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Systemic immune-inflammatory index mediates the association between regular walking and depression in the elderly with coronary heart disease

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Abstract

Background Depressive disorders and coronary heart disease (CHD) are significant and pervasive global public health challenges, influenced by various factors such as diet, physical activity, social circumstances, and lifestyle habits. This study aim to investigate the relationship among regular walking, the systemic immune-inflammation index (SII), and depression in CHD patients. Additionally, it seeks to explore the mediating role of SII in the effect of regular walking on depression among these patients.

Methods This cross-sectional study involved 464 patients aged ≥ 65 years with CHD, admitted to the cadre ward of the First Hospital of Jilin University from September 2021 to December 2022. A comprehensive geriatric assessment (CGA) inventory was prepared by compiling and screening regular walking, calculated SII, and the Geriatric Depression Scale (GDS). Binary logistic regression was employed to examine the relationship among walking, ln(SII) and depression. After adjusting for confounding factors, linear regression analysis was used to assess the correlation among exercise-related factors, ln(SII) and depression. Sensitivity analyses were performed through stratified analysis, investigating the relationship between walking and depression within the strata of each variable, as well as the *P*-interaction among stratified variables. Additionally, the Process package in SPSS was used to explore the mediating role of ln(SII) in the association between regular walking and depression.

Results Model 2: Elderly individuals who walk regularly are 72.2% less likely to experience depression compared to those who do not engage in regular walking (odds ratio (OR) = 0.278, 95% CI = 0.178–0.433, $P < 0.001$). However, one-unit increases in ln(SII) corresponds to an approximately sixfold in the likelihood of depression among elderly individuals (OR = 5.899, 95% CI = 4.183–8.318, $P < 0.001$). Model 3: Participants who walk regularly are 69.4% less likely to suffer from depression compared to those who do not walk regularly (OR = 0.306, 95% CI = 0.190–0.491, $P < 0.001$). Similarly, a one-unit increase in ln(SII) is associated with an approximately sixfold increase in the probability of depression elderly individuals (OR = 5.976, 95% CI = 4.126–8.656, $P < 0.001$). The stratified analysis examining the effect of regular walking on depression in patients with CHD confirms the robustness of these associations. Additionally,

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SII was found to mediate the relationship between regular walking and depression in CHD patients, accounting for 43.19% of the total effect.

Conclusions An interaction exists among SII, regular walking and depression in elderly patients with coronary heart disease. Furthermore, SII partially mediates the relationship between regular walking and depression.

Clinical trial number Not applicable.

Keywords Systemic immune-inflammation index, Regular walking, Depression, Elderly, Coronary heart disease

Introduction

The main symptoms of depression in the elderly include impaired cognitive function, reduced executive capabilities, diminished language fluency, delayed thinking, difficulty concentrating, decreased memory, and weakened problem-solving abilities [1]. Additionally, elderly depression heightens the risk of cerebrovascular disease (CVD), ischemic heart disease, cancer and suicide [2]. Diagnosing depression in older adults is notably complex due to its significant clinical polymorphism, which includes challenges in recognizing depressive symptoms, frequent reporting of physical ailments, and a heightened risk of associated disabilities-factors that can severely impact quality of life [3]. In China, the prevalence of depression among older adults stands at 22.7% [4]. Similarly, an estimated 20.04% of adults aged 65 and over in the United States experience depression, with severe cases showing an upward trend [5]. It is noteworthy that the prevalence of depression is markedly higher among patients with CHD, approximately three times that of the general population [6]. Previous research suggests that SII may be a potential risk factor for depression [7], while regular walking has been shown to alleviate negative emotions in patients with depression [8].

Recent evidence suggests that immune-inflammatory mediators play a pivotal role in regulating various immune and inflammatory processes, thereby increasing the risk of depression [9, 10]. SII is a novel composite indicator derived from the ratio of neutrophils to lymphocytes and platelet count. Consequently, SII is hypothesized to outperform the neutrophil-to-lymphocyte ratio as a biomarker of inflammation in certain diseases [11]. A study utilizing data from the National Health and Nutrition Examination Survey (NHANES) revealed that elevated SII levels significantly heighten the risk of depression, highlighting its potential as a biomarker for anti-inflammatory treatments targeting depression [7]. Another investigation based on the same database demonstrated that, even after adjusting for confounding variables, high SII level remained an independent risk factor for depression in patients with diabetes [12]. Nevertheless, limited research has explored the relationship between SII and depression in elderly patients with CHD.

