Heliyon 7 (2021) e08635

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Physical activity, health and well-being among a nationally representative population-based sample of middle-aged and older adults in India, 2017–2018

Supa Pengpid [a,b], Karl Peltzer [c,d,*]

[a] ASEAN Institute for Health Development, Mahidol University, Salaya, Phutthamonthon, Nakhon Pathom, Thailand
[b] Department of Research Administration and Development, University of Limpopo, Turfloop, South Africa
[c] Department of Psychology, University of the Free State, Bloemfontein, South Africa
[d] Department of Psychology, College of Medical and Health Sciences, Asia University, Taichung, Taiwan

ARTICLE INFO

Keywords:
Physical activity
Health
Well-being
Middle-aged
Older adults
India

ABSTRACT

Background: This study aimed to determine the association between physical activity (PA) and health and well-being in middle-aged and older community-dwelling adults in India.
Methods: The cross-sectional sample consisted of 72,262 individuals (≥45 years) from the Longitudinal Ageing Study in India (LASI) Wave 1 in 2017–2018. Logistic regression, adjusted for relevant confounders, was used to predict associations between PA levels and 23 health indicators.
Results: In all 23.8% of participants were inactive, 12.9% had low, 7.6% moderate, and 55.7% high PA. In the final adjusted logistic regression analyses, higher PA levels were associated with better mental health (less insomnia symptoms, less depressive symptoms, less loneliness, and better cognitive functioning), and better well-being (self-rated health status, life satisfaction, happiness, functional ability, and hand grip strength). Moreover, moderate and/or high PA were negatively associated with diabetes, heart disease, stroke, hypertension, chronic lung disease, vision impairment, cataract, chronic renal failure, and Alzheimer's disease/dementia. While in unadjusted analysis, moderate and/or high PA were protective against major depressive disorder and bone or joint diseases, this became non-significant in the adjusted model. PA was not significantly associated with abdominal obesity and cancer.
Conclusion: Overall, higher PA levels were positively associated with 10 of 11 mental health and well-being indicators as well as being protective against 9 of 12 chronic conditions.

1. Introduction

The World Health Organization (WHO) [1] defines "physical activity (PA) as any bodily movement (including during leisure time, for transport to get to and from places, or as part of a person's work) produced by skeletal muscles that requires energy expenditure." Regular PA (both moderate- and vigorous-intensity) "is proven to help prevent and manage noncommunicable diseases such as heart disease, stroke, diabetes and several cancers. It also helps prevent hypertension, maintain healthy body weight, and can improve mental health, quality of life and well--being" [1].

Regarding mental health and well-being, studies show that PA reduces fair or poor health [2], poor mental health [1, 3], depression [4, 5, 6, 7, 8, 9, 10], loneliness [11, 12], anxiety [13], and increases life satisfaction and happiness [14], cognitive function [15, 16], and functional ability [17]. In addition, some studies and a review [5, 18, 19, 20, 21] showed that PA or exercise improves sleep quality, including among middle-aged and older adults.

PA may be protective against several chronic diseases, including metabolic syndrome [7], type 2 diabetes [1, 2, 4, 7, 10], cardiovascular disease [1], coronary artery disease [7], heart disease [1, 2, 4, 10], stroke [1, 6], hypertension [1, 2, 7, 10], dyslipidaemia [7], obesity [1, 10], arthritis [2, 6, 7, 22], osteoporosis [1, 7, 10], less musculoskeletal problems [23], several cancers [1, 10], colon cancer [7], breast cancer [7], lung disease, COPD [4], asthma [2], non-alcoholic fatty liver disease [7], sarcopenia [7] cognitive impairment [7], dementia [4] renal disease [4], and multi-morbidity [24]. In addition, some studies found an association between sedentary behaviour or physical inactivity and visual

* Corresponding author.
E-mail address: kfpeltzer@gmail.com (K. Peltzer).

https://doi.org/10.1016/j.heliyon.2021.e08635
Received 7 June 2021; Received in revised form 3 November 2021; Accepted 15 December 2021

impairment, and hearing problems [25, 26], and some previous research [27, 28, 29] showed an association between low PA, and higher cataract prevalence, and sub-optimal ART adherence [30].

Studies on associations between PA and health and well-being among middle-aged and older adults have largely been researched in high-income countries [5]. Taking into account that physical activity patterns and socioeconomic contexts are different in low- and middle-income countries, such as in India, an understanding of the associations of PA with health outcomes and well-being among middle-aged and older adults in India is important. Therefore, this study aimed to determine the association between PA and health and well-being in middle-aged and older community-dwelling adults in India in 2017–2018.

2. Method

2.1. Sample and procedures

This secondary data analysis utilized data from the "cross-sectional and nationally representative Longitudinal Ageing Study in India (LASI) Wave 1, 2017–2018"; "the overall household response rate was 96%, and the overall individual response rate was 87%" [31]. In a household survey, "interview, physical measurement and biomarker data were collected from individuals aged 45 years and above and their spouses, regardless of age, from 35 states and union territories of India (excluding Sikkim)" [31]. "India is a union comprising 30 states and 6 union territories. Within each state, LASI Wave 1 adopted a three-stage sampling design in rural areas and a four-stage sampling design in urban areas. In each state/union territories, the first stage involved the selection of Primary Sampling Units (PSUs), that is, subdistricts (Tehsils/Talukas), and the second stage involved the selection of villages in rural areas and wards in urban areas in the selected PSUs." [31] "In rural areas, households were selected from selected villages in the third stage. However, sampling in urban areas involved an additional stage. Specifically, in the third stage, one Census Enumeration Block (CEB) was randomly selected in each in urban area. In the fourth stage, households were selected from this CEB." [31] The study was approved by the "Indian Council of Medical Research (ICMR) Ethics Committee and written informed consent was obtained from the participants" [31].

2.2. Measures

2.2.1. Health indicator outcome variables

Self-rated health status was sourced from the question, "In general, would you say your health is excellent, very good, good, fair, or poor?" Responses were coded as "1 = poor, 2 = fair, 3 = good, 4 = very good and 5 = excellent" [31].

