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

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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...
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...”[31]. 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 tumblering “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/m²), normal weight (18.5–22.9 kg/m²), overweight (23.0–24.9 kg/m²), class I obesity (25.0–29.9 kg/m²), and class II obesity (>30.0 kg/m²)” [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, 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

| 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         | Scale (1–5)            | 2.77  | 2.60      | 2.69| 2.76     | 2.86 |
| Self-rated health status  | Scale (1–5)            | 3.49  | 3.44      | 3.46| 3.54     | 3.52 |
| Life satisfaction         | Scale (1–4)            | 2.48  | 2.32      | 2.44| 2.54     | 2.55 |
| Happiness                 | Scale (0–32)           | 18.7  | 17.6      | 18.6| 19.2     | 19.0 |
| Cognitive functioning     | Scale                  | 25.9  | 23.5      | 25.8| 26.1     | 27.1 |
| Grip strength-male        | Scale                  | 17.3  | 15.9      | 16.9| 16.7     | 17.9 |
| Grip strength-female      | Scale                  | 28.8  | 32.6      | 32.6| 32.6     | 32.6 |
| Functional disability (2 or more) | Yes                   | 12.7  | 30.1      | 14.2| 6.9      | 48.8 |
| Insomnia symptoms         | Yes                    | 7.6   | 26.7      | 14.1| 6.5      | 52.7 |
| Major depressive disorder | Yes                    | 27.6  | 27.4      | 13.5| 7.5      | 51.6 |
| Depressive symptoms       | Yes                    | 13.3  | 28.7      | 14.0| 7.9      | 49.4 |
| Loneliness                | Yes                    | 11.6  | 28.2      | 13.9| 8.5      | 49.4 |
| Abdominal obesity         | Men ≥ 90 cm, women ≥ 80 cm | 49.8  | 22.5      | 13.3| 8.2      | 56.0 |
| Diabetes                  | Yes                    | 40.4  | 26.5      | 13.6| 8.5      | 51.4 |
| Hypertension              | Yes                    | 3.6   | 31.9      | 14.4| 7.3      | 46.4 |
| Heart disease             | Yes                    | 1.8   | 51.8      | 12.4| 5.8      | 30.0 |
| Stroke                    | Yes                    | 0.6   | 27.9      | 13.9| 5.5      | 52.7 |
| Cancer                    | Yes                    | 6.3   | 32.7      | 12.0| 7.8      | 47.5 |
| Chronic lung disease      | Yes                    | 15.7  | 26.9      | 13.5| 8.0      | 51.6 |
| Bone or joint disease     | Yes                    | 34.0  | 27.8      | 13.8| 8.4      | 50.0 |
| Vision impaired           | Yes                    | 13.1  | 33.9      | 13.5| 8.8      | 43.7 |
| Cataract                  | Yes                    | 0.6   | 35.7      | 16.4| 4.9      | 43.0 |
| Chronic renal failure     | Yes                    | 0.7   | 45.7      | 9.8 | 5.7      | 38.8 |
| 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) |
|----------------------------|-------------------------|-------------------------------------------------------|----------------------------------------------------|
| **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                        | 1.11 (1.04, 1.18)***     | 1.05 (1.01, 1.11)*                                    |                                                    |
| Moderate                   | 1.07 (1.03, 1.11)***     | 1.06 (1.03, 1.10)***                                  |                                                    |
| **Happiness**              | Scale                   | Inactive 1 Reference                                  | 1 Reference                                        |
| Low                        | 1.25 (1.15, 1.35)***     | 1.21 (1.12, 1.31)***                                  |                                                    |
| Moderate                   | 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                        | 12.34 (6.93, 22.01)***   | 2.73 (1.50, 4.99)***                                  |                                                    |
| Moderate                   | 35.30 (25.02, 49.8)***   | 6.87 (5.02, 9.40)***                                  |                                                    |
| **Grip strength-female**   | Scale                   | Inactive 1 Reference                                  | 1 Reference                                        |
| Low                        | 0.60 (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)***                                  |                                                    |
| **Functional disability (2 or more)** | No | Inactive 1 Reference                                  | 1 Reference                                        |
| Low                        | 0.85 (0.79, 1.00)        | 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)***                                  |                                                    |
| **Insomnia symptoms**      | No | Inactive 1 Reference                                  | 1 Reference                                        |
| 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)***                                  |                                                    |
| **Major depressive disorder** | No | Inactive 1 Reference                                  | 1 Reference                                        |
| 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)***                                  |                                                    |
| **Depressive symptoms**    | No | Inactive 1 Reference                                  | 1 Reference                                        |
| Low                        | 1.04 (0.95, 1.14)        | 1.13 (0.99, 1.29)                                      |                                                    |
| Moderate                   | 0.99 (0.91, 1.08)        |                                                        |                                                    |
| High                       | 0.90 (0.78, 1.03)        | 0.98 (0.85, 1.13)                                      |                                                    |
| **Loneliness**             | No | Inactive 1 Reference                                  | 1 Reference                                        |
| Low                        | 0.72 (0.60, 0.85)***     | 0.85 (0.74, 0.98)***                                  |                                                    |
| Moderate                   | 0.85 (0.77, 0.93)***     | 0.92 (0.84, 1.02)                                      |                                                    |
| High                       | 0.68 (0.61, 0.75)***     | 0.85 (0.77, 0.93)***                                  |                                                    |
| **Abdominal obesity**      | No | Inactive 1 Reference                                  | 1 Reference                                        |
| Low                        | 0.85 (0.77, 0.93)***     | 0.92 (0.84, 1.02)                                      |                                                    |
| Moderate                   | 0.85 (0.77, 0.93)***     | 0.92 (0.84, 1.02)                                      |                                                    |
| High                       | 0.85 (0.77, 0.93)***     | 0.85 (0.77, 0.93)***                                  |                                                    |
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.

### 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)* |
|-------------------|------------------------|-----------------------------------------------|-----------------------------------------------|
| Heart disease     | No Inactive            | 1 Reference                                   | 1 Reference                                   |
|                   | Yes Low                | 0.83 (0.68, 1.00)                             | 0.88 (0.71, 1.10)                             |
|                   |                        | 0.71 (0.54, 0.92)**                          | 0.73 (0.55, 0.98)*                           |
|                   |                        | 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)**                          |
|                   |                        | 0.34 (0.24, 0.49)**                          | 0.51 (0.35, 0.75)**                          |
|                   |                        | 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)                             | 0.62 (0.36, 1.05)                             |
|                   |                        | 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)*                           |
|                   |                        | 0.72 (0.58, 0.89)**                          | 0.88 (0.71, 1.09)                           |
|                   |                        | 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)                             |
|                   |                        | 0.91 (0.77, 1.07)                             | 1.02 (0.86, 1.21)                           |
|                   |                        | 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)**                          |
|                   |                        | 0.76 (0.67, 0.86)**                          | 0.88 (0.77, 0.99)**                          |
|                   |                        | 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)**                          |
|                   |                        | 0.78 (0.64, 0.94)                             | 0.89 (0.75, 1.07)                           |
|                   |                        | 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)                             |
|                   |                        | 0.43 (0.23, 0.79)**                          | 0.48 (0.25, 0.92)**                          |
|                   |                        | 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)**                          |
|                   |                        | 0.38 (0.21, 0.69)**                          | 0.51 (0.27, 0.97)**                          |
|                   |                        | 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(Coeff.) = exponentiated coefficient. 

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

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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.

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