Currently, suboptimal treatment outcomes, poor compliance and low uptake of prescribed therapies underscore the growing need for alternative and supplementary treatment options [13, 14]. Systematic reviews and meta-analyses have shown that exercise not only enhances the effectiveness of medication in alleviating and treating depression but also reduces metabolic risk factors associated with cardiovascular disease, improves brain function, and mitigates medication side effects [15]. Furthermore, exercise exhibits direct antidepressant effects and offers promising protective benefits [16–18].

Previous research has established a connection between walking [19] and SII [20] with depression. However, the interplay among walking, SII and depression remains unclear. In this study, we hypothesize that SII mediates the relationship between walking and depression in elderly patients with CHD. To investigate this, we will analyze the correlation using date from the comprehensive geriatric assessment (CGA) database.

Materials and methods

Sample

This cross-sectional study included 480 patients aged 65 years or older with CHD. The patients were admitted to the Cadre Ward Department of the First Hospital of Jilin University from September 2021 to December 2022. All participants underwent coronary angiography prior to enrollment, confirming the diagnosis of CHD, and all were in the stable phase of the disease. Only elderly patients who voluntarily agreed to participate in the study were included. Patients were excluded if they were unable to walk due to neuromusculoskeletal disorders, such as severe cerebrovascular disease, Parkinson's disease, knee or hip osteoarthritis, or lumbar spinal stenosis. Those with severe cognitive impairment, infections, autoimmune diseases, severe liver and kidney dysfunction, or malignant tumors, were also excluded. Additionally, 16 participants were excluded due to incomplete data following a CGA. Ultimately, 464 patients were included in the study. The research adhered to the Helsinki Declaration and was approved by the Ethics Committee of the First Hospital of Jilin University (21K103-002).

Data measurement

Depression assessment

The Geriatric Depression Scale (GDS) is a screening questionnaire specifically designed for older adults.

Among these items, 10 questions with a "no" response indicate depressive symptoms, while 20 questions with a "yes" response are also associated with depressive symptoms. A GDS score exceeding 10 is indication of depression. Previous studies have shown that this threshold demonstrates 100% sensitivity and 84% specificity when compared to other depression assessment scale criteria [21].

Regular walking

Regular walking is defined as patients engaging in walking [8] for over one hour per day, at least five days per week (Patients document the number of days they walk each week alongside the total duration of their walking).

Systemic immune inflammatory (SII) Blood samples were collected by a qualified nurse after an overnight fast, the morning following hospital admission. These samples were then analyzed by clinical laboratory technicians in a certified hospital laboratory. SII was calculated using the formula: SII = P × N/L, where P, N and L represent the respective counts of peripheral platelets, neutrophils, and lymphocytes [11].

Covariate assessment

General information General information was gathered about the patients, including their age, gender, high-fat diet (HFD) (high-fat diet defined as the habitual consumption of foods rich in fatty acids, but low in fiber, vitamins and minerals [22].), smoking history, drinking history (referring to regular smoking and drinking habits, regardless of quantity and sustained for over a year.), and the presence of chronic disease such as hypertension, diabetes or CVD.

Activities of daily living and instrumental activities of daily living (ADLs and IADLs) Composite scores for ADLs and IADLs are calculated based on various activities. ADLs encompass essential self-care tasks such an walking, eating, dressing, washing hair, brushing teeth, and using the toilet routinely. Meanwhile, IADLs include more complex activities necessary for independent living, such as driving or using a vehicle, preparing meals, performing household chores, doing laundry, shopping, managing medications, making phone calls, and organizing personal belongings [23].

Anthropometric measurements and blood biochemical indicators The body composition of all patients was assessed using Bioelectrical Impedance Analysis (BIA) with the Inbody S10 device (Biospace, Seoul, South Korea) [24]. BIA employs electrical impedance measurements at varying frequencies to evaluate parameters such as upper arm circumference (UAC), calf circumference (CC), body fat rate (BFR), visceral fat area (VFA), and muscle mass (MM) [25]. In addition, blood biochemical indicators including triglycerides (TG) and low-density lipoprotein cholesterol (LDL-C) were analyzed.

