nature medicine

Article

https://doi.org/10.1038/s41591-026-04237-5

Physical activity for public health in the 21st century

Received: 14 June 2025

Accepted: 23 January 2026

Published online: 9 March 2026

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A list of authors and their affiliations appears at the end of the paper

With over 5 million attributed deaths per year, physical inactivity is a major global public health issue. Although the importance of physical activity is well recognized within the scope of obesity and cardiometabolic disease prevention and control, its broader benefits for the health of individuals and societies are yet to be fully harnessed. Furthermore, the role of active leisure, active transport and active labor—primary domains of physical activity—in supporting or hindering social and health equity has been largely overlooked. Here we (1) used a health equity lens to describe global domain-specific physical activity inequalities through an analysis of World Health Organization STEPwise approach to NCD risk factor surveillance (WHO STEPS) data from 68 countries; (2) summarized evidence linking physical activity with health outcomes beyond cardiometabolic disease, including immunity and infectious disease, depression and cancer; and (3) developed a new model reconceptualizing physical activity to better respond to 21st-century public health challenges. Our global, intersectional analysis of gender and socioeconomic physical activity inequalities revealed a 40-percentage-point gap in active leisure—the only domain consistently driven by choice—between historically privileged groups (wealthy men in high-income countries) and historically disadvantaged ones (poor women in low-income countries). Robust evidence supports the benefits of physical activity for immunity and infectious disease, depression and cancer. Our reconceptualized model recognizes the influence of social identities, norms, policies and structures on physical activity for health and wellbeing and emphasizes the urgent need to develop and roll out policies and programs that disseminate and harness the full benefits of physical activity for human, societal and planetary health.

With an estimated 7.2% of yearly global deaths (all-cause) attributed to physical inactivity[1], the role of physical activity for noncommunicable disease (NCD) prevention and management is well recognized[1]. In an attempt to tackle the obesity and associated cardiometabolic disease crises of high-income countries and of low- and middle-income countries (LMICs) undergoing economic and epidemiological transitions, the message that 'every move counts' for health has been widely promoted[2].

However, in the globalized world of the 21st century, it is common to encounter colliding NCD, infectious disease and mental health emergencies[3,4]. These syndemics are taking place against the backdrop of climate change and persistent health and social inequalities[5,6]. Such complex scenarios demand a reassessment of the broader role of physical activity for the health of individuals and societies, including, but not limited to, obesity and cardiometabolic disease prevention and management. Current definitions of health, including those by the WHO[7,8], describe health as 'complete wellbeing'[9], going beyond the absence of physical illness by also encompassing the attainment of the highest standards of mental health, wellbeing and human dignity.

e-mail: dsalvo@austin.utexas.edu

https://doi.org/10.1038/s41591-026-04237-5

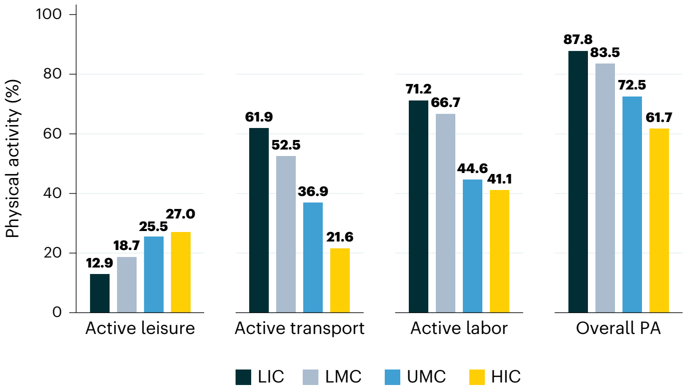

Fig. 1 | Domain-specific physical activity prevalence by country income categories. Percentage of the population meeting WHO Physical Activity Guidelines with leisure-specific, transport-specific, labor-specific and overall (all domains) moderate-to-vigorous-intensity physical activity, by World Bank country income categories (LIC, low-income country; LMC, lower middle-income country; UMC, upper middle-income country; HIC, high-income country) (source data: WHO STEPS, n = 68 countries; prevalence data date range: 2008–2019). PA, physical activity.

It is estimated that, worldwide, almost one out of three adults[10], and eight out of 10 adolescents[11], do not meet WHO physical activity guidelines (150–300 weekly minutes of moderate-to-vigorous-intensity aerobic physical activity for adults and 60 daily minutes for children and adolescents[12]). However, global gender and socioeconomic inequalities in domain-specific physical activity—that is, physical activity for leisure, transport or labor—have not been previously assessed. Here we present findings from a theoretically informed inequality analysis of active leisure, active transport and active labor data from nationally representative WHO survey data from 68 countries across all World Bank regions collected between 2002 and 2019 (ref. 13). Furthermore, we summarize the evidence of less-recognized benefits of physical activity, including infectious disease, mental health disorders and cancer prevention and control.

The overarching goal of this paper is to reconceptualize global physical activity research and promotion to better respond to the public health and societal complexities of the 21st century. Specifically, we underscore the need to recognize the role that physical activity can play in supporting or hindering social and health equity and highlight its importance for often overlooked health outcomes. To attain this goal, we (1) use a health equity lens to describe global domain-specific physical activity inequalities; (2) summarize the evidence on the links of physical activity with key health outcomes beyond cardiometabolic disease: immunity and infectious disease, depression and cancer; and (3) introduce a new model to help guide global physical activity measurement, surveillance, research and promotion, centered on a 'physical activity for health and wellbeing' approach.

Results

Global physical activity inequalities

The main results of the global, domain-specific physical activity inequalities analysis are shown in Figs. 1–3, Extended Data Fig. 1 and the Supplementary Information.

This analysis was informed by three theoretical frameworks or concepts: (1) physical activity security, (2) necessity-based versus choice-based physical activity and (3) intersectionality. The concept of 'physical activity security' aims to elevate physical activity access as a human right and has been defined as 'when all people, at all times, have physical and economic access to sufficient, safe, and enjoyable physical activity to meet not only their health needs, but to promote physical and emotional well-being and social connectedness, for an active and healthy life'[14].

Complementarily, the necessity-based versus choice-based physical activity framework posits that, for many worldwide, a major driver of physical activity is economic necessity rather than free, non-economically coercive healthy choices[15]. As a consequence, a large portion of global physical activity takes place in the occupational and transport domains and, for many, occurs in suboptimal conditions for health, safety and wellbeing (for example, having to travel long distances by foot in unsafe environments and forced or not entirely safe labor conditions). Thus, despite high levels of overall physical activity, globally, many people remain 'physical activity insecure'. Thus, the necessity-based versus choice-based physical activity framework calls into question the ethics of assuming all physical activity as being supportive of optimal physical, mental and social wellbeing. Importantly, this framework does not deny the well-documented positive effects of overall physical activity on cardiometabolic health and all-cause mortality, but, rather, it adopts a holistic definition of health, aligned with that of the WHO[7].

Finally, intersectionality theory is rooted in the US Black feminist movement[16], underscoring that 'human experience is jointly shaped by multiple social positions (for example, race, gender), and cannot be adequately understood by considering social positions independently'[17]. Intersectionality recognizes the interdependent and interactive nature of systems of oppression in societies (for example, structural racism, sexism, gender-based discrimination, ableism, etc.) and their interwoven impacts on individuals belonging to not one but multiple groups disadvantaged by societal norms, systems and policies.

Together, these theoretical concepts and frameworks motivated our examination of the relative contribution to overall physical activity of three domains: active leisure, primarily associated with choice-based physical activity; active labor, primarily associated with economic necessity; and active transport, which, depending on its environmental and societal context, can result from free, non-coercive choices or from economic necessity. We hypothesized that more socially advantaged individuals based on status-conferring characteristics (that is, men, people of high socioeconomic status and residents of high-income countries) would have greater access to choice-based physical activity. Furthermore, we hypothesized that the intersection of multiple social status-conferring elements (gender, socioeconomic status and country of residence) could lead to magnified inequalities in domain-specific physical activity.

Socioeconomic physical activity inequalities. We found evidence of both within-country and between-country socioeconomic inequalities across physical activity domains. Figure 1 shows that when considering overall levels of physical activity (that is, occurring in any domain), the higher the World Bank country income category, the lower the prevalence of meeting physical activity guidelines, with the prevalence difference between the high-income versus low-income World Bank country income categories of −26.1 percentage points (pp). This could be interpreted as suggestive that physical inactivity is a major public health problem only in wealthy nations. However, domain-specific findings reveal a more complex scenario. Generally, the higher the World Bank country income category, the higher the prevalence of meeting guidelines with active leisure, whereas the lower the World Bank country income category, the higher the prevalence of meeting guidelines through active transport and active labor. Between-country income grouping inequalities were wider for physical activity domains in which necessity-based physical activity takes place (active labor and, in many contexts, active transport) than for active leisure (always choice based). The prevalence difference between the high-income versus low-income country categories was of −40.3 pp for active transport and of −30.1 pp for active labor.

