Doctor of Economics

Research on the Sustainable Development of China's Sports Industry

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Research on the Sustainable Development of China's Sports Industry

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Abstract

With the continuous development of the modern economy and the enhancement of residents' health consciousness, sports participation has gradually become one of the main choices for people's daily leisure and entertainment. The sustainable development of the sports industry has also become a topic that cannot be ignored in China's overall economic development. This paper mainly focuses on two issues in the development of the sports industry in China.

Part I: The impact of residents' sports consumption on the development of regional green economy. The relationship between sports consumption behavior and environmental protection has always been controversial. As a key project supported by the Chinese government for the development of green economy, the green transformation of sports consumption has received more attention at this stage. This part collects panel data from 30 provinces in China, calculates the green GDP Index and sports consumption level of each province, describes the spatial distribution characteristics, and explores the effect of residents' sports consumption on the regional green economy development. This study further divided the samples according to the geographic east-west location and initial Green GDP Index level, focusing on the heterogeneity between different regions. In terms of spatial distribution characteristics, GGDP index shows a gradually decreasing distribution characteristic from the southeast to the northwest. While the sports consumption level does not show an obvious step-by-step pattern of decreasing from the southeast to the northwest like the GGDP index. The regression results show that the sports

consumption level has a positive effect on the GGDP Index from the perspective of the whole country. In terms of regional differences, this effect is not significant in the western and poor initial foundation regions. While in the eastern and good initial foundation regions, promoting residents' sports consumption has become an effective way to develop the green economy, a 10% increase in sports consumption level can raise the green GDP Index by more than 0.3 percentage points. While continuing to promote green sports consumption, the rational distribution of sports resources and the cooperation of sports markets among different regions should be the key points for future development.

Part II: The impact of physical exercise on the mental health of the elderly. China's aging trend continues to deepen, and the mental health problems of the elderly are getting more serious. As one of the treatment methods to deal with the mental health problems of the elderly, this study aims to provide new empirical evidence for the effect of physical exercise on mental health of the elderly. Based on the cross-sectional data of the China Longitudinal Aging Social Survey 2016, this part constructed an economic model of mental health score according to the depression dependence scale with the participation of the elderly in physical exercise as the main explanatory variable. This study further studied that among the elderly who participated in physical exercise, how the frequency, intensity, and items of physical exercise impacts their mental health. The results show that physical exercise has a significantly positive impact on the mental health of the elderly for the vigorous elderly in 60-74 years old, but not on the mental health of the elderly aged 75 and

above. The frequency of physical exercise has no significant positive impact on the mental health of the elderly. Compared with low-intensity physical exercise, the impact of high-intensity physical exercise on the mental health of the elderly is significantly negative. Among the sports items, square dance has a significantly positive impact on the mental health of the elderly than walking. The frequency of physical exercise varies from person to person, while low-intensity physical exercise and square dance are more conducive to promoting the mental health of the elderly.

Keywords: Sports Industry; Sustainable development; Residents' sports consumption; Green economy; Green GDP index; Physical exercise; Mental health; Aging society

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Part I. The Impact of Residents' Sports Consumption on the Development of Regional Green Economy

1. Introduction

1.1 Research Background

With the continuous development of the modern economy and the enhancement of residents' health consciousness, sports consumption has increasingly become a major choice for people's leisure and entertainment (Lan, 2020). However, the debate between sports consumption and economic green development has never stopped. In recent years, the United Nations Environmental Program has paid more attention to the field of sports consumption due to the negative impact of these activities on the global ecosystem and the large amount of carbon emissions (Triantafyllidis, 2018). As one of the "important enablers" of the 2030 Agenda, the relevance of sustainable development goals in different sectors of the sports industry has been frequently mentioned in many international conferences (Lindsey and Darby, 2019). In the 26th Session of the United Nations Framework Convention on Climate Change in 2021, including the most representative international large-scale sports organizations such as FIFA and ATP, more than 280 sports groups and associations announced that they would abide by the UNFCCC and join the zero-carbon-emission initiative advocated by the United Nations (Dong, 2022). As a result of pressure from environmental organizations in modern consumption-driven societies, new environmental legislation has increased in the last few decades. Many countries revised the environmental

protection law, focusing on the cross-area of sports and ecology, and promoting a sustainable development of sports consumption (Salome et al., 2013). Non-governmental organizations, fans, suppliers, league offices, and consumers have also joined in the trend of promoting change (Pfahl, 2013).

The sustainable sports consumption pursues a rational consumption behavior with ecological awareness, and its basic connotation is to benefit health and protect the ecological environment at the same time. In the 2008 Beijing Olympics, the concept of the Green Olympic Games has become one of the three major themes of the event. The organizing committee spent more than 17 billion dollars in preparatory work to solve environmental problems including transportation infrastructure upgrades, energy development, water protection, and waste disposal (Yang and Xu, 2014). Since then, an ecologically friendly and sustainable model has become the mainstream direction of China's sports consumption development. The China State Council has issued a series of policies, emphasizing that the development of sports consumption is an inevitable requirement for improving physical fitness and health levels, and is conducive to meeting the diverse sports needs of the people, improving people's livelihood, expanding domestic demand, increasing employment, and enhancing cultural competitiveness. Venue transformation, media integration, service diversification, and product technology are all regarded as important aspects of the green upgrading of sports consumption (Liu, 2019). Reducing the consumption of critical natural resources such as energy and the environment is crucial for the sustainable development of China’s economy (Yang and Zhao, 2020). Cultivating the

sports consumption as a new growth point of green economy has become an important goal of the new era (Huang, 2020).

The scale of China's sports consumption market is showing a continuous expansion trend. By 2020, the total expenditure on sports consumption has reached 1.5 trillion yuan, and it is expected to exceed 2.8 trillion yuan in 2025 under this rapid growth trend. As the key project supported by the Chinese government for the development of the green economy, it is worth paying attention to whether the increase in residents' sports consumption can effectively promote the regional green economy. Based on the panel data of 30 provinces in China from 2014 to 2019, this study measures the green GDP Index and the sports consumption level of each province, summarizes the spatial distribution characteristics, and conducts a regional heterogeneity analysis, aiming to provide new empirical evidence for the impact of residents' sports consumption on the development of regional green economy.

1.2 Research significance

The first marginal contribution of this paper is to optimize the accuracy of the proxy variable of residents' sports consumption in the model construction. Based on the available data from the National and Provincial Bureau of Statistics in China, some scholars have chosen per capita cultural and entertainment expenditure as a proxy variable for measuring sports consumption levels (Shi, 2019; Han and Yan 2021). However, the accuracy requires a rather large assumption that the proportion of sports consumption to total cultural and entertainment consumption is the same across all provinces. This assumption is obviously too large due to the inequality and

regional differences in consumption expenditure have been pointed out (Zhao et al., 2017; Liu et al., 2021). From the "China Cultural and Tourism Statistics Yearbook," we found a proxy variable that represents tourism consumption, which is an important component of residents' cultural and entertainment consumption other than sports consumption. By including this proxy variable for tourism consumption, we attempt to eliminate the impact of non-sports consumption on regional green economic development in the regression analysis.

The second marginal contribution of this paper is to add a new grouping standard for analyzing regional heterogeneity. In addition to the traditional standard of dividing regions into the eastern and the western based on geographic location, considering the non-synchronization of the development level of the green economy in different regions, we further divide the sample into two groups: good initial foundation region and poor initial foundation region according to the initial green GDP Index in each province. This grouping can help us to better explore the effect of residents' sports consumption in different stages of green economy development.

1.3 Literature review

Existing research has two contradictory views on the relationship between sports consumption and the green economy. Some scholars suggest a clear conflict between sports consumption behavior and the environment. Cachay (1993) points out that the construction of sports facilities and indirect requirements such as car parks and access roads take up a considerable amount of land. Besides, outdoor sports such as sailing, surfing, mountain climbing, and skiing often attract people to some ecologically

sensitive areas, causing damage to the ecological life system. Shen and Kou (2012) studied golf courses in China and pointed out that golf is highly dependent on land and resources. More than 600 golf courses in China consume more than 1.56 million tons of water per day, and the average site covers an area of about 60 hectares. The pesticides and herbicides that need to be sprayed to maintain the fairways also cause environmental pollution and ecological damage. In addition to land occupation and ecological destruction, large events often consume a lot of energy resources and produce carbon emissions that are much higher than the environmental sustainability standard of the United Nations (Atalay, 2021). A FIFA World Cup will consume about 3 million kilowatt-hours of electricity generated by fossil fuel, which is equivalent to the annual electricity needs of 700 households (Schmidt, 2006). Even a campus football match will produce significantly higher carbon emissions than usual due to crowd gathering and transportation. During the event, the operation of the stadium requires more energy such as water and electricity. Waste disposal resulting from the food and drink consumed by the audience also contributes to carbon emissions (Triantafyllidis et al., 2018).

