THE RELATIONSHIP BETWEEN CARDIOPULMONARY FUNCTION AND COGNITIVE FUNCTION IN THE ELDERLY IN BEIJING

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Abstract. *Objective: This study was conducted on 27 senior adults in a community in Beijing with the purpose of examining the possible correlation between cardiorespiratory function and cognitive function. Methods: A questionnaire was designed for the basic demographic characteristics. The electronic blood pressure meter and electronic lung capacity meter were used to test cardiorespiratory function. The items of the cardiorespiratory function were scored in standard percentage. The MoCA Scale was used for cognitive function measurement. Results: The average heart rate (beats per minute) was 78.9 with a standard deviation of 13.5, and the average vital capacity (ml) was 1386.3 with a standard deviation of 37.0. In 15 people, the measured blood pressure was above the hypertension standard. The average cognitive function score was 22.5 with a standard deviation of 4.3. Eighteen people (66.7%) had mild cognitive impairments. Multiple linear regression analysis showed that there was no statistically significant correlation between cardiorespiratory function and cognitive function in the elderly (P > 0.05). Conclusion: No correlation was found between cardiopulmonary function and cognitive function in the elderly participating in this study and further large-scale population research is needed in the future. In this study, the prevalence of mild cognitive impairment was higher than in other studies. Attention should be paid to this issue, and early intervention should be done to avoid inactivity in senior adults.*

Keywords: *cardiopulmonary function, cognitive function, senior adults.*

Introduction

The abundant material conditions and advanced medical treatment in modern society bring people's life expectancy closer to the upper limit of human life stipulated by genetic potential, which makes the proportion of senior adults continuously higher, and the consequent problem is the aging of the population. Population aging refers to the process in which the proportion of the elderly increases due to the unbalanced growth rate of the elderly population and the young population. The international standard for a country or region to enter an aging society is that the population over 60 years old accounts for more than 10% of the total population or the population over 65 years old accounts for more than 7% of the total population. It is estimated that by 2020 China's elderly population will reach 248 million, and the aging level will reach 17.17%. The aging rate of Chinese society needs to arouse widespread attention.

The aging of the population will bring a series of problems to society. With the imbalance of the population proportion, the decline of the workforce proportion is accompanied by the elderly population's ability to carry out their daily activities. According to statistics, the loss rates of basic and instrumental daily living abilities of Chinese elderly over 60 years old reached 23.8% and 35.4%, respectively, in 2013 (Qian et al., 2016). The loss of daily activity ability has a serious impact on the quality of life of the elderly and involves social work and medical resources. In the context of the continuous aging of the population in China, improving the health level and the ability of daily living activities of the elderly has been a major concern

for society. In May 1987, the World Health Organization (WHO) put forward the concept of healthy aging. In 2015, the definition of this concept was updated as follows: "Healthy aging is a continuous process of optimizing opportunities to maintain and improve physical and mental health, independence, and quality of life throughout the life course" (PAHO/WHO, 2015). If the elderly in China can achieve healthy aging in the future, it will improve their quality of life, save a lot of labour and medical resources and be conducive to the healthy development of society. Cognitive dysfunction will also greatly affect the health of the elderly. Therefore, it is necessary and meaningful to study the influencing factors of cognitive function in the elderly.

This research is conducted on senior adults living in a Beijing community and investigates their cardiopulmonary function, cognitive function and other relevant data to control confounding factors by finding a possible connection between these components in order to provide references for healthy aging and put forward some suggestions as theoretical support aimed at improving their cognitive function and cardiopulmonary function.

The human body produces a series of changes in the aging process, which translate into certain characteristics of its organs and systems. These characteristics are concentrated in the cardiovascular, respiratory and nervous systems: the main physiological changes in the heart are myocardial atrophy, pericardial fat thickening and endocardial thickening. In addition, after the age of 50, the elasticity of large and medium artery walls decreases, while the arteriole and capillary fragility increase. Taken together, these factors lead to decreased compliance, decreased stroke output, increased differential pulse pressure and increased probability of cardiovascular events in the elderly. The main changes in the respiratory system include decreased thoracic compliance caused by the decline in bone mass, decreased respiratory motion range, decreased vital capacity, increased residual volume and decreased efficiency of pulmonary ventilation. Changes in the cardiovascular system will also involve the lungs, for example, a narrowed diameter of pulmonary vessels, increased pulmonary arterial pressure and increased burden on the right heart (Zhang & Ding, 2010).

Therefore, maintaining cardiopulmonary function is crucial for the health of the elderly. Existing surveys in China show that, with increasing age, the physical fitness, physical function and physical quality of the elderly decline (Li, 2013). Another survey found that many elderly had abnormal blood pressure, hypertension and obesity, suggesting that their physical condition, especially cardiopulmonary function, was not optimistic (Zhang, 2012).