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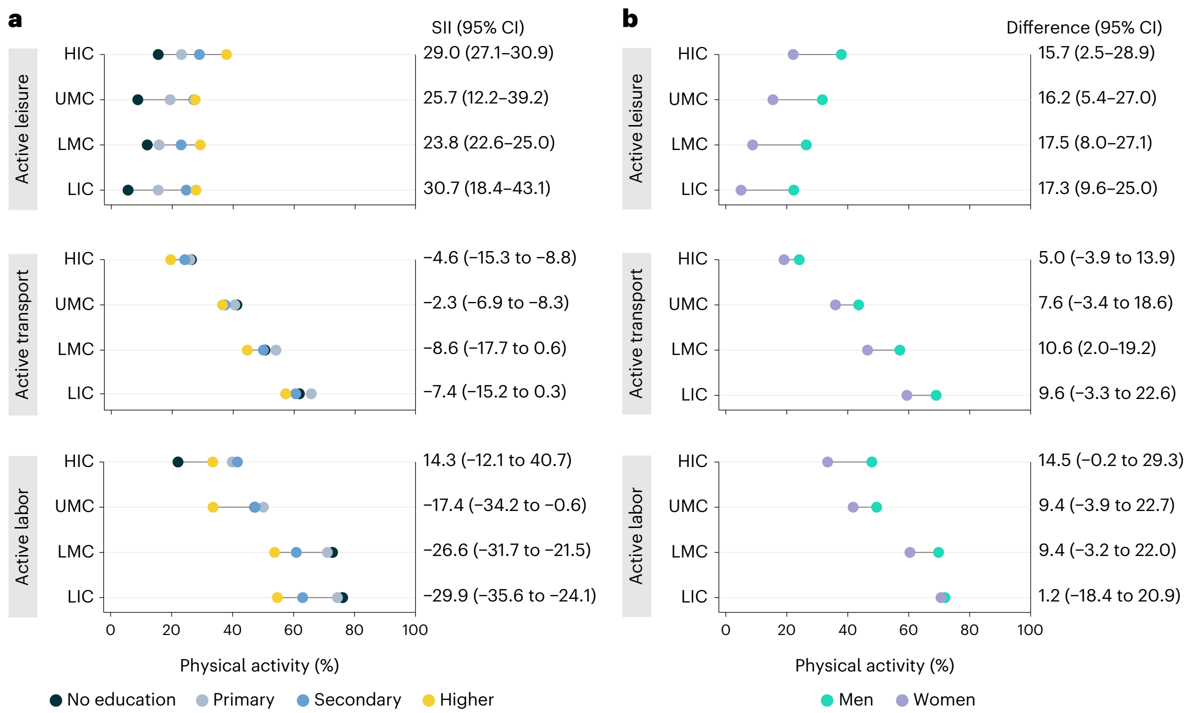

Fig. 2 | Socioeconomic and gender-based domain-specific physical activity inequalities by country income category. Unidimensional socioeconomic (education used as proxy) (**a**) and gender-based (**b**) inequalities in prevalence of meeting WHO Physical Activity Guidelines through leisure time (active leisure), transport-related (active transport) and occupational (active labor) physical activity by World Bank country income categories (LIC, low-income country; LMC, lower middle-income country; UMC, upper middle-income country; HIC, high-income country). In **a**, SII (slope index) denotes the absolute differences in predicted values (percentage points) between those with the highest versus lowest educational attainment, taking into consideration the entire distribution of education in the population, by using a logistic regression model. In **b**, 'Difference' denotes absolute differences in percentage points between men and women (source data: WHO STEPS, n = 68 countries; prevalence data date range: 2008–2019). CI, confidence interval.

In addition, the prevalence difference between the high-income versus low-income country categories for active leisure was of 14.1 pp. Furthermore, when examining the proportional contribution of physical activity by domain to overall physical activity by country income level (Extended Data Fig. 1), the same pattern becomes apparent: the higher the country income level, the higher the contribution of choice-based physical activity (active leisure). In low-income and lower middle-income countries, less than 10% of overall physical activity derives from active leisure, contrasting with high-income countries where over 30% of overall physical activity corresponds to active leisure.

Findings from the within-country analysis of socioeconomic inequalities (Fig. 2a) show that the prevalence of meeting physical activity guidelines through active leisure was approximately 20 pp higher among individuals of high versus low socioeconomic status (median slope index of inequality (SII) = 19.5, SII min = −18.8, SII max = 46.1, SII range = 64.9). Inequalities of similar magnitude were observed across World Bank country income categories (Fig. 3a), emphasizing that unequal access to active leisure exists across societies, including in wealthy countries. Across all country income categories, lower prevalence of meeting guidelines through active transport was observed among those of higher socioeconomic status relative to those of lower socioeconomic status, although higher variability in socioeconomic inequalities was observed across countries for this domain (median SII = −4.8, SII min = −34.9, SII max = 39.7, SII range = 74.6). The widest within-country socioeconomic inequalities were observed in the occupational domain, with the prevalence of meeting physical activity guidelines through active labor being approximately 16 pp higher among individuals with no formal education compared to those with high educational attainment (median SII = −16.1, SII min = −37.4, SII max = 12.2, SII range = 28.6).

Gender-based physical activity inequalities. Within-country findings show that across domains and country income categories, the prevalence of meeting physical activity guidelines was higher among men than among women (Fig. 2b). For active leisure, the prevalence was 15 pp lower among women versus men (median difference = 15.4, difference min = −16.8, difference max = 36.1, difference range = 52.9), with the active leisure gender gap being similar in magnitude regardless of macroeconomic country context (Fig. 3b). Notably, the prevalence of meeting guidelines with active leisure was similar among women in high-income countries and men in low-income countries. Patterns for active transport and active labor were similar. The prevalence of meeting guidelines through either active transport or active labor was approximately 8 pp higher for men versus women (active transport: median difference = 7.6, difference min = −14.5, difference max = 47.9, difference range = 62.4; active labor: median difference = 8.0, difference min = −10.0, difference max = 27.8, difference range = 38.8). The active transport gender gap was smaller in high-income countries than in all other country income categories (that is, LMICs). In addition, the active labor gender gap was widest in high-income countries and virtually absent in low-income countries.

Country-level estimates of socioeconomic and gender-based inequalities in active leisure, transport and labor for the 68 WHO STEPS countries are available in the Supplementary Information.

Socioeconomic and gender-based inequalities: an intersectionality approach. In addition to the unidimensional analysis of socioeconomic-based and gender-based physical activity inequalities, we assessed physical activity inequalities at the intersection of these two social identities. When comparing the wealthiest men to the poorest women within countries, we observed an absolute difference of approximately 28 pp for meeting physical activity guidelines

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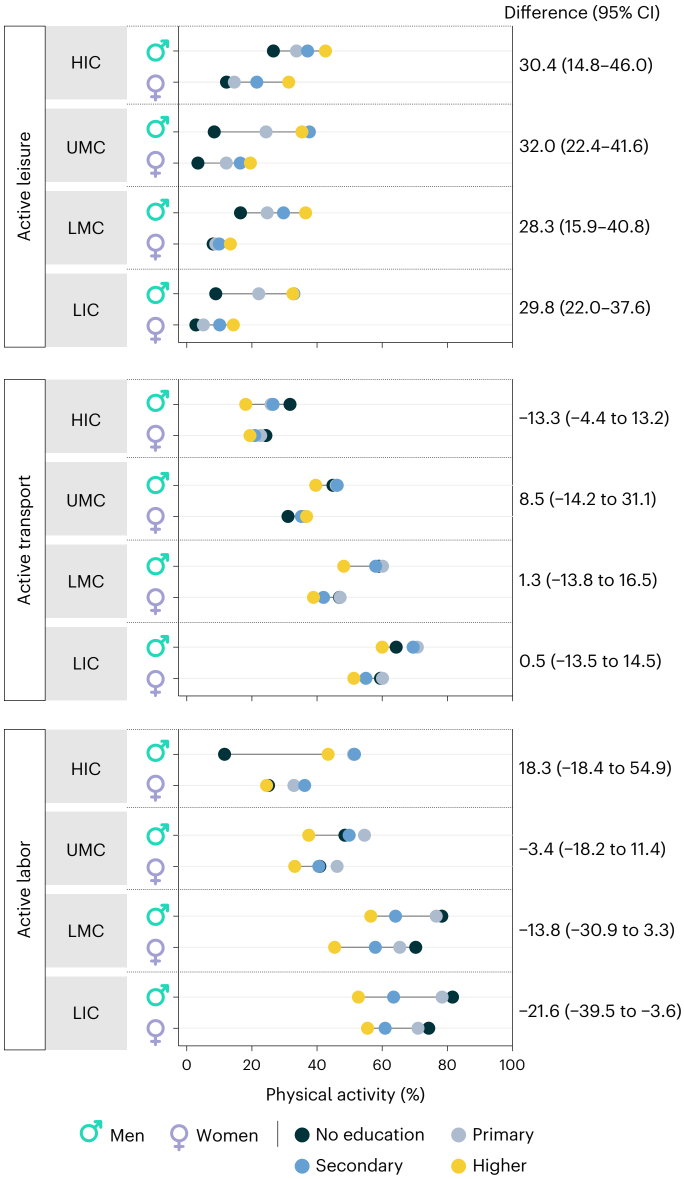

Fig. 3 | Intersectional analysis of socioeconomic and gender-based inequalities in domain-specific physical activity, by country income group. Multidimensional gender and socioeconomic (education as proxy) inequalities in prevalence of meeting WHO Physical Activity Guidelines through leisure time (active leisure), transport-related (active transport) and occupational (active labor) physical activity, by World Bank country income categories (LIC, low-income country; LMC, lower middle-income country; UMC, upper middle-income country; HIC, high-income country). The 'Difference' column denotes the absolute difference in percentage points between men of the highest socioeconomic strata and women of the lowest socioeconomic strata (source data: WHO STEPS, n = 48 countries; prevalence data date range: 2008–2019). CI, confidence interval.

through active leisure. The gap in active leisure between wealthy men and poor women is similar across country income categories and is wider than the gap observed in the unidimensional analysis for gender-based inequalities. When adding the dimension of macroeconomic country context, by contrasting wealthy men in rich nations with the most socioeconomically disadvantaged women in poor nations, the estimated gap became 40 pp.