Another point of view is that with the efforts of the government, sports organizations, enterprises, and consumers, sports consumption at this stage is more conducive to developing the green economy. The importance of sustainable design and construction of sports facilities has received more attention. Newly built sports facilities such as swimming pools, ice rinks, and ski slopes have to comply with strict regulatory and environmental constraints to control resource consumption and

environmental damage, which has also promoted the continuous upgrading of supporting equipment such as water conservation and energy optimization (Erten & Özfiliz, 2006; Burszta-Adamiak & Spychalski, 2021; Elnour et al., 2022). Major sports events, with the Olympic Games as a prime example, are known for their significant contribution to the list of environmental impacts. Conserving energy, biodiversity, landscapes, and green transportation have become crucial themes in the evaluation of the sustainability of these major events. Organizers of major events have implemented many programs to offset carbon emissions and promote recycling, which also drives green awareness among spectators and consumers (Mallen et al., 2010; Hayes & Karamichas, 2012). More than 75 percent of fans felt green products were worth the additional cost and appreciated the environmental initiative of professional sports teams due to the survey by Pro Green Sports. Increasing their sustainability initiatives have be seen as an extension of the social responsibility of professional sports clubs (Blankenbuehler and Kunz, 2014). Evidence indicated associative behavior among sports organizations with respect to environmental management is increasing and the guiding role of this kind of environmental social responsibility on people's green sports consumption is highlighted (Babiak & Trendafilova, 2011; Trendafilova et al., 2013; Widawska-Stanisz, 2022).

Few scholars adopt empirical research on the impact of sports consumption on the green economy. The relevant research in China mainly focuses on the promotion effect of the regional sports industry on the greening of the economy. Using the cointegration test and error correction VEC model, Kong and Hao (2021) prove that

there is a positive long-term relationship between the development of the sports industry, economic growth, and CO2 emissions. Under the influence of technological innovation and the advancement of information technology, the carbon emissions of the sports industry and sports product consumption are significantly lower than some traditional industries. A mutual promotion effect between the new infrastructure and green total factor productivity of the sports industry has been illustrated, the sports industry in most provinces has been in the stage of constant return to the green economy (Dong, 2022). In terms of regional differences, scholars have demonstrated the heterogeneity between regions in different geographical locations. Xu and Yang (2019) point out that the concentration of the sports industry has a significant impact on green economic growth, but the effect in the western region is much lower than that in the central and eastern regions. This view is consistent with the research of Yang et al. (2020), using the entropy method and coupling coordination model, they demonstrate that the comprehensive level of the sports industry and regional sustainable development of 11 provinces in eastern China is showing a steady growth trend, and the growth rate of the sports industry is even faster than regional sustainable development.

Based on the existing literature, it can be found that although the debate still exists, the transformation of sports consumption has been regarded as an important link in the development of green economy, and the sports industry at this stage has been proved to be conducive to promoting the green economy, especially in the eastern region of China. However, there is a lack of empirical research related to

residents' sports consumption expenditure, and the heterogeneity of residents' sports consumption in different regions still needs to be further explored. Compared with existing research, this study aims to provide new empirical evidence from the perspective of residents' sports consumption expenditure and build a more detailed analysis of regional differences for the effect of sports consumption on the green economy.

2. Data and methodology

2.1 Variable selection and data source

For the measurement of the green economy, the green GDP (GGDP) is the most commonly used indicator which can be traced back to the 1970s. Countries began to pay attention to the relationship between economic development and environmental protection, and strove to find new economic indicators that can reflect green and sustainable development. Tobin and Nordhaus (1972) first proposed the indicator of net economic welfare. They advocated that the output value generated by economic behaviors that produce environmental pollution and excessive consumption should be partially deducted from the traditional GDP measurement process. The Norwegian government published the Natural Resources Report in 1981 and began to conduct official statistical accounting on the consumption of natural resources at the national level (Alfsen et al., 1987). In 1993, the United Nations Bureau of Statistics and the World Bank jointly formulated the System of Integrated Environmental and Economic Accounting (SEEA) and formally proposed the concept of green GDP. In this system, the resource cost and environmental cost are deducted from the national economic accounting to adjust the traditional GDP (Bartelmus & Tardos, 1993). Since 2001, the China National Bureau of Statistics began to compile natural physical tables including four natural resources, including land, minerals, forests, and water, and carried out resource value accounting and environmental protection expenditure accounting. Based on these available data, scholars began to calculate the GGDP in various provinces and cities to reflect the proportion of the environmentally friendly and

sustainable part of the total economic volume. This study refers to the algorithm of the System of Integrated Environmental and Economic Accounting (Shen et al., 2017; Wang et al., 2020; Qi et al., 2021), and the specific formula is:

$$GGDP = GDP - Resource\ Depletion\ Value - Environmental\ Loss\ Value \quad (1)$$

Considering that the representativeness of GGDP output to the degree of green economic development in each province is easily overshadowed by the huge gap in the overall economy volume, this study further calculates the GGDP Index (GI) of each province as the explained variable. GI is calculated as a percentage of GGDP to traditional GDP (GDP), and the formula is:

$$GI = GGDP * 100/GDP \quad (2)$$

Table 1. Indicator detail and accounting method of GGDP

Indicator detail	Accounting method
Depletion value of water	Water price × Depletion
Depletion value of energy	Standard coal unit price × Depletion
Depletion value of cultivated land	Cultivated land price × Depletion
Depreciation loss on fixed assets	Gross industrial output × Ratio of maintenance costs × Ratio of environmental maintenance
Lost value of water pollution Lost value of air pollution Lost value of solid waste	Sum of actual pollutant governance cost
Lost value of natural disasters	Direct economic losses by natural disasters

The specific accounting indicators and methods of GGDP are shown in Table 1. In the accounting of GDP, resource prices and governance costs, the data are processed according to the GDP deflator, energy price index, and consumer price index to ensure the comparability.

For the measurement of the sports consumption level, the per capita expenditure on culture and entertainment is chosen as a proxy variable same as previous research (Shi, 2019; Han & Yan 2021). This is the most detailed available data on household expenditure covering sports consumption from the Provincial Statistical Yearbooks. Further, to more accurately separate the effect of sports consumption, this study tries to find another proxy variable that can represent tourism consumption which is an important part of residents' cultural and entertainment consumption in addition to sports consumption. From the China Culture and Tourism Statistical Yearbook, the per capita daily spending of overnight tourists in each province is chosen as a proxy variable to represent the heterogeneity of tourism consumption levels in different provinces. By adding this variable to our regression model, the effect of non-sports consumption on the green economy can be further eliminated, and the difference in sports consumption levels among provinces can also be more accurately reflected.

In the selection of control variables, referring to the relevant literature on the green economy, including Eaton (2013); Zhao et al. (2019); Zheng et al. (2020); and Chen et al. (2021), this paper focuses on four perspectives: government fiscal capacity, human capital level, technological innovation level, and severity of environmental pollution. The government fiscal capacity is measured by the level of fiscal

decentralization of local governments. The human capital level focuses on the education level of residents. The technical innovation level is measured by the regional number of technology patent authorizations. The measurement of the severity of environmental pollution includes three variables: wastewater pollution, waste gas pollution, and solid pollution. The interpretation and detailed measurement standards of explained variables, explanatory variables, and control variables are shown in Table 2.

Table 2. Interpretation and measurement standard of variables

Variable name	Symbol	Measurement standards
Green GDP Index	GI	Percentage of GGDP to GDP
Sports Consumption	SC	Per capita expenditure on culture and entertainment
Tourism Consumption	Tou	Per capita daily spending of overnight tourists
Government fiscal capacity	Fis	Proportion of provincial fiscal expenditures to national budgetary fiscal expenditures
Human capital level	Edu	Per capita years of education
Technological innovation	Inn	Per capita technology patent authorizations
Wastewater pollution	COD	Per capita Chemical Oxygen Demand in wastewater
Exhaust gas pollution	NOE	Per capita Nitrogen Oxides Emission in exhaust gas
Solid waste pollution	SW	Per capita Solid Waste

2.2 Model construction

Consumerism culture refers to the pursuit of superior spiritual feelings and social evaluation through excessive consumption of material products. Consumerism in residents' sports consumption is mainly reflected in the excessive use of resources, environmental pollution, and waste caused by entertainment. The green transformation of sports consumption is considered to be related to the green economy because it seeks to change the unsustainable trend of consumerism by reducing resource consumption and environmental pollution (Li, 2016). Through system theory and industry segmentation theory, the sports industry has been regarded as an important part of the whole economic system, and the increase in sports consumption has also proved to be of some significance to economic growth (Pitts et al., 1994; Miao, 2013).

Therefore, I try to build a production function economic model to reveal the effect of sports consumption on promoting the green economy. The production function approach is the most commonly used in research fields related to GDP growth and can also be used to reveal the effect of increasing certain consumption on a certain proportion. (Xu & Yang, 2019; Papke, 2005). In our study, the explanatory variable is the GI which is the percentage of GGDP to GDP. The production function model can be written as:

$$GI_{it} = \beta_1 + \beta_2 LnSC_{it} + \beta_3 LnTou_{it} + \beta_4 LnEdu_{it} + \beta_5 LnInn_{it} + \beta_6 Fis_{it} + \beta_7 LnCOD_{it} + \beta_8 LnNOE_{it} + \beta_8 LnSW_{it} + \alpha_i + u_{it} \quad (3)$$

where α_i is the unobserved province effect and u_{it} is the idiosyncratic error that

changes across time for each province. Considering the differences in economic development, climate environment, customs and culture among different provinces, it is necessary to allow for a correlation between sports expenditure and unobserved provincial heterogeneity in the model. By adding the tourism consumption variable $LnTou_{it}$ to our regression model, the coefficient before $LnSC_{it}$, the β_2 in Equation (3) can be closer to the true effect of sports consumption.

Regression analysis on the entire sample and explore the effect of residents' sports consumption on the GGDP index was performed from the whole country dimension. After that, the regression of the split samples was carry out according to the two criteria: the geographical division of the east and the west and the initial level of the GGDP Index. Through different grouping methods, this study aims to find the heterogeneity of the effect of residents' sports consumption on the GGDP Index in different geographical locations and different green economy development stages.

