest that SB is closely related to perceived stress in some LMICs, and that increasing levels of SB are associated with increasing levels of perceived stress. It is well established that SB is associated with several negative health outcomes, and this data adds to the literature by showing that among LMICs, SB has a negative association with perceived stress as well. Given this, it is

imperative that interventions are put in place to target SB. For example, interventions designed for the workplace [3], or the home context targeting social isolation among older adults [44] may be effective. A possible starting direction could be to first evaluate types of SB being engaged in by individuals of these LMICs, and then designing interventions based on these findings. Such interventions could target SB, thereby reducing its negative effects on perceived stress, as well as reducing the potential deleterious effects of stress on physical and mental health.

This study, while it provides novel findings and includes a large sample, is not without its limitations. The SB data is based on self-report rather than objective measures which is prone to recall bias [6]. Self-report measures were also used to assess perceived stress, and thus may be subject to recall bias. The data also does not include information about the type of SB being engaged in, and who is present during this SB for possible social support. Furthermore, the data is cross-sectional and thus causality and temporal associations cannot be inferred. It is likely that this relationship is bidirectional, such that SB may affect stress just as stress may affect SB.

In conclusion, our data show that higher SB is associated with higher levels of perceived stress. Future longitudinal research should take into account the type of SB, for example with time-lapse cameras [44], and objectively measure levels of SB using accelerometry. As there was some evidence of relevant differences across countries, future research should attempt to explore the possible reasons for this, and ultimately create interventions based on these cultural differences, in order to decrease SB and ultimately stress.

Contributors

Garcia Ashdown-Franks analyzed and interpreted data, and participated in the drafting of the paper.
Ai Koyanagi conceived and designed the study, collected and analyzed data, and participated in the drafting of the paper.
Davy Vancampfort conceived and designed the study, collected and analyzed data, and participated in the drafting of the paper.
Brendon Stubbs conceived and designed the study, collected and analyzed data, and participated in the drafting of the paper.
All authors contributed data.

Conflict of interest

The authors declare that they have no conflict of interest.

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Ethical approval

Ethical approval was obtained from the WHO Ethical Review Committee and local ethics research review boards. Written informed consent was obtained from all participants.

Provenance and peer review

This article has undergone peer review.

Research data (data sharing and collaboration)

Data from the SAGE were analyzed. These data are publically available through http://www.who.int/healthinfo/sage/en/.

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Table 1 Sample characteristics (overall and by country)

Characteristic		Overall	China	Ghana	India	Mexico	Russia	South Africa
Sedentary time (h/day)		3.9 (4.8)	3.9 (4.4)	3.7 (4.6)	3.3 (4)	2.6 (4.8)	5.3 (5.3)	3.3 (4.7)
Age (years)		62.4 (16.0)	62.6 (16.7)	64.4 (19.9)	61.5 (13.7)	63.0 (18.9)	63.9 (15.4)	61.6 (18.4)
Sex	Female	52.1	50.2	47.6	49.0	53.2	61.1	55.9
Education	≥Secondary	42.6	37.0	24.7	23.9	20.4	92.5	28.6
Marital status	Currently married/cohabiting	75.5	85.0	59.3	76.9	73.0	58.3	55.9
	Never married	1.8	1.1	1.3	0.7	7.0	2.7	14.3
	Separated/divorced/widowed	22.8	13.8	39.4	22.3	20.0	39.0	29.8
Unemployed	Yes	57.3	56.3	30.9	56.8	62.6	59.9	69.9
Urban	Yes	46.2	47.3	41.1	28.9	78.8	72.7	64.9
Obesity	Yes	11.5	5.8	10.0	2.5	28.7	34.5	46.9
No. of chronic diseases		1.4 (2.1)	1.2 (1.9)	1.1 (1.7)	1.2 (1.8)	1.2 (1.9)	1.9 (2)	1.4 (2.1)
Disability	Yes	7.1	1.6	7.8	12.3	9.0	8.0	8.2
Depression	Yes	6.0	1.1	7.2	12.9	10.8	3.5	3.0
Social cohesion index		21.3 (23.3)	17.4 (19.3)	42.8 (37.3)	24.9 (22.2)	16.9 (25.6)	18.6 (17.1)	33.4 (33.1)
Pain	Yes	61.4	48.5	80.0	73.8	54.1	61.8	63.9
Physical activity	High	49.1	43.6	61.5	52.2	40.0	57.4	27.8
	Moderate	22.8	27.5	12.5	22.9	22.4	15.8	12.4
	Low	28.1	28.8	26.0	25.0	37.6	26.8	59.8

Data are percent or mean (standard deviation).
[a] Total number of a maximum of seven chronic physical conditions.
[b] The social cohesion index ranged from 0 to 100 with higher scores representing higher levels of social cohesion.