Other scholars have also conducted a large number of studies on the relationship between cardiopulmonary function and health in the elderly. Kodama et al. (2009) have shown that low levels of cardiopulmonary function are associated with early mortality due to cardiovascular disease and a variety of other causes, while improved cardiopulmonary function is associated with reduced mortality from a variety of causes. Blair et al. (1995) investigated physical function and all-cause mortality, and the results showed that high levels of cardiopulmonary function were associated with higher levels of physical activity habits, and many health benefits could be obtained by forming these habits.

Cognitive function is the comprehensive performance of the human body's abilities to collect information, memorise, calculate, express and execute and is an important part of quality of life (Shen, 2014). Mild cognitive impairment (MCI) is a neurodegenerative disease that refers to a clinical condition of human cognitive function between dementia and normal

aging. The degree of cognitive impairment is not proportional to age and does not meet the diagnostic criteria for dementia; MCI is a pre-dementia condition. (Deng & Yang, 2013)

According to the American Institute of Cardiovascular Health, the prevalence of MCI in people over 65 years old is about 18.8% (95% CI = 17.3-20.4%) (Lopez et al., 2003). Ravaglia et al. (2008) reported a prevalence of MCI of 7.7% (95% CI = 6.1-9.7%) in Italians over 65 years of age. According to the study conducted by Petersen (2004), about 10% to 40% of MCI patients develop dementia every year, while the incidence of dementia in people with normal cognitive function is 1% to 2%. Effective intervention measures at this stage can prevent or delay the continued impairment of cognitive function and can delay the onset and development of dementia (Chen et al., 2016; Meng et al., 2000).

In clinical practice, cognitive function is commonly measured by scales, and the most widely used for the preliminary screening of various types of cognitive impairments and dementia are Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA). Mini-Mental State Scale (MMSE) includes six dimensions and 30 items, requiring 5 to 10 minutes to administer. The score is influenced by the level of education and it is mainly used to screen and assess dementia. MoCA is used for rapid screening of cognitive dysfunction and assesses visual/spatial perception, executive function, naming, memory, attention, language, abstract thinking, delayed recall and orientation ability. MoCA is sensitive to MCI induced by various causes (such as vascular factors, encephalitis, Parkinson's disease, mild Alzheimer's disease), and its sensitivity is significantly higher than that of MMSE. The highest score of the scale is 30 points, and 1 point is added if the participant has less than or equal to 12 years of education. A score higher than or equal to 26 points is considered normal. (Sun & Qin, 2010)

There are relatively few studies on cardiopulmonary function and cognitive function in the elderly. Zhao (2015) conducted a cardiopulmonary exercise experiment and cognitive function assessment in the elderly and found that the total score of cognitive function, memory, retelling and symbol- and number-matching abilities for the normal oxygen intake group were significantly higher than those of the low oxygen intake group. Research on the relationship between cardiopulmonary function and cognitive function in the elderly will help provide references for healthy aging and theoretical support for improving their cognitive function and cardiopulmonary function. There is sufficient evidence that aerobic exercise intervention can have a protective effect on the cognitive function of the elderly, promote the recovery of cognitive function after brain injury and prevent or delay cognitive impairment caused by aging and neurodegenerative diseases. Albinet et al. (2016) found that a water aerobics programme could significantly improve the executive function of older adults, and another study (Mortimer et al., 2012) showed that the speech fluency of the elderly was significantly improved after 40 weeks of Taijiquan intervention. Domestic studies (Liu, 2014) also found that the attention span and distribution in middle-aged and elderly women practising Qigong were significantly improved. Another domestic study (Wang & Sheng, 2016) showed that 3 months of Tai-Chi exercise improved the memory of the elderly with MCI. Since cardiopulmonary function can be improved through aerobic exercise, it can be inferred that cardiopulmonary function improvement is related to cognitive function improvement.

Methodology

Participants

Thirty-four residents over the age of 60 from the Beijing Sport University community were selected as research participants, who were included if they had lived in their community for more than 5 years and had no disability. The exclusion criteria were: being ill in bed or having limited mobility during the research period or 1 month before the research; having Parkinson's disease, epilepsy or dementia; having a history of stroke in the last 3 months.

Data collection

The on-site investigation was conducted in the Beijing Sport University community. Before the investigation, respondents were explained the purpose of the survey for which they gave their consent and then began to complete the one-to-one questionnaire. They completed the questionnaire by themselves, and the examiner was responsible for clarifying any doubts but without providing relevant responses. Once completed, the questionnaire was withdrawn.

Survey of general demographic characteristics

Self-designed questionnaires were used to collect general information about the respondents, including gender, date of birth, height, weight, education level, average sleep duration, sleep quality, chronic diseases and type of chronic diseases.