3. Result and discussion

3.1 Summary statistics

Table 3. Descriptive statistics for GGDP Index and sports consumption level

	GGDP Index（GI）				Sports Consumption level（SC）			
	2014	2019	Average	Rank	2014	2019	Average	Rank
Beijing	96.78	97.57	97.26	1	1566	1712	1625	2
Tianjin	91.85	93.19	92.56	16	804	1367	1058	8
Hebei	88.10	89.21	88.73	22	706	935	809	27
Shanxi	82.36	83.95	83.03	27	810	1061	919	16
Inner Mongolia	82.41	83.99	83.36	26	870	1108	1000	9
Liaoning	87.52	88.37	87.85	24	990	1234	1069	7
Jilin	89.38	92.20	90.74	20	791	1137	938	14
Heilongjiang	88.59	88.78	88.55	23	719	1057	844	21
Shanghai	95.18	96.37	95.78	2	1362	2155	1794	1
Jiangsu	94.70	95.90	95.38	3	1131	1303	1235	4
Zhejiang	94.46	95.76	95.02	5	1086	1569	1313	3
Anhui	93.58	95.15	94.19	9	690	1012	822	25
Fujian	94.39	95.91	95.01	6	897	1108	954	13
Jiangxi	93.26	94.75	93.95	10	681	1005	830	23
Shandong	91.97	92.54	92.43	17	757	1046	932	15
Henan	92.27	94.99	93.71	12	679	966	824	24

Hubei	93.30	95.14	94.22	8	728	1072	884	18
Hunan	92.60	94.85	93.90	11	854	1291	1096	6
Guangdong	94.54	96.10	95.35	4	986	1439	1201	5
Guangxi	90.33	93.25	92.04	18	675	943	808	28
Hainan	88.80	94.89	92.96	14	596	1132	807	29
Chongqing	92.94	95.45	94.45	7	687	1046	875	19
Sichuan	91.71	93.94	93.14	13	668	964	810	26
Guizhou	86.24	92.36	89.98	21	828	1131	991	10
Yunnan	88.28	93.25	91.63	19	641	922	772	30
Shaanxi	92.37	93.52	92.84	15	858	1097	962	12
Gansu	86.10	88.84	87.46	25	699	923	850	20
Qinghai	75.38	82.26	78.71	29	752	950	841	22
Ningxia	75.58	76.24	76.30	30	783	1150	966	11
Xinjiang	80.19	83.73	81.76	28	726	994	905	17

Source: Calculated by the authors based on 2014-2019 data from China Statistical Yearbook, Provincial Statistical Yearbook, China Energy Statistical Yearbook, and China Environmental Statistical Yearbook.

Note: The measurement unit of sports consumption level is CNY.

Table 3 provides the descriptive statistics of the GGDP Index and sports consumption level of the 30 provinces in China. From 2014 to 2019, the GGDP index generally shows a volatile upward trend. The spatial distribution characteristics are

shown in Figure 1. It can be seen that there is a gradually decreasing distribution characteristic from the southeast to the northwest. This distribution is consistent with the results of green GDP accounting of each province in China from 1997 to 2013 by Shen et al. (2017). Eastern coastal provinces such as Shanghai, Jiangsu, Guangdong, and Zhejiang rank highest. These areas generally have better natural geographical conditions, complete infrastructure and transportation facilities, fast and efficient information dissemination, and a more optimized industrial structure, which contribute to their leading stage in the process of economic green transformation. While in some western provinces such as Shanxi, Gansu, Ningxia, Qinghai, and Xinjiang, due to the large proportion of resource-consuming industries, insufficient technological innovation capabilities, low environmental governance efficiency, and serious natural disaster losses, the green GDP index is relatively low.

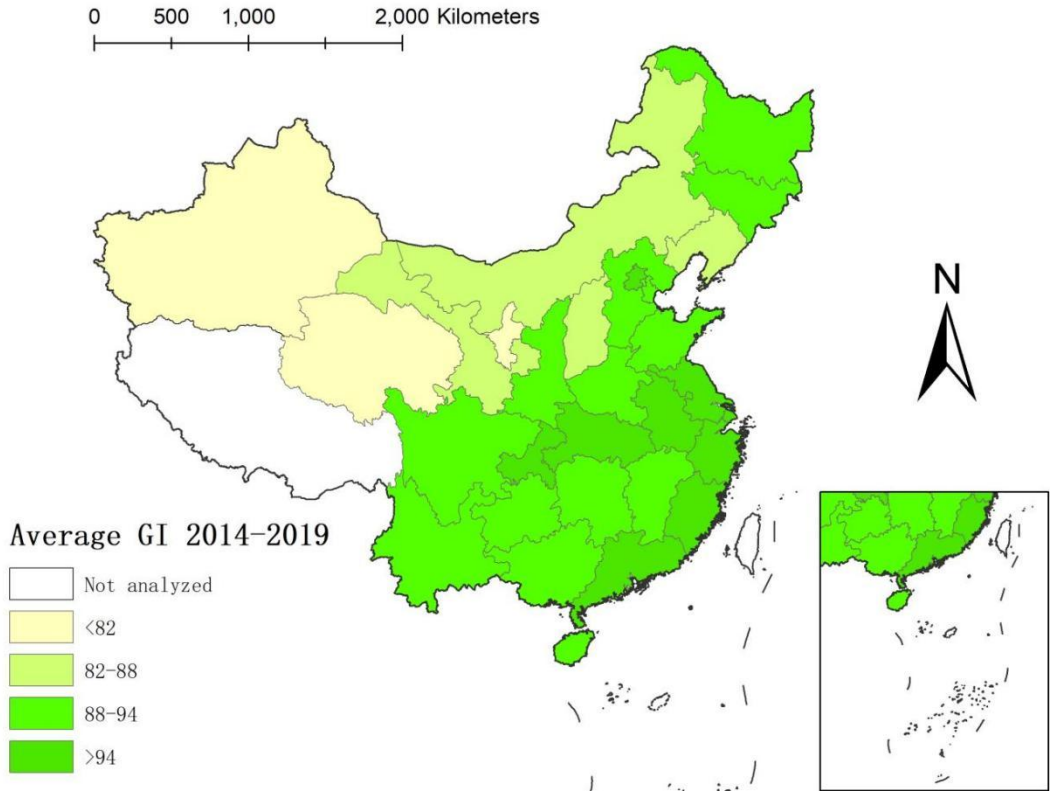

Figure. 1 Spatial distribution of Average GI from 2014 to 2019

Source: Plotting based on 2014-2019 data from China Statistical Yearbook, Provincial Statistical Yearbook, China Energy Statistical Yearbook, and China Environmental Statistical Yearbook.

The sports consumption level of all provinces steadily increased in the 2014-2019 period. The spatial distribution characteristics are shown in Figure 2. It can be seen that the sports consumption level does not show an obvious step-by-step pattern of decreasing from the southeast to the northwest like the GGDP index. The sports consumption level in the eastern coastal areas is relatively higher, but there is no big gap between other provinces. Among them, Shanghai, Beijing, Zhejiang,

Jiangsu, and Guangdong still rank the highest. These provinces can be regarded as the regions with the best economic development in China. In addition to the advantages of the overall economic size, they generally have more sports-related resources including sports venues and facilities, professional sports teams, advanced technological support, and industrial talents. Coupled with the appropriate macro-control by the local government, a well-functioning sports market has been formed in these regions. The bottom-ranked provinces are not the same as the GGDP index. Since the gap is not very obvious, the order of ranking at the bottom does not make much sense.

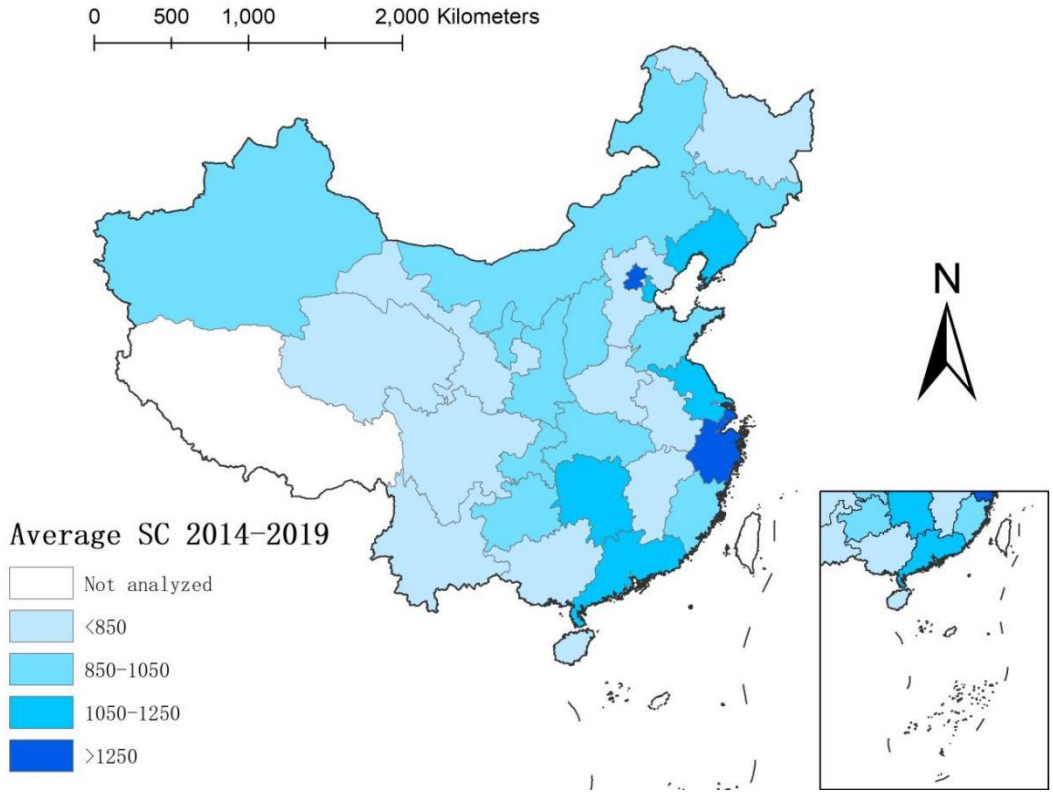

Figure. 2 Spatial distribution of Average SC from 2014 to 2019

Source: Plotting based on 2014-2019 data from China Statistical Yearbook and Provincial Statistical Yearbook.

