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SYSTEMATIC REVIEW

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The association between physical activity and risk of gastric cancer; an umbrella review

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Abstract

Introduction Gastric cancer (GC), as a highly lethal malignancy, is the fourth most common malignancy and the second leading cause of cancer-related death worldwide. This study is an umbrella review of systematic reviews and meta-analyses to present an overview of the extent and reliability of the claimed association between physical activity and the likelihood of developing or dying from GC.

Method This study was conducted following the Joanna Brigs Institute (JBI)'s methods for conducting umbrella reviews. A systematic search was performed in PubMed, Scopus, Web of Science, and ProQuest databases until July, 2024 with predefined keywords. Two independent authors assessed the Risk of Bias in included studies using the JBI critical appraisal tool for the assessment of the quality of systematic reviews and disagreements between the authors were resolved through discussion or the opinion of another author.

Result Five systematic reviews were included in this analysis, offering a more comprehensive understanding of the inverse relationship between physical activity and gastric cancer risk. Compared to previous studies, this review provides stronger evidence that moderate-to-high levels of physical activity significantly reduce the overall risk of developing gastric cancer.

Conclusion While a link between physical activity and reduced cancer risk is promising, further research is crucial to unravel the specific mechanisms at play and to quantify the impact of increased activity levels on cancer prevention. Based on the findings of this study, physical activity is found to be associated with a decreased risk of GC; however, the limitation of the evidence suggested a need for future studies on this topic.

Keywords Physical activity, Gastric Cancer, Systematic review

Introduction

Gastric cancer (GC), also known as stomach cancer, a highly life-threatening disease, is the fourth most prevalent type of cancer and the second deadliest cause of cancer globally [1]. The etiology of gastric cancer is multifactorial that results from complex interplay of genetic, environmental, and lifestyle factors [2].

Studies show that migrants from a high to low-risk area acquire the host place's cancer pattern, proofing the potential role of environmental factors as a trigger in the carcinogenic process [3]. Several environmental risk factors such as *H. pylori* infection, gastric surgery, peptic

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ulcer disease, dietary factors, consumption of fruit and vegetables, salt, nitrite and nitrate, ionizing radiation, pernicious anemia, smoking, alcohol consumption, exposure to asbestoses and other factors are believed to play a role in incidence of GC [4].

In addition to genetic factors [5, 6], various environmental factors such as lifestyle factors are suggested to contribute to the pathogenesis of the GC [7]. A healthy lifestyle was found to be associated with extended gains in life-lived cancers [8], which suggested lifestyle medicine, a cost-effective approach to the prevention and management of multiple conditions [9].

Previously, the conducted studies have assessed the role of dietary factors on the incidence of GC which found modifiable lifestyle habits, such as a balanced diet that emphasizes fresh fruits, vegetables, and whole grains while minimizing salt-preserved foods and alcohol consumption, can significantly lower the risk of developing gastric cancer (GC) [10]; On the other hand, consuming a diet rich in antioxidants, such as vitamin C, carotenoids, and flavonoids, along with fiber and following a Mediterranean-style diet, appears to be associated with a lower risk of gastric cancer [11, 12].

Studies suggested beneficial effects of physical activity in prevention of malignancies [13].Physical activity refers to the movements generated by skeletal muscles that lead to the consumption of energy. [14]. According to the results of studies, one of the important modifiable factors in cancer prevention research is physical activity. Numerous studies have demonstrated its link to lower all-cause mortality risk and decreased incidence of major causes of death, including cardiovascular disease and cancer [15–18]. In addition, other studies have shown that maintaining a high level of physical activity can help reduce the risk of various types of cancer. However, given the limited research on the relationship between physical activity and gastric cancer risk, no definitive conclusions can be drawn about this particular tumor. A recent evaluation highlighted the pressing necessity for additional and improved research focusing on the impact of physical activity in the development of gastric cancer [19]. Currently, the relationship between physical activity and gastric cancer risk remains inconclusive, according to the World Cancer Research Fund [20].

In the context of gastric cancer, the relationship between physical activity and risk of gastric cancer is of particular interest. Several studies, including cohort studies, case-control studies, and randomized controlled trials (RCTs), have investigated this association with different results. While some studies suggest a protective effect of physical activity against gastric cancer, others report no significant association. A comprehensive study is needed to combine the results of these studies and determine the relationship between these two issues. The umbrella review synthesis the result from multiple systematic reviews and meta-analyses to provide the association between physical activity and gastric cancer risk.