Cognitive function measurement

Montreal Cognitive Assessment (MoCA) is used to measure cognitive function. In this survey, MoCA was used for rapid screening of cognitive dysfunction and assessing visual/spatial perception, executive function, naming, memory, attention, language, abstract thinking, delayed recall and orientation ability. MoCA is sensitive to MCI induced by various causes (such as vascular factors, encephalitis, Parkinson's disease, mild Alzheimer's disease). The highest score of the scale is 30 points, and 1 point is added if the participant has less than or equal to 12 years of education. A score higher than or equal to 26 points is considered normal.

Cardiopulmonary function measurement

Relying on comprehensive tests and relevant literature, heart rate, blood pressure and vital capacity were selected as indicators to assess the cardiopulmonary function of the elderly. Prior to testing, participants were screened for risk factors, and those at risk were excluded. The cardiopulmonary function of the included participants was tested using an electronic blood pressure monitor (HEM-7052, OMRON, JAPAN) and an electronic spirometer (FCS-10000, YILIAN, CHINA). Heart rate and blood pressure were measured using an electronic sphygmomanometer when the participants were sitting still. In the vital capacity test, the mouth is placed on the pneumatic air inlet tube of the electronic spirometer, and then the handle of the

tube must be held while keeping the pressure guide hose above the tube; the head is bent slightly back while inhaling deeply until inhalation is no longer possible; this is followed by slow exhalation through the mouth until exhaling is no longer possible. At this point, the value displayed is the vital capacity value. The test is performed twice and the maximum number is recorded in millilitres (without decimals). Cardiopulmonary function was assessed by the standard percentage of heart rate and vital capacity and the blood pressure score. The standard percentage algorithm is 50 + 20* (z-score of specific indicators), and the standard percentage range is from 0 to 100. Blood pressure score refers to the national fitness measurement method used in China. The normal score (SBP ≦140 mmHg and diastolic blood pressure ≦90 mmHg) and abnormal score (SBP ≧140 mmHg and/or DBP ≧90 mmHg) were 100 and 80, respectively. The total score of cardiopulmonary function (ranging from 0 to 300 points) was obtained by adding the scores of the three individual cardiopulmonary function tests.

Statistical analysis

Excel software was used to establish the database, and SPSS 18.0 software was used for statistical analysis. Due to the small sample size, participants were divided into two groups according to different characteristics. Their grouping was based on the median, mean or special cut-off value of the sample. Continuous data were expressed as the difference between or median and interquartile range, while the data for classification variables were expressed as constituent ratio or rate. The independent sample t-test was used to compare the total mean represented by the two groups, and the chi-square test was used to compare the classification variables between the two groups. The relationship between cardiopulmonary function and cognitive function in the elderly was analysed by the multiple linear regression model.

Results

A total of 34 questionnaires were sent out, 34 were returned and 27 were completed with an effective rate of 79.41%. The respondents were 7 males (25.9%) and 20 females (74.1%), and their mean age was 79.52 ± 7.45 years. The average age of the sample was higher than that of similar studies, and most respondents suffered from one or more chronic diseases.

The results of the 27 valid questionnaires showed that the heart rate of the participants was 78.89 ± 13.47. In 15 (55.6%) of them, blood pressure was above the hypertension threshold, and vital capacity was 1386.33 ± 37.02. The total score of cardiopulmonary function was 188.28 ± 37.20. The MoCA scale was used to assess cognitive function in this research. Cognitive impairment was defined as a sum of cognitive scores less than 26. The results showed that the average cognitive function score of the 27 participants was 22.52 ± 4.28. A total of 18 (66.7%) respondents had mild cognitive impairments. The incidence of MCI was higher than that reported in similar studies.

Theoretical reasoning prior to statistical analysis showed that possible variables affecting cardiopulmonary function and cognitive function included gender, age, education level, chronic disease, sleep duration and sleep quality. Therefore, we conducted independent sample t-tests on the indicators and total scores of the continuous variables of cardiopulmonary

function with the above characteristics, and the results showed that there was a statistically significant difference between the total scores of cardiopulmonary function in men and women, with males having higher scores than females. The chi-square test indicated that there was no statistically significant difference between these variables and abnormal blood pressure. (Table 1)

Table 1. *T-tests on cardiorespiratory function and different characteristics*

Characteristics	Heart rate (bpm)	Vital volume (ml)	Total score of cardiopulmonary function
Gender			
Male	71.14 ± 13.30	2122.71 ± 1228.99	220.13 ± 41.12*
Female	81.60 ± 12.75	1128.60 ± 563.42	177.13 ± 28.92
Age			
< 80	77.00 ± 14.75	1675.33 ± 1224.96	200.86 ± 42.81
≥ 80	79.83 ± 13.12	1241.83 ± 645.63	181.99 ± 33.28
Chronic disease			
1 or more	79.43 ± 12.15	1197.29 ± 624.20	184.43 ± 28.31
0	77.00 ± 18.63	2048.00 ± 1345.23	201.73 ± 60.35