Table 2 Association between sedentary time and perceived stress estimated by multivariable linear regression

		Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Characteristic	Category	b	95%CI	b	95%CI	b	95%CI	b	95%CI	b	95%CI	b	95%CI
Sedentary time (h/day)	0-<4	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
	4-<8	2.40***	[1.01,3.78]	2.12**	[0.75,3.49]	2.04**	[0.67,3.40]	2.04**	[0.66,3.41]	2.00**	[0.62,3.38]	1.97**	[0.57,3.36]
	8-<11	8.87***	[6.73,11.00]	7.87***	[5.73,10.00]	7.67***	[5.55,9.80]	7.45***	[5.35,9.54]	7.19***	[5.08,9.30]	7.11***	[4.96,9.27]
	≥11	11.34***	[7.55,15.13]	10.45***	[6.77,14.13]	10.16***	[6.59,13.73]	9.58***	[6.09,13.08]	9.15***	[5.60,12.70]	9.02***	[5.45,12.59]
Age (years)		0.15***	[0.08,0.22]	0.10**	[0.03,0.18]	0.11**	[0.03,0.19]	0.10*	[0.02,0.18]	0.08*	[0.00,0.16]	0.08*	[0.00,0.16]

Sex	Female vs. Male	1.35*	[0.17,2.53]	1.37*	[0.06,2.69]	1.28	[-0.01,2.57]	1.02	[-0.36,2.39]	0.62	[-0.81,2.05]	0.64	[-0.79,2.06]
Wealth	Poorest	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
	Poorer	-3.38***	[-5.18,-1.58]	-3.46***	[-5.22,-1.69]	-3.36***	[-5.14,-1.58]	-3.15***	[-4.90,-1.41]	-3.08***	[-4.80,-1.36]	-3.08***	[-4.80,-1.36]
	Middle	-4.51***	[-6.17,-2.85]	-4.84***	[-6.54,-3.14]	-4.67***	[-6.42,-2.92]	-4.35***	[-6.09,-2.61]	-4.32***	[-6.06,-2.58]	-4.31***	[-6.04,-2.57]
	Richer	-7.28***	[-8.98,-5.58]	-7.45***	[-9.18,-5.73]	-7.30***	[-9.02,-5.58]	-6.89***	[-8.65,-5.13]	-6.64***	[-8.43,-4.85]	-6.64***	[-8.43,-4.85]
	Richest	-11.62***	[-13.82,-9.41]	-12.05***	[-14.28,-9.83]	-11.72***	[-13.96,-9.47]	-11.19***	[-13.55,-8.82]	-10.78***	[-13.23,-8.34]	-10.77***	[-13.22,-8.32]
Education	≥ vs. <Secondary	-1.33*	[-2.58,-0.08]	-1.38*	[-2.67,-0.10]	-1.28	[-2.57,0.01]	-0.96	[-2.25,0.34]	-0.67	[-1.96,0.63]	-0.65	[-1.95,0.64]
Marital status	Married/cohabiting	Ref.		Ref.		Ref.		Ref.		Ref.			
	Never married	0.53	[-2.56,3.62]	0.6	[-2.61,3.81]	0.71	[-2.48,3.90]	0.43	[-2.74,3.60]	0.53	[-2.49,3.55]	0.51	[-2.51,3.52]
	Else[a]	1.16	[-0.55,2.86]	1.24	[-0.48,2.95]	1.19	[-0.55,2.92]	1.05	[-0.71,2.81]	1.06	[-0.79,2.91]	1.05	[-0.80,2.91]
Unemployed	Yes vs. No	1.78**	[0.65,2.91]	0.93	[-0.22,2.07]	0.92	[-0.20,2.04]	0.28	[-0.89,1.46]	0.19	[-0.99,1.37]	0.17	[-1.02,1.36]
Setting	Urban vs. Rural	-2.72**	[-4.60,-0.83]	-2.73**	[-4.61,-0.85]	-2.82**	[-4.69,-0.95]	-3.03**	[-4.93,-1.14]	-2.56*	[-4.51,-0.60]	-2.51*	[-4.47,-0.56]
Obesity	Yes vs. No			0.37	[-2.06,2.79]	0.46	[-1.95,2.86]	0.42	[-2.01,2.85]	0.26	[-2.26,2.78]	0.26	[-2.25,2.78]
No. of chronic diseases[b]				1.50***	[0.94,2.05]	1.33***	[0.77,1.88]	1.32***	[0.75,1.89]	0.82**	[0.28,1.35]	0.81**	[0.28,1.35]
Disability	Yes vs. No			6.84***	[4.26,9.42]	6.04***	[3.44,8.65]	5.74***	[3.16,8.31]	5.29***	[2.75,7.83]	5.18***	[2.66,7.70]
Depression	Yes vs. No					7.63***	[3.78,11.48]	7.58***	[3.67,11.49]	6.96***	[3.04,10.87]	6.98***	[3.09,10.87]
Social cohesion index[c]								-0.13***	[-0.19,-0.06]	-0.12***	[-0.18,-0.06]	-0.12***	[-0.18,-0.06]
Pain	Yes vs. No									5.39***	[4.19,6.60]	5.41***	[4.20,6.61]
Physical activity	High											Ref.	
	Moderate											-0.54	[-1.81,0.73]
	Low											0.53	[-0.88,1.94]