This study performed an umbrella review of systematic reviews and meta-analyses to present an overview of the extent and reliability of the claimed association between physical activity and the likelihood of developing or dying from GC. Our comprehensive evaluation sought to assess the robustness of evidence between physical activity and GC, while also highlighting hints of uncertainty and bias in the literature.

Methods

This study was conducted following the Joanna Brigs Institute (JBI)'s methods for conducting umbrella reviews [21], and the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA 2020) statement [22].

Eligibility criteria

Specific criteria were applied to select eligible articles in order to guarantee the reliability and validity of the data.

The inclusion criteria were as follows:

1. Systematic review studies evaluating the association between physical activity and incidence of GC.
2. All systematic review studies regardless of the type of reviewed studies.

The exclusion criteria were as follows.

1. Studies in languages other than English
2. Systematic review of animal studies or in vitro studies.
3. Conference abstracts, letters, commentaries, opinion articles, narrative reviews.
4. Articles whose full text could not be accessed. Two articles excluded for this reason including Shaodi Ma (2023) [23] and Besseling (2022) [24].

Search methods

A systematic search was performed in PubMed, Scopus, Web of Science, and ProQuest databases and google scholar without time limit with predefined keywords. The details of search strategies are presented in supplementary material 1. Also, a manual search was conducted based on the references and citations of included articles.

Search strategy

An example of a search strategy is provided in this section. Pubmed: ((("physical activity"[MeSH Terms] OR ("physical"[All Fields] AND "activity"[All Fields]) OR "physical activity"[All Fields] OR "exercise"[MeSH

Terms] OR "exercise"[All Fields]) AND ("stomach neoplasms"[MeSH Terms] OR ("stomach"[All Fields] AND "neoplasms"[All Fields]) OR "stomach neoplasms"[All Fields] OR "gastric cancer"[All Fields])) AND ("systematic review"[Publication Type] OR "meta-analysis"[Publication Type]))

Scopus: TITLE-ABS-KEY(("physical activity" OR exercise OR "physical fitness" OR "recreational activity") AND ("gastric cancer" OR "stomach neoplasms" OR "gastric neoplasms") AND ("systematic review" OR "meta-analysis")).

WoS: TS=("physical activity" OR exercise OR "physical fitness" OR "recreational activity") AND TS=("gastric cancer" OR "stomach neoplasms" OR "gastric neoplasms") AND TS=("systematic review" OR "meta-analysis").

Screening methods

The results of hand search were also added and the records were exported to EndNote software. Two independent authors reviewed the articles in title/abstracts and full-text stages and selected the articles that met the eligibility criteria. Any disagreements between the authors were resolved through discussion or the opinion of another author.

Risk of bias assessment

Two independent authors assessed the Risk of Bias in included studies using the JBI critical appraisal tool for the assessment of the quality of systematic reviews and disagreements between the authors were resolved through discussion or the opinion of another author. This tool assessed the explicitly of the review question, appropriate eligibility criteria and search strategy, search for sources and resources, appropriate appraisal tool and methods, methods to minimize errors in data extraction, appropriate methods for combine studies, assessment of publication bias, appropriate recommendations s for policy and/or practice and directives for new research based on the findings.

Data extraction

The data extraction was conducted in a data extraction table which included the study name, the final search date, the number of included studies, the RoB assessment of included studies and appraisal ratings, the publication bias, GC subtypes and physical activity, and finally the reported outcome of meta-analysis. One author supplemented the data extraction table and another one checked the extracted data.

Results

Search results and screening process

Out of 1440 results of database searches, finally, five systematic review studies were included in this umbrella review. The detailed information on searching, selecting, and reasons for excluded studies is summarized in the PRISMA diagram (Fig. 1). A summary of the included studies is presented in Table 1 and the details of RoB assessments are presented in Table 2.

The studies that were excluded due to unavailability of the article full text or lack of examination the relationship between the risk of gastric cancer and physical activity listed in the Table 3.