Different inequality patterns were observed for active transport and active labor, with large variations in the degree of inequality between wealthy men and poor women across country income categories (Fig. 3). For instance, in high-income and upper middle-income countries, more women of low socioeconomic status meet guidelines through active transport than wealthy men, but smaller differences are observed in lower middle-income and low-income countries. Likewise, in all country income groups except high-income countries (that is, in LMICs), the prevalence of meeting guidelines through active labor is higher in women of low socioeconomic status than in men of high socioeconomic status.

Health benefits of physical activity beyond cardiometabolic health

In addition to pervasive inequalities and the obesity and cardiometabolic disease crises that many countries are undergoing, infectious disease emergencies, mental health disorders and high mortality and morbidity due to cancer are common elements of 21st century syndemics[3,18,19]. The sections below summarize findings of three narrative reviews on the connections of physical activity with immunity and infectious diseases, depression and cancer.

Physical activity, immunity and infectious diseases. It has been argued that the importance of physical activity in immune function for preventing and mitigating infections has been underestimated by scientific consensus groups[20], despite growing evidence linking physical activity to reduced infection risk and enhanced immunity.

Regular moderate-to-vigorous physical activity boosts immune responses to vaccines, reduces viral loads, lowers inflammation, enhances peripheral immune cell function and increases survival in mice challenged with respiratory pathogens (for example, influenza)[21]. Physical activity enhances immunity through three key biological pathways (Fig. 4): (1) increased immune surveillance[21–25]—the body's natural defence mechanism, continuously monitoring and recognizing abnormal cells or foreign invaders; (2) favorable immune system remodeling[25–28]—the dynamic process of alterations within the immune system due to aging or stress or in response to infections, with physical activity promoting more youthful phenotypes associated with improved immune response; and (3) inflammation reduction[25,29,30]—physical activity can directly and indirectly reduce chronic inflammation by altering the phenotype and function of inflammatory immune cells and by reducing highly inflammatory white adipose tissue, respectively.

Epidemiological evidence aligns with mechanistic research. Findings from population-based studies conducted during the COVID-19 pandemic support that physical activity participation at recommended levels[12] is associated with lower risks of COVID-19-related health outcomes. In a meta-analysis of 16 studies including more than 1.8 million adults, regularly active individuals, compared to those inactive prior to infection, experienced the following: (1) 11% lower risk of COVID-19 infection (relative risk = 0.89, 95% confidence interval: 0.84–0.95); (2) 36% lower risk of hospitalization (relative risk = 0.64, 95% confidence interval: 0.54–0.76); (3) 34% lower risk of severe COVID-19 illness (relative risk = 0.66, 95% confidence interval: 0.58–0.76); and (4) 43% reduction in COVID-19-related mortality (relative risk = 0.57, 95% confidence interval: 0.46–0.71)[31]. When examining physical activity as a continuous measure with risk of severe disease, the dose–response curve showed a sharp reduction in risk until the equivalent of 150 minutes per week of activity, with lesser risk reduction/plateauing thereafter. The associations of physical activity with lower risks of severe COVID-19 outcomes appear consistent across age, sex, race/ethnicity, body mass index and preexisting cardiovascular disease[32,33].

Physical activity and mental health. Depression is among the most pressing mental health issues globally[34]. A large body of research has examined the links between physical activity and depression, with over 150 systematic reviews with meta-analysis found through May 2024 (Supplementary Information).

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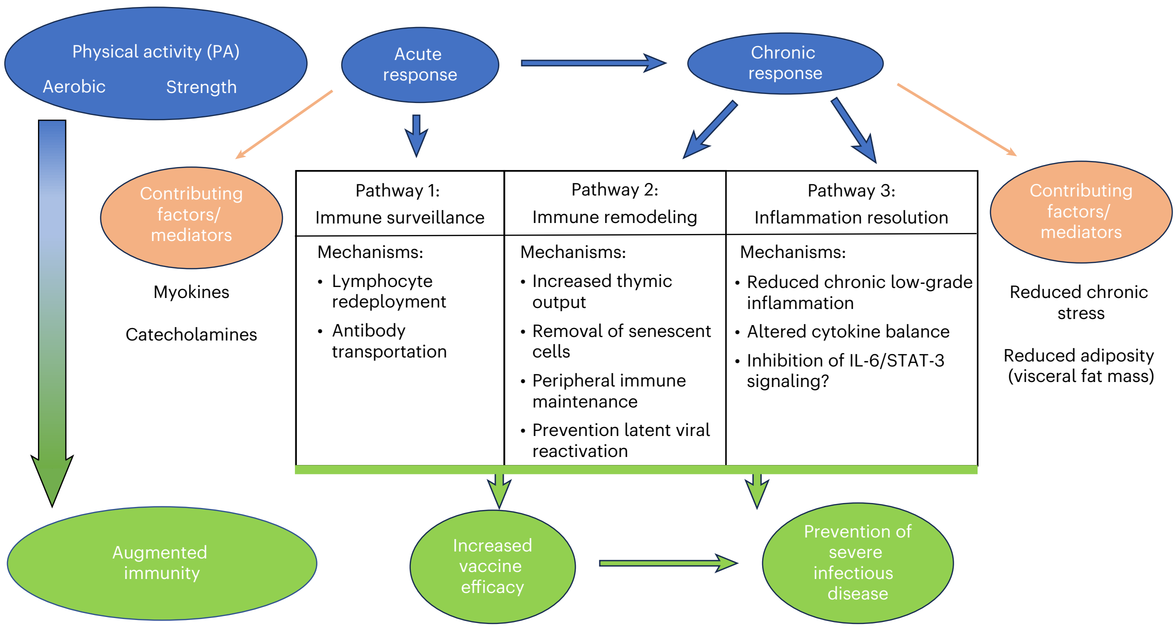

Fig. 4 | The three main known pathways by which physical activity enhances immunity. Physical activity augments immunity by increasing vaccine efficacy and preventing severe infectious disease outcomes. Known pathways include improvements in (1) immune surveillance (acute response), (2) immune remodeling (chronic response) and (3) inflammation resolution (chronic response).

The available evidence supports that physical activity can help prevent and attenuate depression and depressive symptoms among adults, adolescents and older adults. A recent (2022) harmonized meta-analysis of 15 prospective cohort studies summing more than 12 million person-years of follow-up assessed the effect of non-occupational physical activity on incident depression among adults and reported evidence of an inverse curvilinear association: accumulating half of the recommended amount of physical activity was associated with an 18% lower incidence of depression (95% confidence interval: 13–23), and meeting guidelines was associated with a 25% (95% confidence interval: 18–32) lower incidence[35]. The associations appeared similar across gender and age groups. In another meta-analysis of prospective cohort studies[36], inverse associations of physical activity with depressive symptoms were reported for adolescents and young adults (odds ratio = 0.90, 95% confidence interval: 0.83–0.98) and for older adults (odds ratio = 0.79, 95% confidence interval: 0.72–0.86).

Evidence also supports physical activity as a promising treatment for depression. A 2024 meta-analysis summarized findings from 218 randomized controlled trials (RCTs) with a combined total of 14,170 participants with major depressive disorder[37]. Findings support that physical activity across a variety of modalities (walking and jogging, yoga, strength training, mixed aerobic exercises, tai chi or qigong) has moderate yet clinically significant effects in reducing depressive symptoms relative to controls. Although similarly large meta-analyses of RCTs are lacking for youth, the available evidence is consistent with that of adults[38].

Physical activity and cancer. Cancer is the second leading cause of death worldwide, with over 10 million cancer deaths in 2023 (ref. 39). The link between physical activity and cancer prevention and control has long been established.

Multiple large-scale reviews of epidemiological studies consistently report higher levels of active leisure, non-occupational or overall aerobic physical activity being associated with lower risk of several types of cancer. Findings from a recent (2019) and robust systematic review show that people with the highest versus the lowest levels of aerobic physical activity have risk reductions of approximately 10–20% for multiple site-specific cancers, including breast, colorectal, bladder, endometrial, esophageal, renal and gastric cancers[40]. Furthermore, a 2025 review identified individual studies published since 2019 reporting consistent findings[41]. With respect to muscle-strengthening physical activity, a 2021 review found a significant association between high (versus low) levels of muscle-strengthening activity and a 26% lower risk of renal cancer (hazard ratio = 0.74; 95% confidence interval: 0.56–0.98)[42]. However, this evidence was drawn from only two studies. More work is needed assessing the possible independent or cumulative contributions of muscle-strengthening activity to cancer prevention, beyond or compounded with those of aerobic physical activity.

