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# Associations between objectively assessed physical fitness levels and sleep quality in community-dwelling elderly people in South China

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## Abstract

**Purpose** The aim of this study was to explore associations between objectively assessed physical fitness levels and sleep quality in community-dwelling elderly people in South China.

**Methods** One thousand one hundred thirty-six (504 males and 632 females) community-dwelling adults aged ≥ 50 years old in Dongguan City, South China, were included in the cross-sectional study. All the participants were asked to complete all prepared multi-instrument questionnaire, including the Pittsburgh Sleep Quality Index (Chinese version), for the assessment of the sleep quality and information regarding socio-demographic characteristics, lifestyle, and physical health data. Physical fitness was measured by grip strength, one-leg standing test (OLST) with eyes open, back scratch test, and the forced vital capacity (FVC).

**Results** The percentage of poor sleep quality among elderly people (≥ 50 years old) was up to 18.2%. Lower FVC was associated with the poorer sleep quality (adjusted OR = 0.74 per SD increase; $P = 0.009$), and participants with lower performance in back scratch test were more likely to suffer poor sleep quality (adjusted OR = 1.17 per SD increase; $P = 0.035$). The independent contribution of physical fitness tests results on the risk of poor sleep quality was 22.1%.

**Conclusions** Our results indicated that sleep quality was strongly associated with physical fitness among community-dwelling elderly people; the lower of the physical fitness predicted poorer sleep quality.

**Keywords** Sleep quality · Physical fitness · Pittsburgh Sleep Quality Index · Cross-sectional study

## Introduction

Sleep is considered as the state of mind and body in a biological periodic cycle of a human, which is essential for maintaining physical and mental health. Sleep disorders are relatively common among elderly people, which are characterized as decreased efficiency of sleep and shorter sleep times, as same as increased wake-up after sleep onset [1]. Emerging evidences reveal that poor sleep quality leads to significant negative effects on physical and mental health, such as poor sleep quality can be associated with an increased risk of falls, memory problems, chronic fatigue, frailty, mortality, and decreased physical performance [2–6]. However, sleep quality is relatively

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difficult to be measured in community-based studies because of the challenge of using objective sleep instruments such as polysomnograms to assess the sleep complaints in a large population. Thus, self-reported questionnaires are employed to measure the sleep complaints in community-based studies [7]. Pittsburgh Sleep Quality Index (PSQI), always used as a self-report questionnaire, is regarded as one of the most validated and widely used questionnaire for evaluation of sleep quality and sleep disorders [8] over a time interval of 1 month. Here, it was used in our investigation during the last month as the validated scale. It is also considered as a recommended assessment implemented for the basic research on the mechanisms of sleep disorders and large-scaled epidemiological studies [9].

Physical fitness is the capability to achieve certain performance standards for physical activity and also an outcome of habitual physical activity or exercise [10]. The evaluation of the physical fitness among elderly people is of significance because the improvement in physical fitness seems to be one of the main reasons for decreasing the rates of cardiovascular disease to delay all-cause mortality [11]. Previous studies reported that regular physical activity and exercise can significantly improve sleep quality and decrease self-reported sleep disturbance [12–14].

However, to the best of our knowledge, there have not been any reports to date addressing the effect of the objectively measured physical fitness on sleep quality among southern Chinese community-dwelling elderly people (aged ≥ 50 years old). Thus, our main purpose was to explore the relationship between self-reported sleep quality and the physical fitness tests in these people. Based on the existing evidences, it was hypothesized that lower assessed physical fitness levels are associated with the poorer sleep quality in community-dwelling elderly people in South China.

## Methods

### Study sample

The present study was carried out in Dongguan, Guangdong province, China, which was based on a cross-sectional survey. Details of the sampling method in our study have been described elsewhere [15]. In the present study, 1225 subjects were ≥ 50 years of age. Participants were excluded from the study if they had physical dysfunctions that may potentially affect the measurements and those who had not completed the questionnaires or had not completed the physical fitness tests. Finally, completed data were available for 1136 individuals; all of which was included in the data analysis.