Summary of findings

In the most updated one, Xie et al. [25], in a systematic review of the association between physical activity and digestive system cancers, showed that high physical activity can reduce the incidence of GC. In this study quality of physical activity was assessed based on weekly metabolic equivalent tasks; which resulted in low, moderate, and high physical activity categories. What is important in this systematic review is the evaluation of the combined relationship between high vs. low physical activity levels and the risk of digestive-system cancer (DSC) (gastric cancer (RR=0.83, 95%CI: 0.76–0.91)). The results of the meta-analysis were consistent across different study designs, with case-control studies (RR=0.73, 95%CI: 0.68–0.78) and prospective cohort studies (RR=0.88, 95%CI: 0.80–0.91) showing a similar pattern. The meta-analysis of 9 studies suggests a possible association between moderate physical activity (PA) and a reduced risk of developing gastric cancer (DSC). Compared to low PA, moderate PA was associated with a lower risk (RR=0.89, 95%CI: 0.80–1.00). While the findings for high PA were not statistically significant, there was a slight indication of an increased risk compared to moderate PA (RR=1.11, 95%CI: 0.94–1.32). Limited evidence from 5 studies suggests that meeting the recommended PA guidelines may not have a significant impact on DSC risk (RR=0.96, 95%CI: 0.91–1.02).

Chen et al. [26] indicated that the risk of GC was 13% lower among the most physically active people than among the least active people. This study did not report a significant difference in subgroup analysis with respect to study designs, sex, and risk of bias, study population, and domain and subtype of physical activity. In addition, this study suggested a dose-response relationship between physical activity and risk of GC. A comprehensive meta-analysis of 15 studies revealed that individuals engaged in the highest levels of physical activity exhibited a 13% reduced risk of developing gastric cancer compared to those with the least physical activity (RR=0.87, 95% CI: 0.78, 0.97). The meta-analysis findings indicated

