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Original Paper

The Importance of Activity Space: Implication from the COVID-19 Pandemic

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Abstract

Objective: *This study aims to observe the influence of activity space factors on physical health by analyzing the changes in the physical fitness of the general public at the beginning of the pandemic, and to provide a reference for the government to revise the national fitness program.* ***Methods:*** *The study was cross-sectional and based on a sample (N=29562; age:20-69 years) of the residents in Zhejiang from 2018 to 2020. Data were analyzed with SPSS (version 26.0).* ***Result:*** *Over the past two years, the residents' unqualified rate and physical fitness scores have been consistently declining. In 2020, the probability of urban residents failing the physical fitness test is 1.61 times that of rural residents. Compared to 2019, the lung capacity, step test index, sit-and-reach, and BMI scores of residents improved in 2020. However, the grip strength, vertical jump, standing time on one foot with eyes closed, and selective reaction time scores of residents have been declining over the past two years.* ***Conclusion:*** *Activity spaces are crucial for residents to maintain and improve overall physical fitness. It is necessary to strengthen strength training and plan more open public activity spaces to improve the physical fitness level of residents.*

Keywords

physical fitness, activity space, eastern China

1. Introduction

Health is closely related to a person's daily lifestyle and mental state, and is a state of complete physical, mental, and social well-being.[1] Increasing evidence shows that a fast-paced lifestyle and high competition pressure are important factors leading to health problems and are also significant reasons affecting the well-being of individuals and social groups.[2] Nowadays, diseases troubling the health of

modern urban populations are gradually increasing, such as various allergies, cardiovascular diseases, and depression.[3] Although the occurrence of these diseases is related to genetics and individual differences, unhealthy lifestyle habits, such as prolonged desk work due to intense competition and reduced exercise time due to a fast-paced lifestyle, are direct causes of these diseases.[4] For example, during the COVID-19 outbreak in 2020, in addition to the virus directly affecting health, people's anxiety, mental stress, and physical activity restrictions also directly weakened people's health, and this impact continues to this day.

Numerous studies have shown that physical activity is influenced not only by individual psychological and physiological characteristics but also by the environment in which one is situated. The activity space of the environment has been proven to be a key factor affecting physical activity.[5] The accessibility and connectivity of activity spaces are important indicators of urban livability.[5] Ulrich proposed the concept of 'healing gardens' long ago, believing that a good outdoor activity environment in hospitals can greatly improve the recovery outcomes of diseases.[6] Liu et al. used data from a fitness app to verify that there is a strong positive correlation between open and convenient public activity spaces and residents' health levels.[7] Good public facilities and space accessibility can not only increase transportation-related physical activities but also promote residents' recreational physical activities.[2,3,6] Ulrich et al. showed that when people living in a state of depression reside in areas where they can engage in outdoor activities, their psychological stress is significantly alleviated, such as feeling calm and having a good sense of well-being.[8] Takeru et al. showed that elderly people living near walkable areas have increased lifespans.[9] People who frequently engage in outdoor exercise are much less likely to feel stressed; in other words, the higher the frequency of outdoor activities, the lower the risk of stress-related diseases.[10] Using the Paris region of France as an example, Chaix et al. confirmed that open public activity spaces can provide residents with a low-cost environment for activities, significantly impacting the physical activity levels of people of different age groups, such as increasing adults' leisure walking levels and moderate to high-intensity physical activity.[11]

The COVID-19 outbreak in early 2020 posed multiple threats, casting profound economic, social, and political shadows. In response to the escalating threat of COVID-19, global strategies predominantly pivoted towards the implementation of lockdowns and quarantine measures. While these interventions were instrumental in curtailing the virus's rapid transmission, they inadvertently precipitated a cascade of secondary challenges. Especially the closure of public activity spaces has exacerbated the challenges of maintaining health during this unprecedented period. Empirical research spanning multiple nations underscores that such restrictive measures have engendered profound alterations in the daily routines of the populace.[12] The mandates of home confinement not only restricted residents' movement and curtailed physical activity but also culminated in a 28% escalation in sedentary behaviors and a predilection for less nutritious dietary choices.[13] Poor dietary habits lead to an increase in obesity.[14] Moreover, residents have also become afraid to go out because of psychological reasons such as fear of

infection. When people were “frozen” by COVID-19, the importance of healthy lifestyles gradually became increasingly widely recognized, leading to an increased demand for outdoor sports. Outdoor activity space is an essential public service facility for enhancing immunity and preventing viral infections after the COVID-19 pandemic.[15] The spatial distribution and accessibility of outdoor sports venues directly affect the public's exercise and health status.