### Assessment of the sleep quality

The PSQI consists of 19 items that generate seven dimensions: sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, sleeping medication usage, and daytime dysfunction [9]. Each subscale ranged 0–3, and one global score of the subjective sleep quality was yielded from 0 to 21 with the sum of all these abovementioned component scores. Score level is negatively related to sleep quality. The Chinese version of the PSQI also has an overall sleep quality evaluation ($r = 0.82$–$0.83$) in test-retest reliability ($r = 0.77$–$0.85$) [16]. A total PSQI score > 5 means poor sleep quality; on the contrary, good sleep quality was defined as the score ≤ 5 of PSQI.

### Measurements of physical fitness

Participants were also required to complete four health-related physical fitness tests in our study including grip strength, one-leg standing test (OLST) with eyes open, back scratch test, and forced vital capacity (FVC), which were considered to be standard indicators of physical fitness. The reasons were first, handgrip strength is a simple, convenient, and noninvasive assessment method for muscle strength and function measurement and also a good indicator to reflect an individual's overall health and nutritional status [17]. Participants were required to use a handheld dynamometer and then asked to perform a maximum-force trial for one hand. Grip strength is determined in kilograms (kg) and obtained from the commonly used hand [18]. Second, OLST is an indicator of the ability to stand on one leg [19] which is measured by a stopwatch. Standing time was recorded when the participants were standing by one leg and lifted the opposite foot off the ground. Time interval was recorded until the raised leg was put down, with maximum 60 s allowed [20]. Third, the back scratch test is a widely used test to assess the upper body flexibility. The participants should put back one of their hand to reach as far as possible down the middle of the back, and the other hand behind the back and fingers reach up as far as possible attempting to touch the middle fingers of both hands. The distance between the tips of the middle fingers was measured [21]. Fourth, FVC is a measurement of the amount of air that can be forcibly expelled out of the lungs after taking a breath to fill the lungs as much as possible. A value in liters of air is typically used to express FVC. This measurement is an important indicator of lung health and used to help determine both the presence and severity of lung diseases. Measurements were taken as participants breathe in and then breathe out (exhale) as forcefully as possible into vital lung capacity instrument.

### General questionnaire

The general study questionnaire consists of information of social demographic characteristics such as age, gender, educational levels, and marital status and also including the health-related factors, such as smoking, drinking, exercise, illness within 2 weeks, annual hospitalization, and body max index (BMI). Smoking was considered as the participant who has smoked at least 100 cigarettes as well. Drinking status was supposed to at least 30 mL of alcohol consumption per week. Exercise was defined as taking exercise at least 1 day in a week for no less than 30 min per time. BMI was calculated as weight in kg/height in $m^2$. Illness within 2 weeks and annual hospitalization were defined as being sick in the past 2 weeks and being hospitalized in the last year.

### Statistical analysis

All analyses were conducted by employing SPSS version 19.0 (SPSS Inc., Chicago, IL, USA). Demographic characteristics were analyzed using descriptive statistics. One-way analysis of variance (ANOVA) test was used for comparison of the PSQI score between different groups. The unpaired *t* test was used to compare means in physical fitness tests between the good and poor sleep group. A logistic regression model was employed to estimate the association between sleep quality and physical fitness measurements. Clustered logistic regression [22] was facilitated for the exploration of the impact of three clusters on sleep quality including the social demographic characteristics, health-related factors, and physical fitness. Details of the clustered logistic regression have been described elsewhere [15].

## Results

### Descriptive statistics of the study population

The PSQI total mean score was 3.6 ± 2.6, and the percentage of poor sleep quality among elderly people was 18.2%. To sum up, 1136 elderly people (65.3 ± 9.7 years) were included in this study and the complete data on all variables were available. Characteristics of the participants were presented in Table 1.

