



Burden of Diseases Attributable to Low Physical Activity in the Middle East and North Africa: an Analysis Based on Global Burden of Disease Study

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Background: Research on low physical activity (LPA) in the Middle East and North Africa (MENA) region remains limited.

Aims: To assess the disease burden associated with LPA using data from the Global Burden of Disease (GBD) study.

Study Design: Longitudinal epidemiological study.

Methods: GBD 2021 data were used to extract information on the burden of eight LPA-related conditions-breast cancer, chronic kidney disease, colorectal cancer, diabetes mellitus (DM), ischemic heart disease, lower extremity peripheral arterial disease, stroke, and tuberculosis-analyzed by age group, sex, country within MENA, and year (1990-2021).

Results: The age-standardized disability-adjusted life year (DALY) rate for LPA-related diseases in MENA declined by 8.62%, from 431.84 per 100,000

people in 1990 to 394.64 per 100,000 in 2021. In 2021, Sudan (846.47 per 100,000), Iraq (630.29 per 100,000), and Afghanistan (626.88 per 100,000) recorded the highest age-standardized DALY rates. Across all age groups, females had higher DALY rates than males in both 1990 and 2021.

Conclusion: Despite a recent decline, the MENA region continues to experience a greater LPA-attributable disease burden than the global average. The increasing contribution of DM and breast cancer highlights evolving trends, emphasizing the need for targeted interventions such as lifestyle promotion and improved access to health facilities.

INTRODUCTION

Low physical activity (LPA) is a key modifiable risk factor for non-communicable diseases (NCDs), including cardiovascular diseases (CVDs), diabetes, and certain cancers such as colon and breast cancer, as well as mental health disorders.¹⁻³ Research has shown

that regular physical activity has a protective effect against stroke and ischemic heart disease (IHD).⁴ Additionally, studies have reported a positive association between LPA and specific cancers, including renal cancer, bladder tumors, breast cancer, and colorectal cancer, with many cases potentially preventable through regular physical activity.^{5,6} Globally, insufficient physical activity is a major contributor



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to morbidity, mortality, and premature death, leading to substantial socioeconomic costs.⁷ The global age-standardized prevalence of insufficient physical activity rose to approximately 30% in 2022, increasing from 23.4% in 2000 and 26.4% in 2010.⁸ A 2021 population-based prevalence study estimated that LPA accounted for 7.2% of all-cause mortality and 7.6% of CVD-related deaths worldwide.⁷ The concerning global rise in LPA highlights the urgent need for targeted interventions to promote physical activity.

Although LPA is a global issue, its impact is particularly significant in the Middle East and North Africa (MENA) region, where distinct socioeconomic and environmental factors contribute to its high prevalence. In this region, approximately 47% of adults and 78% of adolescents do not engage in sufficient physical activity.⁹ The increasing burden of NCDs in MENA is further aggravated by rising obesity and diabetes rates, which are linked to sedentary lifestyles. Notably, individuals aged 40-60 are at a higher risk of developing diabetes due to these lifestyle factors, posing major public health challenges.¹⁰ The concern surrounding LPA is heightened by the growing incidence of LPA-associated cancers associated in the region, particularly in Arab countries.¹¹

Several sociocultural and environmental factors make physical activity patterns in MENA a priority for public health intervention. Unlike many Western countries, where active commuting and outdoor exercise are common, the hot climate in much of MENA discourages outdoor physical activity for much of the year.¹² Gender norms such as the expectation that women be accompanied in public spaces and the lack of gender-segregated fitness facilities, further limit physical activity among women in the region.¹³ Additionally, restricted access to public recreational spaces, inadequate pedestrian-friendly infrastructure, and a reliance on car-based transportation discourage daily physical activity.¹⁴ Moreover, rapid urbanization, technological advancements, improved transportation infrastructure, and economic growth have contributed to increasing sedentary lifestyles and LPA in the region.¹⁵ Key barriers to adequate physical activity in MENA include a shortage of sports facilities, limited social support, cultural and gender norms, and unfavorable weather conditions. LPA is also more prevalent among specific demographic groups, including older adults, women, and individuals with lower educational attainment.¹⁶ The socioeconomic impact of LPA in this region is substantial, as the rising prevalence of NCDs places a growing burden on healthcare systems and economies.¹⁷ These factors underscore the need for further research on LPA and its consequences in MENA.

The diverse sociocultural, environmental, and economic factors in the MENA region highlight the need for localized data to implement targeted interventions.¹⁸ However, despite global recognition of LPA as a significant health risk, there is a lack of region-specific data on LPA and its associated disease burden in MENA.¹³ To develop effective, evidence-based interventions, it is crucial to collect gender-stratified data for adult and youth populations in this region.¹⁹ This data is essential for understanding LPA trends and informing resource allocation and program development.²⁰ Without a comprehensive assessment of the burden attributable to LPA, policymakers face challenges in formulating effective strategies to

reduce its impact.²¹ Addressing this gap is critical, as inaction may lead to rising healthcare costs, worsening health outcomes, and an increasing burden of LPA-related diseases in the region.