Statistical analysis

The statistical analysis in this study was conducted using SPSS/WIN 23.0 software (IBM Corp., Armonk, NY, United States) and GraphPad Prism 8 (GraphPad Prism Software Inc., San Diego, CA, United States). The Kolmogorov-Smirnov test (K-S test) was used to test the normality of continuous variables. Continuous variables conforming to the normal distribution were expressed as mean ± standard deviation (SD), whereas those that did not adhere to the normal distribution were described using median and inter-quartile range (IQR). To detect differences between non-depression group and depression group, the independent sample t-test or the Mann-Whitney U test was utilized. Categorical variables were presented as absolute values and percentages, with chi-square tests applied to compare between the two groups. The SII was transformed using a natural logarithm to normalize the data, yielding the variable ln(SII). Binary logistic regression was performed to explore relationships among walking, ln(SII) and depression. After adjusting for confounding factors, linear regression analyses were further used to evaluate links among exercise-related factors, ln(SII) and depression. (Model 1 did not adjust for confounding factors, while Model 2 adjusted for age, HFD, Hypertension, Diabetes, CVD, ADLs and IADLs. In addition, besides adjusting the factors of Model 2, Model 3 also adjusted UAC, CC, BFR, MM, TG, LDL-c.) Sensitivity analysis was performed using stratified analysis to assess the correlation between walking and depression cross various stratified variables, along with *P*-interaction values among these factors. Furthermore, the mediating role of ln(SII) between walking and depression was analyzed using Process package of SPSS. The proportion of the mediating effect was calculated with the formula: (mediated effect / total effect)× 100%.

Result

Characteristics of participants non-depression and depression

This study included a total of 464 participants, comprising 313 participants without depression and 151 participants with depression. The prevalence of depression among elderly individuals with CHD was calculated to be 32.54%. Compared to non-depressed patients, depressed individuals demonstrated higher ln(SII) levels($P < 0.05$). Additionally, the proportion of depressed patients who engaged in walking was lower, while the prevalence of HFD and exercise-related conditions such

Table 1 Characteristics of participants non-depression and depression

Variates		Non-depression($N=313$)	Depression(151)	*P*
Age, years		80.24 ± 8.76	82.11 ± 8.98	0.033
Gender, %	Male	203(64.86)	92(60.93)	0.410
	Female	110(35.14)	59(39.07)	
Walking, %	Yes	189(60.38)	44(29.14)	< 0.001
	No	124(39.62)	107(70.86)	
HFD, %	Yes	84(26.84)	69(45.70)	< 0.001
	No	229(73.16)	82(54.30)	
Smoking, %	Yes	104(33.23)	46(30.46)	0.551
	No	209(66.77)	105(69.54)	
Drinking, %	Yes	74(23.64)	41(27.15)	0.412
	No	239(76.36)	110(72.85)	
Hypertension, %	Yes	149(47.60)	88(58.28)	0.031
	No	164(52.40)	63(41.72)	
Diabetes, %	Yes	106(33.87)	81(53.64)	< 0.001
	No	207(66.13)	70(46.36)	
CVD,%	Yes	105(33.55)	67(44.37)	0.024
	No	208(66.45)	84(55.63)	
ADLs and IADLs		17.00(14.00, 23.00)	20.00(17.00, 29.00)	< 0.001
Ln(SII)		6.38 ± 0.79	7.70 ± 0.83	< 0.001
UAC, cm		27.76 ± 3.35	26.74 ± 3.29	0.002
CC, cm		33.27 ± 3.27	31.65 ± 4.24	< 0.001
BFR, %		28.87 ± 6.39	31.05 ± 4.95	< 0.001
VFA, cm^2		85.10(64.05, 107.20)	90.30(71.10, 121.40)	0.038
MM, kg		45.71 ± 8.02	42.30 ± 7.63	< 0.001
TG, mmol/L		1.17(0.88, 1.58)	1.62(1.07, 1.90)	< 0.001
LDL-C, mmol/L		2.54(1.80, 3.10)	2.91(2.04, 3.47)	0.002