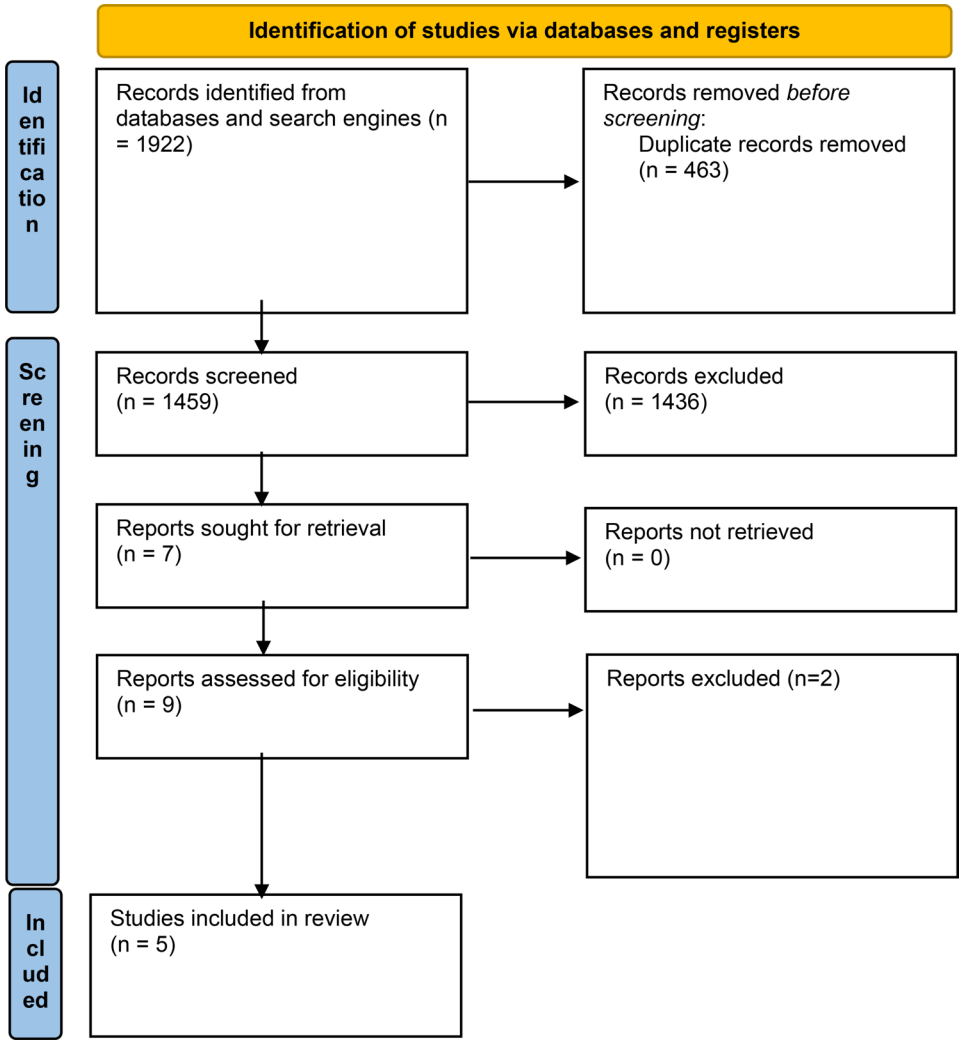

Fig. 1 PRISMA flow diagram

a moderate degree of heterogeneity among the studies (I2=49.8%, *P*=.012). Some evidence of publication bias was observed in the primary meta-analysis. Meta-regression analyses revealed that no variables significantly influenced the association between physical activity and gastric cancer (*P*>.05 in all regression analyses). Begg's and Egger's tests did not provide evidence of significant publication bias in the studies examined. The P value of Egger's test for the highest versus lowest physical activity analysis was 0.134.

Psaltopoulou et al. [27], in a systematic review in 2016, reported an association between a lower risk of gastric cancer with any type of physical activity. In sub-group analyses, this relationship was more evident in men, the Asian population, and non-cardia type of GC. A total of 10 cohort studies (7,551 incident cases in 1,541,208 participants) and 12 case-control studies (5,803 cases and 73,629 controls) were included in the meta-analysis. he pooled relative risk (RR) for gastric cancer associated with any physical activity was 0.81 (95% CI: 0.73, 0.89), indicating that individuals who engaged in any amount of physical activity had a 19% lower risk of developing gastric cancer compared to those who did not. The protective effect of physical activity was evident in both men and women, with pooled RRs of 0.87 (95% CI: 0.77, 0.99) and 0.73 (95% CI: 0.65, 0.82), respectively. The protective effect of physical activity was particularly pronounced for noncardia gastric cancer (pooled RR=0.62; 95% CI: 0.52, 0.75) and studies conducted in Asia (pooled RR=0.82; 95% CI: 0.74, 0.90).

Ajibola Ibraheem Abioye et al. [28] also reported the protective effects of physical activity against GC. In subgroup analyses of this study, the associations appear weaker in smokers, and distal none-cardia type of the disease in meta-regressions. In this study, sufficient physical activity was defined as 150 min of moderate-intensity aerobics 75 min of vigorous-intensity activity, or an equivalent combination of both in a week and based on

Table 1 Summary of the characteristics and findings of the included studies

Study	Final Search date	Databases	Number of included studies*	Type of included studies	Risk of bias assessment	appraisal ratings			publication bias	Gastric cancer subtypes	Assessed lifestyle risk factors	Reported outcome in Meta-analysis	Number of (comparisons) included in this meta-analysis	Heterogeneity (I^2)	Statistics (95% CIs, *p*-values)
						High (More than 50%)	Moderate (50%)	Low (Less than 50%)							
Fangfang Xie 2020 [25]	January 2008 to November 2018	PubMed, Embase, Web of Science, Cochrane Library, and China National Knowledge Infrastructure	17	Case-control & cohort studies	NOS	-	-	-	-	Gastric cancer	Physical activity	High versus low physical activity levels	17	33%	RR: 0.83; 95%CI: 0.76–0.91
Yi Chen 2014 [26]	May 2013	Medline and Embase	15	Case-control & cohort studies	Methodological quality was assessed using; study design, measurement of physical activity and confounding effects	7		8	No evidence of significant publication bias.	Gastric cancer	Physical activity	The most physically active compared to the least active	16	49.8%	RR: 0.87; 95%CI: 0.78–0.97
Theodora Psaltopoulou 2016 [27]	June 01, 2015	PubMed	22	Case-control & cohort studies	NOS	The quality of studies was mainly compromised by the ascertainment of exposure, as well as the difference in nonresponse rates between cases and controls in case-control studies			No evidence of significant publication bias.	Gastric cancer	Physical activity	Any Type of Physical Activity	24	53.1%	EE: 0.81 (95%CI: 0.73–0.89)
												Any Type of Physical Activity (Cohort studies)	10	51.2%	EE: 0.83 (95%CI: 0.72–0.96)
												Any Type of Physical Activity (Case–control studies)	14	41.0%	EE: 0.79 (95%CI: 0.70–0.90)
												Any Type of Physical Activity (Cardia cancer)	4	0.0%	EE: 0.80 (95%CI: 0.64–1.01)
												Any Type of Physical Activity (Non-cardia cancer)	5	0.0%	EE: 0.62 (95%CI: 0.52–0.75)
												Any Type of Physical Activity (Asia)	11	41.4%	EE: 0.82 (95%CI: 0.74–0.90)
												Any Type of Physical Activity (Europe)	7	66.6%	EE: 0.78 (95%CI: 0.51–1.19)
												Any Type of Physical Activity (USA/Canada)	6	60.7%	EE: 0.83 (95%CI: 0.66–1.05)
												Any Type of Physical Activity (Males)	14	47.0%	EE: 0.87 (95%CI: 0.77–0.99)
												Any Type of Physical Activity (Females)	9	62.3%	EE: 0.77 (95%CI: 0.53–1.12)