Due to the limited research on LPA in the MENA region, this study aimed to assess the disease burden associated with LPA using data from the Global Burden of Disease (GBD) database to estimate its health impact. Specifically, this study addresses the following research question: What is the extent of the disease burden attributable to LPA in the MENA region? It is hypothesized that the burden of LPA-related diseases in MENA is disproportionately high due to regional sociocultural and environmental factors that contribute to physical inactivity. By quantifying this burden, the study provides valuable insights to support evidence-based public health policies and enhance health outcomes in the MENA region.

MATERIALS AND METHODS

Overview

This study utilized data from GBD 2021, conducted by the Institute for Health Metrics and Evaluation, which evaluated the burden of 288 diseases and 88 risk factors across 204 countries from 1990 to 2021. The methodological details of GBD 2021 have been described previously.^{22,23} Data were extracted on the burden of eight conditions attributable to LPA, including breast cancer, chronic kidney disease, colorectal cancer, diabetes mellitus (DM), IHD, lower extremity peripheral arterial disease, stroke, and tuberculosis, at the global level, within the MENA region, and across individual MENA countries. These countries include Afghanistan, Algeria, Bahrain, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, Türkiye, the United Arab Emirates, and Yemen.

Ethics

This study utilized the GBD database for secondary data analysis. No participants were directly involved, and no individual data were collected. In accordance with ethical guidelines, the dataset is publicly available and does not contain personally identifiable information; therefore, informed consent was not required. The study protocol was approved by the Ethics Committee of the Iran University of Medical Sciences (approval number: IR.IUMS.REC.1403.909).

Definition of condition and modeling strategy

In the GBD study, the disease burden attributable to LPA was assessed for individuals aged 25 years and older. Total physical activity levels were determined based on the intensity, frequency, and duration of activities lasting at least 10 min across all domains, including leisure, work, household, and transportation. LPA activity was defined as a total physical activity of less than 3600 to 4400 metabolic equivalent (MET)-minutes per week. Estimates were derived from self-reported surveys conducted using random sampling. The primary tools used to assess physical activity were the Global Physical Activity Questionnaire (GPAQ) and the International Physical Activity Questionnaire (IPAQ).^{22,24,25} However, studies

employing other instruments that evaluated intensity, frequency, and duration across all physical activity domains were also included. Physical activity levels were categorized into four groups: inactive (< 600 MET-min/week), low activity (600-3999 MET-min/week), moderately active (4000-7999 MET-min/week), and highly active (\geq 8000 MET-min/week).²²

A systematic literature review was conducted on December 31, 2019, to identify prospective studies examining the association between LPA-considering activity duration and frequency and the risk of breast cancer, colorectal cancer, DM, IHD, and stroke. For chronic kidney disease, lower extremity peripheral arterial disease, and tuberculosis, the link to LPA was mediated through high fasting plasma glucose. In other words, the GBD study indirectly estimated the burden of these conditions attributable to LPA by assessing the disease burden caused by elevated fasting plasma glucose resulting from LPA. Since self-reported physical activity levels may be biased and subject to measurement errors,^{22,26} an adjustment factor was applied to questionnaire data to estimate accelerometer-adjusted physical activity levels. To determine this adjustment factor, the GBD study conducted a systematic review to identify studies that examined the relationship between self-reported physical activity levels (measured by GPAQ or IPAQ) and accelerometer-measured physical activity.^{22,27-29} This review identified 15 studies, which were used in the meta-regression-Bayesian, regularized, trimmed (MR-BRT) model to estimate the log difference between the two measurement methods. The resulting accelerometer-adjusted physical activity values were then incorporated into the spatiotemporal Gaussian process regression model, the preferred method for age-stratified data, to estimate physical activity levels across genders, age groups, countries, and years. The primary predictors for estimating physical activity levels (MET-min/week) were the proportion of individuals employed in agriculture and the number of four-wheeled vehicles per capita, with super-region, region, and country-level random intercepts included for model fitting. MR-BRT was then used to model the non-linear dose-response relationship between LPA and breast cancer, colorectal cancer, DM, IHD, and stroke. The model was adjusted for potential study-level confounders, such as whether a washout period was included, whether data were sourced from self-reports or administrative records, and adjustments for factors including sex, age, smoking status, educational level, income, and body mass index (BMI). BMI was specifically used to adjust the physical activity-breast cancer model, as it was the only model where BMI significantly introduced bias.²²