*: $P < 0.05$

We conducted independent sample t-tests on the indicators and total scores of the continuous variables of cardiopulmonary function with the above characteristics, and the results showed that there were statistically significant differences in naming between the scores of participants in different age groups and with different education levels. Thus, the older the participants, the lower their education levels and the better their naming scores. The attention item revealed that chronic diseases had an influence on the attention score in the sense that the elderly without chronic diseases had higher attention scores. The results showed that the differences between these variables were not statistically significant for cognitive dysfunction. (Table 2)

Table 2. *T-tests on cognitive function and different characteristics*

Characteristics	Naming	Attention	Total score of MoCA
Gender			
Male	2.43 ± 0.98	2.71 ± 1.77	22.57 ± 3.60
Female	2.40 ± 1.10	2.20 ± 1.96	22.50 ± 4.58
Age			
< 80	3.00 ± 0.00*	2.67 ± 0.50	24.11 ± 3.66
≥ 80	2.11 ± 1.18	2.78 ± 0.65	21.72 ± 4.44
Chronic disease			
1 or more	2.29 ± 1.15	2.67 ± 0.66*	22.29 ± 4.31
0	2.83 ± 0.41	3.00 ± 0.00	23.33 ± 4.46
Years of education			
≤ 12	2.89 ± 0.33*	2.56 ± 0.73	22.11 ± 4.08
> 12	2.17 ± 1.20	2.83 ± 0.51	22.72 ± 4.48

*: $P < 0.05$

According to the above monofactorial analysis, gender can be the influencing factor of cardiopulmonary function, while age, education level and chronic disease can influence cognitive function. Multiple linear regression analysis was used to assess the relationship

between cardiopulmonary function and cognitive function after checking the variables that might be related to these two functions. The results showed no statistically significant association between cardiopulmonary function and cognitive function (Table 3).

Table 3. *Multiple linear regression of cognitive function and other variables*

Variables	β	t-value	P-value	Total P-value
Total score of cardiopulmonary function	-0.361	-1.249	0.225	0.240
Age	-0.525	-2.230	0.036	
Gender	-0.358	-1.291	0.210	
Education level	0.351	1.595	0.125	
Constant		3.162	0.005	

Discussion

The difference between men and women in terms of total cardiopulmonary function score can be influenced by the selection of assessment indices. Lung capacity is affected by height, weight, age and other known factors. Because height and weight are generally higher in men than women, a direct assessment of absolute vital capacity may result in a tendency for men's final cardiopulmonary function score to be higher than that of women. Although the difference in spirometry between male and female participants was not statistically significant, the score may have contributed to its overall significance. Using the vital mass index instead of vital capacity for scoring may mitigate the effect of the participant's size. In addition, due to lack of time and place, the 6-minute walking experiment originally scheduled for measurement was not completed. The assessment results will be more comprehensive if the results of the 6-minute walking experiment are added to the score.

A large number of studies have shown that age is an important factor affecting cognitive function (Zhou et al., 2011; Unverzagt et al., 2011). The nerve cell can increase with age and ceaseless apoptosis, causing a decrease in nervous system function; the ability of the central nervous system to process information declines and impairs cognitive function.

Studies have pointed out that there is a close relationship between different education levels and cognitive function (Yang et al., 2010; Petersen et al., 2010). The mechanism may be that the educational process is essentially a cognitive exercise that can repeatedly arouse the central nervous system, improve the basic cognitive function of the body and reduce the degree of cognitive decline caused by age. However, the contrary conclusion of this study may be due to the fact that respondents were generally older and their cognitive decline was more severe. It may also be because other characteristics of participants from different educational groups cannot remain relatively consistent, interfering with other variables too.

Most chronic diseases are characterised by the long duration of action and extensive involvement of organs and systems. Among them, hypertension and diabetes have been shown by many studies to be risk factors for cognitive function (Annanmaki et al., 2011; Zhang et al., 2013). Both hypertension and diabetes can cause changes in the capillaries, affect blood supply to the brain and lead to neuronal degeneration and death, thus impairing cognitive function.

The strength of this research is that the entire investigation process is well controlled and makes the data reliable. Its main disadvantage is the small sample size. If the sample size is too

small, the power of the test will be too low, making it more likely to have false negative results. This suggests that we can expand the sample size in the next study to get more reliable results.

Conclusion

The prevalence of mild cognitive dysfunction in this survey is relatively high. Because mild cognitive dysfunction can easily develop into dementia, it requires attention and prompt intervention to avoid the onset of disability in the elderly. No correlation was found between cardiopulmonary function and cognitive function in the elderly. To get more specific results, we need to expand the sample size of our study in the future.

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