Table 1 (continued)

Study	Final Search date	Databases	Number of included studies*	Type of included studies	Risk of bias assessment	appraisal ratings			publication bias	Gastric cancer subtypes	Assessed lifestyle risk factors	Reported outcome in Meta-analysis	Number of (comparisons) included in this meta-analysis	Heterogeneity (I^2)	Statistics (95% CIs, *p*-values)
						High (More than 50%)	Moderate (50%)	Low (Less than 50%)							
Ajibola Ibraheem Abioye 2015 [28]	July 2012	PubMed, EMBASE, CINAHL, PsycINFO and Google Scholar	11	Case-control & cohort studies	NOS	Quality scores ranged from 5 to 8, median score of 7 of a maximum possible of 10			No evidence of significant publication bias.	Gastric cancer	Physical activity	sufficient physical activity (Prospective studies)	9	68.5%	RR: 0.81 (95%CI: 0.69–0.96)
												sufficient physical activity (Case-control studies)	5	0%	RR: 0.78 (95%CI: 0.66–0.91
												High level physical activity (Prospective studies)	9	61.7%	RR: 0.82 (95%CI: 0.70–0.97)
												High level physical activity (Case-control studies)	6	49.8%	RR: 0.83 (95%CI: 0.66–1.04)

Table 1 (continued)

Study	Final Search date	Databases	Number of included studies*	Type of included studies	Risk of bias assessment	appraisal ratings			publication bias	Gastric cancer subtypes	Assessed lifestyle risk factors	Reported outcome in Meta-analysis	Number of (comparisons) included in this meta-analysis	Heterogeneity (I^2)	Statistics (95% CIs, *p*-values)
						High (More than 50%)	Moderate (50%)	Low (Less than 50%)							
Siddharth Singh 2014 [29]	February 2013	PubMed, Embase, and Web of Science	15	Case-control & cohort studies	Boyle methodology	Six studies have high risk of bias and 10 have low risk of bias			No evidence of significant publication bias.	Gastric cancer	Physical activity	Most physically active versus least physically active	16	57%	OR: 0.79 (95%CI: 0.71–0.87)
												Most physically active versus least physically active (Cardia)	4	0.0%	OR: 0.80 (95%CI: 0.63–1.00)
												Most physically active versus least physically active (Non-cardia)	5	3.0%	OR: 0.63 (95%CI: 0.52–0.76)
												Most physically active versus least physically active (Males)	10	63.0%	OR: 0.86 (95%CI: 0.75–0.99)
												Most physically active versus least physically active (Females)	3	0.0%	OR: 0.72 (95%CI: 0.55–0.94)
												Most physically active versus least physically active (Case–control)	9	0.0%	OR: 0.75 (95%CI: 0.69–0.82)
												Most physically active versus least physically active (Cohort)	7	59.0%	OR: 0.83 (95%CI: 0.71–0.97)
												Most physically active versus least physically active (Asian)	5	59.0%	OR: 0.79 (95%CI: 0.63–0.99)
												Most physically active versus least physically active (Western)	11	27.0%	OR: 0.74 (95%CI: 0.64–0.84)
												Most physically active versus least physically active (High study quality)	6	51.0%	OR: 0.86 (95%CI: 0.75–0.99)
												Most physically active versus least physically active (Low study quality)	10	0.0%	OR: 0.74 (95%CI: 0.69–0.81)
												Most physically active versus least physically active (Middle tertile)	11	27.0%	OR: 0.91 (95%CI: 0.82–1.02)
												Most physically active versus least physically active (Highest tertile)	11	43.0%	OR: 0.78 (95%CI: 0.68–0.90)