3.2 Econometric findings

Table 4. The regression results of full sample

	(1)				(2)	(3)
	Correlated RE_robust				FE	FE_robust
LnSC	2.240*	Mean_LnSC	-8.581***	LnSC	2.249**	2.249*
	[1.303]		[2.545]		(0.917)	[1.270]
LnTou	1.766	Mean_LnTou	2.483	LnTou	1.745	1.745
	[5.038]		[6.589]		(2.632)	[4.915]
LnEdu	2.440	Mean_LnEdu	1.361	LnEdu	2.441	2.441
	[3.095]		[4.271]		(2.911)	[3.021]
LnInn	1.265*	Mean_LnInn	0.125	LnInn	1.262***	1.262*
	[0.740]		[1.006]		(0.352)	[0.721]
Fisc	-1.296	Mean_Fisc	18.668***	Fisc	-1.305	-1.305
	[5.363]		[6.724]		(4.772)	[5.240]
LnCOD	-0.268	Mean_LnCOD	-0.025	LnCOD	-0.267	-0.267
	[0.307]		[0.989]		(0.198)	[0.300]
LnNOE	-0.222	Mean_LnNOE	-4.860**	LnNOE	-0.221	-0.221
	[0.650]		[1.962]		(0.458)	[0.634]
LnSW	-0.383	Mean_LnSW	-1.124	LnSW	-0.379	-0.379
	[0.567]		[1.006]		(0.151)	[0.562]
R^2		0.893		R^2	0.444	0.444
Observations		180		Observations	180	180

Note: *P<0.1, **P<0.05, ***P<0.01, usual standard errors in the parentheses, fully robust standard errors in the brackets. Column (1) uses the correlated random effect model according to Mundlak (1978). Column (2) (3) uses the fixed effect model.

The regression results of the full sample are shown in Table 4. A fully robust regression-based Hausman test according to Wooldridge (2010) is used for the choice of fixed effect and correlated random effect. The test gives a strong rejection (chi2(8)=62.96, p-value<0.001), indicating that the fixed effect model gives us a more robust result.

Comparing column (2) and column (3), when fully robust standard errors are used, the significance level of the coefficient on sports consumption drops, but it still passes the 10% significance level. Since I use the logarithmic form of sports consumption, to obtain the percentage point change in GGDP Index given a 10% increase in sports consumption, the coefficient on the GGDP Index is divided by 10. The results show that when the sports consumption level is increased by 10%, the provincial GGDP Index can be increased by about 0.225 percentage points (t=1.77). This volume of increase may seem small, but considering that China's sports industry still accounts for less than 2% of the total GDP output value by 2020, the size of this regression coefficient is reasonable. Among the control variables, the positive effect of technical innovation level also passed the 10% significance level test, which proves that the promotion of technology innovation plays an important role in the development of green economy.

The regression results of the full sample prove that the sports consumption level has a positive effect on the GGDP level at the 10% significance level from the perspective of the whole country. However, considering the imbalance of the regional green GDP index and sports consumption level, the effect of sports consumption level on the GGDP Index may vary widely among provinces with different geographic locations and different initial GGDP Index levels. In the following, a regression analysis on the split sample will be performed, focusing on this heterogeneity of effects across different regions.

3.3 Analysis of regional differences

Table 5. The regression results of split sample

	(1) Western Region	(2) Eastern Region	(3) Initial GI below average	(4) Initial GI above average
LnSC	2.557	3.581***	2.782	3.017***
	[1.744]	[1.047]	[2.209]	[0.645]
LnTou	-6.608	7.562*	2.260	3.000
	[7.261]	[3.785]	[8.729]	[2.351]
LnEdu	1.673	-0.562	1.710	-0.365
	[3.799]	[2.492]	[6.246]	[1.552]
LnInn	2.011*	0.200	1.201	0.579*
	[1.048]	[0.427]	[11.257]	[0.322]
Fisc	42.031*	1.606	19.366	0.453

	[23.155]	[3.162]	[15.273]	[3.652]
LnCOD	-0.564	-0.322	-1.101**	-0.040
	[0.547]	[0.331]	[0.501]	[0.167]
LnNOE	-0.076	-0.018	-0.137	-0.061
	[0.986]	[0.396]	[0.725]	[0.362]
LnSW	-0.082	-0.793	-0.423	-0.311
	[1.078]	[0.606]	[11.095]	[0.251]
R^2	0.616	0.412	0.400	0.530
Observations	72	108	84	96

Note: *P<0.1, **P<0.05, ***P<0.01, all columns use fixed effect model, fully robust standard errors in the brackets.

First, the 30 provinces are divided into two groups: the western region and the eastern region, based on the geographic location. In the seventh population census, the Chinese government divides the entire country into four parts: the western region, the central region, the northeastern region, and the eastern region. However, given the relatively small sample size of our study and the spatial distribution characteristics of GGDP, this study put the central region, the northeastern region, and the eastern region together as the eastern region. The division of the western region and the eastern region is shown more intuitively in Figure 3.

Columns (1) and (2) in Table 5 are the regression results for split samples of the western and eastern regions. Very different results were shown between the two

groups. In the western region, although the regression coefficient is positive, the effect of sports consumption level on the GGDP Index is not significant. Technological innovation and the government's fiscal capacity seem to be more important in the western region. While in the eastern region, the sports consumption level has a positive effect on the GGDP Index at the 1% significance level (t=3.68). When the sports consumption level is increased by 10%, the province's GGDP Index can be increased by about 0.358 percentage points. One possible explanation is that the transformation and upgrading of green sports consumption in the eastern region is better, while sports consumption in the western region is still highly dependent on the environment. This result is similar to the regional differences in the positive impact of sports industry agglomeration on the green economy (Xu & Yang, 2019). Increasing residents' sports consumption has become an effective way to promote the development of the green economy in the eastern region, but not in the western region.

Another grouping criterion is based on the level of the GGDP Index of each province in the initial year of the sample data. The entire sample was divided into two groups: good initial foundation region and poor initial foundation region according to whether the GGDP Index of the initial year is higher than the average level. The spatial distribution of grouping results after this standard is intuitively shown in Figure 4. Compared with the previous grouping standard based on geographical location, 13 provinces in the eastern region and the good initial foundation region are the same, which is in line with the spatial distribution characteristics of the GGDP

Index. The grouping results of six provinces have changed from the previous grouping criteria.

As shown in columns (3) and (4) in Table 5, in the poor initial foundation region, only the variable COD, which represents the level of wastewater pollution, has a significant negative correlation with the GGDP Index. For provinces with a relatively low GGDP Index, pollution control and reduction seem to be more important aspects of green economic development. In the good initial foundation region, the sports consumption level has a positive effect on the GGDP Index at the 1% significance level (t=4.68). When the sports consumption level is increased by 10%, the province's GGDP Index can be increased by about 0.302 percentage points. This regional difference can be understood as when the green economy develops to a certain stage, the environmental governance has been maintained at a certain scale, and increasing residents' sports consumption has become one of the effective ways to drive the growth of the GGDP Index. The poor initial foundation region is still facing serious environmental pollution and resource waste problems, and the increase of a certain amount of residents' sports consumption cannot effectively improve the green economy. The result also confirms the viewpoint of Yang et al. (2020) that the sports industry in more developed eastern coastal provinces can effectively promote sustainable economic development.

Based on the results of regional difference analysis, sports consumption should continue to be encouraged in the eastern region and good initial foundation region. We should further promote the green transformation of sports consumption, establish

a good value orientation and market model, and fully stimulate this effect in promoting the regional green economy. Meanwhile, in the overall development process of green economy, we should strengthen the circulation of sports resources across regions, improve environmental governance and technological innovation in the western region and the poor initial foundation region, and gradually introduce the green sports consumption mode to these regions to explore the new driving force of green economic development.