We investigated the physical fitness of residents in eastern China and attempted to observe the impact of activity space factors on physical health through changes in public fitness during the early stages of the pandemic, providing references for the government to revise the national fitness plan.

2. Methods

2.1 Participants

Zhejiang Province, an economically developed region in eastern China, consistently ranks at the forefront nationally in physical fitness qualification rates and comprehensive indices.[16] The participants of this study had were residents aged between 20 and 69 who had lived in Zhejiang Province for more than six months. Individuals below the age of 20 were excluded due to their typical lack of physical and psychological maturity. Similarly, residents aged 70 and above were excluded from the study, given the heightened probability of these individuals exhibiting compromised cognitive and motor functions during testing.

2.2 Data Collection

National physical fitness monitoring serves as a state-mandated initiative aimed at systematically overseeing the health status of the populace. This monitoring process entails assessing national physical fitness via sampling surveys, and analysis being conducted in alignment with the national physical fitness testing standards as stipulated by the state.[17] In Zhejiang, this monitoring work is routinely conducted between September and October each year. Our data collection spanned from September 2019 to October 2020. The introduction of novel monitoring metrics in 2021 precluded the possibility of cross-year comparisons. Four cities — Hangzhou, Jiaxing, Wenzhou, and Lishui — were chosen from Zhejiang Province using a random stratified sampling technique. This yielded a total of 29562 eligible participants. The yearly breakdown was as follows: 19,684 in 2019, and 9,828 in 2020. Incomplete data from 840 participants necessitated their exclusion. Consequently, the final dataset comprised 28785 adult samples, reflecting a response rate of 97.16%.

2.3 Measures

Participants underwent three distinct evaluations: the Body Shape Test, the Physical Function Test, and the Physical Fitness Test. These evaluations used both single-item scores and aggregate ratings. For single-item scoring, a 5-point grading system was utilized. Aggregate ratings were derived from the cumulative scores of individual items, segmented into four tiers: Level 1 (Excellent), Level 2 (Good), Level 3 (Pass), and Level 4 (Unqualified).[18] Notably, the categorization "Qualified" encompasses Levels 1 through 3.

Body shape test. This assessment involved measuring participants' height (in meters) and weight (in kilograms) to compute their Body Mass Index (BMI, kg/m^2). Within the Chinese context, categorizations for weight based on BMI are as follows:

Underweight: BMI < 18.5 kg/m^2

Normal weight: 18.5 kg/m^2 ≤ BMI < 24 kg/m^2

Overweight: 24 kg/m^2 ≤BMI < 27.5 kg/m^2

Obese: 28 kg/m^2 ≤BMI

These categorizations exhibit slight deviations from international standards.[19]

Physical function test. This evaluation comprised two components. The first, vital capacity, gauges the volume and expansiveness of an individual's lungs. The second, the step test index, assesses the functional efficacy of the cardiovascular system.

$$\text{Step test index}=\frac{duration\ of\ exercise(s)}{\text{Sum of 3 pulse tests}}\times 100.$$

Physical fitness test. The Physical Fitness Test includes a variety of evaluations, for example, grip strength, push-ups (for men), one-minute sit-ups (for women), vertical jump, sit and reach, selective reaction time, and the duration of standing on one foot with eyes closed. Push-ups, sit-ups, and vertical jumps are exclusively administered to adults within the age bracket of 20-39 years.