Indexes

We extracted LPA-attributable death and disability-adjusted life year (DALY) rates, along with age-standardized rates per 100,000 people where applicable, across different age groups, sex, countries, years (1990-2021), and diseases. For each value, the corresponding 95% uncertainty interval (UI) (95% UI) was also obtained. All estimated burdens represent the mean of 500 drawn estimations, with the 95% UI reflecting the 2.5th and 97.5th percentiles of those draws.²² Additionally, we extracted sociodemographic index (SDI) values for each country, the MENA region, and the world from 1990 to 2021. SDI is calculated based on income per capita, fertility rate, and

educational attainment, ranging from 0 to 1, with higher values indicating better socioeconomic status.³⁰

Statistical analysis

Data analysis and visualization were conducted using R version 4.4.2, employing the ggplot2, tidyverse, tidyr, dplyr, stringr, and map packages. The proportion of each disease burden attributable to LPA was calculated by dividing the age-standardized DALY rate attributable to LPA by the total age-standardized DALY rate for that disease. To analyze the relationship between the LPA-attributable age-standardized DALY rate for each condition (as well as the total rate) and the SDI of MENA countries over time, locally estimated scatterplot smoothing (LOESS) regression was applied with a smoothing parameter of 0.3. LOESS regression was chosen due to its widespread use in GBD studies for assessing the association between SDI and disease burden, allowing comparisons with previous research. Additionally, this method enabled the examination of the relationship between LPA-attributable disease burden and SDI without relying on prior assumptions.^{31,32}

RESULTS

Between 1990 and 2021, the age-standardized DALY rate of diseases attributable to LPA in the MENA region declined by 8.62% (95% UI, -18.91 to -2.75), decreasing from 431.84 to 394.64 per 100,000 people (Table 1). In 1990, IHD had the highest age-standardized DALY rate attributable to LPA (178.23 per 100,000 people; 95% UI, 79.81 to 272.61). However, by 2021, DM had surpassed other conditions, with the highest age-standardized DALY rate attributable to LPA (139.58 per 100,000 people; 95% UI, 60.62 to 219.11). Unlike other conditions, the age-standardized DALY rates of DM (67.63%; 95% UI, 48.2 to 87.34), breast cancer (63.04%; 95% UI, 39.19 to 88.99), and colorectal cancer (0.14%; 95% UI, -16.35 to 22) attributable to LPA increased from 1990 to 2021. The largest reductions in age-standardized DALY rates attributable to LPA during this period were observed for tuberculosis (-65.87%; 95% UI, -74.74 to -52.15), stroke (-31.36%; 95% UI, -43.48 to -19.16), and IHD (-29.63%; 95% UI, -39.64 to -18.84). In both 1990 and 2021, LPA contributed the highest percentage of the age-standardized DALY rate for DM among all conditions, whereas tuberculosis had the lowest proportion. Table 2 presents the percentage of the disease burden attributable to LPA in the MENA region for 1990 and 2021.

In both 1990 and 2021, the age-standardized DALY rate of diseases attributable to LPA was higher in the MENA region than the global average (Figure 1). In 1990, Sudan (1027.34 per 100,000), Bahrain (692.78 per 100,000), and Qatar (650.78 per 100,000) had the highest age-standardized DALY rates attributable to LPA, while Tunisia (195.31 per 100,000), Libya (278.76 per 100,000), and Iran (316.63 per 100,000) had the lowest. By 2021, Sudan (846.47 per 100,000), Iraq (630.29 per 100,000), and Afghanistan (626.88 per 100,000) had the highest rates, whereas Tunisia (210.71 per 100,000), Iran (250.63 per 100,000), and Türkiye (262.88 per 100,000) had the lowest (Figure 2). The largest reductions in the age-standardized DALY rate attributable to LPA were observed in Lebanon (-28.3%), Jordan (-27.83%), and Qatar (-23.46%), while the largest increases

TABLE 1. Burden of Diseases Attributable to Low Physical Activity in the Middle East and North Africa in 1990 and 2021.