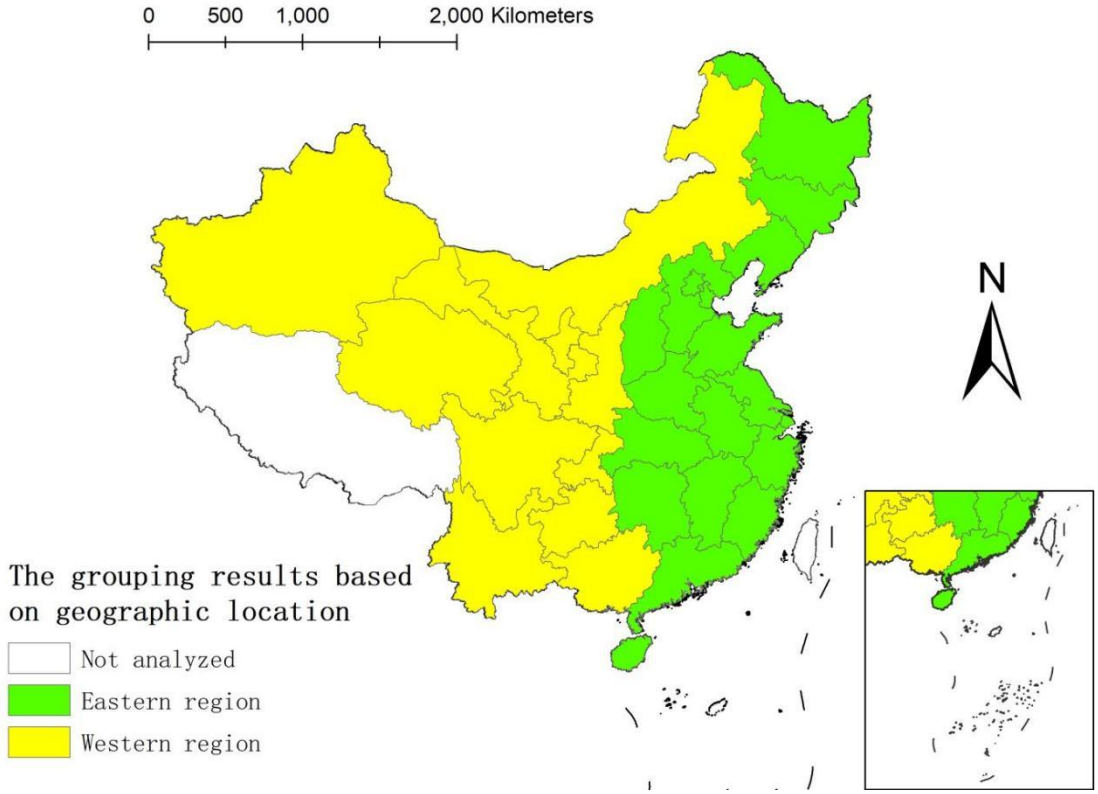

Figure. 3 The Grouping Standard for Eastern Region and Western Region

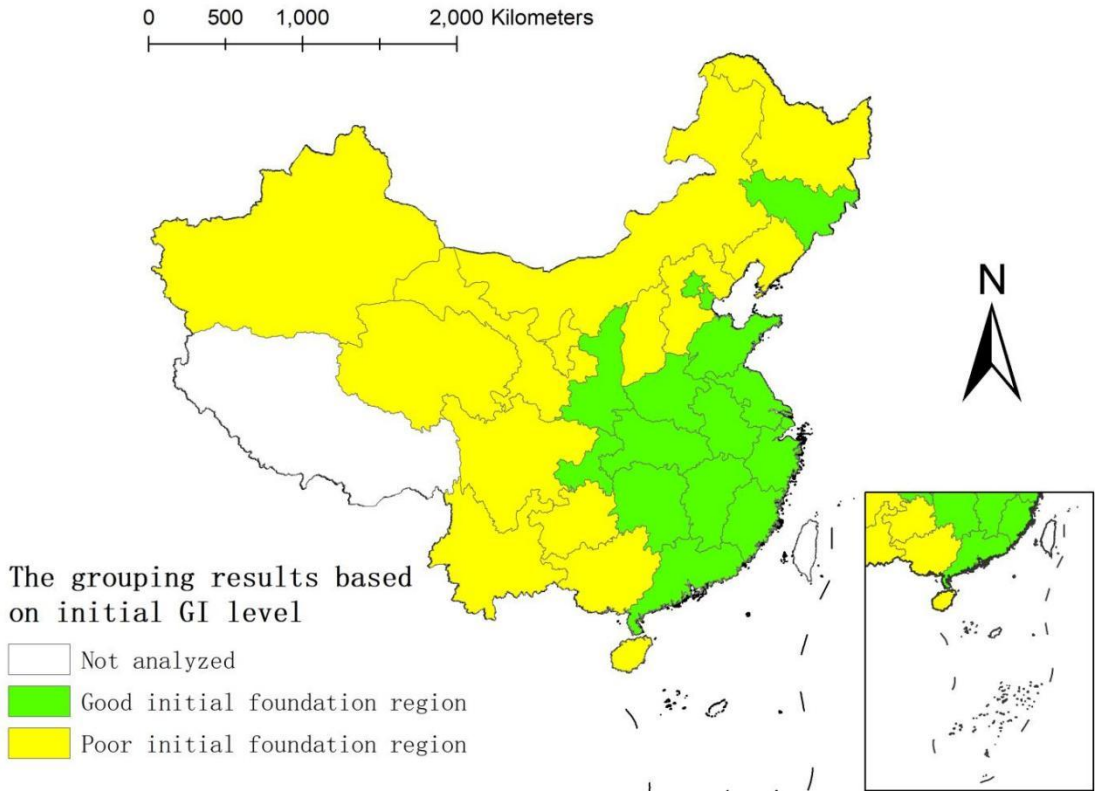

Figure. 4 The Grouping Standard for Good Initial Foundation Region and Poor Initial Foundation Region

4. Conclusions and caveats

Through the econometric method, residents' sports consumption shows a positive effect on the development of regional green economy from the perspective of the whole country. However, it is worth noting that there is large regional heterogeneity in this effect. In the western region or the poor initial foundation region, the positive effect of sports consumption level on the GGDP Index is not significant. Environmental governance and emission reduction are still the main problems faced by these regions. While in the eastern region and the good initial foundation region, a 10% increase in the sports consumption level can raise the GGDP Index by approximately 0.358 and 0.302 percentage points respectively (Both passed the 1% significance level test). For provinces in these regions, the green transformation of sports consumption has achieved some results, increasing sports consumption has become an effective way to promote green economic development.

From the perspective of future development, the government should continue to promote the sustainable development of sports consumption, and strive to form a good value orientation and market model. The promotion effect of residents' sports consumption on the green economy should be further stimulated in the eastern region and the good initial foundation region. Besides, more attention should be paid to the cross-regional circulation of sports resources. While improving environmental governance and technological innovation in the western region or the poor initial foundation region, the government should devote efforts to promoting the upgrade and transformation of local sports consumption markets, strengthening inter-regional

cooperation, and introducing some green sports consumption projects to cultivate new momentum for the development of regional green economy.

There are also some shortcomings in this study. Although we added a proxy variable representing the tourism consumption level into the model to eliminate the effect of non-sports consumption, there are still some other missing factors that affect the fluctuation of the level of sports consumption between provinces. In addition, whether there is an inter-provincial spatial spillover effect in residents' sports consumption has not been considered. With the refinement of China's green economy accounting indicators and the advancement of sports consumption statistics, future research is expected to provide a more precise analysis of the effect of sports consumption on the green economy.

Part II. The Impact of Physical Exercise on the Mental Health of the Elderly - Based on China Longitudinal Aging Social Survey

5. Introduction

Since China entered an aging society in 1999, the aging process has continued to deepen. According to the latest “Seventh National Census” data, due to November 2020, China’s national population has a total of 1411.78 million. The people over 60 years old have reached 264.02 million, accounting for 18.70%. Compared with 2010, The proportion of the elderly has increased by 5.44%, and the growth rate has increased by 2.51%. With the aging process, the mental health problems of the elderly in China have become increasingly prominent. Data from the National Health Commission of China in 2019 shows that the mental health rate of the urban elderly is 30.3%, and the mental health rate of the rural elderly is only 26.8% (Hou et al., 2021). The proportion of elderly people considered mentally healthy is even less than one-third of the total. In response to this situation, under the general guidelines of the "Healthy China 2030" Planning Outline, the National Health Commission has issued the "Notice on Implementing Mental Care Projects for the Elderly", which emphasizes the need to enhance the ability of the elderly to self-care and self-adjust, and improve the elderly’s mental health level.

In a high-tempo and frequent population movement social system, psychological disorders are more common in the elderly than in other sections of society. They are

more likely to have negative feelings such as inferiority complex, worthlessness and insecurity, which may lead to anxiety and even depression in severe cases (El Mrayyan et al., 2020). The theory of strength and vulnerability integration suggests that people's ability to avoid and resolve negative emotions is gradually strengthened with the increase of age. However, due to the decline of physiological function and the limitation of social activities of the elderly, the negative effects will weaken or even reverse the positive effect of age on negative emotion regulation, thus creating greater risks and leading to mental health problems (Charles & Luong, 2013). The formation and development of the negative emotions of the elderly are usually highly hidden and difficult to be detected by other family members. Sometimes they can not be found and noticed until their daily life has been seriously affected. This feature has caused some trouble for the prevention and treatment of mental health problems of the elderly (Qu & Su, 2017).

The factors that affect the mental health of the elderly include not only some individual demographic characteristics such as age and gender (Kolchakova & Akabaliev, 2003; Kiely et al., 2019). and income (Wilkinson, 2016), but also many other aspects including spouse status (Park et al., 2016; Siflinger, 2017), body type (Jung et al., 2017; Lincoln, 2020), nutrition intake (McMartin, 2013), chronic diseases (Maatouk et al., 2016), education (Malekafzali, 2010), and living conditions (Sun & Lyu, 2020). Researchers are looking for various ways to improve the mental health of the elderly. Physical exercise, as one of the essential contents of cultural and entertainment activities for the elderly, has been illustrated to help improve cognitive

function and psychological adjustment ability, increase happiness and self-identity, and also prevent and treat some common diseases such as dementia, diabetes and ischaemic heart disease (Wang et al., 2016; Lorem et al., 2017; Jafari & Behboodi, 2017).