Abbreviation: high-fat diet, HFD; cerebrovascular disease, CVD; Activities of Daily Living and Instrumental Activities of Daily Living, ADLs and IADLs; systemic immune inflammatory, SII; upper arm circumference, UAC; calf circumference, CC; body fat rate, BFR; visceral fat area, VFA; muscle mass, MM; triglycerides, TG; low-density lipoprotein cholesterol, LDL-C

$P < 0.05$ indicates that the difference is statistically significant

as hypertension, diabetes and CVD was notably higher ($P < 0.05$); Furthermore, depressed patients, exhibited higher motor-related indicators, including ADLs and IADLs, BFR, VFA, TG and LDL-c, whereas other indicators such as UAC, CC and MM were comparatively lower ($P < 0.05$);Notably, depressed patients were also relatively older in comparison to their non-depressed counterparts ($P < 0.05$) (Table 1).

Logistic regression model of the impact of walking and ln(SII) on depression

Model 1: The results of the unadjusted multivariable logistic regression model revealed significant correlation between walking (OR = 0.270, 95% CI = 0.178–0.410, $P < 0.001$) and Ln(SII) (OR = 6.375, 95% CI = 4.578–8.877, $P < 0.001$) and depression;

Model 2: After adjusting for age, HFD, hypertension, diabetes, CVD, ADLs and IADLs, it was observed that participants who engage in regular walking are 72.2% less likely to experience depression compared to their counterparts who do not walk regularly (OR = 0.278, 95% CI = 0.178–0.433, $P < 0.001$). Conversely, for every unit increase in ln(SII), the likelihood of depression among elderly individuals rises approximately sixfold (OR = 5.899, 95% CI = 4.183–8.318, $P < 0.001$).

Model 3: Beyond the adjustments made in Model 2, additional factors including UAC, CC, BFR, MM, TG, and LDL-c were taken into account. In this adjusted model, participants who engage in regular walking are 69.4% less likely to suffer from depression compared to those who do not walk regularly (OR = 0.306, 95% CI = 0.190–0.491, $P < 0.001$). Similarly, for every unit increase in ln(SII), the likelihood of depression in elderly individuals rises approximately sixfold (OR = 5.976, 95% CI = 4.126–8.656, $P < 0.001$) (Table 2).

Linear regression analysis of factors related to exercise with GDS score and ln (SII)

The linear regression analysis of GDS score and ln (SII) with factors related to exercise shows that:

Compared to elderly CHD patients who do not engage in regular walking, those who maintain a consistent walking routine exhibit significantly lower GDS scores (β =

Table 2 Logistic regression model of the impact of walking and Ln(SII) on depression

	Model 1[a]		Model 2[b]		Model 3[c]	
	OR 95%(CI)	*P*	OR 95%(CI)	*P*	OR 95%(CI)	*P*
Walking	0.270(0.178, 0.410)	< 0.001	0.278(0.178, 0.433)	< 0.001	0.306(0.190, 0.491)	< 0.001
Ln(SII)	6.375(4.578, 8.877)	< 0.001	5.899(4.183, 8.318)	< 0.001	5.976(4.126, 8.656)	< 0.001

Abbreviation: Systemic immune inflammatory, SII

[a] unadjusted

[b] adjusted for age, HFD, Hypertension, Diabetes, CVD, ADLs and IADLs

[c] adjusted for b + UAC, CC, BFR, MM, TG, LDL-c

$P < 0.05$ indicates that the difference is statistically significant

-1.488, $P<0.001$). Their UAC (β = -0.153, $P=0.019$) and MM (β = -0.074, $P=0.002$) are negatively correlated with GDS scores, and HFD ($\beta=2.641$, $P<0.001$), TG ($\beta=0.782$, $P=0.001$), LDL-C ($\beta=0.598$, $P=0.001$), and ADLs and IADLs ($\beta=0.071$, $P=0.003$) were positively correlated with GDS scores.