Cause	Age-standardized DALY rate (95% UI)			Age-standardized death rate (95% UI)		
	1990	2021	Percentage change	1990	2021	Percentage change
Breast cancer	3.47 (0.69-6.24)	5.66 (1.19-10.19)	63.04 (39.19-88.99)	0.11 (0.02-0.2)	0.19 (0.04-0.34)	70.83 (49.31-95.57)
Chronic kidney disease	19.95 (7.59-37.5)	19.91 (7.13-35.62)	-0.2 (-34-25.59)	0.96 (0.35-1.82)	0.94 (0.35-1.68)	-2.26 (-38.98-27.32)
Colon and rectum cancer	16.02 (10.02-22.3)	16.05 (9.92-22.05)	0.14 (-16.35-22)	0.77 (0.48-1.06)	0.79 (0.5-1.1)	2.81 (-14.07-24.56)
Diabetes mellitus	83.27 (35.75-128.41)	139.58 (60.62-219.11)	67.63 (48.2-87.34)	2.91 (1.23-4.45)	3.56 (1.54-5.5)	22.43 (3.16-40.3)
Ischemic heart disease	178.23 (79.81-272.61)	125.43 (57.53-196.35)	-29.63 [(-39.64)-(-18.84)]	9.37 (4.04-14.61)	6.99 (3.09-11.1)	-25.42 [(-36.48)-(-12.85)]
Lower extremity peripheral arterial disease	0.26 (0.07-0.55)	0.2 (0.05-0.43)	-23.38 (-42.22-2.8)	0.01 (0-0.01)	0.01 (0-0.01)	-0.89 (-41.49-80.96)
Stroke	125.27 (43.61-223.43)	85.99 (29.53-155.76)	-31.36 [(-43.48)-(-19.16)]	5.22 (-0.17-11.2)	3.51 (-0.41-7.9)	-32.86 [(-55.31)-(-17.49)]
Tuberculosis	5.37 (1.53-11.53)	1.83 (0.57-3.48)	-65.87 [(-74.74)-(-52.15)]	0.22 (0.06-0.48)	0.07 (0.02-0.13)	-69.94 [(-79)-(-56.69)]
Total	431.84 (192.11-676.1)	394.64 (184.29-617.49)	-8.62 (-18.91-2.75)	19.57 (8.35-32.19)	16.05 (6.68-26.24)	-17.99 [(-27.06)-(-6.41)]

DALY, disability-adjusted life year; UI, uncertainty interval.

occurred in Libya (39.92%), Morocco (16.64%), and Afghanistan (11.76%) (Supplementary Table 1). In 2021, DM had the highest age-standardized DALY rate attributable to LPA across all MENA countries, except in Syria, Sudan, and Yemen, where IHD had the highest rate (Figure 1).

In both 1990 and 2021, the DALY rate of diseases attributable to LPA was higher in females than in males across all age groups. Additionally, in both genders, the highest DALY rate was observed in the +95 age group (Figure 3). Among individuals aged 25-39 years, the DALY rate for stroke attributable to LPA was higher than that for other conditions in both 1990 and 2021. In 1990, among those aged 40 years and older, IHD had the highest DALY rate attributable to LPA. However, by 2021, DM had the highest DALY rate attributable to LPA among individuals aged 40-79 years, whereas IHD had the highest rate in the older age groups (Figure 4).

There was no clear association between the age-standardized DALY rate of diseases attributable to LPA and SDI (Figure 5). However, the age-standardized DALY rates for tuberculosis and stroke attributable to LPA were negatively associated with SDI, whereas SDI showed a positive association with the age-standardized DALY rates of lower extremity peripheral arterial disease, breast cancer, and DM attributable to LPA (Supplementary Figure 1).

DISCUSSION

This study highlighted the burden of diseases attributable to LPA in the MENA region in 2021, despite a non-significant decline in the LPA-related disease burden. By 2021, DM had become the leading contributor to this burden, replacing IHD, which had been the primary contributor in 1990. Over time, the burden of DM and breast cancer attributable to LPA increased, whereas tuberculosis, stroke, and IHD showed notable reductions. In 2021, Sudan and Iraq had the highest LPA-attributable disease burden. The highest DALY rates attributable to LPA were observed among females and individuals aged 95 years and older. Overall, the LPA-attributable disease burden increased with age. Additionally, fluctuations were observed between all-cause age-standardized DALY rates and socioeconomic status, as measured by SDI.

Our findings indicated that the age-standardized DALY rate of diseases attributable to LPA in the MENA region showed a non-significant decline from 1990 to 2021 but remained higher than global values. Similarly, Ammar et al.³³ reported a non-significant 9.6% reduction in the LPA-attributable age-standardized DALY rate between 1990 and 2019, which was lower than the global decrease. Consistent with our results, their study also found that MENA had a higher age-standardized DALY rate than the global average in 2019 (671.9 vs. 198.4 per 100,000).³³ Additionally, reductions in the estimated annual percent changes of the LPA-attributable burden were observed in both MENA [-0.34%; 95% confidence interval (CI): -0.50, -0.18] and globally (-0.68%; 95% CI, -0.85, -0.50) from 1990 to 2019.³⁴ In 2019, MENA remained one of the regions with the greatest LPA-attributable burden, a trend that our 2021 findings confirmed. Addressing the challenges of physical activity in MENA requires targeted, region-specific recommendations.

TABLE 2. Percentage of the Burden of Diseases Attributable to Low Physical Activity in the Middle East and North Africa in 1990 and 2021.

Cause	1990			2021		
	Total DALY	DALY attributable to LPA	(%) attributable to LPA	Total DALY	DALY attributable to LPA	(%) attributable to LPA
Breast cancer	124.15	3.47	2.79	194.85	5.66	2.9
Chronic kidney disease	759.9	19.95	2.62	846.64	19.91	2.35
Colon and rectum cancer	220.98	16.02	7.25	209.04	16.05	7.68
Diabetes mellitus	811.25	83.27	10.26	1344.97	139.58	10.38
Ischemic heart disease	5763.47	178.23	3.09	4023.22	125.43	3.12
Lower extremity peripheral arterial disease	8.06	0.26	3.26	9.41	0.2	2.14
Stroke	3644.7	125.27	3.44	2026.61	85.99	4.24
Tuberculosis	623.91	5.37	0.86	154.48	1.83	1.19

DALY, disability-adjusted life year; LPA, low physical activity.