GC: gastric Cancer, NOS: Newcastle-Ottawa Scale, RR: relative Risk, OR: odds ratio; EE: Effect Estimate; NOS: Newcastle-Ottawa Scale;

* In case of multiple risk assessments, only studies regarding the lifestyle factors and gastric cancer risk was considered

Table 2 The results of risk of bias assessments

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Fangfang Xie 2020 [25]	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes
Yi Chen 2014 [26]	Yes	Yes	Unclear	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Theodora Psaltopoulou 2016 [27]	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ajibola Ibraheem Abioye 2015 [28]	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Siddharth Singh 2014 [29]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

1. Is the review question clearly and explicitly stated?
2. Were the inclusion criteria appropriate for the review question?
3. Was the search strategy appropriate?
4. Were the sources and resources used to search for studies adequate?
5. Were the criteria for appraising studies appropriate?
6. Was critical appraisal conducted by two or more reviewers independently?
7. Were there methods to minimize errors in data extraction?
8. Were the methods used to combine studies appropriate?
9. Was the likelihood of publication bias assessed?
10. Were recommendations for policy and/or practice supported by the reported data?
11. Were the specific directives for new research appropriate?

Table 3 The studies that excluded from study

First Author	title	Type of study	Reason for exclude full text
Shaodi Ma [23]	Effect of physical activity on incidence and mortality in patients with gastric cancer	A systematic literature search	Not having access to the article full text
J Besseling [24]	Exercise and Nutritional Interventions in Patients with Advanced Gastroesophageal Cancer: A Systematic Review	A Systematic Review	Not having access to the article full text
Yi Chen [30]	Body mass index and risk of gastric cancer: a meta-analysis of a population with more than ten million from 24 prospective studies	a meta-analysis of a population with more than ten million from 24 prospective studies	In this study, physical activity along with alcohol consumption and smoking are considered as confounding factors and there is not enough evidence of the effect of physical activities on GC.

the findings, high-level physical activity did not significantly differ from the sufficient physical activity group. The meta-analysis included a comprehensive dataset drawn from seven prospective cohort studies and four case-control studies, encompassing 1,535,006 individuals and 7,944 cases of gastric cancer.

The meta-analysis found a modest but consistent protective association between sufficient physical activity and gastric cancer risk. This association was observed in both prospective cohort studies and case-control studies, with a pooled relative risk of 0.81 (95% CI: 0.69, 0.96). However, the association was found to be weaker in smokers compared to non-smokers and may also be weaker for gastric cardia cancer compared to the distal non-cardia subtypes.

Siddharth Singh et al.'s study [29] also approved the findings of previously mentioned studies regarding the protective effects of physical activity against GChe meta-analysis revealed a consistent association between physical activity and reduced gastric cancer risk. Individuals who were the most physically active had a 21% lower risk of developing the disease compared to those who were the least active (OR, 0.79; 95% CI, 0.71, 0.87). This protective effect was seen for both gastric cardia and distal stomach cancer subtypes.

Discussion

This study aims to evaluate the possible relationship between physical activity and the risk of gastric cancer. Based on the previously published systematic review and meta-analysis studies, physical activity is found to be associated with decreased risk of GC.

There are other individual studies (not included in a systematic review) in this area, including these studies, Body mass and physical activity and gastric cancer risk in a population-based cohort study [31] and Physical activity and gastric cancer risk in patients with and without Helicobacter pylori infection: a hospital-based case-control study [32] and because it has not been systematically reviewed and the evidence and reasons for the effect of physical activity on the risk of gastric cancer have not been comprehensively reviewed in them, it was reasoned that Do not use in this study.

GC is a significant burden on global health. In 2020, there were an estimated 1.1 million new cases of gastric cancer and 800,000 deaths globally [33]. The burden of gastric cancer is particularly high in low- and middle-income countries, where over two-thirds of cases occur. The five year overall age-standardized relative survival rate of GC is about 40%, which decreased to about 10% in patients with distant-stage GC [34]. The economic

burden of gastric cancer is also significant so the disease can lead to lost productivity and income for patients and their families. In this condition, seeking prevention methods is key to reducing the burden of gastric cancer. This covers tactics including expanding access to healthcare and screening programs, encouraging healthy lifestyles, and minimizing exposure to established risk factors like smoking and H. pylori infection [35]. One of the easy-accessible methods in this regard is physical activity.