Life satisfaction was measured with the question, "Please think about your life as a whole. How satisfied are you with it? Are you completely satisfied, very satisfied, somewhat satisfied, not very satisfied, or not at all satisfied?" [31].

Happiness was assessed with the question, "During the past week, how often did you feel happy?" Response options included "1 = rarely or never (<1 day), 2 = sometimes (1 or 2 days), 3 = often (3 or 4 days), and 4 = most or all of the time (5–7 days) in a week prior to the interview." [31].

Cognitive functioning was assessed with tests for immediate and delayed word recall, serial 7s, and orientation based on the Mini-Mental State Exam, totalling 0–32 scores [32].

Hand grip strength (HGS) was assessed with a "Baseline Smedley Spring type dynamometer" on "each hand twice, beginning with the dominant hand, alternating hands in between measurements" [31]. A "mean HGS (kg) variable was calculated from all four measurements" [33].

Functional disability was measured based on "Activities of Daily Living (ADL) (6 items) and Instrumental Activities of Daily Living (IADL) (7 items)" [34, 35]; (Cronbach alpha 0.89). Response options were "Yes = 1/No = 0"; all responses from the 13 items were summed to scores 0–13. Total scores were dichotomized into ≥2 ADL/IADL scores = 1 and 0–1 = 0.

Insomnia symptoms were assessed with four questions: 1) "How often do you have trouble falling asleep?" 2) "How often do you have trouble with waking up during the night?" 3) "How often do you have trouble with waking up too early and not being able to fall asleep again?" 4) "How often did you feel unrested during the day, no matter how many hours of sleep you had?" Responses options were "never, rarely (1–2 nights per week), occasionally (3–4 nights per week), and frequently (5 or more nights per week)" [36]. Insomnia problems were coded as "frequently" for the any of the four symptoms as one [37].

Major depressive disorder (MDD) in the past 12 months was assessed with the Health and Retirement Study (HRS) Composite International Diagnostic Interview short form (CIDI-SF) [38]. Study respondents were required to "endorse either anhedonia or depressed mood for most of the day for most of a 2-week period or more," and those who fulfilled this criterion "completed an additional seven symptoms: lost interest, feeling tired, change in weight, trouble with sleep, trouble concentrating, feeling down, and thoughts of death." [39]. "Those with a score ≥3 was considered to meet the criteria for having MDD in the previous 12 months; MDD symptomology scores ranged from 0 to 7." [39].

Depressive symptoms were sourced from a modified Centre for Epidemiological Studies Depression Scale (CES-D-10) [40]. The 10 items "included seven negative symptoms (trouble concentrating, feeling depressed, low energy, fear of something, feeling alone, bothered by things, and everything is an effort), and three positive symptoms (feeling happy, hopeful, and satisfied)." Scores of four or more of 10 symptoms were classified as depressive symptoms [41] (Cronbach α was 0.79 in this study).

The loneliness item asked for "How often did you feel alone in the past week?" Response options were "1) Rarely or never (less than 1 day), 2) Sometimes (1 or 2 days), 3) Often (3 or 4 days) and 4) most or all of the time (5–7 days)" Items 1 and 2 were scored "0", and items 3 and 4 were scored "1." [40].

Waist Circumference was measured with a soft measuring tape (Gulik Tape) to the nearest 0.1 cm [35]. Central or abdominal obesity was defined using South Asian criteria for men ≥90 cm and for women ≥80 cm [42].

Hypertension or raised blood pressure (BP) was defined as "systolic BP ≥ 140 mm Hg and/or diastolic BP ≥ 90 mm Hg (based on the last two averaged of three BP readings) or where the participant is currently on antihypertensive medication." [43].

Other chronic conditions were assessed with the following items, "Has any health professional ever told you that you have…?": "1) diabetes or high blood sugar; 2) cancer or malignant tumor; 3) chronic lung disease such as asthma, chronic obstructive pulmonary disease/chronic bronchitis or other chronic lung problems; 4) chronic heart diseases such as coronary heart disease (heart attack or myocardial infarction), congestive heart failure, or other chronic heart problems; 5) Stroke; 6) arthritis or rheumatism, osteoporosis or other bone/joint diseases; " 7) cataract, 8) chronic renal failure, and 9) Alzheimer's disease, dementia (Yes, No) [31].

Vision. Visual acuity was measured for both far and near vision of each eye using a tumbling "E" log MAR chart [44] and classified into "low vision (0.01–0.25 decimal) and normal vision (0.32–1.6 decimal)" [45]. Impaired vision was defined as low vision if he or she had either low near or far vision in both eyes.

2.2.2. Exposure variable

Physical activity was assessed with the questions 1) "How often do you take part in sports or vigorous activities, such as running or jogging, swimming, going to a health center or gym, cycling, or digging with a spade or shovel, heavy lifting, chopping, farm work, fast bicycling, cycling with loads: everyday, more than once a week, once a week, one to

three times a month, or hardly ever or never?" 2) "On the days you did vigorous activity, how much time did you usually spend doing any vigorous activity? (__minutes)", 3) "How often do you take part in sports or activities that are moderately energetic such as cleaning house, washing clothes by hand, fetching water or wood, drawing water from a well, gardening, bicycling at a regular pace, walking at a moderate pace, dancing, floor or stretching exercises (everyday, more than once a week, once a week, one to three times a month, hardly ever, or never)?" and 4) "How much time did you usually spend doing any moderate activity on an average in a day?" [31].

The participants were classified into 4 levels of PA according to their waking duration throughout the week: a) inactive PA (0 min/week), b) low- PA (1 to <150 min/week moderate intensity or "1–74 min/wk vigorous intensity or 1–149 min/wk moderate + vigorous intensity; whereby time in vigorous activity is doubled"), c) moderate PA (150–300 min/week moderate intensity or 75–149 min/wk vigorous intensity or "150–300 min/wk moderate + vigorous intensity; whereby time in vigorous activity is doubled"), and high PA (>300 min/week moderate PA or ">150 min/wk vigorous intensity or >300 min/wk moderate + vigorous intensity; whereby time in vigorous activity is doubled") [46, 47].