Compared with elderly CHD patients who walk regularly, those who do not engage in regular walking exhibit higher ln(SII) value (β = -0.351, $P<0.001$). Their CC levels (β = -0.039, $P=0.007$) show a negative correlation with ln(SII) values, while HFD ($\beta=0.522$, $P<0.001$), ADLs and IADLs ($\beta=0.016$, $P=0.005$) display positive correlation. Furthermore, elderly patients CHD with a history of diabetes, demonstrate significantly higher ln(SII) values compared to those without such a history ($\beta=0.318$, $P=0.001$) (Table 3).

Hierarchical regression analysis of the effect of regular walking on depression in elderly patients with CHD

In Table 4, we analyzed the interaction between covariates and regular walking, finding no significant interaction (P-interaction > 0.05). The result indicates that the association remains consistent across various subgroups. Additionally, the table presents the outcomes of hierarchical regression analysis. When combined with the findings from Tables 2 and 3, the data demonstrate a significant relationship between depression and regular walking in CHD patients, along with the mediating role of SII (Table 4).

Table 3 Linear regression analysis of factors related to exercise with GDS score and ln (SII)

Variates	GDS score		Ln(SII)	
	β	*P*	β	*P*
Walking	-1.488	< 0.001	-0.351	< 0.001
HFD	2.641	< 0.001	0.522	< 0.001
UAC	-0.153	0.019	0.011	0.490
CC	-0.088	0.153	-0.039	0.007
BFR	0.056	0.071	0.007	0.362
MM	-0.074	0.002	-0.010	0.077
TG	0.782	0.001	0.021	0.695
LDL-C	0.598	0.001	0.058	0.197
ADLs and IADLs	0.071	0.003	0.016	0.005
Hypertension	0.524	0.159	0.072	0.415
Diabetes	0.683	0.080	0.318	0.001
CVD	0.658	0.087	0.072	0.435

Abbreviation: Geriatric Depression Scale, GDS; systemic immune inflammatory, SII; high-fat diet, HFD; upper arm circumference, UAC; calf circumference, CC; body fat rate, BFR, visceral fat area, VFA, muscle mass, MM; triglycerides, TG; low-density lipoprotein cholesterol, LDL-C; Activities of Daily Living and Instrumental Activities of Daily Living, ADLs and IADLs;, cerebrovascular disease, CVD

$P<0.05$ indicates that the difference is statistically significant

The mediating role of Ln(SII) in the association between regular walking and GDS scores

As shown in Fig. 1, the result reveal the following: Total Effect = -3.2372($P<0.001$), Indirect Effects = -1.8365($P<0.001$) and Mediated Effect = -1.3961($P<0.001$). These relationships are governed by the equation: Total Effect = Direct Effect + Indirect Effect, which in this case is expressed as: -3.2327 = -1.8365 + -1.3961. The proportion of the intermediate effects is calculated as Mediated Effect / Total Effects (%) = -1.3961/-1.8365 = 43.19%. This demonstrates that the Mediated Effect contributes 43.19% to the Total Effect, a result that is both statistically significant and visually supported by Fig. 1.

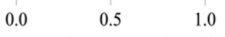
Discussion

This study utilizes the CGA database to examine the relationship among regular walking habits, SII, and depression in elderly patients with CHD. The prevalence of depression in this population is 32.54%. Notably, SII serves as a mediator in the association between regular walking and depression, with the mediated effect accounting for 43.19% of the total effect. To the best of knowledge, this is the first study to investigate the interplay among regular walking, SII, and depression in elderly individuals with CHD. Additionally, linear regression analysis revealed several exercise-related factors associated with SII and depressive disorders in CHD patients. Regular walking, UAC and MM were identified as protective factors against depression. In contrast, HFD, TG, LDL-C, as well as limitations in ADLs and IADLs, emerged as risk factors for depression.