The promotion mechanism of physical exercise on mental health has been explained in several different disciplines. First, physical exercise is considered to have a positive impact on mood states such as anxiety, stress and depression, through physiological and biochemical mechanisms, including endorphins, mitochondria, mammalian target of rapamycin, the hypothalamic-pituitary-adrenal axis and neurotransmitters, and via the thermogenic hypothesis, which can contribute to better health outcomes in people suffering from mood disorders (Mikkelsen et al., 2017). Through the biological experiment of elderly rats, Seyed et al. (2021) illustrated exercise can significantly decreased anxiety as well as improved memory, physical persistence and aerobic power. Similar experiments have also proved that exercise can improved anxiety-like behaviors and aerobic power in rats with Alzheimer's disease (Azarian et al., 2019) and endurance training can improve hippocampus metabolism (Negarandeh et al., 2019). Exercises via the increase in blood flow to the brain, enhance energy substrates, activate the cAMP pathway, modulates glycogen synthase kinase-3 beta, increase phosphoinositide 3-kinase, activate the Akt pathway, decrease oxidative stress, and increase neuronal plasticity, but these effects are depend on intensity, frequency, duration, and type of exercise (Negarandeh et al., 2019; Vedøy et al., 2020). In terms of sociology and psychology, the self-efficacy theory states that

the physiological effect of completing an important and hard task, such as exercise, will bring a sense of mastery, which will enhance the mood itself. (Middelkamp et al., 2017). A good lifestyle and mental health are highly related to positive self-esteem. Those with high self-esteem are less likely to fall into negative emotions (Alexandratos et al., 2012). Another mainstream theory is called dispersion theory, which states suggests that rather than physiological change produced by exercise that some negative emotions can be dispersed or eliminated during exercise (Bahrke & Morgan, 1978). Active distraction task has greater ability to relieve depression than passive distraction, and physical exercise is a good choice for distraction (Nolen-Hoeksema et al., 1993). Besides, the importance of social interaction and support for the elderly in physical exercise has also been pointed out (Mason & Holt, 2012). In the group space for physical exercise, communication and interaction with surrounding people can play an important role in expressing emotions, effectively avoiding the negative emotions of the elderly due to long-term solitude and feelings of loss (An, 2019). Compared with compulsory social participation in adulthood for basic life needs, the elderly who participate in physical exercise are more self-will. The powers, obligations, responsibilities, and social expectations conferred by this non-mandatory role can help the elderly realize their self-worth and focus more on positive things in their life (Chodzko-Zajko et al., 2009).

Some scholars have also proved the effect of physical exercise on the mental health of the elderly through experiments and questionnaires. A study enrolled in the National Fitness Center in Seoul found that resistance exercise and interval training

have a positive impact on cognitive function and mental health of the elderly (Yoon et al., 2019). A Quasi experimental study in Iran also proved this point. The intervention group carried out a total of 16 times of physical exercise for four weeks under the supervision of researchers, with a single time of about 20 minutes. The results show that regular sports in the intervention group can promote the mental health of the elderly (Hekmati & Hojjati, 2016). Through the questionnaire survey, Hua et al. (2016) illustrated that the elderly who participate in TaiChi exercise have significantly higher mental health indicators including vitality, emotion expressing, personality, intellectual development, and mental non-abnormality than those who do not participate in the exercise. Su et al. (2012) suggested that social interaction is considered to be an important aspect of the quality of life of the elderly. The social participation and group identification that can be gained from physical exercise is conducive to promoting their mental health. Similar viewpoint were also confirmed in a Korean study of elderly participants in pickleball. They pointed out that through community participation, neighborhood connections, the elderly who participate in exercise are more likely to enhance their feelings of trust and safety, which is beneficial to their mental health. (Kim et al., 2021).

Overall, while previous studies have confirmed that physical exercise can effectively promote the mental health of the elderly, few studies have focused on the difference of the effect of physical exercise in the elderly at different ages. Futhermore, due to the difficulty of obtaining large sample data, few scholars have studied the impact of the specific details of elderly people's participation in physical

exercise on their mental health.

Based on the cross-sectional data of the China Longitudinal Aging Social Survey, this study aims to provide new empirical evidence for the effect of physical exercise on mental health of the elderly from the perspective of macro data at the national level. The first contribution of this study is to focus on whether this positive impact is heterogeneous among the elderly of different ages. The sample is divided into two groups: “vigorous” elderly and “real” elderly according to the latest classification standard for the elderly proposed by the World Health Organization, to compare the difference of the impact of physical exercise on their mental health level. The second contribution of this study is to further analyzes the specific impact of the different frequency, intensity, and item types of physical exercise on their mental health of the elderly. Through the analysis, this part commits to find a more suitable exercise model for the elderly which can effectively promote their mental health.

6. Method

6.1 Data sources

The data in our study comes from China Longitudinal Aging Social Survey 2016, a national large-scale social survey project implemented by the Research and Data Center of Renmin University of China. The data covers 11494 elderly people from 28 provinces and regions across the country, from 60 to 103 years old. The content of the questionnaire includes the basic personal information of the elderly, health-related evaluation, socioeconomic status, pension planning, cognitive ability, life attitude, family and children status, physical activity status, and other data information. According to the variable selection of this study, after excluding missing values and invalid data, the total number of samples is 4202.

6.2 Measures

Mental Health Score according to the depression propensity scale is the explained variable. It was calculated based on a total of 9 questions including the elderly's mood, loneliness, diet, sleep, sense of worth, from the psychological feeling module of part E in the China aging social survey questionnaire. According to the frequency of occurrence of the negative emotion, the scores of the three different levels are 3 points for never, 2 points for sometimes, and 1 point for often. The range of mental health scores is 9-27 points. The higher the score is, the lower the depression tendency is, which means the higher the level of mental health.

In the selection of explanatory variables, according to the physical activity status of part G in the questionnaire, whether the elderly participate in physical exercise is

set as a binary variable. In the past year those who have not participated in physical exercise are assigned a value of 0, and those who have participated in physical exercise in the past year are given a value of 1.The frequency of elderly participation in physical exercise is based on the number of times they participate in physical activities each week. The intensity of the elderly participating in physical exercise is set as a binary variable. If the breathing and heartbeat do not change much during physical exercise, set it to low intensity and assign a value of 0. If the breathing and heartbeat are significantly accelerated, set it to high intensity and assign a value of 1. The physical exercise item that the elderly most often participate in is set as multiple dummy variables, divided into four types according to the proportion of the most frequently participated sports by the elderly in the sample. Walking is assigned as a benchmark item, and we want to check the difference with running, square dance and other items.

Control variables are also selected from the survey questionnaire including gender, age, whether living in the city, whether spouse is alive, whether from an empty-nest family, whether having elementary school education, the logarithm of pension, and whether suffering from chronic diseases, a total of 8 control variables. The interpretation, detailed measurement standards and descriptive statistical results of the variables are shown in Table 6.

Table 6. Descriptive statistical results of the total sample (n=4202)

Variable name	Symbol	Variable description	Mean (Percent)	Standard deviation

Mental Health Score	Score	According to the Depression Propensity Scale (9-27)	20.66	3.04
Sport	Sport	Do not participate=0，Participate=1	16.04%	
Frequency	Freq	Times of physical exercises per week	4.53	2.28
Intensity	Inte	Low=0，High=1	36.50%	
Item	Item	Walking (Benchmark)	74.04%	
		Running	9.35%	
		Square Dance	8.90%	
		Others	7.71%	
Control variables				
Gender		Female=0，Male=1	49.26%	
Age		Age	68.56	7.01
Live in City		No=0，Yes=1	65.54%	
Spouse alive		No=0，Yes=1	76.13%	
Empty-nest family		No=0，Yes=1	57.73%	
Elementary education		No=0，Yes=1	79.63%	
Pension		Logarithm of pension	2.09	1.41
Chronic diseases		No=0，Yes=1	54.83%	

6.3 Model construction

We first focus on whether the elderly participating in physical exercise have a positive impact on their mental health. The OLS regression model is selected and the regression function is:

$$Score = \alpha_1 + \beta Sport + B_1 X + \varepsilon_1 \quad (1)$$

where X is the matrix of covariates, and B_1 is the corresponding matrix of coefficients. Here we also pay attention to whether this impact is different among the elderly of different ages. According to the latest classification standards for the elderly proposed by the World Health Organization, the elderly from 60 to 74 are defined as “young” or “vigorous” elderly, while those aged 74 above are called the elderly in the traditional sense. The elderly aged 75 and above have been separated from the original social network for a long time, and most of their physical functions have also suffered serious deterioration. Their subjective will and objective conditions to participate in physical exercise will be seriously affected. Therefore, this study choose 75 years old as the boundary, and run regressions on samples from 65 to 74 years old and samples over 74 years respectively to check the existence of heterogeneity.