2.2.3. Covariates and confounders

Sociodemographic variables included age group (45–59, 60 or more years), sex (male, female), level of education (none, ≥1 years), residential and marital status (married or not married). Subjective socioeconomic status was assessed with the question, "Please imagine a ten-step ladder, where at the bottom are the people who are the worst off – who have the least money, least education, and the worst jobs or no jobs, and at the top of the ladder are the people who are the best off – those who have the most money, most education, and best jobs. Please indicate the number (1–10) on the rung on the ladder where you would place yourself." [31]. Steps 1 to 3 on the socioeconomic ladder were defined as low, 4–5 as medium, and 6–10 as high socioeconomic status.

Food insecurity was assessed with four questions, 1) "In the last 12 months, did you ever reduce the size of your meals or skip meals because there was not enough food at your household? (Yes/No) 2) In the last 12 months, were you hungry but didn't eat because there was not enough food at your household? (Yes/No) 3) In the past 12 months, did you ever not eat for a whole day because there was not enough food at your household? 4) Do you think that you have lost weight in the last 12 months because there was not enough food in your household?" [31]. Any positive response to the four questions was scored as one.

Current tobacco use was assessed from 1) "Do you currently smoke any tobacco products (cigarettes, bidis, cigars, hookah, cheroot, etc.)? and 2) Do you use smokeless tobacco (such as chewing tobacco, gutka, pan masala, etc.)?" (Yes, No) [31].

Heavy episodic alcohol use was assessed with the question, "In the last 3 months, how frequently on average, have you had at least 5 or more drinks on one occasion?" [31] and defined as "one to three days per month, one to four days per week, five or more days per week, or daily."

Anthropometry: "Height and weight of adults were measured using the Seca 803 digital scale." [31]. "Body Mass Index = BMI was calculated according to Asian criteria: underweight (<18.5 kg/m^2), normal weight (18.5–22.9 kg/m^2), overweight (23.0–24.9 kg/m^2), class I obesity (25.0–29.9 kg/m^2), and class II obesity (≥30.0 kg/m^2)" [48].

2.3. Data analysis

Descriptive statistics were applied to describe sociodemographic information and health indicators. Logistic regression was utilized to assess the predictors between PA level and various health indicator outcomes. Multivariable logistic regression models were adjusted by age group, education, marital status, subjective socioeconomic status, place of residence, food insecurity, tobacco use status, alcohol use, and body mass index. Confounders were selected based on previous literature review [4, 6, 11, 20]. $P < 0.05$ was considered as significant, only complete cases were included, and no multi-collinearity was identified. Statistical analyses were done with STATA software version 15.0 (Stata Corporation, College Station, TX, USA), considering the complex study design.

3. Results

3.1. Sample characteristics

The sample included 72,262 middle-aged and older adults (45 years and older), 58.0% were female and 42.0% male. Majority (68.2%) of the participants were rural dwellers, 49.5% had no schooling, 75.6% were married, 9.7% had food insecurity, and 37.2% had low subjective socioeconomic status. Almost one in three participants (30.4%) were current tobacco users, 2.9% were heavy episodic drinkers, 20.8% were underweight, and 42.5% had overweight or obesity. Almost one in four middle-age and older adults (23.8%) were inactive, 12.9% had low, 7.6% moderate, and 55.7% high PA. Details of the prevalence of each assessed health indicator are provided in Table 1 (see Table 1).

3.2. Associations between physical activity levels with health indicators

In the final adjusted logistic regression analyses, higher PA levels were associated with better mental health (less insomnia symptoms, less depressive symptoms, less loneliness, and better cognitive functioning), and better well-being (self-rated health status, life satisfaction, happiness, functional ability, and hand grip strength). Moreover, moderate and/or high PA were negatively associated with diabetes, heart disease, stroke, hypertension, chronic lung disease, vision impairment, cataract, chronic renal failure, and Alzheimer's disease/dementia. While in the unadjusted analysis, moderate and/or high PA were protective against major depressive disorder and bone or joint diseases, this became non-significant in the adjusted model. PA was not significantly associated with abdominal obesity and cancer (see Table 2).

4. Discussion

To our knowledge, this study is the first to assess associations between PA levels with a wide range of health indicators in middle-aged and older adults in India in 2017–2018. The study found that higher PA levels were associated with better health status and well-being (life satisfaction, self-rated health status, happiness, cognitive functioning, hand grip strength, and functional ability), better mental health (less insomnia symptoms, less depressive symptoms, and less loneliness), and less chronic conditions (diabetes, chronic lung disease, heart disease, hypertension, stroke, impaired vision, cataract, chronic renal failure, and Alzheimer's disease/dementia). For some health indicators (self-rated health status, functional ability, loneliness, diabetes, hypertension), only high PA was found beneficial. For other health indicators (insomnia symptoms, depressive symptoms, and chronic renal failure), both moderate and high PA were beneficial, while for a number of health indicators (life satisfaction, happiness, cognitive functioning, hand grip strength, stroke, chronic lung disease, impaired vision, cataract, and Alzheimer's disease/dementia) compared to being physically inactive, low, moderate and/or high PA were beneficial. These results may confirm a possible dose-response relationship with various health outcomes [4]. Differences in the associations between different levels of PA and health indicators have been observed in previous research [6], e.g., only moderate PA was negatively associated with stroke, only vigorous PA was negatively associated with COPD, and both moderate and vigorous PA were decreased the odds of depression. While in a study among older adults in Pakistan, those who were physically active for more than 310 min/week had a protective effect against depression, and those who were 120–310 min/week physically active did not have protection against depression [8]. The study was conducted during pre-COVID-19, and studies conducted in the Southeast Asia region during the COVID-19 pandemic may

have lower levels of PA and higher levels of mental and physical symptoms [49]. During the COVID-19 pandemic PA may be vital in improving physical health and then mental health [50].