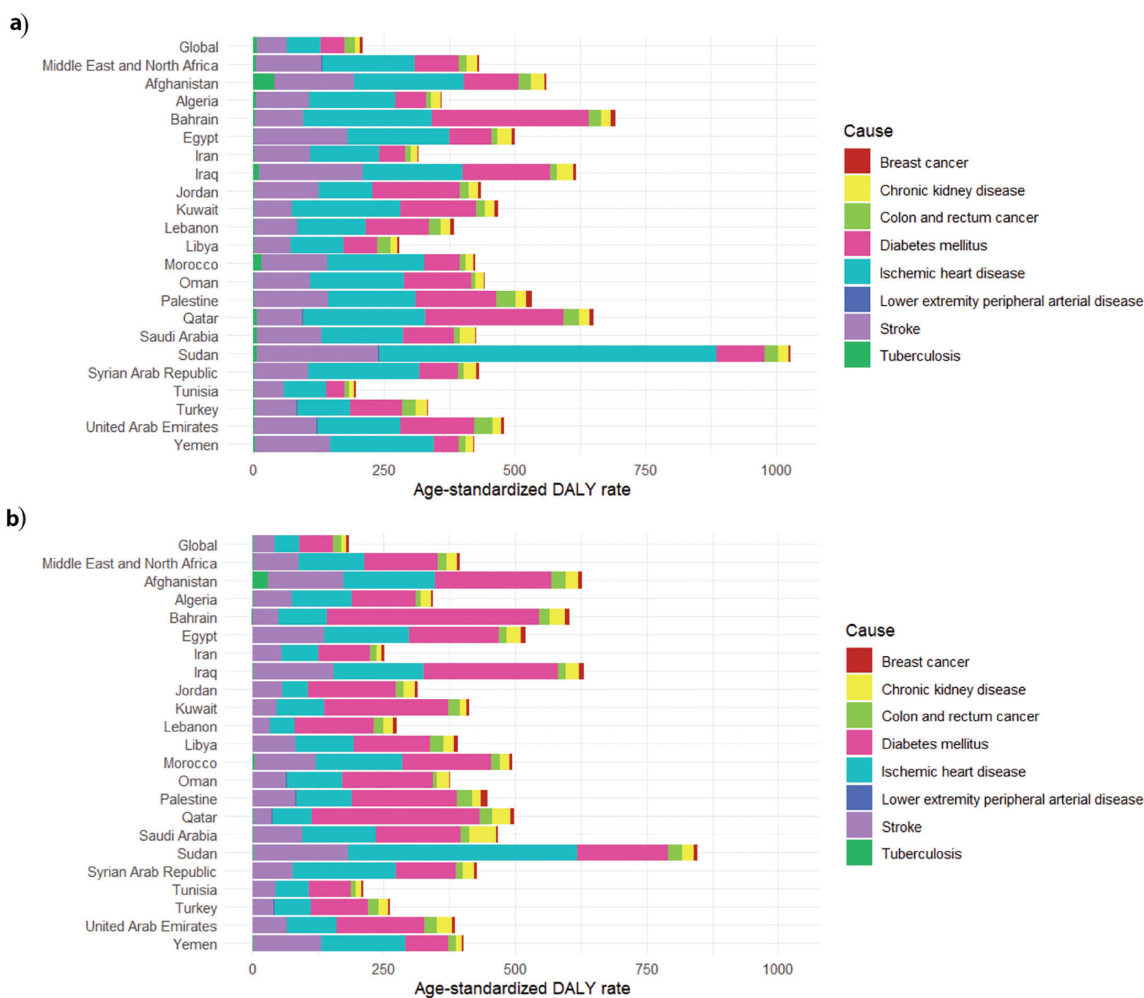


FIG. 1. Age-standardized DALY rate of individual diseases attributable to low physical activity across the Middle East and North Africa countries in 1990 (a) and 2021 (b).

DALY, disability-adjusted life year.