Regarding survival among people diagnosed with cancer, a high-quality systematic review published in 2020 (ref. 43) found compelling evidence from 136 studies supporting higher survival among patients with cancer in the highest versus lowest categories of physical activity. This review assessed the association of both pre-diagnosis and post-diagnosis physical activity with cancer mortality (all sites), with reports of significant mortality risk reductions for both physical activity assessments. A higher risk reduction was observed for post-diagnosis physical activity (37% lower cancer mortality risk among the highest versus lowest activity group; hazard ratio = 0.63, 95% confidence interval: 0.53–0.75) than for pre-diagnosis physical activity (18% lower risk among the highest versus lowest activity group; hazard ratio = 0.82, 95% confidence interval: 0.79–0.86). The authors report similar associations across 11 individual cancer types examined. Notably, these findings were consistent across multiple population subgroups, including by sex, body mass index, menopausal status and colorectal cancer subtype and for both active leisure and overall physical activity levels. These results were recently ratified by a new, large-scale multicenter RCT that tested the effects of a structured exercise intervention after chemotherapy on colon cancer survival outcomes[44]. However, a systematic review by Takemura et al.[45] focused on patients with advanced cancer found weak evidence supporting a protective role of physical activity for mortality risk reduction. This could suggest that the benefits of post-diagnosis physical activity for cancer survival are limited to patients with early-stage or mid-stage cancer, but more research is needed that differentiates the effects of physical activity among patients with advanced cancer with a terminal versus a non-terminal diagnosis.

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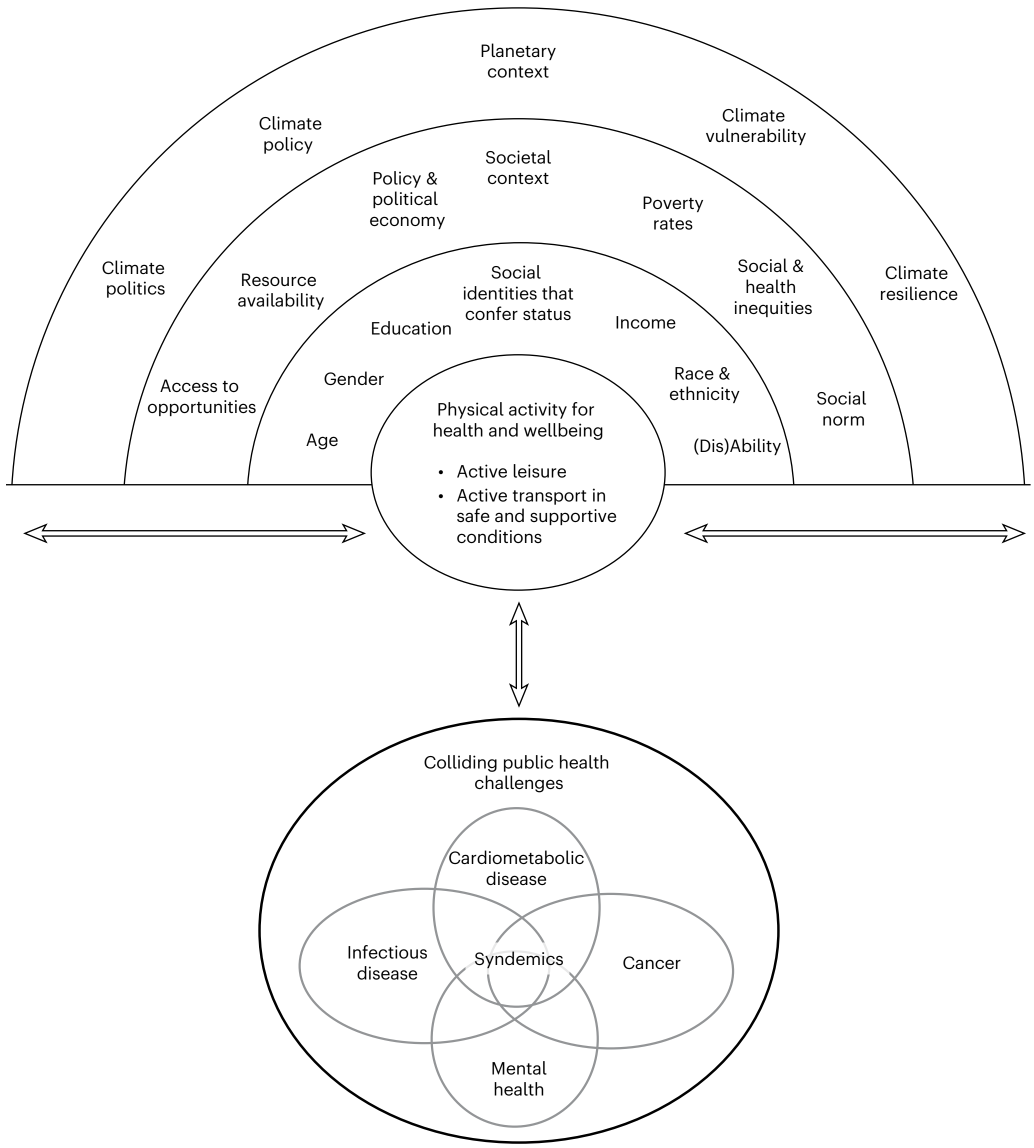

Fig. 5 | Toward a reconceptualized framework of physical activity for public health in the 21st century. A proposal to shift from the current conceptualization of the public health relevance of physical activity, centered on cardiometabolic disease prevention and management (**a**), toward a reconceptualized understanding of physical activity for public health research, policy and practice in the 21st century, centered on 'physical activity for health and wellbeing' (**b**).

Although most evidence linking physical activity to cancer outcomes has focused on overall or leisure time physical activity, results from a new, large-scale prospective study of occupational physical activity show that, although active labor may lower the incidence of some cancers, it is also associated with a higher mortality from other cancer types[46]. It is worth noting that the field of physical activity oncology has also begun to emphasize the effect of physical activity for improving additional outcomes among cancer survivors and patients with advanced cancer, including muscle strength, mental health and quality of life, as well as the possible role of physical activity as an enhancer of cancer treatment[47]. The Supplementary Information provides an extended summary of the evidence linking physical activity to cancer-related outcomes.

Reconceptualizing physical activity for public health in the 21st century

Drawing on lessons from the global analysis of physical activity inequalities and of the critical review of evidence pointing toward multiple health benefits of physical activity for disease prevention and control, we propose shifting from the current physical activity research and practice model anchored on obesity and cardiometabolic disease prevention and management (Fig. 5a) toward one that recognizes the broader role of physical activity for multiple public health and societal priorities. The new model explicitly recognizes the influences of social status-conferring identities, broad societal context (including physical activity policy and political economies, addressed in detail in Series Paper 3 (ref. 48)) and planetary-level factors (Series Paper 2 (ref. 49)) on the circumstances in which activity occurs and, ultimately, on individual and population patterns of physical activity (Fig. 5b). The top part of the model is informed by the Dahlgren–Whitehead Social Determinants of Health model[50] and by the findings of our global inequalities/intersectionality analysis. The bottom section is informed by our review of the less-recognized benefits of physical activity for health and wellbeing. The model highlights the bidirectional relationship between the health status of populations and their physical activity patterns plus broader contextual elements. Finally, informed

Table 1 | Reconceptualization of physical activity for public health in the 21st century