2.4 Statistical Analysis

Data processing and analysis were executed using SPSS version 26.0 (IBM, Armonk, NY, USA). Descriptive statistics for the physical fitness test results of the participants were presented as median and interquartile range. The Wilcoxon test was used to analyze differences in residents' physical fitness results pre- and post- the COVID-19 outbreak. Sample individual characteristics were described using composition ratios and frequency distribution tables. Brown-Forsythe and Welch ANOVA test was used to analyze the differences between rural and urban residents on various physical fitness indicators. The chi-square ($\chi 2$) test facilitated the comparison of physical fitness levels across diverse characteristic groups. To elucidate the changes in related factors influencing residents' physical fitness levels before and after the pandemic, a series of logistic regression models were constructed. For each model, the odds ratio (OR) and its corresponding 95% confidence interval (CI) were reported.

3. Results

3.1 Sample Description

Table 1. The Residents' Physical Fitness Level by Their Characteristics

	2019			2020		
	unqualified	qualified	χ^2	unqualified	qualified	χ^2
	n (%)	n (%)		n (%)	n (%)	
N	808(4.23)	18296(95.77)		279(2.88)	9402(97.12)	
Men(n=22361)	563(5.77)	9194(94.23)	**116.87**	172(3.46)	4799(96.54)	**12.2**
Women(n=21394)	245(2.62)	9102(97.38)		107(2.27)	4603(97.73)	
Town(n=29074)	541(4.21)	12295(95.79)	0.021	221(3.29)	6499(96.71)	**13**
Country(n=14681)	267(4.26)	6001(95.74)		58(1.96)	2903(98.04)	
20-29(n=8141)	175(4.79)	3476(95.21)	**26.33**	56(3.13)	1733(96.87)	**13.21**
30-39(n=8645)	137(3.62)	3648(96.38)		33(1.68)	1934(98.32)	
40-49(n=9018)	138(3.61)	3695(96.40)		66(3.32)	1923(96.68)	
50-59(n=8984)	146(3.72)	3779(96.28)		58(3.01)	1868(96.99)	
60-69(n=8967)	212(5.42)	3698(94.58)		66(3.28)	1944(96.72)	
Underweight(n=1246)	42(11.60)	320(88.40)	**1659.58**	26(13.98)	160(86.02)	**521.71**
Normal(n=25604)	193(1.77)	10716(98.23)		75(1.26)	5877(98.74)	
Overweight(n=14452)	268(4.00)	6436(96.00)		95(3.08)	2993(96.92)	
Obesity(n=2453)	305(27.02)	824(72.98)		83(18.24)	372(81.76)	

Boldface indicates statistical significance

Table 1 delineates the fundamental characteristics of the participants. The gender distribution was relatively balanced, with males representing 51.2% of the total, and females representing 48.8% of the total. The age distribution is also relatively balanced, with an average proportion of 20.0% ± 0.8% in the age group of 20-69 years old per ten years old. Most (67.94%) of residents live in urban areas. When considering BMI, 58.58% of residents were within the standard range. The distribution for underweight, obese, and overweight individuals was 1.90%, 5.50%, and 34.02%, respectively.

3.2 Changes in Physical Fitness Levels of Different Characteristic Populations

Figure 1 shows the changes in physical fitness levels from 2019 to 2020. Compared to the previous year's data, the unqualified rates of residents in 2019 and 2020 decreased by 0.12% and 1.2%, respectively. And the good or above rates in 2019 and 2020 decreased by 8.66% and 4.71%, respectively. Conversely, their pass rates in 2019 and 2020 significantly increased by 8.78% and 5.86%, respectively. The chi-square ($\chi 2$) test was used to observe the difference among groups in two years (Table 1). During the three-year process, significant differences in gender (2019: $\chi 2=116.87$, 2020: $\chi 2=12.20$, $p<0.01$), in age (2019: $\chi 2=26.33$, 2020: $\chi 2=13.21$, $p<0.01$), and in body shape (2019: $\chi 2=1659.58$, 2020: $\chi 2=521.71$, $p<0.01$) were observed. Notably, differences attributed to residential areas were only statistically significant in 2020 ($\chi 2=13$, $p<0.01$).