After removing the samples that do not participate in physical exercise, we further focus on how the frequency, intensity, and item of exercise affect the mental health of the elderly. The OLS regression models are set as:

$$Score = \alpha_2 + \gamma Freq + B_2 X + \varepsilon_2 \quad (2)$$

$$Score = \alpha_3 + \delta Inte + B_3 X + \varepsilon_3 \quad (3)$$

$$Score = \alpha_4 + \pi Item + B_4 X + \varepsilon_4 \quad (4)$$

$$Score = \alpha_5 + \theta_1 Sport + \theta_2 Freq + \theta_3 Item + B_5 X + \varepsilon_5 \quad (5)$$

We first run the regression (2)(3)(4) setting the frequency, intensity, and item as the main explanatory variables separately, and then put them together in the model (5) for regression to check the robustness.

7. Results and Discussion

7.1 Descriptive statistics

Based on the descriptive statistical results in Table 6, we can find that the elderly taking part in physical exercise only accounted for 16.04% of the sample population, which is in relatively low level. There are various reasons can explain why the elderly do not participate in physical exercise. Individuals' characters and personalities may prevent participation in physical exercise due to a lack of skills and interests, stress, and health concerns. Some interpersonal constraints come from interactions and relationships with social groups, such as lack of peer, family support or discrimination from other participants. Besides, external factors such as social economic resources, weather, and work schedule can also have a certain impact (Lin et al., 2022; Zhou et al., 2022). In China, sports resources specifically for the elderly are not rich, and most elderly people still have to take care of their grandchildren or continue to work after retirement. Therefore, lack of resources and time become the main reasons why the elderly do not participate in physical exercise (Dong & Chick, 2012; Lee et al., 2017; Zhu et al., 2016).

In the sample of the elderly who participate in physical exercise, the average frequency of participating in physical exercise per week is 4.53 times and 36.50% of the elderly choose high-intensity exercise. There is a certain fluctuation in the frequency and intensity of physical exercise, because it largely depends on the personal characteristics of the elderly. In terms of the physical exercise item, walking is the most common choice for the elderly, accounting for 74.04%. The proportion of

the elderly who took running and square dance as the most frequent physical exercise items was 9.35% and 8.90%, respectively. The total proportion of other sports items was only 7.71%. The choice of physical exercise for the elderly mainly focuses on the items that are less dependent on sports venues and resources, which also reflects the lack of sports resources for the elderly to a certain extent.

7.2 Basic regression

Table 7. Basic regression results

Variable (Reference group)	Score (Model 1) total (n=4202)	Score (Model 1) age<75 (n=3345)	Score (Model 1) age≥75 (n=857)
Sport (No)	0.429*** (0.132)	0.496*** (0.142)	-0.010 (0.358)
Male (Female)	-0.008 (0.094)	-0.048 (0.105)	0.170 (0.214)
Age	-0.021*** (0.007)	-0.038*** (0.013)	-0.008 (0.023)
Live in City（No）	0.716*** (0.108)	0.629*** (0.121)	1.008*** (0.238)
Spouse alive（No）	0.847*** (0.119)	0.832*** (0.143)	0.879*** (0.217)
Empty-nest family（No）	-0.206** (0.094)	-0.233** (0.106)	-0.065 (0.207)
Elementary education (No）	0.487*** (0.117)	0.604*** (0.138)	0.232 (0.223)
Logarithm of pension	0.124** (0.038)	0.148** (0.043)	0.036 (0.082)
Chronic diseases（No）	-0.453*** (0.093)	-0.475*** (0.104)	-0.297 (0.211)
Constant	20.664*** (0.548)	21.692*** (0.877)	19.599*** (1.835)
R-squared	0.068	0.066	0.058

Note: *P<0.1, **P<0.05, ***P<0.01, with fully robust standard errors in the parentheses.

The basic regression results of physical exercise on the mental health scores of

the elderly are shown in Table 7. From the perspective of the regression results of the total sample, participation in physical exercise has a positive impact on the mental health score of the elderly at a 1% significance level. Participating in physical exercise will increase the mental health score by 0.429 units. Among the control variables, gender do not show a significant impact on mental health scores. Age has a significant negative impact on mental health scores, and the mental health of the elderly shows a downward trend with age. Compared with rural areas, living in cities can significantly improve the mental health scores of the elderly. Since the basic living facilities, medical conditions, cultural and entertainment venues in urban areas are generally better than those in rural areas, it is more conducive to the elderly to increase social interaction, realize self-worth, and express negative emotions (Zhu et al., 2016; Zhang, 2020). The mental health scores of the elderly with a living spouse were significantly higher, and the mental health scores of the elderly were significantly lowered in the empty-nest family. Companion and communication with relatives are the most important way for the elderly to resolve negative emotions. The elderly living alone is more likely to have negative emotions such as anxiety, depression, and loneliness, leading to mental health problems (Li, 2014). Elementary education has a significant positive impact on the mental health of the elderly. A certain level of education is conducive to the improvement of cognitive ability of the elderly, which helps them accept more positive things, develop good living habits, avoid superstition, and reduce the frequency of negative emotions such as anxiety and low self-esteem (Belo et al., 2020). Pension have a significant positive impact on the

mental health scores of the elderly. The elderly with better financial security can choose the old-age care methods more voluntarily, pursue an ideal life in their later years, and reduce the anxiety caused by daily expenditures and potential consumption of medical care and old-age care (Sun, 2020). Suffering from chronic diseases significantly reduces the mental health scores of the elderly. Most patients with chronic diseases suffer from certain stress and negative emotions due to some symptoms or potential threats (Wang et al., 2016). Besides, the accompanying economic burden and care needs also seriously affect the mental health of them (Yan & Liu, 2019).

7.3 Age heterogeneity

The regression results of participation in physical exercise on mental health scores of different age groups are also shown in Table 7. In the under-75 age group, the positive impact of physical exercise on mental health score is still significant at the level of 1%, and the impact coefficient is increased. The elderly who participate in physical exercise will improve their mental health score by 0.496 units. The significance level of other control variables is consistent with their significance level in the regression of the total sample. In the age group of 75 years old and above, the coefficient of participating in physical exercise on the mental health score is negative and not significant. Among the control variables, only the living in city and the spouse's aliveness significantly impact the mental health score. As we have seen, there is enormous heterogeneity in the impact of physical exercise on the mental health scores of the elderly in different age groups. Participation in physical exercise has a

significant positive impact on the mental health of the “vigorous” elderly under 75 years of age. For the elderly aged 75 and above, participation in physical exercise has no significant impact on their mental health.

The results clarifies the heterogeneity of the impact of participation in physical exercise on the mental health of the elderly at different ages. For the vigorous elderly 60-74 years old, participating in physical exercise can significantly improve their mental health. While for the elderly aged 75 and above, whether to participate in physical exercise does not significantly affect their mental health. However, this does not mean that the elderly over 75 years old in real life do not have any benefits for their mental health in participating in physical exercise. The physical conditions of relatively older people vary from person to person. The impact of participating in physical exercise on their mental health is no longer so evident in a statistical sense. But for some of them, physical exercise still has a specific meaning to help them enjoy their old age, resolve negative emotions, and maintain a good mental state.

7.4 Further Analysis of Physical Exercise Participants

After excluding samples of the elderly who did not participate in physical exercise, the regression results with the frequency, intensity, form, and items of physical exercise as the main explanatory variables are shown in Table 8.

Table 8. Regression results of physical exercise participants

Variable (Reference group)	Score (Model 2)	Score (Model 3)	Score (Model 4)	Score (Model 5)
Frequency	-0.009			-0.015
	(0.059)			(0.058)
Intensity (Low)		-1.115***		-1.356***
		(0.274)		(0.290)
Item (Walking)				
Running			0.231 (0.434)	0.811* (0.476)
Dance			1.321*** (0.426)	1.624*** (0.424)
Others			-0.015 (0.461)	0.194 (0.449)
Control Variables	Yes	Yes	Yes	Yes
Constant	19.007***	20.377***	18.119***	19.658***
	(2.245)	(2.250)	(2.244)	(2.153)
N	581	581	581	581
R-squared	0.069	0.099	0.082	0.116

Note: *P<0.1, **P<0.05, ***P<0.01, with fully robust standard errors in the parentheses.

The frequency of physical exercise has no significant impact on the mental health score of the elderly. The intensity of physical exercise was negatively correlated with the mental health score of the elderly at a significance level of 1%. The mental health score of the elderly who participated in high-intensity physical exercise decreased by 1.115 units compared with low-intensity exercise. For different physical exercise items, compared with walking, the benchmark item, square dance has a positive impact on the mental health score of the elderly at a 1% significance level, while running and other physical exercise items are not significant. The coefficients and significance levels of frequency, intensity, and item of square dance in model 5 are consistent with the results obtained in models 2, 3, and 4, which proves its robustness.

From the perspective of the specific details of physical exercise, the results show that the frequency of physical exercise has no significant positive impact on the mental health of the elderly, which means that it is not that more participation in physical exercise is better for the mental health of the elderly. The frequency of exercise for the elderly depends not only on their physical condition, but also on family, time arrangement, sports venues and other factors. The elderly should adjust the frequency of physical exercise according to their personal conditions.

Compared with low-intensity physical exercise, the impact of high-intensity physical exercise on the mental health of the elderly is significantly negative. In high-intensity physical exercises, the elderly may be more likely to feel the decline of their bodily functions, resulting in a sense of loss, powerlessness, and other negative

emotions, which in turn will hurt their mental health. In contrast, low-intensity physical exercises may be more beneficial for the elderly to relax their minds and bodies, adjust their mood, and promote mental health. Objectively speaking, for the elderly with different personal conditions, the intensity of physical exercise is not absolutely high or low. The elderly people in physical exercise should always pay attention to the response of their body to avoid the negative impact of excessive intensity and overload.