Reconceptualization element	Description	Recommendations
(1) Physical activity for health and wellbeing	We propose using the term 'physical activity for health and wellbeing' to refer to physical activity that promotes optimal, holistic health, in alignment with the WHO's definition of health. This term inherently excludes physical activity that occurs in unsafe, economically coercive and/or undignified conditions, that has potential health risks and is associated with social inequalities. This proposal stems from the theoretically informed global analysis of domain-specific and intersectional physical activity inequalities presented in this paper and draws on elements of theories and concepts, including physical activity security, the necessity-based versus choice-based physical activity framework and intersectionality theory.	It is recommended to apply this reconceptualization to physical activity measurement, surveillance, research and promotion. • 'Overall physical activity' and 'physical activity for health and wellbeing' should be differentiated when measuring, tracking population levels (that is, surveillance) and conducting physical activity studies. Researchers should work to develop self-reported measures or statistical approaches that allow for this differentiation. • Promotion efforts should focus on physical activity for health and wellbeing.
(2) Physical activity goals and benchmarking	The findings presented in this paper of the global analysis of domain-specific and intersectional physical activity inequalities support the need to increase the overall prevalence of people meeting physical activity guidelines of international agencies (for example, the WHO), and countries should set targets and use their surveillance systems to track progress for: • Increasing opportunities for physical activity for health and wellbeing, as described in this reconceptualized model of physical activity for 21st century public health. • Reducing physical activity inequalities across multiple dimensions (socioeconomic, gender, race, ethnicity, sexual orientation, disabilities, immigration status, etc.). • Increasing the proportion of the population with access to free, accessible, safe and enjoyable spaces for active leisure. • Improving the safety and overall conditions for transport-related physical activity (walking, bicycling and public transit), especially in areas where these modes are primarily driven by economic necessity and among populations experiencing transport disadvantage.	It is recommended that physical activity inequalities tracking should: • Use domain-specific physical activity data. To support this, researchers should work toward developing more accurate measures of domain-specific physical activity. • Assess the extent to which active transport occurs in safe and dignified conditions. This will require developing measures to determine the environmental and sociocultural conditions where active transport takes place and including them as part of physical activity surveillance systems. • Develop measures to assess and track choice-based versus necessity-based physical activity in populations and set benchmarking goals aiming to maximize choice-based physical activity. • Employ an intersectionality approach to assess the combined impact of multiple dimensions of social disadvantage on physical activity inequalities.
(3) Research on the health and societal effects of physical activity	The summaries presented in this paper on the less well-recognized health benefits of physical activity as well as the global analysis of domain-specific and intersectional physical activity inequalities, plus the insights provided by Series Papers 2 and 3 (refs. 48,49), support the need for expanding and improving research on the effects of physical activity for infectious disease prevention and control, mental health disorder prevention and treatment, cancer prevention and control, the reduction of health inequities and climate action.	Recommended research priorities: • Studies testing the effects of structural-level changes, targeting social injustices, in reducing physical activity inequalities and in increasing physical activity security. • Studies exploring the role of physical activity domains, of choice-based versus necessity-based physical activity and of physical activity settings (for example, open green space) on infectious disease and mental health outcomes. • Studies assessing physical activity as an adjuvant in the evaluation of new vaccines. Both vaccine effectiveness and duration of effect should be evaluated. • Studies directly testing the comparative effectiveness of physical activity as an alternative treatment for mental health relative to established treatments, using newer, more robust designs for causal inference (for example, Mendelian randomization, advanced technologies and data science). • Studies on the biological mechanisms by which physical activity enhances site-specific cancer prevention and survivorship; on the possible effects of physical activity on late-stage cancer; on the role of physical activity intensity on cancer outcomes; and on less researched cancers with regard to the role of physical activity. • Studies on how to safely promote 'physical activity for health and wellbeing' and support physical activity security during times of crises (for example, infectious disease pandemics, natural disasters and extreme temperatures/weather). • Studies assessing the impact of large-scale physical activity promotion strategies on both human and planetary health outcomes, including climate resilience and climate change mitigation and adaptation.
(4) Physical activity promotion policies, programs and messaging	The evidence summarized across all sections of this paper as well as that of Series Papers 2 and 3 (refs. 48,49) support that attaining physical activity security through the promotion of 'physical activity for health and wellbeing' should be prioritized in physical activity policies, programs and messaging across sectors and levels of government as well as by international agencies.	• All physical activity promotion efforts, including those by healthcare providers and public health agencies, should emphasize the full range of health benefits of physical activity. • Physical activity policies should aim to reduce physical activity insecurity, increase access to choice-based physical activity and create safe and dignified conditions for the environments where necessity-based physical activity is common. • Physical activity promotion should not be limited to obesity, cardiometabolic health or even broad NCD prevention and management plans, policies and programs. Within the health sector, entities in charge of mental health and societal wellbeing, as well as infectious disease and cancer prevention and control, should also be engaged. As emphasized by Series Papers 2 and 3 (refs. 48,49), actors beyond the health sector should partake in physical activity policy development, implementation and evaluation and especially those with connections to climate action and planetary health (for example, environment, urban planning and transport). • Physical activity promotion strategies and messaging should use decolonized approaches that are ethical, respectful and responsive to the local culture, values and context. • Messages indicating that 'every move counts' for health should be avoided in contexts where a large portion of physical activity is necessity driven and occurs in unsafe, economically coercive and undignified conditions misaligned with physical activity for health and wellbeing. • Strategies for resolving social injustices, including changing unfair social structures, contexts, policies and norms, and the oppressive systems that drive inequalities in choice-based versus necessity-based physical activity should be included in physical activity promotion plans.

by our global analysis of physical activity inequalities and their theoretical precursors (physical activity security, the necessity-based versus choice-based physical activity framework and intersectionality theory), the proposed reconceptualization posits centering public health research and promotion on the concept of 'physical activity for health and wellbeing'. Table 1 presents the four main elements of this reconceptualization, including recommendations for physical activity surveillance, research and promotion.

Discussion

In this paper, we presented findings from a theoretically informed analysis of global domain-specific physical activity inequalities; summarized decades of evidence demonstrating benefits of physical activity beyond cardiometabolic disease; and proposed a reconceptualized model for physical activity in the 21st century.

Several findings of the inequalities analysis are noteworthy. First, there is a wide opportunity gap for active leisure (the only domain that is always choice driven) between members of historically privileged social groups (men, high socioeconomic status and residents of higher-income countries) and those who have been historically disadvantaged (women, low socioeconomic status and residents of lower-income countries). Second, although economic necessity was expected to be the main driver of active labor, it also appears to act as a key driver of active transport for many across the globe, especially in lower-income countries, denoting transport disadvantage, which exacerbates social exclusion[51]. Third, across all countries and population subgroups studied, the proportion of people meeting physical activity guidelines exclusively through active leisure is low (<50%). Thus, in addition to increasing access to active leisure opportunities, findings support the need to provide safe, efficient and dignified environments to make active transport a viable choice for all rather than remaining the only economically viable mobility option for the socioeconomically disadvantaged. Although scarce, real-world examples of settings where active transport participation is not associated with socioeconomic status exist (for example, The Netherlands)[52], supporting that high levels of choice-based active transport are achievable through adequate environmental supports. Fourth, wider gaps were revealed when assessing multidimensional inequalities than those observed in the unidimensional analysis, supporting that interwoven social injustices and systems of oppression cannot be properly assessed or addressed through oversimplified, unidimensional approaches.

Traditionally, intersectionality theory has been applied to qualitative studies, but recent quantitative applications to physical activity surveillance, research and promotion have emerged, with findings consistent with those of our 48-country analysis. For example, in an initial, unidimensional analysis of Brazilian National Health Survey data, Mielke et al.[53] identified physical activity prevalence gaps of 9.0 pp between men and women; 13.4 pp between the wealthiest and the poorest; 2.2 pp between people with white skin versus black/brown skin; and 26.6 between those with high versus low levels of education. Upon exploring the width of these gaps across multiple dimensions of inequality, the authors reported that among highly educated, white, wealthy men, the prevalence of active leisure was 38.2 pp higher than among poor, black or brown women with a low educational attainment. Intersectional physical activity inequalities have also been studied in high-income countries. Abichahine et al.[54] found that, in Canada, income was strongly positively associated with physical activity among men of racial/ethnic minorities. However, among white men and women, the positive association of income with physical activity was moderate; and among women of racial/ethnic minorities, the association observed was weak to non-existent. Beyond quantifying multidimensional inequalities, embracing an intersectionality approach requires decolonized approaches[55], because physical activity research questions, methods and promotion strategies are predominantly informed by research and practice in high-income countries, which are incompatible with the ground truth of the 'majority world' (84% of the global population lives in LMICs[56]).

Our critical review of the evidence supporting benefits of physical activity for immunity and infectious disease, depression and cancer underscores the need to broadly disseminate and harness the totality of health benefits of physical activity in policy and practice. Recent epidemiological evidence confirmed decades of mechanistic research on the role of physical activity for infectious disease prevention and control and was made possible by the natural experiment of the COVID-19 pandemic. This new evidence showed that lack of physical activity appears similar to obesity—an established risk factor—in its association with severe infectious disease. In a meta-analysis of more than 3.5 million individuals, people with obesity had a 72% increased odds of hospitalization due to COVID-19 (odds ratio = 1.72, 95% confidence interval: 1.62–1.84) and a 25% increased risk of mortality (odds ratio = 1.25, 95% confidence interval: 1.19–1.32)[57], with these measures of association being of similar magnitudes to those reported for physical activity in the 'Results' section of this paper. It is also notable that physical inactivity is one of the few known COVID-19 risk factors that can be modifiable in the short term, as this has important implications for the prevention and management of infectious diseases, both from the perspective of individualized health counseling in primary care units and for pandemic preparedness and response. The Supplementary Information includes a summary of lessons from the pandemic for integrating physical activity with future public health emergency preparedness and response plans.

In this paper, we also summarized decades of evidence on the protective effects of physical activity for depression and cancer prevention and control. Despite years of evidence, many healthcare providers continue to not promote physical activity for depression management[58]. Likewise, findings from an international survey of oncologists showed that less than half promote physical activity with their patients[59]. The lack of awareness of the additional benefits of physical activity beyond cardiometabolic health also permeates the general public. A national survey in the United States found cardiovascular and metabolic effects to be the most known to the public, with 65.8% and 63.5% reporting knowing about these benefits, respectively[60]. By contrast, only 8.0% and 3.4% mentioned possible psychiatric and cancer benefits[60]. Furthermore, a 2019 global analysis of national cancer-related plans found that only 47% out of 150 countries with a plan included a physical activity promotion implementation strategy, in contrast to 90% of plans with a tobacco prevention implementation strategy[61]. Given that cardiometabolic disease, infectious disease, cancer and mental health issues disproportionately burden LMICs[62–64], increasing access to physical activity for health and wellbeing globally, but especially in LMICs, has the potential to help tackle pervasive global health disparities.