3.3 Changes in Physical Fitness Test Scores of the Residents

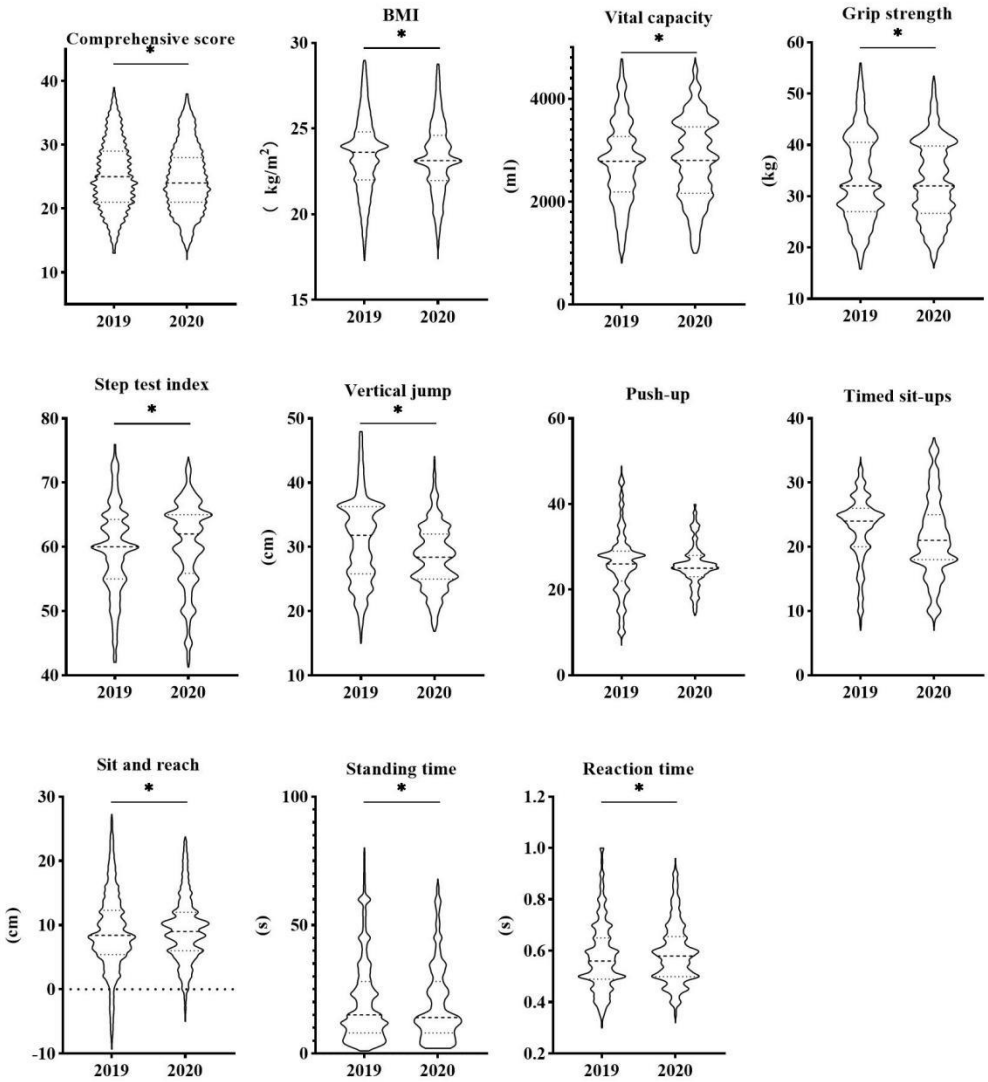

Figure 1. Violin Diagram of Physical Fitness Indicators in Different Years (* p <0.05)