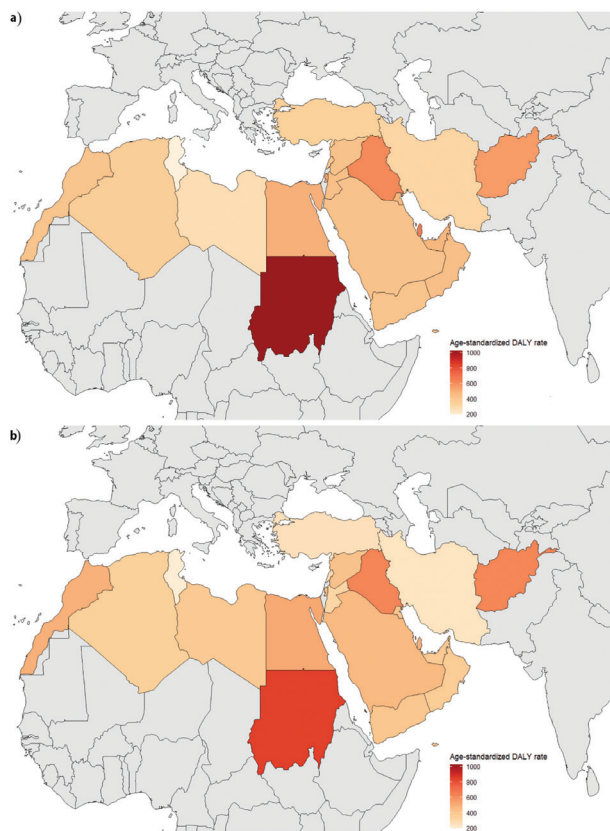


FIG. 2. Total age-standardized DALY rate of diseases attributable to low physical activity across the Middle East and North Africa countries in 1990 (a) and 2021 (b).
 DALY, disability-adjusted life year.

Several barriers to physical activity have been identified, including limited access to sports facilities, lack of time, insufficient social support, and low motivation. Sociocultural factors, such as restrictive gender norms and cultural expectations, along with environmental challenges like extreme weather conditions and high temperatures, further contribute to physical inactivity in the region. Demographic factors such as older age, female gender, lower education levels, and marital status are negatively associated with participation in physical activity. Conversely, health-related motivations, weight management goals, and recreational interests have been shown to encourage engagement in physical activity in MENA.¹⁶ To overcome these barriers, interventions should adopt culturally sensitive and inclusive strategies. Mobile technologies have demonstrated potential in promoting physical activity by offering tools for goal setting, self-monitoring, and educational content delivery.³⁵ Policymakers should prioritize the development and implementation of evidence-based interventions that align with the region’s sociocultural and environmental contexts while evaluating their long-term effectiveness and cultural relevance to ensure sustained improvements in physical activity levels.

Our findings indicated that Sudan and Iraq had the highest age-standardized DALY rates of LPA-attributable burden in 2021, while

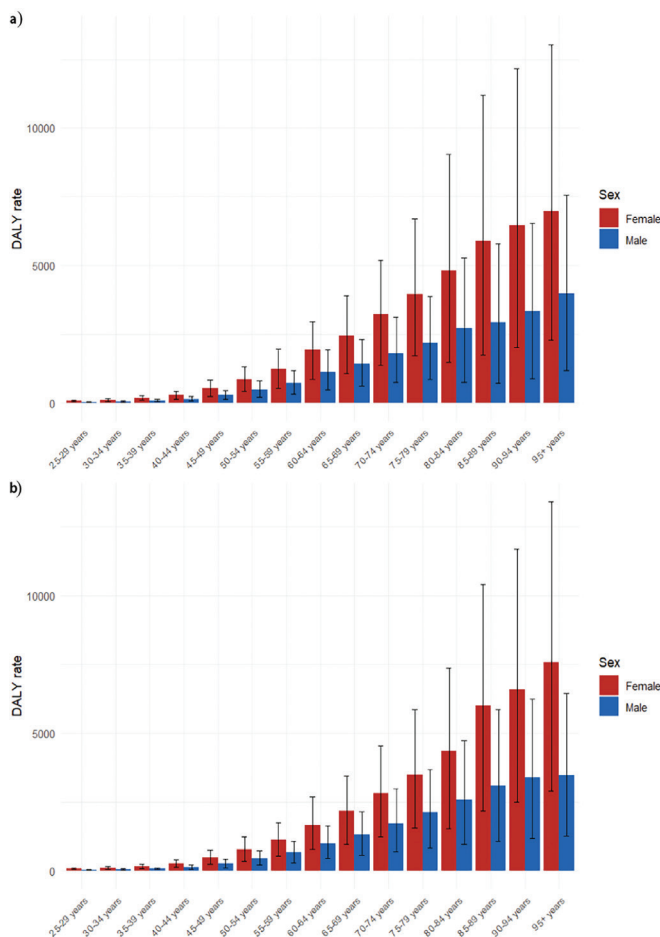


FIG. 3. DALY rate of diseases attributable to low physical activity across age groups in the Middle East and North Africa in 1990 (a) and 2021 (b).
 DALY, disability-adjusted life year.