The association between higher levels of PA and higher life satisfaction, happiness, cognitive functioning, grip strength, functional ability and better self-rated health status, found in this study is in agreement with most previous studies [2, 14, 15, 16, 17]. Some of these findings in terms of physical functioning [51] and cognitive functioning [52] have been confirmed in longitudinal studies, and in a systematic review, "higher PA measures were associated with better upper body muscle strength (hand grip strength)" [53]. The positive effects of PA on subjective well-being may be explained by improvements in physical health in terms of functional and cardiovascular capacity and by improvements in mental health indicators [14].

Regarding mental health, consistent with previous studies [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 18, 19, 20], this study showed that PA reduces the odds of depressive symptoms, loneliness and insomnia symptoms. PA has shown to increase muscle strength and aerobic capacity, and consequently increase physical wellbeing [53]. It is possible that the association between PA and sleep is modified by neurobiological mechanisms, e.g., by altering melatonin levels [20, 54]. A systematic review of PA intervention studies found a reduction of loneliness; however, few studies found that potential mediators need to be considered in this relationship [55]. Some research [56] proposed bi-directionality

Table 1. Sample characteristics by physical activity levels among middle-aged and older adults in India, 2017–2018 (N = 72,262).

Variable	Variable specification	Total	Physical activity level			
			Inactive	Low	Moderate	High
Control factors						
All			23.8	12.9	7.6	55.7
Age in years	45–59	54.1	15.7	11.6	7.0	65.7
	60 or more	45.9	33.3	14.4	8.4	43.9
Sex	Female	58.0	21.2	11.1	7.1	60.5
	Male	42.0	27.3	15.3	8.4	49.0
Education	≥1 year	50.5	21.6	13.4	8.1	57.0
	No schooling	49.5	26.0	12.4	7.2	54.4
Subjective socioeconomic status	Low	37.2	21.9	12.1	6.8	59.2
	Medium	38.7	23.6	13.1	7.8	55.9
	High	24.1	24.5	14.4	9.1	52.1
Food insecurity	Yes	9.7	28.7	13.4	7.6	50.3
Marital status	Not married	24.4	32.6	13.0	7.6	46.8
	Married	75.6	20.9	12.9	7.6	58.6
Residential status	Rural	68.2	23.5	13.0	7.5	56.1
	Urban	31.8	24.4	12.7	8.0	54.9
Current tobacco use	Yes	30.4	21.7	13.2	7.5	57.6
Heavy episodic alcohol use	Yes	2.9	22.2	16.7	7.1	54.0
Body mass index	Normal	36.7	22.0	12.8	7.4	57.7
	Under	20.8	25.9	13.0	7.2	53.9
	Overweight/Obesity	42.5	21.6	13.3	8.4	56.6
Health indicators						
Self-rated health status	Scale (1–5)	2.77 (1.0)	2.60 (1.1)	2.69 (1.0)	2.76 (1.0)	2.86 (1.0)
Life satisfaction	Scale (1–5)	3.49 (0.9)	3.44 (1.0)	3.46 (0.9)	3.54 (0.9)	3.52 (0.9)
Happiness	Scale (1–4)	2.48 (1.0)	2.32 (1.0)	2.44 (1.0)	2.54 (1.0)	2.55 (1.0)
Cognitive functioning	Scale (0–32)	18.7 (5.1)	17.6 (5.2)	18.6 (4.9)	19.2 (4.9)	19.0 (5.1)
Grip strength-male	Scale	25.9 (7.4)	23.5 (7.6)	25.8 (7.6)	26.1 (7.3)	27.1 (7.0)
Grip strength-female	Scale	17.3 (5.2)	15.9 (5.5)	16.9 (5.0)	16.7 (5.2)	17.9 (5.0)
Functional disability (2 or more)	Yes	28.8	32.6	13.5	7.7	46.2
Insomnia symptoms	Yes	12.7	30.1	14.2	6.9	48.8
Major depressive disorder	Yes	7.6	26.7	14.1	6.5	52.7
Depressive symptoms	Yes	27.6	27.4	13.5	7.5	51.6
Loneliness	Yes	13.3	28.7	14.0	7.9	49.4
Abdominal obesity	Men ≥90 cm, women ≥80 cm	49.8	22.5	13.3	8.2	56.0
Diabetes	Yes	11.6	28.2	13.9	8.5	49.4
Hypertension	Yes	40.4	26.5	13.6	8.5	51.4
Heart disease	Yes	3.6	31.9	14.4	7.3	46.4
Stroke	Yes	1.8	51.8	12.4	5.8	30.0
Cancer	Yes	0.6	27.9	13.9	5.5	52.7
Chronic lung disease	Yes	6.3	32.7	12.0	7.8	47.5
Bone or joint disease	Yes	15.7	26.9	13.5	8.0	51.6
Vision impaired	Yes	34.0	27.8	13.8	8.4	50.0
Cataract	Yes	13.1	33.9	13.5	8.8	43.7
Chronic renal failure	Yes	0.6	35.7	16.4	4.9	43.0
Alzheimer's disease/dementia	Yes	0.7	45.7	9.8	5.7	38.8

Table 2. Associations between physical activity level and health status and health indicators.