In terms of exercise items, compared with the benchmark walking, square dance has a significantly positive impact on the mental health of the elderly. Square dance has low requirements on the participants' physical and external field conditions, and it does not have the same standards for dance movement, rhythm, and intensity. Therefore, among a large number of participants in China, the elderly can easily find a suitable and favorite dance group to join in and exercise. When the elderly exercise with group members similar to themselves, they can get more opportunities for social interaction and gain more mutual recognition and support. At the same time, they have more channels to resolve negative emotions, share happiness, and enhance their confidence and initiative in a joyful life to maintain good mental health (Sun & Zhang, 2019; Ou et al., 2022).

8. Conclusion

As one of the behavioral therapies to improve the mental health of the elderly, the impact of physical exercise on the mental health of the elderly has received more attention in recent years. Existing research has pointed out the positive impact of physical exercise on the mental health of the elderly. This study confirms this conclusion and points out that this positive impact is only significant in the vigorous elderly under 75. The promotion effect is not significant in people aged over 75 years based on our sample data. However, considering that certain differences may exist among elderly individuals, the results can not prove that physical exercise has no effect on the mental health of all the elderly at this age stage. In terms of specific details of physical exercise, the results show that low-intensity exercise can significantly promote the mental health of the elderly. Moreover, compared with walking, square dance has a more significant effect on promoting the mental health of the elderly. This result provides guidance for the elderly to participate in physical exercise. The elderly should always pay attention to their mental health and choose more suitable physical exercises according to their own characteristics.

There are also some shortcomings in this study. According to the existing research, some other factors like body type and nutrition intake also impact the mental health of the elderly. However, these information are not included in the data source of this study. The omission of variables may cause some bias in regression analysis results. Besides, the overall and individual characteristics of the elderly population are constantly changing, and there may also be huge regional and temporal differences.

Therefore, any cross-sectional data analysis has certain timeliness and limitations. Future research still needs to explore the connection between physical exercise and mental health treatment from a dynamic perspective, so as to provide more evidence and guidance for improving the mental health level of the elderly.

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Appendix I: Contents of the questionnaire related to Part II in the China Longitudinal Aging Social Survey (CLASS) 2016

CLASS 2016 Household Questionnaire

Dear Sir/Madam:

The China Longitudinal Aging Social Survey is a nationwide social survey project. The first survey was conducted in 2014, and this is a follow-up survey based on the 2014 data. In this survey, we will ask you about your health, family situation, social background, and economic status. The entire process will take about forty minutes. The purpose of the survey is to understand the living conditions and problems of the elderly, and to provide important factual basis for policy formulation and improvement.

This survey is jointly designed and conducted by the Population and Development Research Center and the Institute of Gerontology at Renmin University of China. We have sampled over 10,000 households in hundreds of communities across the country using strict scientific sampling methods. You have been selected as a survey respondent, and the information you provide is of great significance for us to understand the situation of the elderly and formulate relevant policies.

Your truthful answers to each question are very important to our work. We promise that only the researchers involved in the survey can access the personal identity information, and we will keep this information strictly confidential. The survey results will also be limited to academic research only. Thank you for your

support and cooperation!

Population and Development Research Center, Renmin University of China

2016-11-7

Section E: Psychological Feelings

E2. The next questions is about your mental state in the last week.

Questions / Frequency	Often	Sometimes	Never
1. In the past week, did you feel that you were in a bad mood?	1	2	3
2. Did you felt lonely in the past week?	1	2	3
3. Did you feel sad in the past week?	1	2	3
4. In the past week, did you feel that your life was not good?	1	2	3
5. In the past week, did you feel like you don't want to eat?	1	2	3
6. Did you sleep not well in the past week?	1	2	3
7. Did you feel useless in the past week?	1	2	3
8. Did you feel like you had nothing to do in the past week?	1	2	3
9. In the past week, did you feel that there was no fun (interesting things) in your life?	1	2	3

Section G: Physical Activity Status

G2. Have you participated in physical activity in the past year?

Yes = 1, No = 0

G3. How often do you take part in physical exercise in a week?

G4. Your average physical activity time is?

G5. Regarding the intensity of exercise, most of the time when you are physically active, your body feels more:

Little change in breathing and heartbeat = 0

Increased breathing, heart rate, and increased sweating = 1

G6. What physical exercise item do you often participate in? (Please list the first three in order of priority)

1. Walk 2. Run 3. Swim 4. Cycling 5. Table tennis 6. Badminton

7. Tennis 8. Football 9. Basketball 10. Volleyball (soft volleyball)

11. Boccia, gateball, softball 12. Aerobics 13. Dance (square dance)

14. Martial arts (martial arts routines, Tai Chi)

15. Sports fighting (boxing, judo, wrestling, Sanda, taekwondo, etc.)

16. Health Qigong (Yi Jin Jing, Ba Duan Jin, Wu Qin Xi, Liu Zi Jue, etc.)

17. Yoga, Pilates 18. Others (please specify:_____)

A. First digit: [ ] B. Second digit: [ ] C. Third digit: [ ]

요약

현대 경제의 지속적인 발전과 주민들의 건강 의식이 향상됨에 따라 스포츠 참여는 점차 사람들의 일상 레저 및 엔터테인먼트의 주요 선택 중 하나가 되었습니다. 스포츠 산업의 지속 가능한 발전 또한 중국의 전반적인 경제 발전에서 무시할 수 없는 주제가 되었습니다. 이 논문은 주로 중국 스포츠 산업 발전의 두 가지 문제에 초점을 맞추고 있습니다.

파트 I: 주민의 스포츠 소비가 지역 녹색경제 발전에 미치는 영향. 스포츠 소비 행동과 환경 보호 사이의 관계는 항상 논란이 되어 왔습니다. 녹색 경제 발전을 위해 중국 정부가 지원하는 핵심 프로젝트인 스포츠 소비의 녹색 전환은 이 단계에서 더 많은 관심을 받았습니다. 이 파트에서는 중국 30 개 성에서 패널자료를 수집하여 각 성의 녹색 GDP 지수와 스포츠 소비 수준을 산출하고, 공간적 분포 특성을 기술하며, 주민의 스포츠 소비가 지역 녹색 경제 발전에 미치는 영향을 탐색합니다. 이 연구는 다른 지역 간의 이질성에 초점을 맞추어 지리적 동서 위치와 초기 녹색 GDP 지수 수준에 따라 표본을 더 나누었습니다. 공간분포특성은 GGDP 지수가 남동쪽에서 북서쪽으로 갈수록 점차 감소하는 분포특성을 보입니다. 반면 스포츠 소비 수준은 GGDP 지수처럼 동남쪽에서 북서쪽으로 갈수록 뚜렷한 단계별 감소 패턴을 보이지 않습니다. 회귀분석 결과 스포츠 소비 수준은 전국적으로 볼 때 GGDP 지수에 긍정적인 영향을 미치는 것으로 나타났습니다. 지역적 차이로 볼 때 이 효과는 서부 및 초기 기반이 약한 지역에서는 유의하지 않습니다. 동부 및 초기 기반이 좋은 지역에서는 주민들의 스포츠 소비를 촉진하는 것이 녹색 경제를 발전시키는 효과적인 방법이

되었지만 스포츠 소비 수준이 10% 증가하면 녹색 GDP 지수를 0.3% 포인트 이상 높일 수 있습니다. 녹색 스포츠 소비를 지속적으로 촉진하는 동시에 스포츠 자원의 합리적 배분과 지역 간 스포츠 시장의 협력이 향후 발전의 핵심 포인트가 되어야 합니다.

파트 II: 신체 운동이 노인의 정신 건강에 미치는 영향. 중국의 고령화 추세는 계속해서 심화되고 있으며 노인들의 정신 건강 문제는 더욱 심각해지고 있습니다. 본 연구는 노인의 정신건강문제를 해결하기 위한 치료방법의 하나로 신체운동이 노인의 정신건강에 미치는 영향에 대한 새로운 실증적 근거를 제시하는 것을 목적으로 합니다. 중국종단노화사회조사 2016 의 횡단면 자료를 바탕으로 이 파트에서는 노인의 신체운동 참여를 주요 설명변수로 하여 우울의존척도에 따른 정신건강 점수의 경제모형을 구축하였습니다. 본 연구는 신체운동에 참여하는 노인을 대상으로 신체운동의 빈도, 강도, 항목이 정신건강에 어떤 영향을 미치는지 추가로 연구하였습니다. 그 결과 신체운동은 60~74 세의 건강한 노인의 경우 노인의 정신건강에 유의미하게 긍정적인 영향을 주지만 75 세 이상 노인의 정신건강에는 유의미한 긍정적인 영향을 미치는 것으로 나타났습니다. 신체 운동의 빈도는 노인의 정신 건강에 긍정적인 영향을 미치지 않습니다. 저강도 신체운동에 비해 고강도 신체운동이 노인의 정신건강에 미치는 영향은 상당히 부정적입니이다. 스포츠 종목 중 스퀘어댄스는 걷기보다 노인의 정신건강에 유의미하게 긍정적인 영향을 미쳤습니다. 신체 운동의 빈도는 사람마다 다르지만 저강도 신체 운동과 스퀘어 댄스는 노인의 정신 건강 증진에 더 도움이 됩니다.

키워드: 스포츠 산업; 지속 가능한 개발; 주민들의 스포츠 소비; 녹색 경제; 녹색 GDP 지수; 운동; 정신건강; 고령화사회