**Table 1** General characteristics of participants

| Variable | Mean ± SD/N (%) | PSQI score (mean ± SD) | *P* |
|---|---|---|---|
| Socio-demographic | | | |
| Age | 65.3 ± 9.7 | | |
| Gender | | | < 0.001 |
| Male | 504 (44.4) | 3.3 ± 2.3 | |
| Female | 632 (55.6) | 3.9 ± 2.7 | |
| Marital status | | | 0.023 |
| Married | 957 (84.2) | 3.6 ± 2.5 | |
| Single | 179 (15.8) | 4.0 ± 2.7 | |
| Education | | | < 0.001 |
| Senior middle school or higher | 62 (5.5) | 2.6 ± 2.2 | |
| Junior middle school | 288 (25.3) | 3.3 ± 2.3 | |
| Elementary school or lower | 786 (69.2) | 3.9 ± 2.6 | |
| Health-related | | | |
| Smoking | | | 0.002 |
| No | 862 (75.9) | 3.8 ± 2.6 | |
| Yes | 274 (24.1) | 3.2 ± 2.3 | |
| Drinking | | | 0.080 |
| No | 1028 (90.5) | 3.7 ± 2.6 | |
| Yes | 108 (9.5) | 3.3 ± 2.2 | |
| Exercise | | | 0.010 |
| No | 537 (47.3) | 3.8 ± 2.5 | |
| Yes | 599 (52.7) | 3.5 ± 2.6 | |
| Illness within 2 weeks | | | < 0.001 |
| No | 685 (60.3) | 3.3 ± 2.4 | |
| Yes | 451 (39.7) | 4.1 ± 2.7 | |
| Annual hospitalization | | | < 0.001 |
| No | 1054 (92.8) | 3.6 ± 2.5 | |
| Yes | 82 (7.2) | 4.7 ± 3.6 | |
| BMI | 23.9 ± 4.1 | | |
| Physical fitness | | | |
| FVC (mL) | 1602.3 ± 770.8 | | |
| Back scratch test (cm) | 4.9 ± 8.0 | | |
| Grip strength (kg) | 23.8 ± 18.8 | | |
| OLST (s) | 6.9 ± 6.7 | | |
| Dependent: sleep quality | | | |
| Good (score 0–5) | 929 (81.8) | | |
| Poor (score > 5) | 207 (18.2) | | |

*BMI*, body mass index; *OLST*, one-leg standing test with eyes open; *FVC*, forced vital capacity

### Associations between physical fitness and sleep quality

Table 2 displays a lower FVC and a longer distance in back scratch test were significantly associated with poorer sleep quality. The risk of poor sleep quality was significantly increased with the decreasing FVC (crude OR = 0.69 per SD increase; 95%CI = 0.56–0.85; $P < 0.001$) and the distance in back scratch test conversely (crude OR = 1.19 per SD increase; 95%CI = 1.03–1.37; $P = 0.016$). The unpaired *t* test also showed a significant difference ($P < 0.001$) in the FVC and back scratch test between the good sleep quality and poor sleep quality groups (Fig. 1). On average, FVC and back scratch test in the two groups of sleep quality resulted in the

**Table 2** Associations between physical fitness and sleep quality

| | Sleep quality | | |
|---|---|---|---|
| | OR | 95% CI | $P$ |
| FVC | 0.69 | (0.56–0.85) | < 0.001* |
| Back scratch test | 1.19 | (1.03–1.37) | 0.016* |
| Grip strength | 0.97 | (0.79–1.18) | 0.752 |
| OLST | 0.97 | (0.81–1.15) | 0.691 |

* $P < 0.05$

*OR*, odds ratio per SD increase in a predictor variable; *CI*, confidence intervals; *FVC*, forced vital capacity; *OLST*, one-leg standing test with eyes open

following: FVC in good sleep quality group ($n = 929$) was 1656.2 ± 776.8 mL and in poor sleep quality group ($n = 207$) was 1360.5 ± 695.3 mL; and the back scratch test in good sleep quality group was 4.5 ± 7.8 cm and that in poor sleep quality group was 6.7 ± 9.5 cm.