Abbreviation: Ref. Reference category; CI Confidence interval
Models are adjusted for all covariates in the respective column and country.
Perceived stress was a scale ranging from 0 to 100 with higher scores representing higher levels of perceived stress.
[a] Separated/divorced/widowed
[b] Total number of a maximum of seven chronic physical conditions.
[c] The social cohesion index ranged from 0 to 100 with higher scores representing higher levels of social cohesion.
* p<0.05, ** p<0.01, *** p<0.001

Table 3 Association between sedentary time and perceived stress estimated by multivariable linear regression by age groups

		Age (50-64 years)		Age (≥65 years)	
		b	95%CI	b	95%CI
Sedentary time (h/day)	0-<4	Ref.		Ref.	
	4-<8	2.33**	[0.73,3.94]	1.40	[-0.53,3.33]
	8-<11	5.25***	[2.50,7.99]	8.55***	[5.74,11.35]
	≥11	7.82**	[2.37,13.28]	8.45***	[4.20,12.71]

Abbreviation: Ref. Reference category; CI Confidence interval
Models are adjusted for age, sex, wealth, education, marital status, unemployment, setting, obesity, number of physical diseases, disability, depression, social cohesion, pain, and physical activity, and country.
Perceived stress was a scale ranging from 0 to 100 with higher scores representing higher levels of perceived stress.
** $p<0.01$, *** $p<0.001$