This work has limitations. Although our global intersectional analysis is novel, it remains relatively superficial. Exploring how the combination of additional social identities beyond socioeconomic status and gender (for example, race, ethnicity, sexual identity and disabilities) influence choice-based and necessity-based physical activity and impact physical activity security warrants increased attention. The range of dates when the WHO STEPS data used in this analysis across 68 countries were collected spans a full decade (2008–2019), with all data used for this analysis corresponding to the pre-COVID-19 pandemic period. The self-reported nature of the WHO STEPS data may lead to overestimations of physical activity, but this method also allows differentiation by domain. Additionally, some of the epidemiological studies assessing the associations of physical activity with infectious disease outcomes referred to in this paper had issues related to study design, selection bias and timing/period effects associated with the multiple challenges in conducting this type of research during the COVID-19 pandemic. It is important to underscore, however, that despite these research limitations, the associations of physical activity and COVID-19 outcomes are likely to be real because the totality of evidence indicates the following: consistency of findings across studies of different designs and in different countries; existence of plausible biological mechanisms underpinning physical activity and improved immune function; and clear evidence from clinical trials showing that physical activity improves many of the risk factors for COVID-19-related outcomes. Likewise, shortcomings of the studies reporting on the association between physical activity and depression include insufficient blinding and suboptimal randomization in RCTs and lack of diverse study populations. Finally, our summary of the key findings of the field of physical activity and cancer epidemiology focuses on highlighting the most robust and consistent findings, yet 'cancer' is a broad term used to refer to over 100 distinct diseases with the commonality of uncontrolled cell growth. The mechanisms by which physical activity may or may not influence the development and/or management of different types of cancer vary substantially and, in many cases, remain unknown.

Despite its diverse benefits, the medical and public health fields continue to view physical activity as mostly relevant for obesity and cardiometabolic disease. Most discussions of physical activity lack differentiation between physical activity occurring in safe and supportive conditions versus activities driven by economic necessity and done in suboptimal, potentially risky and sometimes unhealthy conditions. Our summary of decades of research on the benefits of physical activity for immunity, mental health and cancer sheds light on the public health relevance of physical activity for multiple complex public health issues. Likewise, our reconceptualization of physical activity for public health as that which is supportive of holistic health and wellbeing, emphasizing physical activity that is safe, non-economically coercive and dignified (that is, primarily choice based), builds upon recent studies on the physical activity paradox hypothesis, with findings suggesting that active labor may not convey the same degree of physical health benefits as active leisure and may even have detrimental health effects for some population groups[65–68]. Beyond the physical activity paradox, which, to date, has primarily focused on the physiological health outcomes (cardiovascular and all-cause mortality) of occupational physical activity and which some have questioned[69], our proposed reconceptualization adds an ethical dimension to the differentiation of physical activity domains when assessing their contributions to health and wellbeing (including physical, mental and social wellbeing), health equity and social justice. The need for this reconceptualization is supported by a novel global inequalities analysis, which, to our knowledge, is the first to apply an intersectionality approach to a large, multinational, domain-specific physical activity dataset. Notably, this proposed reconceptualization aligns with other recent calls to move away from purely physiological definitions of physical activity and toward more holistic approaches that conceptualize health within its biosocial context[70]. Although this reconceptualization diverts from the WHO's Global Action Plan on Physical Activity (GAPPA)[71] message that 'every move counts', there are multiple aligned elements that can support the development of an updated global action plan for physical activity promotion. Points of convergence include GAPPA's emphasis on (1) increasing awareness and appreciation for the multiple health benefits of physical activity; (2) the importance of providing people with opportunities for enjoyable physical activity; (3) the need to increase access to environments that facilitate healthy choices through active leisure and transport; and (4) the importance of safe, inclusive and contextually appropriate physical activity opportunities for all[71]. The evidence presented in this and the other series papers[48,49] provides a strong basis for harnessing the full human, societal and planetary potential of physical activity by positioning it as a key element of a broad, integrative 21st century global public health agenda.

Online content

Any methods, additional references, Nature Portfolio reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at https://doi.org/10.1038/s41591-026-04237-5.

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Deborah Salvo[1,2]✉, Inacio Crochemore-Silva[3], Andrea Wendt[4], Jakob Tarp[5], Eric J. Shiroma[6], Richard J. Simpson[7], I-Min Lee[8], Ulf Ekelund[5,9], Ester Cerin[10,11], Youssouf Keita[12], Adrian Bauman[13], Pedro C. Hallal[14], Andrea Ramirez Varela[15,16,17,18], Michael Pratt[19], Rodrigo Reis[20], Erica Hinckson[21], Ding Ding[14,22], Harold W. Kohl III[1,15] & James Sallis[19]

[1]People, Health, and Place Lab, Department of Kinesiology and Health Education, College of Education, The University of Texas at Austin, Austin, TX, USA. [2]Center for Research to Community Impact, College of Education, The University of Texas at Austin, Austin, TX, USA. [3]Postgraduate Program in Epidemiology, and Postgraduate Program in Physical Education, Federal University of Pelotas, Pelotas, Brazil. [4]Graduate Program in Health Technology, Pontifícia Universidade Católica do Paraná, Curitiba, Brazil. [5]Oslo Research Centre for Physical Activity and Population Health, Department of Sport Medicine, Norwegian School of Sport Sciences, Oslo, Norway. [6]Division of Cardiovascular Sciences, National Heart, Lung, and Blood Institute, Bethesda, MD, USA. [7]School of Nutritional Sciences and Wellness; Department of Pediatrics; Department of Immunobiology, The University of Arizona, Tucson, AZ, USA. [8]Division of Preventive Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA. [9]Department of Chronic Diseases, Norwegian Public Health Institute, Oslo, Norway. [10]Mary MacKillop Institute for Health Research, Australian Catholic University, Melbourne, Victoria, Australia. [11]School of Public Health, Li Ka Shing Faculty of Medicine, The University of Hong Kong, Hong Kong SAR, China. [12]Global Financing Facility, World Bank, Bamako, Mali. [13]The Charles Perkins Centre, The University of Sydney, Camperdown, New South Wales, Australia. [14]Department of Kinesiology and Community Health, University of Illinois at Urbana-Champaign, Urbana, IL, USA. [15]Department of Epidemiology, The University of Texas Health Science Center at Houston (UTHealth) School of Public Health, Houston, TX, USA. [16]Department of Pediatrics, McGovern Medical School, The University of Texas Health Science Center at Houston (UTHealth), Houston, TX, USA. [17]Center for Health Promotion and Prevention Research, Center for Health Equity, The University of Texas Health Science Center at Houston (UTHealth), Houston, TX, USA. [18]Institute for Implementation Science, The University of Texas Health Science Center at Houston (UTHealth), Houston, TX, USA. [19]Herbert Wertheim School of Public Health and Human Longevity Science, University of California San Diego, La Jolla, CA, USA. [20]People Health and Place Unit, Prevention Research Center, Brown School, Washington University in St. Louis, St. Louis, MO, USA. [21]School of Sport and Recreation, Auckland University of Technology, Auckland, New Zealand. [22]Sydney School of Public Health, Faculty of Medicine and Health, The University of Sydney, Camperdown, New South Wales, Australia. ✉e-mail: dsalvo@austin.utexas.edu

 https://doi.org/10.1038/s41591-026-04237-5

Methods

Analysis of global domain-specific socioeconomic and gender-based physical activity inequalities

We analyzed surveys from the WHO STEPS[13] program to describe pre-pandemic socioeconomic inequalities in leisure time, transport-related and occupational physical activity. STEPS provides a framework and approach to strengthen comparable and standardized surveillance of core information on NCDs, including physical activity. Population-based household surveys are coordinated and implemented at the country level by ministry of health officials, and the WHO provides technical and resourcing support. STEPS surveys usually include between 5,000 and 6,000 participants, enabling countries to generate strata-specific estimates. These surveys are based on face-to-face interviews conducted by trained interviewers[13,72].

The present analysis included the most recent survey of each country, and the estimates were generated for participants 18–69 years of age. Subnational surveys and surveys lacking information on sample weights were excluded. Physical activity was assessed based on the Global Physical Activity Questionnaire (GPAQ)[73], which collects the frequency, duration and intensity of physical activity performed during at least 10 consecutive minutes in three distinguished domains: leisure time, transport (walking and cycling to get to and from places) and occupation (paid or unpaid). Codes provided by the WHO STEPS program were implemented in sample weighting and to generate physical activity indicators according to the current guidelines. Therefore, domain-specific prevalence of meeting WHO physical activity guidelines was based on the proportion of participants reaching 600 METs per week, which is equivalent to at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity physical activity per week (or any corresponding combination of the two)[12]. Leisure time, transport and work-related physical activity were specifically addressed in the main set of analyses, and overall physical activity combining all domains was also calculated.