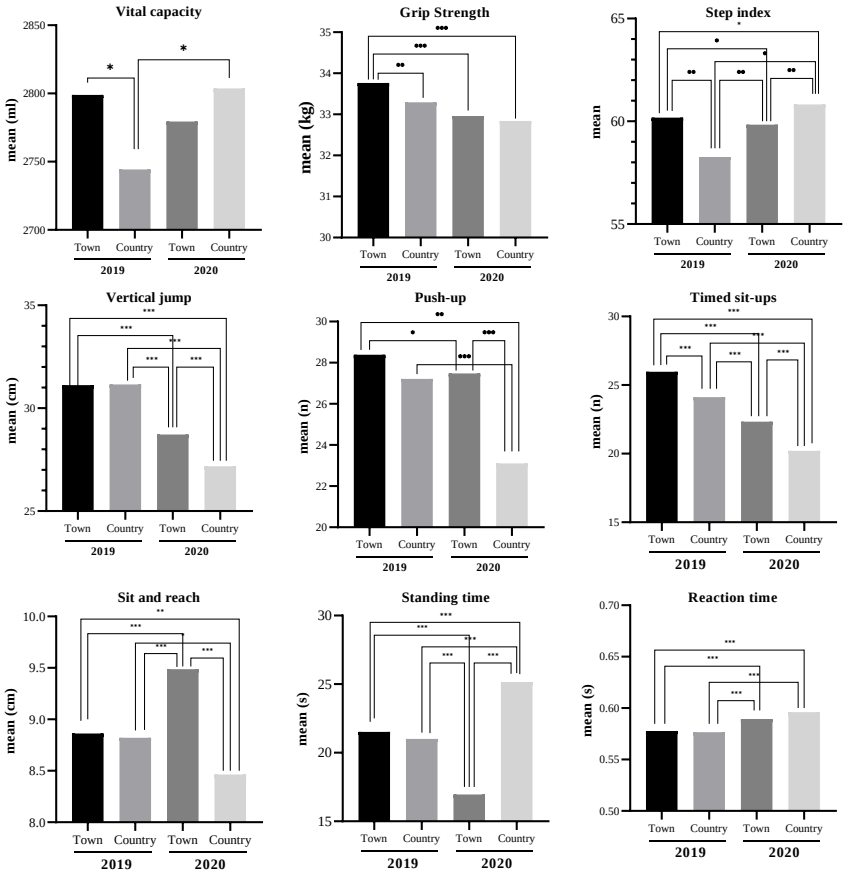

Figure 2. Differences of Mean in Physical Fitness among Residents in Town and Country (* p<0.05, ** p <0.01, *** p <0.001).

As shown in Figure 1, significant changes were observed in the results of all physical fitness test items ($p<0.05$), except sit-ups and pull-ups, as detailed in Table 2. The indices for vital capacity (median: 2785 vs. 2800), step index (median: 60 vs. 62), and sit-and-reach (median: 8.4 vs. 9.0) exhibited a rising trend during the COVID period. Conversely, several fitness test metrics diminished, namely BMI index (median: 23.59 vs. 23.23), grip strength (median: 31.2 vs. 28.1), vertical jump (median: 31.2 vs. 28.1), single-leg standing with eyes closed (median: 15 vs. 14), and selective reaction time (median: 0.56 vs. 0.59). The total physical fitness test scores of residents showed a gradually decreasing trend.

Figure 2 shows multiple comparisons between rural and urban areas in different years. Compared to 2019, indicators of sit and reach as well as selective reaction time have increased among urban residents in 2020, while other physical fitness indicators were decreasing. The indicators of vital capacity, standing time on one foot with eyes closed, sit and reach, step test index and selective reaction time among rural residents in 2020 have shown an increase. Among the declining indicators, strength indicators such as grip strength, vertical jumping, push ups, and sit ups have decreased more than urban residents.

3.4 Factors Affecting Changes in Residents' Physical Fitness Level

Table 2. Logistic Regression Analysis of Factors Affecting Residents' Physical Fitness Level

Variables	2019		2020	
	OR	95%CI	OR	95%CI
Gender(ref.=Women)	**2.12****	1.79-2.50	**1.40***	1.08-1.82
Area(ref.=Country)	1.03	0.88-1.20	**1.61****	1.20-2.20
Age(ref.=20-29)				
30-39	**0.7****	0.55-0.89	**0.52****	0.33-0.81
40-49	**0.75***	0.59-0.96	0.98	0.67-1.44
50-59	**0.66****	0.52-0.84	0.75	0.50-1.11
60-69	0.91	0.72-1.13	0.89	0.61-1.32
Body Shape (ref.=Normal)				
Underweight	**8.11****	5.59-11.52	**13.39****	8.14-21.46
Overweight	**1.97****	1.63-2.39	**2.39****	1.74-3.28
Obesity	**19.55****	16.04-23.87	**16.06****	11.47-22.54

Boldface indicates statistical significance (* $p < 0.05$; ** $p < 0.01$).