Outcome variables		Physical activity level	Model 1: unadjusted odds ratio or exp (Coef.) (95% CI)	Model 2: adjusted odds ratio or exp (Coef.) (95% CI)[a]
Self-rated health status	Scale	Inactive	1 Reference	1 Reference
		Low	1.09 (1.04, 1.14)***	1.01 (0.96, 1.05)
		Moderate	1.18 (1.08, 1.29)***	1.07 (1.00, 1.14)
		High	1.30 (1.24, 1.36)***	1.16 (1.12, 1.21)***
Life satisfaction	Scale	Inactive	1 Reference	1 Reference
		Low	1.02 (0.97, 1.07)	0.99 (0.95, 1.03)
		Moderate	1.11 (1.04, 1.18)***	1.05 (1.01, 1.11)*
		High	1.07 (1.03, 1.11)***	1.06 (1.03, 1.10)***
Happiness	Scale	Inactive	1 Reference	1 Reference
		Low	1.13 (1.07, 1.19)***	1.10 (1.05, 1.15)***
		Moderate	1.25 (1.15, 1.35)***	1.21 (1.12, 1.31)***
		High	1.26 (1.21, 1.31)***	1.26 (1.21, 1.32)***
Cognitive functioning	Scale	Inactive	1 Reference	1 Reference
		Low	2.62 (2.04, 3.38)***	1.53 (1.21, 1.93)***
		Moderate	4.92 (3.48, 6.93)***	2.56 (2.01, 3.27)***
		High	4.02 (3.05, 5.30)***	2.27 (1.93, 2.66)***
Grip strength-male	Scale	Inactive	1 Reference	1 Reference
		Low	9.70 (6.09, 15.45)***	3.09 (2.10, 4.53)***
		Moderate	12.34 (6.93, 22.01)***	2.73 (1.50, 4.99)***
		High	35.30 (25.02, 49.8)***	6.87 (5.02, 9.40)***
Grip strength-female	Scale	Inactive	1 Reference	1 Reference
		Low	3.00 (2.13, 4.22)***	1.53 (1.14, 2.07)**
		Moderate	2.38 (1.30, 4.33)**	1.27 (0.74, 2.20)
		High	8.13 (6.06, 10.89)***	2.11 (1.63, 2.73)***
Functional disability (2 or more)	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.66 (0.59, 0.73)***	0.90 (0.80, 1.02)
		Moderate	0.63 (0.55, 0.72)***	0.85 (0.71, 1.02)
		High	0.48 (0.44, 0.52)***	0.71 (0.63, 0.78)***
Insomnia symptoms	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.85 (0.74, 0.96)**	0.91 (0.79, 1.03)
		Moderate	0.67 (0.57, 0.78)***	0.73 (0.63, 0.86)***
		High	0.65 (0.59, 0.73)***	0.74 (0.66, 0.82)***
Major depressive disorder	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.96 (0.80, 1.14)	1.11 (0.93, 1.33)
		Moderate	0.75 (0.61, 0.93)**	0.86 (0.70, 1.06)
		High	0.82 (0.69, 0.98)*	0.91 (0.77, 1.07)
Depressive symptoms	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.83 (0.76, 0.91)***	0.91 (0.83, 1.00)
		Moderate	0.76 (0.68, 0.85)***	0.81 (0.71, 0.93)**
		High	0.70 (0.65, 0.76)***	0.74 (0.68, 0.81)***
Loneliness	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.85 (0.76, 0.97)*	0.94 (0.83, 1.07)
		Moderate	0.80 (0.67, 0.96)*	0.84 (0.67, 1.05)
		High	0.67 (0.57, 0.79)***	0.75 (0.64, 0.87)***
Abdominal obesity	No	Inactive	1 Reference	—
	Yes	Low	1.04 (0.95, 1.14)	
		Moderate	1.13 (0.99, 1.29)	
		High	0.99 (0.91, 1.08)	
Diabetes	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.90 (0.78, 1.03)	0.98 (0.85, 1.13)
		Moderate	0.93 (0.79, 1.09)	0.87 (0.69, 1.09)
		High	0.72 (0.60, 0.85)***	0.85 (0.74, 0.98)*
Hypertension	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.85 (0.77, 0.93)***	0.92 (0.84, 1.02)
		Moderate	0.91 (0.81, 1.02)	0.96 (0.86, 1.07)
		High	0.68 (0.61, 0.75)***	0.85 (0.77, 0.93)***

(*continued on next page*)

Table 2 (*continued*)

Outcome variables		Physical activity level	Model 1: unadjusted odds ratio or exp (Coef.) (95% CI)	Model 2: adjusted odds ratio or exp (Coef.) (95% CI)[a]
Heart disease	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.83 (0.68, 1.00)	0.88 (0.71, 1.10)
		Moderate	0.71 (0.54, 0.92)**	0.73 (0.55, 0.98)*
		High	0.61 (0.48, 0.78)***	0.81 (0.60, 1.07)
Stroke	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.43 (0.33, 0.57)***	0.63 (0.47, 0.85)**
		Moderate	0.34 (0.24, 0.49)***	0.51 (0.35, 0.75)***
		High	0.24 (0.19, 0.30)***	0.46 (0.36, 0.58)***
Cancer	No	Inactive	1 Reference	—
	Yes	Low	0.92 (0.59, 1.43)	
		Moderate	0.62 (0.36, 1.05)	
		High	0.81 (0.54, 1.20)	
Chronic lung disease	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.66 (0.55, 0.78)***	0.81 (0.69, 0.95)*
		Moderate	0.72 (0.58, 0.89)**	0.88 (0.71, 1.09)
		High	0.60 (0.47, 0.76)***	0.77 (0.63, 0.93)**
Bone or joint disease	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.91 (0.80, 1.03)	1.02 (0.90, 1.15)
		Moderate	0.91 (0.77, 1.07)	1.02 (0.86, 1.21)
		High	0.79 (0.68, 0.91)***	0.92 (0.80, 1.05)
Vision impaired	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.72 (0.66, 0.79)***	0.80 (0.72, 0.89)***
		Moderate	0.76 (0.67, 0.86)***	0.88 (0.77, 0.99)*
		High	0.56 (0.51, 0.61)***	0.65 (0.59, 0.72)***
Cataract	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.69 (0.62, 0.78)***	0.84 (0.74, 0.96)**
		Moderate	0.78 (0.64, 0.94)*	0.89 (0.75, 1.07)
		High	0.50 (0.45, 0.56)***	0.78 (0.69, 0.89)***
Chronic renal failure	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.84 (0.57, 1.25)	0.85 (0.55, 1.29)
		Moderate	0.43 (0.23, 0.79)**	0.48 (0.25, 0.92)*
		High	0.51 (0.37, 0.70***	0.62 (0.44, 0.89)**
Alzheimer's disease/dementia	No	Inactive	1 Reference	1 Reference
	Yes	Low	0.39 (0.25, 0.63)***	0.51 (0.30, 0.89)*
		Moderate	0.38 (0.21, 0.69)***	0.51 (0.27, 0.97)*
		High	0.36 (0.24, 0.55)***	0.48 (0.30, 0.78)**

CI = Confidence Interval; ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; exp(Coef) = exponentiated coefficient.