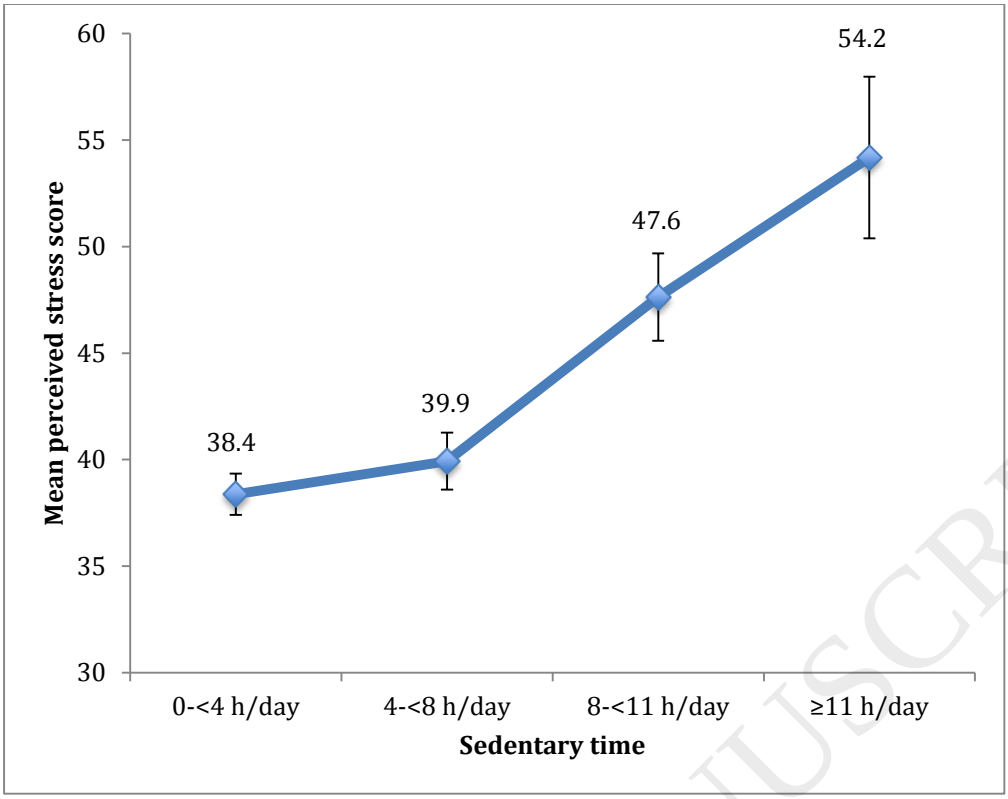

Figure 1 Mean perceived stress score by time spent sedentary
Bars denote 95% confidence intervals.
The perceived stress score ranged from 0 to 100 with higher scores representing higher levels of stress.