A set of logistic regression models, as presented in Table 2, were used to observe the relevance between residents' characteristics and their physical fitness levels, and to ascertain the influence of these variables. Across the two models, gender, age, and body shape were significantly related to residents' physical fitness levels. Males exhibited a higher propensity for disqualification compared to females (2019: OR=2.12, $p<0.01$; 2020: OR=1.40, $p<0.05$). In 2019, the physical fitness of residents aged 20-29 and 60-69 was more likely to be unqualified ($p<0.05$). However, in 2020, physical fitness tended to be unqualified in all age groups except 30-39 years olds (OR=0.52, $p<0.01$). Residents with abnormal BMI values were more inclined towards disqualification of physical fitness than their counterparts with standard BMI. Among them, Obese individuals have a more significant likelihood of failing the standard (2019: OR=19.55, $p<0.01$; 2020: OR=16.06, $p<0.05$). Notably, the residential area variable was non-significant in the 2019 model but changed significance in 2020. Urban dwellers were more prone to physical fitness disqualification compared to their rural counterparts (OR=1.61, $p<0.01$).

4. Discussion

Physical activity is indispensable for enhancing and maintaining physical and mental health, thereby improving overall quality of life. Physical activity primarily refers to any bodily movement produced by skeletal muscles that requires energy expenditure, including work-related, household, transportation,

and recreational activities.[1] From a physical standpoint, physical activity strengthens the immune system and reduces the risk of infection, notably on outdoor sports. However, the rapid spread of COVID-19 has led to many regions limiting people's outdoor space and commuting patterns. Many outdoor sports venues are no longer accessible to the public, especially in cities, the time cost of outdoor exercise has greatly increased, and the diversity of activity spaces has become imbalanced.[15] To the best of our knowledge, no studies have focused on analyzing the impact of activity space restrictions on physical health in emergency situations.

An important finding of this study is the significant difference in physical fitness levels between urban and rural residents in the first year of the COVID-19 pandemic. Rural residents seem to be more likely to have qualified physical fitness than urban residents. Actually, this unexpected finding is reasonable. Due to the sudden lockdown, urban residents' normal lifestyles were disrupted, many public activity venues were no longer accessible to the public and activity space were limited, leading to restrictions on outdoor activities, an increase in sedentary time, unbalanced diets, and other passive unhealthy behaviors.[13,15,20] In contrast, rural areas are less densely populated, have smaller lockdown scope, and rural areas had received targeted policy support in recent years such as investments in rural sports infrastructure, advocacy for a healthy lifestyle, and endeavors to enhance residents' cognizance about the health dividends of regular exercise.[21] Rural areas had more free living and entertainment spaces, which provided more convenience for sports activities.[22] Additionally, rural residents in Eastern China were more inclined towards high-intensity physical activities than urban residents, which also helps rural residents maintain good physical health.[20]

Notably, the physical fitness test scores of residents in eastern China in 2020 (excluding vital capacity) showed a downward trend compared to the previous year. However, there were differences between rural and urban residents. Rural residents experienced an increase in cardiopulmonary function (i.e., vital capacity and step index) and balance (standing time on one foot with eyes closed), while urban residents saw a decline. Several studies have shown that air quality in rural areas is generally better than in urban areas, while lower residential densities in rural areas during epidemics reduce the risk of viral transmission, resulting in more opportunities for rural dwellers to engage in outdoor activities such as farm work and walking.[20,23,24] Additionally, in 2020, the overall productivity of the country declined, reducing the workload of farmers and increasing their leisure time, which in turn improved their cardiopulmonary function. Urban residents have also seen an increase in flexibility. This is due to the fact that outdoor activity venues have been canceled for the public due to the epidemic, and many people have turned to home-based fitness and exercise. However, home fitness activities carried out in China mainly focused on aerobic or flexibility training such as low-intensity gymnastics or stretching exercises.[25] Aerobic training was easily achievable in limited exercise space and produced noticeable benefits.[26]