The exact mechanism by which physical activity decreases the risk of gastric cancer is not fully understood [36]; However, several hypotheses such as reduced inflammation, improved immune function, reduced risk of obesity, as well as alternation of gut microbiome are suggested. Physical activity has been shown to reduce chronic inflammation in the body, which is a risk factor for cancer development [37]. In addition, physical activity can improve insulin sensitivity and reduce insulin resistance [38]. Insulin resistance has been linked to an increased risk of several types of cancer, including gastric cancer [39].

In contrast to previous studies, this study provides a more comprehensive analysis of the inverse relationship between physical activity and the risk of gastric cancer, as indicated by five systematic reviews. The updated meta-analysis data support the notion that moderate to high levels of PA act as a protective factor, significantly lowering overall GC risk. However, the reduction rate for specific GC subtypes may vary. Furthermore, limited evidence suggests that meeting the international PA guidelines might not significantly impact GC risk. Therefore, more research is warranted to establish the optimal PA regimen for effectively reducing GC risk.

In the second study a comprehensive review of existing studies indicates that physical activity may offer some protection against esophageal and gastric cancer. This finding suggests that future research should delve deeper into the remaining ambiguities of this association, such as whether sedentary behavior or non-aerobic physical activity increases cancer risk and whether the intensity of physical activity influences the protective effect of physical activity against gastric and esophageal cancer. Additionally, further studies are needed to elucidate the mechanisms through which physical activity may safeguard against these cancers and determine whether increasing physical activity can effectively reduce cancer risk.

In the third study A comprehensive meta-analysis of 10 cohort and 12 case-control studies examining the link between physical activity and gastric cancer risk suggests a substantial protective association. Individuals engaging in the highest levels of physical activity exhibited a 19% lower risk of developing gastric cancer compared to those with the lowest physical activity levels. This finding corroborates the protective effects of physical activity observed for other cancer sites.8,14,20 Importantly, the protective association held true across both case-control and cohort studies. In summary, the fourth meta-analysis highlights a potential protective role of regular physical activity (PA) in reducing the risk of gastric cancer. This finding has crucial implications for comprehending the underlying causes of gastric cancer and developing effective prevention strategies. Additionally, it provides further evidence supporting the benefits of an overall healthy lifestyle with regular PA in minimizing the risk of noncommunicable diseases. In the last study stated due to the high incidence and dismal prognosis of gastric cancer, the development of cost-effective preventive strategies is urgently needed. Although chemoprevention holds promise, its cost-effectiveness and risk-benefit profile remain uncertain. This systematic review and meta-analysis of 16 observational studies encompassing 1.6 million patients and 11,111 gastric cancer cases revealed a 21% lower risk of gastric cancer among the most physically active individuals compared to the least physically active individuals, after controlling for relevant confounders like age, obesity, and other gastric cancer risk factors (smoking, alcohol consumption, dietary patterns, and socioeconomic status).

Based on the findings of this study, physical activity is found to be associated with a decreased risk of GC; however, the limitation of the evidence suggested a need for future studies on this topic. Several methodological flaws in the research on the connection between physical activity and GC prevent us from drawing a definite conclusion [40]. A limited number of well-designed prospective studies, lack of appropriate adjustment for all of the known cofounders such as genetic factors, the companionship of high physical activity with other lifestyle factors such as healthy diet as well as better socioeconomic condition, self-administered nature of the studies, lack of attention to histology of GC, and finally the observed great level of heterogeneity between the studies, were the main limitation of the studies.

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Author contributions
M.M: Design, Gathering data, Analysis and Interpretation of data, Article writing. V.F: Design, Analysis and interpretation of data, Article writing. Z.M: Design, Gathering data, Analysis and interpretation of data, Article writing.

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Data availability
Not applicable (this manuscript does not report data generation or analysis).

Declarations

Ethics approval and consent to participate
The study was approved by Tabriz University of Medical Sciences (TUOMS) ethical committee (IR.TBZMED.REC.1401.484). All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication
Not applicable.

Conflict of interest
The authors declare no conflict of interest.

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