[a] Adjusted for age group, education, marital status, subjective socioeconomic status, place of residence, food insecurity, tobacco use status, alcohol use, and body mass index.

between PA and mental health. For example, in the UK Whitehall II cohort study, PA increased the odds of mental health and vice versa [57].

In line with several previous investigations [1, 2, 4, 7, 10, 25, 27, 28, 29], we found that PA decreased the odds of diabetes, heart disease, stroke, hypertension, chronic lung disease, impaired vision, cataract, chronic renal failure, and Alzheimer's disease/dementia. Regarding diabetes, PA may increase insulin sensitivity in trained muscles inducing glucose uptake [58]. The impact of PA on hypertension and cardiovascular disease may be multifactorial, including vascular, neuro-hormonal, and structural adaptations [58]. In persons with chronic lung disease PA does not improve lung function but increases cardiorespiratory fitness through effects on muscles and the heart [58]. For the ageing person PA may act as an adjunct to the treatment of mental and cognitive disorders by assisting to delay neurogenerative processes through mechanisms of cerebral blood flow alteration and neurotransmitter release [59]. Furthermore, regular PA may contribute to preventing age-related cataracts by keeping low levels of systemic oxidative stress [29]. Older adults may have more restricted patterns of PA because of visual impairment, which points to the need of longitudinal research on the impact of visual impairment in PA decline [59].

In unadjusted analysis we found a negative association between high PA and bone or joint disease, which is in agreement with previous findings [1, 2, 6, 7, 10, 22, 23]. It is possible, however, that lower PA among individuals with bone or joint disease was mediated by pain, mobility problems, and poor mental health [25]. Unlike some previous research [1, 7, 10] that found an association between PA and less cancer and less obesity, we did not find any significant association in this regard. Possible reasons for this could be the low overall prevalence of cancer (0.6%) and high prevalence of abdominal obesity (49.8%).

Study limitations include the self-report of most data collected and the cross-sectional study design. A subjective bias may be less pronounced for health care provider diagnosed chronic diseases than for self-reported health. However, we for example, compared self-reported diagnosed hypertension with measured hypertension, and found the same protective effects of PA (analysis not shown). Some specific study variables, such as dietary pattern, were not assessed and should be included in future studies. Furthermore, the study focused on older adults living in the community and excluded institutionalized persons.

5. Conclusion

The study found in a nationally representative sample of middle-age and older adults in India, higher PA levels were associated with better health status and well-being (self-rated health status, life satisfaction, happiness, cognitive functioning, hand grip strength, and functional ability), better mental health (less insomnia symptoms, less depressive symptoms, and less loneliness), and less chronic conditions (diabetes, heart disease, stroke, hypertension, chronic lung disease, impaired vision, cataract, chronic renal failure, and Alzheimer's disease/dementia). Overall, higher PA levels were positively associated with 10 of 11 mental health and well-being indicators as well as being protective against 9 of 12 chronic conditions. The current study may provide a better understanding on potential benefits of PA on a wide range of health indicators among middle-aged and older adults in India, which may help in targeting PA promotion and improve health care delivery.

Declarations

Author contribution statement

Supa Pengpid and Karl Peltzer: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Funding statement

This work was supported by Ministry of Health and Family Welfare, Government of India, the National Institute on Aging and the United Nations Population Fund, India (R01 AG042778, R01 AG030153).

Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

References

[1] World Health Organization (WHO), Physical Activity Fact Sheet, 2020. URL: https://www.who.int/news-room/fact-sheets/detail/physical-activity#:~:text=Regular%20physical%20activity%20is%20proven,of%20life%20and%20well%2Dbeing.
[2] B.R. Humphreys, L. McLeod, J.E. Ruseski, Physical activity and health outcomes: evidence from Canada, Health Econ. 23 (1) (2014 Jan) 33–54.
[3] L. Maynou, H.M. Hernández-Pizarro, M. Errea Rodríguez, The association of physical (in)Activity with mental health. Differences between elder and younger populations: a systematic literature review, Int. J. Environ. Res. Publ. Health 18 (9) (2021 Apr 29) 4771.
[4] S. Musich, S.S. Wang, K. Hawkins, C. Greame, The frequency and health benefits of physical activity for older adults, Popul. Health Manag. 20 (3) (2017 Jun) 199–207.
[5] S. Kadariya, R. Gautam, A.R. Aro, Physical activity, mental health, and wellbeing among older adults in South and Southeast Asia: a scoping review, BioMed Res. Int. 2019 (2019 Nov 17) 6752182.
[6] S. Patel, F. Ram, S.K. Patel, K. Kumar, Association of behavioral risk factors with self-reported and symptom or measured chronic diseases among adult population (18-69years)in India :evidence from SAGE study, BMC Publ. Health 19 (1) (2019 May 14) 560.
[7] F.W. Booth, C.K. Roberts, M.J. Laye, Lack of exercise is a major cause of chronic diseases, Compr. Physiol. 2 (2) (2012 Apr) 1143–1211.
[8] M.A. Bhamani, M.M. Khan, M.S. Karim, M.U. Mir, Depression and its association with functional status and physical activity in the elderly in Karachi, Pakistan, Asian J Psychiatr 14 (2015 Apr) 46–51.
[9] F.B. Schuch, D. Vancampfort, J. Firth, S. Rosenbaum, P.B. Ward, E.S. Silva, et al., Physical activity and incident depression: a meta-analysis of prospective cohort studies, Am. J. Psychiatr. 175 (7) (2018 Jul 1) 631–648.
[10] D.E. Warburton, C.W. Nicol, S.S. Bredin, Health benefits of physical activity: the evidence, CMAJ (Can. Med. Assoc. J.) 174 (6) (2006 Mar 14) 801–809.
[11] D. Vancampfort, E. Lara, L. Smith, S. Rosenbaum, J. Firth, B. Stubbs, et al., Physical activity and loneliness among adults aged 50 years or older in six low- and middle-income countries, Int. J. Geriatr. Psychiatr. 34 (12) (2019) 1855–1864.
[12] R.M. Gyasi, D.R. Phillips, F. Asante, S. Boateng, Physical activity and predictors of loneliness in community-dwelling older adults: the role of social connectedness, Geriatr. Nurs. 42 (2) (2021) 592–598.
[13] F.B. Schuch, B. Stubbs, J. Meyer, A. Heissel, P. Zech, D. Vancampfort, et al., Physical activity protects from incident anxiety: a meta-analysis of prospective cohort studies, Depress. Anxiety 36 (9) (2019) 846–858.
[14] H.Y. An, W. Chen, C.W. Wang, H.F. Yang, W.T. Huang, S.Y. Fan, The relationships between physical activity and life satisfaction and happiness among young, middle-aged, and older adults, Int. J. Environ. Res. Publ. Health 17 (13) (2020) 4817.
[15] P. de Souto Barreto, J. Delrieu, S. Andrieu, B. Vellas, Y. Rolland, Physical activity and cognitive function in middle-aged and older adults: an analysis of 104,909 people from 20 countries, Mayo Clin. Proc. 91 (11) (2016) 1515–1524.
[16] Z. Huang, Y. Guo, Y. Ruan, S. Sun, T. Lin, J. Ye, et al., Associations of lifestyle factors with cognition in community-dwelling adults aged 50 and older: a longitudinal cohort study, Front. Aging Neurosci. 12 (2020) 601487.
[17] T.M. Barrett, M.A. Liebert, J.M. Schrock, T.J. Cepon-Robins, A. Mathur, H. Agarwal, et al., Physical function and activity among older adults in Jodhpur, India, Ann. Hum. Biol. 43 (5) (2016) 488–491.
[18] F. Wang, S. Boros, The effect of physical activity on sleep quality: a systematic review, Eur. J. Physiother. 23 (1) (2021) 11–18.
[19] M. Banno, Y. Harada, M. Taniguchi, R. Tobita, H. Tsujimoto, Y. Tsujimoto, et al., Exercise can improve sleep quality: a systematic review and meta-analysis, PeerJ 6 (2018), e5172.
[20] D. Vancampfort, B. Stubbs, L. Smith, M. Hallgren, J. Firth, M.P. Herring, et al., Physical activity and sleep problems in 38 low- and middle-income countries, Sleep Med. 48 (2018 Aug) 140–147.
[21] A.E. Mesas, E.W. Hagen, P.E. Peppard, The bidirectional association between physical activity and sleep in middle-aged and older adults: a prospective study based on polysomnography, Sleep 41 (9) (2018) zsy114.
[22] A. Jaiswal, K. Goswami, P. Haldar, H.R. Salve, U. Singh, Prevalence of knee osteoarthritis, its determinants, and impact on the quality of life in elderly persons in rural Ballabgarh, Haryana, J. Fam. Med. Prim. Care 10 (1) (2021) 354–360.
[23] A. Nawrocka, M. Niestrój-Jaworska, A. Mynarski, J. Polechoński, Association between objectively measured physical activity and musculoskeletal disorders, and perceived work ability among adult, middle-aged and older women, Clin. Interv. Aging 14 (2019) 1975–1983.
[24] S. Srivastava, K.J.V. Joseph, D. Dristhi, T. Muhammad, Interaction of physical activity on the association of obesity-related measures with multimorbidity among older adults: a population-based cross-sectional study in India, BMJ Open 11 (5) (2021), e050245.
[25] D. Vancampfort, A. Koyanagi, P.B. Ward, S. Rosenbaum, F.B. Schuch, J. Mugisha, et al., Chronic physical conditions, multimorbidity and physical activity across 46 low- and middle-income countries, Int. J. Behav. Nutr. Phys. Activ. 14 (1) (2017 Jan 18) 6.
[26] D. Vancampfort, B. Stubbs, A. Koyanagi, Physical chronic conditions, multimorbidity and sedentary behavior amongst middle-aged and older adults in six low- and middle-income countries, Int. J. Behav. Nutr. Phys. Activ. 14 (1) (2017) 147.
[27] S. Pengpid, K. Peltzer, Prevalence and correlates of cataract among a nationally representative population-based sample of older adults in Mexico, Int. J. Disabil. Hum. Dev. 19 (3) (2020) 561–566.
[28] Y.H. Shih, H.Y. Chang, M.I. Lu, B.S. Hurng, Time trend of prevalence of self-reported cataract and its association with prolonged sitting in Taiwan from 2001 and 2013, BMC Ophthalmol. 14 (2014) 128.
[29] J. Zheng Selin, N. Orsini, B. Ejdervik Lindblad, A. Wolk, Long-term physical activity and risk of age-related cataract: a population-based prospective study of male and female cohorts, Ophthalmology 122 (2) (2015) 274–280.
[30] A.K. Dang, L.H. Nguyen, A.Q. Nguyen, B.X. Tran, T.T. Tran, C.A. Latkin, M.W.B. Zhang, R.C.M. Ho, Physical activity among HIV-positive patients receiving antiretroviral therapy in Hanoi and Nam Dinh, Vietnam: a cross-sectional study, BMJ Open 8 (5) (2018 May 10), e020688.
[31] International Institute for Population Sciences (IIPS), NPHCE, MoHFW, Harvard T. H. Chan School of Public Health (HSPH) and the University of Southern California (USC) 2020. Longitudinal Ageing Study in India (LASI) Wave 1, 2017-18, India Report, International Institute for Population Sciences, Mumbai.
[32] J. Lee, J.P. Smith, Regional disparities in adult height, educational attainment and gender difference in late- life cognition: findings from the longitudinal aging study in India (LASI), J. Econ. Ageing 4 (2014 Dec 1) 26–34.
[33] H.C. Roberts, H.J. Denison, H.J. Martin, H.P. Patel, H. Syddall, C. Cooper, et al., A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach, Age Ageing 40 (4) (2011) 423–429.
[34] S. Katz, A.B. Ford, R.W. Moskowitz, B.A. Jackson, M.W. Jaffe, Studies of illness in the aged. the index of adl: a standardized measure of biological and psychosocial function, JAMA 185 (1963) 914–919.
[35] M.P. Lawton, E.M. Brody, Assessment of older people: self-maintaining and instrumental activities of daily living, Gerontologist 9 (3) (1969) 179–186.
[36] Y. Min, P.A. Nadpara, P.W. Slattum, The association between sleep problems, sleep medication use, and falls in community-dwelling older adults: results