The regression model showed significant differences in residents' physical fitness levels due to age, gender, and BMI. In 2020, the age range of people with qualified physical fitness expanded compared

to 2019, with only those aged 30-39 being more likely to achieve qualified physical fitness. This may be due to government initiatives such as the “home fitness” proposal and the surge of online fitness streaming during the quarantine period,[27,28] which significantly impacted residents' physical health levels. Men lag behind women in terms of physical fitness, which may be attributed to the fact that men typically make more harmful lifestyle choices, such as smoking and excessive drinking.[29] The widespread unemployment during the COVID-19 lockdown has further exacerbated this situation. Additionally, obesity poses significant health hazards.[14] Consistent with other studies,[30] our data also suggests that residents with a normal BMI have a higher qualification rate. And the elevated BMI pass rate of rural residents compared to urban ones explains the increase in the physical fitness pass rate of rural residents. It also suggests that more space for farmers to move around is good for their health. The physical fitness level of people with overweight were seemed to be superior to the others among people with abnormal BMI, which may be explained by more muscle mass in overweight individuals. After all, BMI indicates overall body weight and doesn't differentiate weight between various body components like bone, muscle mass, and fat.[19] In short, this pandemic seems to have raised public cognizance of the beneficial effects of regular exercise, as evidenced by the decrease in disqualified rates of physical fitness.

In response to the threat posed by the outbreak, the WHO and governments worldwide quickly launched lifestyle-centric interventions, such as guidelines on home-based physical activities and dietary habits. Like other countries,[31-33] China also implements the "National Fitness Plan", aiming to expand outdoor public activity spaces, increase the qualification rate of residents' physical fitness, and ensure public health. According to the Zhejiang Province National Fitness Implementation Plan (2016-2020), it's projected that over 94.5% of urban and rural residents (excluding students) will meet the National Physical Fitness Testing Standards.[34] This is also reflected in our study. The physical fitness levels of residents not only did not deteriorate after the pandemic's outbreak but the pass rate even increased. This trend is consistent with findings from Lauren Arundell's research.[35] Lauren Arundell and others have shown that after an outbreak, women were more likely to engage in activities at home that require almost no equipment or facilities, and thus were more likely than men and minors to meet the testing standards for high-intensity sports activities. Conversely, certain studies have shown a gradual decline in residents' physical fitness after the implementation of the lockdown. For instance, Rubén López-Bueno et al.[36] found the decline in individuals' cardiopulmonary function and overall health is related to prolonged confinement. This decline was attributed to diminished physical activity, although they gradually adjusted their health behaviors over time.

While our data reflects an uptick in the physical fitness pass rate, there's a concomitant decline in the comprehensive scores over the two-year period, with significant decreases in residents' strength indicators, including grip strength, push-ups (males), and sit-ups (females). This is because the epidemic reduced the intensity of labor, reduced muscle use, or lack of strength training, whether the population was engaged in agricultural activities or home-based fitness activities. Strength training

requires the support of professional equipment, and may also require more supervision, at least at the beginning.[37] However, during the pandemic, support could not be provided due to the closure of public fitness facilities. In addition, we also found that the residents' reaction times had significantly increased. We speculated that residents' responsiveness has declined, possibly because of environmental changes, social isolation, economic factors, as well as lifestyle changes that could later modify neurological and neuropsychiatric function.[38] Of course, it is also possible that the government's focus on increasing the number of people participating in physical exercise, while ignoring the different levels and needs of fitness practitioners, has led to a weakening of the effectiveness of fitness. And the government's focus on increasing the number of people participating in physical exercise, while ignoring the different levels and needs of fitness practitioners, can also lead to a weakening of the effectiveness of fitness.

In response to the National Fitness Implementation Plan (2021-2025), it is essential to strengthen public fitness infrastructure and increase spaces for physical activity while appropriately increasing professional guidance and supervision. Additionally, it suggests that in the face of future public health emergencies, densely populated cities need safer or more diverse fitness spaces to ensure the physical and mental health of residents.

5. Conclusions

The results of this study show that activity spaces are crucial for residents to maintain and improve overall physical fitness. The specific content of activities influences various indicators of physical fitness. Therefore, it is important to ensure that residents have the space and the full range of activities to maintain and promote health in the event of an emergency.

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