Tunisia had the lowest. Consistent with our results, Sudan also had the highest age-standardized DALY rate in 2019 (1176.2 per 100,000), whereas Tunisia had the lowest (260.7 per 100,000).³³ Similarly, a study by Sharara et al.¹³ reported that Sudan had the highest prevalence of LPA (86.8%) among Arab countries, as assessed by the World Health Organization’s STEPwise approach to surveillance programs. Factors such as limited facilities, economic challenges, and inadequate awareness of the benefits and recommended levels of physical activity may contribute to high LPA levels in Sudan.^{36,37} Some measures, including integrating physical activity modules into school curricula, have been implemented to promote active lifestyles.³⁸ However, despite some reduction in the LPA burden, initiatives such as physical activity awareness campaigns have not been fully effective, suggesting that current efforts remain insufficient.³⁹ Given the significant burden of LPA, additional interventions and policy measures will be required in the coming years. Effective strategies may involve incorporating physical activity into school programs, community initiatives, and workplace

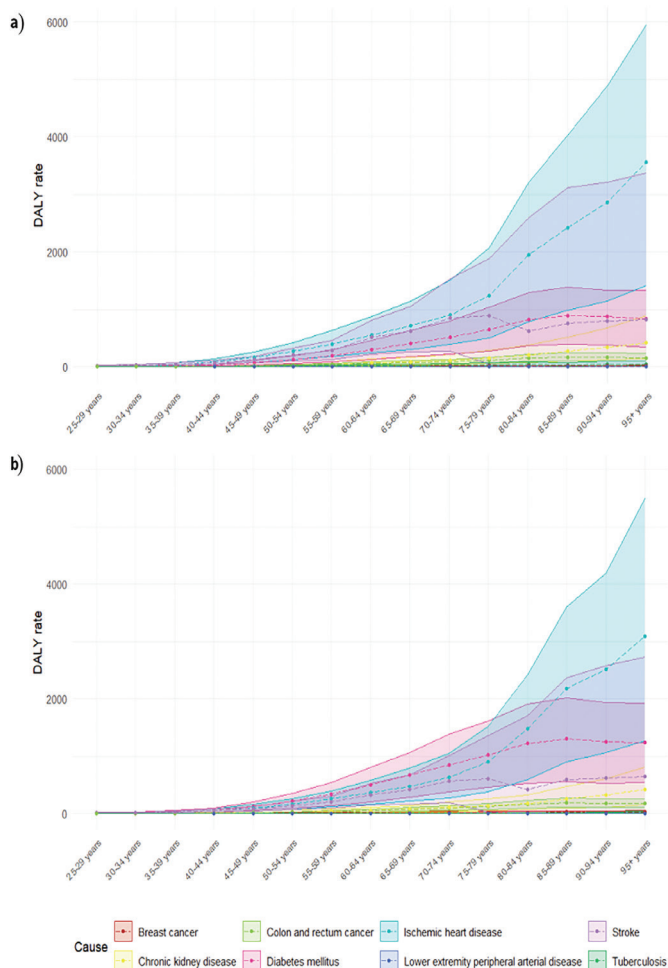


FIG. 4. DALY rate of individual disease attributable to low physical activity across age groups in the Middle East and North Africa in 1990 (a) and 2021 (b). DALY, disability-adjusted life year.

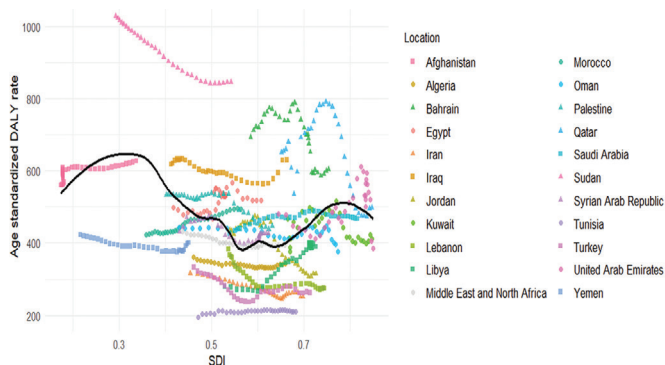


FIG. 5. Association between the age-standardized DALY rate of diseases attributable to low physical activity and SDI. DALY, disability-adjusted life year; SDI, sociodemographic index.

wellness programs, along with targeted interventions for individuals with comorbidities.⁴⁰ Additionally, lessons from countries in the region that have successfully reduced LPA could provide valuable guidance.

The contribution of various diseases to the LPA-attributable burden has changed over the past three decades. While IHD was the primary contributor in 1990, DM became the leading condition by 2021, with a notable increase in the burden of breast cancer. Similarly, between 1990 and 2019, the age-standardized DALY rate of IHD in MENA declined by 33.3%,⁴¹ whereas that of DM increased by 31.2%.⁴² This shift may be attributed to the rising burden of DM, while the overall burden of IHD has declined in recent decades in MENA. Additionally, individuals with DM tend to have lower adherence to physical activity and lifestyle recommendations compared to those with other conditions, which may further contribute to the higher burden of DM attributable to LPA.³⁴ The increasing impact of DM on the LPA-attributable disease burden in MENA highlights the need for targeted interventions to enhance physical activity as a key strategy for reducing the burden of DM. Further research is needed to assess the effectiveness of different interventions in this regard.