Data disaggregation and inequality dimensions. We estimated the prevalence of active leisure, transport and labor according to gender (men/women) and educational levels (none, primary, secondary and tertiary) as a proxy of socioeconomic status. These analyses were made feasible through a harmonization process of variable categories included in this study. Using participants' report of their highest level of educational attainment, each was categorized as having attained the following: no formal education; primary education level (including less than primary/elementary school or primary/elementary school completed as well as those with complete primary/elementary schooling but incomplete secondary schooling); secondary education level (secondary/high school or secondary technical/trade schooling completed); and higher education (anyone with some college/university, whether complete or incomplete, and including those with a graduate degree or specialization). When country-specific situations were encountered not allowing to clearly differentiate among the four harmonization categories, a meticulous case-by-case examination of the country's educational structure was performed by consulting official online sources and, when feasible, direct country contacts. For example, in Bahamas, technical education and professional education are considered secondary education (high school level). In Togo, secondary education includes what they denominate as lower secondary, upper secondary, technical and vocational education. In Zambia, both junior secondary school and secondary higher school are considered secondary education.

Additionally, we performed a double stratification of sex and education to apply an intersectional approach in the analysis. By combining these dimensions, we derived eight new categories: men with no education, men with primary education, men with secondary education, men with tertiary education, women with no education, women with primary education, women with secondary education and women with tertiary education.

Formal inequality measures. To assess gender inequality, we presented the absolute difference in physical activity prevalence between men and women, expressed in percentage points. This summary measure of inequality is indicated when the dimension used is a binary variable[5]. These calculations, along with their corresponding 95% confidence intervals, were derived with the post-estimation command 'lincom' in Stata. The difference ranges from −100 to +100, with positive values denoting a higher prevalence of physical activity among men, negative values indicating a higher prevalence among women and zero representing equality. Consequently, differences with a 95% confidence interval encompassing zero were deemed statistically non-significant.

Socioeconomic inequality was analyzed using the SII, which is an absolute and complex measure expressed in percentage points, indicated to be employed when the dimension of inequality is an ordinal variable[74]. In brief, the SII was initially developed based on linear regression, but, currently, it can be calculated using logistic regression, which is more suitable for coverage/prevalence indicators[74]. The SII ranges from −100 to +100, with positive values indicating a higher prevalence among individuals with higher levels of education and negative values indicating a higher prevalence among those with lower levels of education. Zero indicates equality in this case, and SII values with a 95% confidence interval including zero were considered statistically non-significant.

Finally, to express the inequality among the combined variable (sex and socioeconomic level), the same abovementioned analytical approach to calculate the absolute difference was implemented to compare men with the highest education level and women with the lowest education level.

Pooled estimates according to income classification of countries. Data presented in the 'Results' section of this article include only pooled estimates by income group according to the World Bank (low, lower middle, upper middle and high income)[75]. In this regard, the units of analysis were the countries, and we estimate the median of physical activity prevalence for each inequality dimension using quantile regression. Confidence intervals were estimated using the bootstrap method with 100 resampling iterations. The same approach was applied to calculate pooled absolute differences and SII.

Pooled inequality measures were calculated considering only countries with at least 20 individuals in the categories used to each calculation. This approach resulted in the inclusion of 48 countries for calculating the pooled median difference for double stratification.

The data were predominantly presented in equiplots, a chart that facilitates visual inspection of inequalities. In these plots, dots represent the prevalence of physical activity corresponding to each category of the inequality dimension, and lines indicate the absolute distance between extreme categories.

Ethical approval was not sought for this study as it relied exclusively on deidentified, publicly available data.

Review of the evidence of the effects of physical activity on immunity and infectious disease

A critical summary of the known biological pathways and mechanisms through which physical activity enhances immunity was drafted by R.J.T. and critically reviewed by D.S., E.C. and U.E. These include (1) increased immune surveillance, (2) immune system remodeling and (3) inflammation reduction. As part of this review, a glossary of basic immunology terms for a broad public health audience was developed (see the Supplementary Information for the glossary and a full critical summary).

Additionally, a narrative review of the literature of the epidemiological evidence for the associations between physical activity and COVID-19-related outcomes was conducted, given that the recent pandemic provided a considerable increase in the amount of epidemiological evidence available demonstrating the role of physical activity for infectious disease prevention and control. This process involved two main stages: (1) searching and identifying high-quality existing reviews and meta-analyses and (2) supplementing with original research articles published since the latest high-quality existing review. Three investigators (I.M.L., J.T. and E.J.S.) independently searched PubMed/MEDLINE for English language, peer-reviewed systematic reviews and meta-analyses that examined the relationship between pre-COVID physical activity levels and COVID-19-related outcomes. No time or date restrictions were used during the search, but the search criteria, as defined by our search terms, helped ensure that only systematic review articles published within the context and timeline of the COVID-19 pandemic (that is, as of 2020) were included. The search was last updated in August 2023. Outcomes of interest included COVID-19 infection, hospitalization/intensive care unit, severity, post-COVID condition (PCC, 'long COVID', or post-acute sequelae of SARS-CoV-2 (PASC)) and related mortality. The largest, most recent systematic review and meta-analysis identified at the time of the search was a meta-analysis of 16 studies of more than 1.8 million individuals by Ezzatvar et al.[31]. The investigators searched for original articles published since the review using the same search terms as listed in Ezzatvar et al., augmenting the terms list with 'long COVID', 'post-COVID condition (PCC)' and 'post-acute sequelae of SARS-CoV-2 (PASC)', and for articles that reference Ezzatvar et al. The Supplementary Information includes a critical appraisal of the evidence identified through this review as well as a detailed summary of study limitations and recommendations for improving epidemiological research on physical activity and infectious disease.

Ethical approval was not sought for this study as no human subjects or animal data were collected or employed, given that this was a review of published peer-reviewed literature.

Review of the evidence of the effect of physical activity on depression

We conducted a narrative review to identify and summarize the most relevant epidemiological evidence of the associations between physical activity and depression, including incident depression (that is, examining preventive effects) and outcomes among individuals diagnosed with depression (that is, examining treatment effects). The review included the effects of physical activity on clinical depression as well as on depressive symptoms and was conducted in three main stages: (1) a PubMed search using standardized search terms; (2) among search results, a selection of recent, high-quality meta-analyses focused on general populations (versus clinical populations, country-specific populations, etc.) was identified, including those restricted to summarizing findings from RCTs (for studies examining physical activity as a treatment for depression) and prospective cohort studies (for studies exploring physical activity as a preventive factor for developing depression); and (3) a summary of key methods and takeaways from the selected recent, high-quality meta-analyses. One investigator (D.S.) searched PubMed/MEDLINE for English language, peer-reviewed systematic reviews and meta-analyses that examined the relationship between physical activity and depression. D.S. and two additional investigators (J.T. and E.S.) helped identify the selection of recent, high-quality meta-analyses to highlight when summarizing the state of the science. No time or date restrictions were used during the search. The search was last updated in May 2024. We searched for articles including the following: (1) a 'physical activity' term in the title ('physical activity' OR exercis*), (2) a 'depression' term in the title (depression OR 'depressive symptoms') and (3) a 'meta-analysis' term in the title (meta-analysis OR 'meta analysis').

Ethical approval was not sought for this study as no human subjects or animal data were collected or employed, given that this was a review of published peer-reviewed literature.

Review of the evidence of the effect of physical activity on cancer

A narrative review of the literature of the epidemiological evidence for the associations between physical activity and cancer incidence and survival (mortality) was conducted. This process involved two main stages: (1) searching and identifying high-quality reviews and meta-analyses and (2) supplementing with information from high-quality narrative or umbrella reviews, if available, and from high-quality original research papers published since the last high-quality review. D.S. searched PubMed/MEDLINE for English language, peer-reviewed systematic reviews and meta-analyses that examined the relationship of physical activity and cancer prevention and control. The review was limited to systematic reviews and meta-analyses published in the past decade. The search was last updated in October 2025. Outcomes of interest included cancer incidence, cancer survival (including both all-cause mortality among people diagnosed with cancer and cancer-specific mortality) and additional survivorship-related outcomes (for example, mental health and quality of life, among people living with cancer). Given the large number of systematic review and meta-analyses on the associations between physical activity and cancer and cancer-related outcomes, our review focused only on reviews about all cancers versus on reviews focused on site-specific cancers. The Supplementary Information includes a critical appraisal of the evidence identified through this review and a summary of study limitations and recommendations for future research on physical activity and cancer.

Ethical approval was not sought for this study as no human subjects or animal data were collected or employed, given that this was a review of published peer-reviewed literature.

Ethics and inclusion

Acknowledging that 84% of the population of the world resides in LMICs and that most physical activity research stems from high-income countries and, as such, is shaped by research priorities, questions, methods and interpretations that may not be relevant to the reality of those in the 'majority world', we sought to include a globally diverse team of investigators, including a female, Latin American (Mexican) first author and multiple co-authors from other LMICs, including from other Latin American countries, Africa and Asia, in conjunction with leading experts from North America, Europe and Australia.