An interventional randomized controlled study revealed that exercise intervention can reduce SII in children with cancer [26]. Similarly, findings from an analysis based on the NHANES database examining the correlation between lifestyle characteristics in the general population and SII, indicated that physical activity is negatively correlated with SII. These results suggest that reducing inflammation through lifestyle improvements may offer greater benefits for disease prevention [27]. Additionally, a study involving blood samples from 195 healthy national Olympic team athletes, collected before and after exercise, identified a negative correlation between aerobic exercise and SII upon analysis [28], this study is consistent with our research conclusion, which is that exercise is negatively correlated with SII. In parallel, a review focusing on SII as an immune marker in clinical practice, explore its link with exercise physiology, emphasizing that chronic physical activity may aid in improving SII [29]. Furthermore, researchers studying populations characterized by short sleep durations observed that engaging in up to 2400 min of physical exercise per week was associated with lower SII levels, though increased

Table 4 Hierarchical regression analysis of the effect of regular walking on depression in elderly patients with CHD

Variates	N	Forest plot	OR(95%CI)	*P*	*P*-interaction
Age					0.440
65-75	148		0.189(0.092, 0.426)	<0.001	
76-85	160		0.360(0.173, 0.747)	0.006	
>85	156		0.268(0.134, 0.535)	<0.001	
Gender					0.124
Male	295		0.196(0.112, 0.342)	<0.001	
Female	169		0.427(0.223, 0.818)	0.010	
Smoking					0.569
Yes	150		0.308(0.147, 0.646)	0.002	
No	314		0.253(0.153, 0.420)	<0.001	
Drinking					0.373
Yes	115		0.286(0.081, 1.009)	0.052	
No	349		0.232(0.141, 0.382)	<0.001	
HFD					0.109
Yes	153		0.219(0.107, 0.448)	<0.001	
No	311		0.355(0.198, 0.567)	<0.001	
Hypertension					0.810
Yes	237		0.281(0.161, 0.491)	<0.001	
No	227		0.241(0.126, 0.460)	<0.001	
Diabetes					0.731
Yes	187		0.298(0.162, 0.548)	<0.001	
No	277		0.232(0.127, 0.424)	<0.001	
CVD					0.154
Yes	172		0.209(0.106, 0.421)	<0.001	
No	292		0.321(0.188, 0.548)	<0.001	



Abbreviation: high-fat diet, HFD; cerebrovascular disease, CVD;

P and *P*-interaction < 0.05 indicates that the difference is statistically significant.

exercise beyond this threshold did not yield added benefits [30]. Although the study targeted a different population than ours, it also suggests that moderate physical activity can reduce SII. These studies consistently highlight the association between exercise and SII, supporting the conclusions drawn from our research findings.

Extensive prior research has consistently demonstrated a significant correlation between exercise and depression. For instance, a randomized controlled study involving 48 patients with severe depression revealed that walking could alleviate negative emotions in these patients; however, the effects were not sustained beyond 48 h [8]. Another randomized clinical trial, conducted in a primary healthcare setting, examined 347 patients aged 65 years and older with mild to moderate depressive disorders. Results indicated that patients receiving both

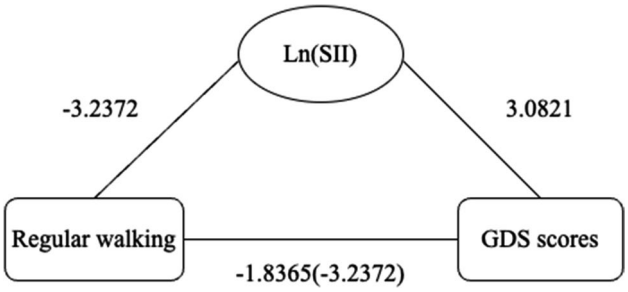


Fig. 1 The mediating role of Ln(SII) in the association between regular walking and GDS scores

antidepressant medication and physical activity interventions experienced a reduction in depressive symptoms, with the physical activity group showing superior outcomes in the medium term [31]. Additionally, a cross-sectional survey conducted in northern China, assessed the relationship between physical exercise frequency and depression among 1604 urban residents aged 50 and older. The research found that the prevalence of depression in urban communities in Jinan was 16.52%, with exercising three times per week being associated with a lower prevalence of depression [32]. Surprisingly, some prior studies have corroborated the notion that exercise may be as effective as medication in reducing depressive symptoms in patients with depression [33, 34]. Exercise appears to alleviate depression through various mechanisms one of which is its neurobiological impact. Aerobic exercise acutely regulates key physiological factors such as 5-HT/NE, BDNF, TNF-α, IL-6, and IL-10 [15].