### Determinants of sleep quality

The cluster logistic regression was illustrated in Table 3 to explain the sleep quality and adjusted for all the other variables. We found that only age was related to poor sleep quality in the first cluster. The independent contribution of social demographic variables was 42.9%. In those indicated health-related variables, illness within 2 weeks and lower BMI were risk factors of sleep quality. The independent contribution of the second cluster was 35.1%. In the third cluster, FVC was negatively associated with the poor sleep quality (adjusted OR = 0.74 per SD increase; 95%CI = 0.58–0.93; $P = 0.009$), and longer distance in the back scratch test was more likely to suffer poor sleep quality (adjusted OR = 1.17 per SD increase; 95%CI = 1.07–1.36; $P = 0.035$). The independent contribution of physical fitness test results on the risk of poor sleep quality was 22.1%.

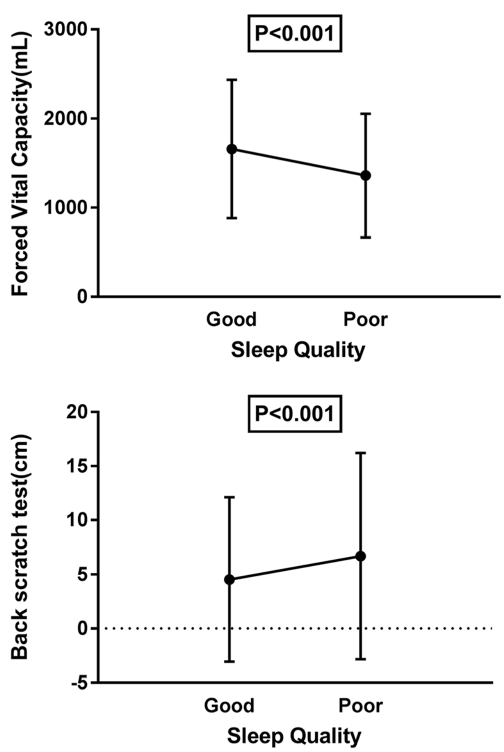


**Fig. 1** Forced vital capacity and back scratch test in two groups of sleep quality

## Discussion

This study was to examine associations between objectively assessed physical fitness levels and sleep quality in community-dwelling elderly people in South China. Most subjects (81.8%) thought themselves to have good sleep quality. However, the prevalence rate of poor sleep quality among elderly people in rural China was reported to be 49.7% [23]. The difference might be caused by the choice of different population, regional variations, and economic status. It was the first time to research the association between sleep quality and the objectively measured physical fitness in Chinese community-dwelling elderly people. The results of this study supported our hypothesis that there was a positive relationship between decreased physical fitness and poor sleep quality. Particularly, lower FVC and the lower performance in back scratch test proved to be associated with poorer sleep quality, even after adjusting social demographic characteristics and health-related factors as potential confounders. Similar to previous studies, age was a risk factor [24] and the most influential independent contribution to poor sleep quality. At the same time, we also proved that higher illness within 2 weeks and lower BMI are health-related factors associated to poor sleep quality. The independent influence of the health-related factors was greater than that of physical fitness but less than that of socio-demographic variables. The association between sleep quality and the three clusters suggested that age might be the main factor in poor sleep quality among Chinese community-dwelling elderly people.

We found that illness within recent 2 weeks and BMI as health-related variables were related to sleep quality in cluster logistic regression analysis. There was little evidence that the condition of illness within 2 weeks or lower BMI can predict the poor sleep quality. Illness within 2 weeks was considered as one of the risk factors of poor sleep quality in our study and showed poor health status accompanied by poor sleep quality in another study [25]. Our research also demonstrated that decreasing BMI tended to poor sleep quality. In particular, older adults with low BMI suffer a much poorer diet quality and a significantly lower health-related quality of life [26]. These suggest that some sleep problem might be related to BMI.

**Table 3** Cluster logistic regression models associated with sleep quality

| Predictor variable | OR[a] (95% CI) | $P^*$ | Negelkerke $R^2$ | Independent contribution (%) |
|---|---|---|---|---|
| Cluster 1 | | | | |
| Age | 1.02 (1.00, 1.04) | 0.023 | | |
| Total | | | 0.033 | 42.9% |
| Cluster 2 | | | | |
| Illness within 2 weeks | 1.56 (1.13, 2.15) | 0.008 | | |
| BMI | 0.95 (0.91, 0.99) | 0.027 | | |
| Total | | | 0.060 | 35.0% |
| Cluster 3 | | | | |
| FVC | 0.74 (0.58, 0.93) | 0.009 | | |
| Back scratch test | 1.17 (1.01, 1.36) | 0.035 | | |
| Total | | | 0.077 | 22.1% |

[*] Variables enter the final model if $P < 0.05$

[a] Adjusted for all other variables included in the table

*OR*, odds ratio; *CI*, confidence intervals; *BMI*, body mass index; *FVC*, forced vital capacity.