Significant disparities exist in the burden of diseases attributable to LPA based on gender and age. Females had higher DALY rates than males, with the burden being particularly pronounced in older populations and varied by condition across different age groups. These findings align with previous studies that have examined LPA epidemiology at global, regional, and national levels concerning age and gender patterns.^{1,33,43-45} In MENA, sociocultural barriers, traditional roles, and competing responsibilities disproportionately limit women’s opportunities for physical activity. Addressing these disparities requires targeted interventions, such as women-only facilities and supportive programs during key life transitions, to promote equitable health outcomes.¹⁶ The high burden of LPA-attributable diseases among older adults may be due to age-related declines in physical function and mobility, which reduce their ability to engage in regular physical activity. Additionally, chronic health conditions, frailty, and a lack of tailored exercise programs for older adults further exacerbate the issue. Implementing interventions that focus on low-impact and accessible physical activities, such as walking groups or community-based exercise programs, could help reduce this burden and improve overall health outcomes in aging populations.

The relationship between socioeconomic development and the burden of diseases attributable to LPA was complex and varied by condition. While no clear overall association was observed, individual diseases such as tuberculosis and stroke, in contrast to breast cancer, exhibited opposite trends with SDI levels. This may partly explain the declining trends in the burden of stroke and tuberculosis attributable to LPA in MENA over time. For instance, improvements in socioeconomic status across MENA countries may have contributed to the overall reduction in tuberculosis burden attributable to LPA.^{46,47} In 2019, the global association between age-standardized DALY rates attributable to LPA and SDI showed the highest burden at an SDI of approximately 0.8, whereas in our study, the highest burden in the MENA region was observed

at an SDI of 0.3.³³ This discrepancy may reflect inequalities in healthcare infrastructure, awareness, and access to physical activity opportunities in less socioeconomically developed settings within MENA. Additionally, the relationship between LPA-attributable burden and specific conditions can be understood within the broader context of disease burden. For instance, the negative association between SDI and tuberculosis burden is consistent with the observed inverse relationship between SDI and the LPA-attributable burden of tuberculosis in this study.⁴⁸

A key strength of this study is its comprehensive evaluation of the disease burden attributable to LPA in the MENA region, utilizing robust statistical methods from the GBD framework. However, several limitations should be acknowledged. First, the LPA data primarily relied on self-reported tools, which are prone to biases. Additionally, data scarcity, particularly in the MENA region and low- and lower-middle-income countries, remains a major limitation of GBD studies. Second, the analysis was restricted to adults aged 25 years and older, excluding younger populations whose LPA behaviors may differ significantly. This exclusion was due to the structure of the GBD framework, which primarily estimates disease burden in adults based on available epidemiological data linking LPA to NCDs. Since many chronic conditions associated with LPA, such as CVDs, typically develop later in life, the current framework focuses on older age groups. Addressing LPA estimates for children and adolescents remains an important consideration for future GBD iterations. Furthermore, the ecological and cross-sectional nature of the GBD dataset limited the ability to establish direct associations between LPA exposure and individual health outcomes. Another limitation is the inability to apply weighting to the LOESS model due to the lack of information on factors such as data quality and survey volume across countries. Lastly, while this study considered LPA as a risk factor for conditions like breast cancer, it did not account for breast cancer subtypes or other pathological variations, which could provide a more detailed understanding. Future research incorporating objective LPA measurements, younger populations, and more specific pathological data would enhance the depth and applicability of GBD findings. Despite these limitations, this study is the first to report the LPA-attributable burden in the MENA region and its countries using the latest GBD data, offering valuable insights for health policymakers.

The study highlighted a significant disease burden attributable to LPA in the MENA region, which, despite a decline over the past three decades, remains higher than global averages. The increasing contribution of DM and breast cancer to this burden reflects shifting epidemiological trends in the region. These findings underscore the need for targeted interventions, including initiatives to promote active lifestyles through public campaigns, improved access to recreational facilities, and the integration of physical activity promotion into primary healthcare systems. Comparisons with global trends highlight the importance of regional collaboration to share best practices and enhance intervention strategies. Future research should investigate the sociocultural and environmental factors influencing LPA in MENA countries and evaluate the cost-effectiveness of interventions. This would support the development

of evidence-based policies to address existing and emerging health challenges associated with LPA.

Ethics Committee Approval: The study protocol was approved by the Ethics Committee of the Iran University of Medical Sciences (approval number: IR.IUMS.REC.1403.909).

Informed Consent: Not applicable.

Data Sharing Statement: The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

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Supplement Fig 1: <https://l24.im/Xvqj>

Supplement Tab 1: <https://l24.im/u9MJ>

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