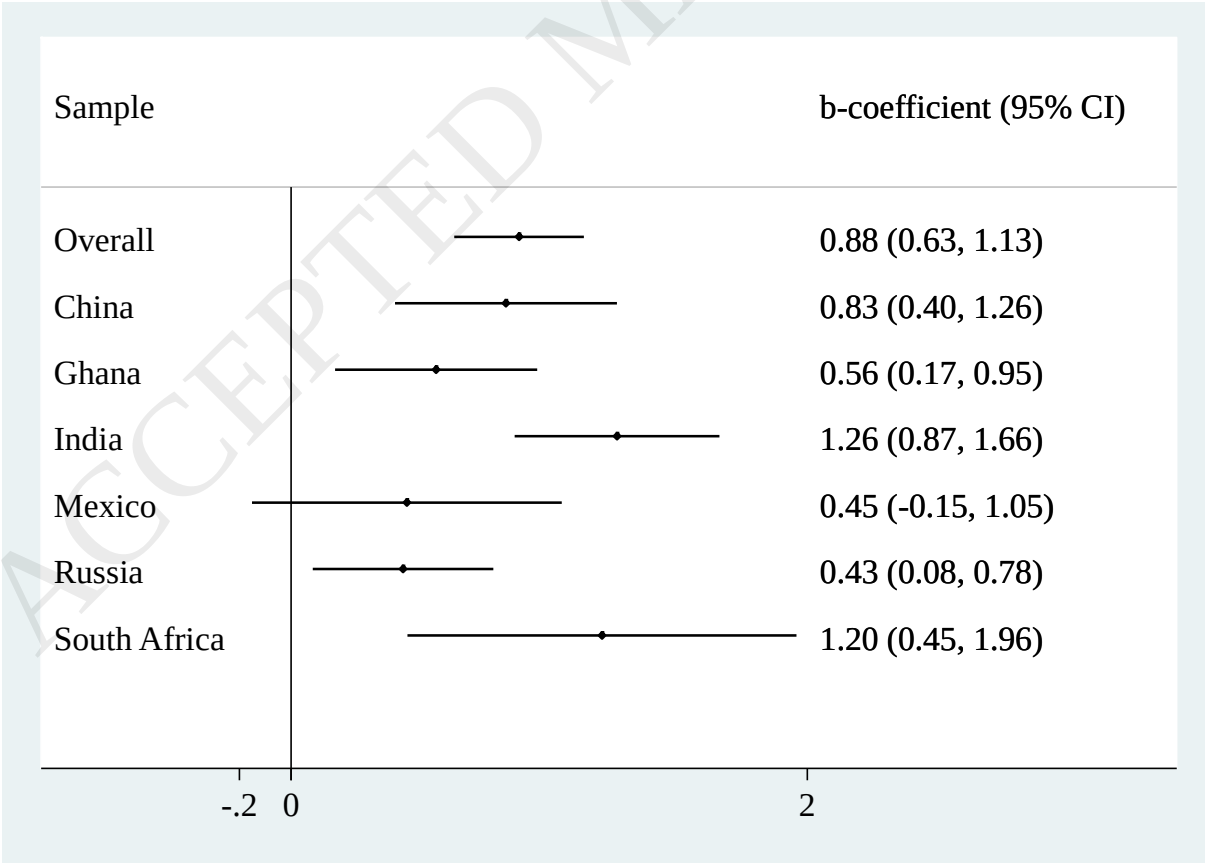

Figure 2 Association between time spent sedentary (hours/day) and perceived stress estimated by multivariable linear regression (overall and by country)
Abbreviation: CI Confidence interval
Models are adjusted for age, sex, wealth, education, marital status, unemployment, setting, obesity, number of physical diseases, disability, depression, social cohesion, pain, and physical activity. Overall model is additionally adjusted for country.
Time spent sedentary (hours/day) was included in the model as a continuous variable.
Perceived stress was a scale ranging from 0 to 100 with higher scores representing higher levels of perceived stress.

Appendix

eTable 1 Details on the diagnosis of chronic conditions

Condition	(a) Self-reported diagnosis	(b) Symptom-based algorithm or other method of diagnosis[a]
Angina	Have you ever been diagnosed with angina or angina pectoris (a heart disease)?	Rose questionnaire[19]
Arthritis	Have you ever been diagnosed with/told you have arthritis (a disease of the joints, or by other names rheumatism or osteoarthritis)?	Affirmative answers to all four of the following: 1. During the last 12 months, have you experienced pain, aching, stiffness or swelling in or around the joints (e.g., in arms, hands, legs or feet) which were not related to an injury and lasted for more than a month? 2. During the last 12 months, have you experienced stiffness in the joint in the morning after getting up from bed, or after a long rest of the joint without movement? 3. Did this stiffness last for less than 30 minutes? 4. Did this stiffness go away after exercise or movement in the joint?
Asthma	Have you ever been diagnosed with asthma (an allergic respiratory disease)?	1. During the last 12 months, have you experienced attacks of wheezing or whistling breathing? (Yes) **AND** 2. "Yes" to at least one of the following (past 12 months): (a) Have you experienced an attack of wheezing that came on after you stopped exercising or some other physical activity? (b) Have you had a feeling of tightness in your chest? (c) Have you woken up with a feeling of tightness in your chest in the morning or any other time? (d) Have you had an attack of shortness of breath that came on without an obvious cause when you were not exercising or doing some physical activity?

Chronic lung disease	Have you ever been diagnosed with chronic lung disease (emphysema, bronchitis, COPD)?	1. During the last 12 months, have you experienced any shortness of breath at rest (while awake)? (Yes) **OR** 2. "Yes" to both of the following (past 12 months): (a) Have you experienced any coughing or wheezing for 10 minutes or more at a time? (b) Have you experienced any coughing up of sputum or phlegm on most days of the month for at least 3 months?
Diabetes	Have you ever been diagnosed with diabetes (high blood sugar)? (not including diabetes associated with a pregnancy)	NA
Hypertension	Have you ever been diagnosed with high blood pressure (hypertension)?	Blood pressure was measured three times with a one-minute interval with the use of a wrist blood pressure monitor (Medistar Wrist Blood Pressure Model S) and the mean value of the three measurements was calculated. Hypertension was defined as having at least one of the following: systolic blood pressure ≥140 mmHg; diastolic blood pressure ≥90 mmHg.
Stroke	Have you ever been told by a health professional that you have had a stroke?	NA

For all chronic conditions, we assumed that the individual had the condition if they fulfilled at least one of the following: (a) affirmative answer to self-reported diagnosis or (b) symptom-based algorithm or other method of diagnosis.
[a] These algorithms have been used in previous publications [2, 3] and those of arthritis, asthma, and chronic lung disease have been validated [2, 4].

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