from the health and retirement study 2010, J. Ageing Res. (2016). Article ID 3685789.
[37] E. Cho, T.Y. Chen, The bidirectional relationships between effort-reward imbalance and sleep problems among older workers, Sleep Health 6 (3) (2020 Jun) 299–305.
[38] R.C. Kessler, A. Andrews, D. Mroczek, B. Ustun, H.U. Wittchen, The World health organization composite international diagnostic interview short-form (CIDI-SF), Int. J. Methods Psychiatr. Res. 7 (1998) 171–185.
[39] D. Steffick, Documentation of Affective Functioning Measures in the Health and Retirement Study, 2000. URL: http://hrsonline.isr.umich.edu/sitedocs/userg/dr-005.pdf. (Accessed 2 May 2021).
[40] E.M. Andresen, J.A. Malmgren, W.B. Carter, D.L. Patrick, Screening for depression in well older adults: evaluation of a short form of the CES-D (Center for Epidemiologic Studies Depression Scale), Am. J. Prev. Med. (1994) 77–84.
[41] S. Kumar, A. Nakulan, S.P. Thoppil, R.P. Parassery, S.S. Kunnukattil, Screening for depression among community-dwelling elders: usefulness of the center for epidemiologic studies depression scale, Indian J. Psychol. Med. 38 (5) (2016) 483–485.
[42] Harvard School of Public Health, Abdominal obesity measurement guidelines for different ethnic groups, URL: https://www.hsph.harvard.edu/obesity-prevention-source/waist-circumference-guidelines-for-different-ethnic-groups/, 2020.
[43] A.V. Chobanian, G.L. Bakris, H.R. Black, W.C. Cushman, L.A. Green, J.L. Izzo Jr., et al., The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report, JAMA 289 (19) (2003) 2560–2571.
[44] G. Virgili, R. Acosta, L.L. Grover, S.A. Bentley, G. Giacomelli, Reading aids for adults with low vision, Cochrane Database Syst. Rev. 10 (2013) CD003303.
[45] International Council of Ophthalmology (ICO), Visual Acuity Measurement Standard, Visual Functions Committee; ICO: San Fransisco, CA, USA, 1984.
[46] World Health Organization (WHO), WHO Guidelines on Physical Activity and Sedentary Behaviour, World Health Organization, Geneva, 2020. Licence: CC BY-NC-SA 3.0 IGO.
[47] M.D. Huffman, S. Capewell, H. Ning, C.M. Shay, E.S. Ford, D.M. Lloyd-Jones, Cardiovascular health behavior and health factor changes (1988-2008) and projections to 2020: results from the National Health and Nutrition Examination Surveys, Circulation 125 (21) (2012) 2595–2602.
[48] C.P. Wen, Cheng TY. David, S.P. Tsai, H.T. Chan, H.L. Hsu, C.C. Hsu, et al., Are Asians at greater mortality risks for being overweight than Caucasians? Redefining obesity for Asians, Publ. Health Nutr. 12 (4) (2009) 497–506.
[49] C. Wang, M. Tee, A.E. Roy, M.A. Fardin, W. Srichokchatchawan, H.A. Habib, et al., The impact of COVID-19 pandemic on physical and mental health of Asians: a study of seven middle-income countries in Asia, PLoS One 16 (2) (2021), e0246824.
[50] C. Wang, A. Chudzicka-Czupała, M.L. Tee, M.I.L. Núñez, C. Tripp, M.A. Fardin, et al., A chain mediation model on COVID-19 symptoms and mental health outcomes in Americans, Asians and Europeans, Sci. Rep. 11 (1) (2021) 6481.
[51] M.M. Hillsdon, E.J. Brunner, J.M. Guralnik, M.G. Marmot, Prospective study of physical activity and physical function in early old age, Am. J. Prev. Med. 28 (3) (2005) 245–250.
[52] F. Sofi, D. Valecchi, D. Bacci, R. Abbate, G.F. Gensini, A. Casini, et al., Physical activity and risk of cognitive decline: a meta-analysis of prospective studies, J. Intern. Med. 269 (1) (2011 Jan) 107–117.
[53] K.A. Ramsey, A.G.M. Rojer, L. D'Andrea, R.H.J. Otten, M.W. Heymans, M.C. Trappenburg, et al., The association of objectively measured physical activity and sedentary behavior with skeletal muscle strength and muscle power in older adults: a systematic review and meta-analysis, Ageing Res. Rev. 67 (2021) 101266.
[54] O.M. Buxton, M. L'Hermite-Balériaux, U. Hirschfeld, E. Cauter, Acute and delayed effects of exercise on human melatonin secretion, J. Biol. Rhythm. 12 (6) (1997) 568–574.
[55] F. Pels, J. Kleinert, Loneliness and Physical Activity: a Systematic Review, International Review of Sport and Exercise Psychology, 2016.
[56] S. Steinmo, G. Hagger-Johnson, L. Shahab, Bidirectional association between mental health and physical activity in older adults: Whitehall II prospective cohort study, Prev. Med. 66 (2014) 74–79.
[57] B.K. Pedersen, B. Saltin, Exercise as medicine - evidence for prescribing exercise as therapy in 26 different chronic diseases, Scand. J. Med. Sci. Sports 25 (Suppl 3) (2015) 1–72.
[58] A. Deslandes, H. Moraes, C. Ferreira, H. Veiga, H. Silveira, R. Mouta, et al., Exercise and mental health: many reasons to move, Neuropsychobiology 59 (4) (2009) 191–198.
[59] Y. Cai, J.A. Schrack, H. Wang, J.Y. E, A.A. Wanigatunga, Y. Agrawal, et al., Visual impairment and objectively measured physical activity in middle-aged and older adults, J. Gerontol. Biol. Sci. Med. Sci. (2021) glab103.