Physical activity has been shown to alleviate symptoms of depression in patients to varying degrees. While studies indicate that the antidepressant effect of exercise may not be long-lasting, the advantages of regular moderate, and appropriately tailored exercise for individuals with depression are well-established, particularly for those whose physical condition permits such activity. Both the decline in physiological function and the presence of emotional disorders are significant predictors of poor outcomes in patients with CHD. As such, integrating physical and psychological assessments and treatments has become increasingly critical in managing CHD patients. Effective cardiac rehabilitation exercises not only enhance exercise tolerance, heart function, and overall quality of life, but also lower the risks of major cardiovascular events, while mitigating psychological issues such as anxiety and depression [35]. Research has demonstrated that exercise based cardiac rehabilitation programs significantly improve the physical capacity of CHD patients [36]. Furthermore, a meta-analysis highlights the benefits of incorporation Tai Chi into rehabilitation programs, revealing that this form of holistic exercise can promote both physical and mental health in CHD patients. These findings suggest that Tai Chi may serve as a viable approach to cardiovascular rehabilitation [37]. Among various types of exercise recommended in clinical guidelines, brisk walking stands out for several reasons. It is a widely accessible and practical form of physical activity particularly living with CHD [38].

Research utilizing NHANES data indicates that the SII index is associated with an increased risk of depressive disorder, including depressive disorder coexisting with diabetes and post-stroke depressive disorder [7, 12, 39]. Additionally, a cross-sectional study found an association between SII and the severity of coronary heart disease [40]. The deterioration of physiological function and the presence of emotional disorders are strong predictors of poor prognosis in patients with CHD. Therefore, it has become increasingly important to consider both physical and psychological diagnosis and treatment when managing CHD patients [35]. In summary, the SII demonstrates a substantial negative impact on both depression and CHD. Nevertheless, our study has not established a definitive causal relationship among these factors, and the mechanisms underlying their interactions remain unclear. Further investigation into these relationships could provide meaningful insights for disease prevention and the improvement of prognostic strategies.

This study offers several key advantages. It investigates the mediating role of SII in the relationship between regular walking and depression by observing the daily habits of elderly patients with CHD, providing valuable insights into this population. Importantly, the elderly sample we collected demonstrates a certain degree of representativeness strengthening the study's broader applicability. Additionally, this research offers theoretical support for preventing depression in elderly patients with CHD who are able to engage in walking. Walking, an inexpensive, convenient, and accessible form of exercise, is particularly suitable for the elderly, and has been shown to be an effective method for alleviating depression. It helps elderly CHD patients mitigate depressive symptoms, prevent psychological disorders, reduce hospitalization time, and conserve medical resources. However, this study also has several limitations. First, its cross-sectional design prevents the establishment of causation. Future longitudinal research would be invaluable in exploring the causal relationships among walking, SII, and depression. Second, some variables, such as walking habits were self-reported, and the lack of specific measurements, may have introduced recall bias, potentially leading to an overestimation or underestimation of the association between SII and depressive disorder in CHD patients. Third, there was no precise measurement of walking pace or quantification of walking duration, which limits the study's findings. Additionally, the relatively small sample size underscores the need for future muti-center studies with large sample to enhance the robustness of

the conclusions. Finally, incorporating additional factors, such as patients' medication use and economic status into future studies, would be meaningful as these variables could influence the results. Moreover, exploring age, gender and medical history on the relationship between walking and SII is critically important for more comprehensive understanding of this association.

Conclusion

An interaction exists among SII, regular walking and depression in elderly patients with coronary heart disease. Furthermore, SII partially mediates the relationship between regular walking and depression.

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Author contributions
YMJ, ZLL and XCL drafted the manuscript. YMJ and LZ revised the manuscript. XXX, HYJ, and TYC made tables. YMJ, XCL and LZ were responsible for the data acquisition. JYC, SBM and XXX performed the data analysis. YMJ and ZLL performed the statistical analyses. YMJ, ZLL and XCL conceived of and designed the study. All authors have read and approved the final manuscript. All authors reviewed the manuscript.

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Data availability
If the request is reasonable, the first author will provide the original data that supports the conclusions of this article without reservation.

Declarations

Ethics approval
The studies involving human participants were reviewed and approved by the Ethics Committee of The First Hospital of Jilin University. The patients/participants provided their written informed consent to participate in this study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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