Our findings showed that physical fitness was a critical independent determinant of sleep quality. A lower FVC and a longer distance in back scratch test were significantly associated with poorer sleep quality. Associations between sleep disorders and physical function also have been reported in other cross-sectional studies [27] that use different methods and tests to measure the sleep quality and to assess the physical fitness [5, 6]. Our speculation that poor physical fitness is probably an important risk factor related to sleep disorders is in agreement with previous studies that had been discussed [20, 28]. In our study, the association between sleep quality and grip strength was not shown; however, the association between sleep quality and grip strength was strong among Japanese community-dwelling older adults [20]. It might be due to the association between sleep quality and other physical fitness which was stronger than grip strength in Chinese elderly people. Disturbed sleep and poor quality of sleep are common in these patients suffering from lung disease [29, 30]. As an important indicator of lung health, lower FVC was associated with poor sleep quality in our results. The shoulder range of motion can be assessed by the back scratch test, and the upper body flexibility allows everyday tasks to be completed (e.g., combing hair and putting on clothes) [21]; and therefore, better performance in the back scratch test suggested better health status of the participants. Our results reported that the association between poor sleep quality and the lower performance in the back scratch test was statistically significant ($P = 0.016$). Although studies have found a positive correlation between sleep quality and physical fitness, there has not been any research investigating the underlying reasons of the physiology behind this association, so further research to evaluate mechanisms is needed to reveal the basic principles.

This study had several strengths and limitations. One advantage was that the most comprehensive and extensive questionnaire (PSQI) was used to assess the sleep quality and ensure the reliability of the results to the utmost extent. Another advantage was the use of objective measurement of physical fitness tests, representing the basic physical performance aspects. Furthermore, different from other studies, cluster logistic regression was used for the classification of the related factors into three clusters and explored the independent contribution possibility of each cluster in the present study. Several limitations also should be considered in our study. Firstly, the data were collected in the self-report questionnaire forms; there was a possibility that participants completed it at times exaggerating the score or understating the actual situation. Secondly, we adjusted several confounding factors in the analysis, but there are still other possible confounding factors that have not been assessed, such as chronic diseases. Finally, this was a cross-sectional study that we can find the correlation between variables, but it is difficult to determine their causal relationship; we could not draw the conclusion whether poor sleep quality precedes the decline of physical strength or vice versa.

In conclusion, our study provides an initial evidence for an association between sleep quality and physical fitness among southern Chinese community-dwelling elderly people. Future research is expected to control the limitations and elucidate the interventions for enhancing physical performance to improve sleep quality in the elderly, and further determination of the temporality of the associations is required.

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Xi Wang, Dr. Qing-Feng Du, and Ms. Xin Peng are the guarantors of this work and, as such, had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

**Authors' contributions** Xin Peng designed the study, analyzed the data, and wrote the draft manuscript. Nan Liu managed the study, organized cross-sectional investigation, and wrote the draft manuscript. Xiao-Xia Zhang performed data analysis and wrote the draft manuscript. Xin-Yu Bao, Yi-Xian Xie, and Jun-Xuan Huang collected the data, performed data analysis, and edited the manuscript. Pei-Xi Wang and Qing-Feng Du designed and supervised the study, performed data analysis, and critically reviewed and edited the manuscript. All authors contributed to the interpretation of the data and approved the version for submission.

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## Compliance with ethical standards

**Ethics approval and consent to participate** The study was approved by the Research Ethics Committee of the Guangzhou Medical University. The written informed consent was obtained from all study participants prior to study entry.

**Consent for publication** All authors gave their consent to the publication.

**Competing interests** The authors declare that they have no conflict of interest.

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