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Data availability

The data used for the global analysis of domain-specific physical activity inequalities are publicly available from the WHO STEPS dataset[13]. All other data resulting from the different narrative and scoping reviews conducted as part of this work are available in the Supplementary Information.

Code availability

The code used for the global analysis of domain-specific physical activity inequalities presented in this paper is available at https://github.com/dsalvolab/pa-inequalities.

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Acknowledgements

D.D. is funded by the Australia National Health and Medical Research Council (Investigator Grant 2009254), the NSW Ministry of Health (Early-Mid Career Researcher Grant G212775) and the Ian Potter Foundation (Public Health Grant). I.C.-S. is funded by the Brazilian National Research Council (CNPQ) and the Rio Grande do Sul State Research Support Foundation (FAPERGS), Brazil (grant number 21/2551-0000670-6, ARD 10/2020). The funders had no role in the design, implementation, analysis and write-up of the study. No other authors received funding to support this work. The views expressed in this paper are those of the authors and do not necessarily represent the views of the National Heart, Lung, and Blood Institute, the National Institutes of Health or the US Department of Health and Human Services or of any of the institutions with which authors are affiliated or employed. We thank L. I. C. Ricardo (Medical Research Council Epidemiology Unit, University of Cambridge, Cambridge, UK) and V. Hernandez Botelho (Postgraduate Program in Epidemiology, Federal University of Pelotas, Pelotas, Brazil) for their support with dataset harmonization for the global physical activity inequalities analysis. We thank C. Borges (Postgraduate Program in Epidemiology, Federal University of Pelotas, Pelotas, Brazil) for her help with figure preparation and design. We thank A. A. de Paula da Silva, H. Mai, A. Messineo and E. Resendiz for their support with data cleaning and abstraction tasks for the systematic scoping reviews. We thank J. Mejía-Grueso for her support assembling and formatting the Supplementary Information file. We dedicate this paper to the late Harold W. (Bill) Kohl III, co-author of this work, who passed away during the completion of the manuscript. We thank him for his unwavering support for this work and for his immeasurable contributions to the field of physical activity and public health.

Author contributions

D.S. conceptualized the manuscript and led all aspects of the work, including supervision, visualization, investigation, methodology and writing of the original draft, and conducted the systematic reviews for the mental health and cancer sections of the manuscript. I.C.-S. led the inequalities analysis, including supervision, data curation, formal analysis, investigation, methodology, visualization and writing sections for the original draft. A.W. contributed to data curation, formal analysis, methodology, visualization and writing (review and editing). J.T. contributed to literature search, interpretation, critical appraisal of the literature and writing original draft sections for the section on the epidemiological evidence of the associations of physical activity with infectious disease. R.S. conducted the critical summary of the evidence on the pathways and mechanisms by which physical activity enhances immunity, contributing to literature search, interpretation, critical appraisal of the literature and writing (original draft sections). I.-M.L. contributed to overall paper conceptualization, interpretation and writing (review and editing), supporting the work for the review of the epidemiological evidence of the associations of physical activity with infectious disease. U.E. and E.C. contributed to interpretation, critical appraisal and writing (review and editing), supporting the critical summary of the evidence of the pathways and mechanisms by which physical activity enhances immunity. Y.K. contributed to literature search, interpretation and critical appraisal of the literature and writing original draft sections for the interpretation of the inequalities analysis through a global equity, social justice and intersectionality lens. A.B., P.H., A.R.V., R.R. and M.P. contributed to interpretation and writing (review and editing). H.W.K. contributed to conceptualization, interpretation and writing (original draft). J.S. contributed to conceptualization, interpretation and writing (original draft). All others critically reviewed all sections of the manuscript and provided their approval of the final draft.

Competing interests

The authors declare no competing interests.

Additional information

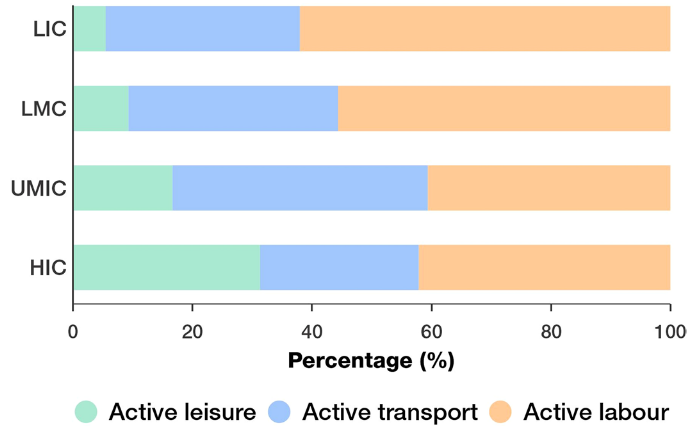
Extended data is available for this paper at https://doi.org/10.1038/s41591-026-04237-5.

Supplementary information The online version contains supplementary material available at https://doi.org/10.1038/s41591-026-04237-5.

Correspondence and requests for materials should be addressed to Deborah Salvo.

Peer review information *Nature Medicine* thanks Verity Cleland and the other, anonymous, reviewer(s) for their contribution to the peer review of this work. Peer reviewer reports are available. Primary Handling Editor: Liam Messin, in collaboration with the *Nature Medicine* team.

https://doi.org/10.1038/s41591-026-04237-5



Extended Data Fig. 1 | Relative contribution of active leisure, active travel, and active labour, to overall physical activity by country-income categories. Percentage (%) of overall physical activity corresponding to active leisure, active transport, and active labour, by World Bank country-income categories (LIC: low-income countries; LMC: lower middle-income countries; UMIC: upper middle-income countries; HIC: high-income countries) (source data: WHO STEPS, n = 68 countries, data date range: 2008-2019).

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Corresponding author(s): Deborah Salvo

Last updated by author(s): Jan 16, 2026

Reporting Summary

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☒	☐	For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings
☒	☐	For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes
☒	☐	Estimates of effect sizes (e.g. Cohen's *d*, Pearson's *r*), indicating how they were calculated

Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	We did not collect data as part of this study.
Data analysis	Data analysis was conducted using Stata (StataCorp. 2025. Stata Statistical Software: Release 19. College Station, TX: StataCorp LLC.). Our code is available at: https://github.com/dsalvolab/pa-inequalities

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Portfolio guidelines for submitting code & software for further information.

Data

Policy information about availability of data

All manuscripts must include a data availability statement. This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

The data utilized for the global analysis of domain-specific physical activity inequalities are publicly available from the WHO STEPS dataset (reference: his is a secondary datanalysis of publicly available WHO STEPS data: World Health Organization. STEPwise approach to NCD risk factor surveillance (STEPS). https://

www.who.int/teams/noncommunicable-diseases/surveillance/systems-tools/steps). All other data resulting from the different narrative and scoping reviews conducted as part of this work is available in the Online Supplement.

Research involving human participants, their data, or biological material

Policy information about studies with human participants or human data. See also policy information about sex, gender (identity/presentation), and sexual orientation and race, ethnicity and racism.

Reporting on sex and gender	The analysis and findings in this paper pertain to gender and are reported as such.
Reporting on race, ethnicity, or other socially relevant groupings	We do not report on race or ethnicity, but do report on socioeconomic status, assessed using educational attainment as a proxy. A meticulous harmonization process took place, and is described in the Methods section, for calculating this variable.
Population characteristics	All data used in this secondary analysis is from adult participants, but specific age values were not used in the analysis, nor were other variables beyond gender and socioeconomic status (educational attainment) employed, as described above.
Recruitment	No primary data collection or recruitment took place. This is a secondary data analysis.
Ethics oversight	This study is exempt for ethics board approval as it is a secondary data analysis of publicly available, de-identified data from WHO.

Note that full information on the approval of the study protocol must also be provided in the manuscript.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☐ Life sciences ☒ Behavioural & social sciences ☐ Ecological, evolutionary & environmental sciences

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Behavioural & social sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	Quantitative, survey-based data of self-reported physical activity, self-reported gender, and self-reported educational attainment, from the WHO STEPS dataset.
Research sample	Representative samples of free-living adults from the WHO STEPS dataset across 68 countries.
Sampling strategy	This is a secondary data analysis, so our research team is not in charge of the sampling protocol. However, briefly, the WHO STEPS data derive from nationally representative surveys that use a multistage, clustered-random sampling protocol standardized across participating countries.
Data collection	Again, our team was not involved in data collection activities and only used secondary data from WHO STEPS. Briefly, WHO works through the Ministries of Health of affiliated countries and through their corresponding national health surveillance systems for collection of the data.
Timing	We did not collect the data ourselves, as this is a secondary data analysis. However, WHO reports that the WHO STEPS data we utilized were collected between 2008 and 2019.
Data exclusions	This is a secondary data analysis. Only data from countries reporting domain-specific physical activity estimates, with gender and educational attainment data were included. Subnational surveys and surveys lacking information on sample weights were excluded from our analysis. Our analysis is based on data from 68 countries out of the original 122 countries that participated in STEPS.
Non-participation	We did not collect primary data for this study, so this is a non-applicable item.
Randomization	Non-applicable.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

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☒	☐ Animals and other organisms
☒	☐ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Plants

Seed stocks	Non-applicable
Novel plant genotypes	Non-applicable
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