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Reliability and Validity of Healthy Fitness Measurement Scale Version1.0 (HFMS V1.0) in Chinese Elderly People

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Abstract

Purpose. We examined the reliability and validity of the Healthy Fitness Measurement Scale Version 1.0 (HFMS V1.0) specifically on elderly people in China.

Methods. We carried out a cross-sectional study in December 2020 and enrolled 800 elderly people through stratified sampling technique. The level of healthy fitness was measured using the HFMS V1.0. The Cronbach's alpha coefficient, split-half reliability, test-retest reliability, convergent and discriminant construct validity, exploratory factor and confirmatory factor were calculated for assessing the reliability and validity of HFMS V1.0.

Results. The valid samples were comprised of 777 samples (with a mean age of 71.81 ±8.36 years), 382(49.2 %) were women. HFMS V1.0 consists of 8 dimensions and 38 items. The scale had acceptable reliability (Cronbach's alpha = 0.920, split-half = 0.946, test-retest = 0.878). The correlation of each item, dimension and subscales ranged from 0.528 to 0.888 ($p < 0.001$). Exploratory factor analysis uncovered 11 factors with the cumulative contribution rate of 68.09% and all factor loads over 0.40. The item distribution was consistent with the initial expectation of the scale. The confirmatory factor analysis indicated good fit: CMIN/DF=2.773, RMSEA=0.048, IFI=0.915, TLI=0.904, CFI=0.915.

Conclusion. HFMS V1.0 was shown to have acceptable reliability and validity. Collectively, HFMS V1.0 is reliable and efficient to measure the healthy fitness of elderly people.

Introduction

Fitness refers to the individual's ability to actively or passively adapt to changing environment, including all physical, mental and social responses [1]. A high level of fitness allows people to effectively cope with the internal and external events and to restore to a balanced state following stress reaction and adjustments; otherwise, individual with poor fitness are more vulnerable to health impacts of external forces and even many diseases [2]. Fitness is an indispensable ability for people living in modern society, also an important factor in health[3].

Physical fitness is one's ability to adapt to internal and external stresses, which is originated from the initiative of American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) [4]. At present, it is generally recognized the definition of physical fitness proposed by the WHO in 1968: the ability to cope with daily work without undue fatigue, and with energy to enjoy leisure and respond to emergencies [5].The physical fitness test in the United States was traced back to the 1880s[6]. The Physical Best (PB) is currently prevalent test for assessing physical fitness [7], whose selected indicators consist of cardiopulmonary function, muscle strength and endurance, flexibility and body composition. The Japanese physical fitness tests are made up of different test items based on age and grade, with grip strength, sit-ups and sit-and-reach as general items [8, 9]. China's physical fitness test was developed late, and the test follows *National Fitness Standards* covering all people different ages (from infants, children and adolescents, adults to the elderly)[10].

Mental fitness is defined as the interaction between an individual and a changing environment, and it is a dynamic process of individual psychological self-regulation [11]. Psychological adjustment is closely related to disease progression and people's physical health [12], so it is considered as an important aspect of healthy fitness. Paula Robinson [13] describes mental fitness as the capacity to use one's resources and skills to flexibly adapt to environmental changes, and proposes that mental fitness can be measured, when the mental fitness can be understood in a similar way to physical fitness. Linda Bolier [14] pointed out that positive thinking and problem-solving capacity has a positive effect on health. Different from the quantitative assessment of physical fitness using instruments and equipment, evaluation of mental fitness at home and abroad is mostly carried out by the scale or the evaluation index system, such as Adolescence Psychological Adaptability Scale (APAS) [15] for evaluating the psychological adaptability of adolescents, Symptom Check List-90 (SCL-90) [16] for evaluating mental health status, and Self-Rating Anxiety Scale (SAS) for evaluating psychological anxiety [17].

Social fitness is defined as the ability of individuals to adjust their own body and psychological state to achieve the goals expected by the society [18], particularly encompassing the availability and compatibility of social environment [19]. This kind of fitness is affected by both internal and external factors [20]. Individuals with lower level of social adaptability are more prone to maladaptation with symptoms such as fear and cringe, and even environmental shock [21–23]. At present, there have been some researches on the measurement of individual social adaptiveness and adaptability at home and abroad, such as Vineland Social Maturity Scale (VABS) [24] and the Social Adaptation Self-evaluation Scale (SASS) [25], American Association for Mental Deficiency Adaptive Behavior Scales (AAMD ABS) [26], and Psychosomatic Symptom Scale (PSSS) [27].

Fore-mentioned studies on adaptability evaluation mostly focus on a certain aspect of fitness other than integration of physical, mental and social fitness. In 1948, World Health Organization (WHO) defined health as a state of the absence of illness or weakness, and the presence of physical, psychological, and social well-being [28], discarding the narrow concept of "health", but encompassing psychological and social well-being. Social competence and adaptability have become essential to health. Therefore, comprehensive assessment of adaptability should not only include measures of physical fitness (health-related physical fitness), but also detect mental and social fitness [29]. On the basis of previous studies on physical fitness and health-related physical fitness, our previous study put forward with the concept of "healthy fitness" [30]: the best physical, mental and social adaptability. Further, Jun Xu et al. established a healthy fitness assessment index system of Healthy Fitness Measurement Scale Version 1.0 (HFMS V1.0) involving physical, mental and social fitness when considering China’s social culture and existing health-related physical fitness scale (IFIS, SRFIT), mental fitness scale (APAS, SCL-90, SAS), and social fitness scale (VABS, SASS, ABS, CTAB) [31].

The increase in life expectancy and the decline in fertility are facilitating the aging of the world’s population [32].By the end of 2019, China’s elderly population has exceeded 250 million, accounting for 18.1% of the total population [33]. By 2053, China’s elderly population will climb to 487 million, reaching the peak of population aging, which will account for a quarter of the global elderly population at that time. From 2000 to 2050, the ratio of China's population aging will increase from 10–34%, over two times as the global growth rate [34]. The disease spectrum in China has begun to transit from infectious diseases to non-communicable diseases. The prevalence of chronic non-communicable diseases will increase by at least 40% by 2030, when approximately 80% of people aged 60 and over will die from chronic non-communicable diseases. Whether an aging population can create a “third demographic dividend” for society depends heavily on the health [35].Biological aging is characterized by physical weight loss [36], decline in organ function [37], and psychological memory[38], emotional instability, and reduced adaptability [39]. Due to reduced adaptability in many aspects, the prevalence of chronic diseases in the elderly is 2.3–3.2 times that of the total population [40]. Therefore, it is imperative to strengthen the healthy fitness management of the elderly to prevent physical, mental, and social adaptability disorder. In the present we evaluated the reliability and validity of HFMS V1.0 in elderly population through the quantitative analysis of the healthy fitness level of the elderly population in Guangzhou. These data might underlie the effective quantitative evaluation of the healthy fitness of the elderly, as well as the development of future study to identify factors affecting healthy fitness.

Materials & Methods

Study design

A cross-sectional survey was conducted using a stratified sampling technique with three stage in December 2020. The first stage involved 4 administrative districts within Guangzhou while considering their economic level and geographical distributions. The second stage involved 1~3 streets of the selected districts. The final stage involved sampling of 1~2 neighborhood committees from the selected streets and the stratified sampling was conducted based on gender (male: female = 1:1) and age ((60-64):(65-69):(70-74):(75-79):(80 years and older)=1:1:1:1:1:1) to ensure sample representativeness. Inclusion criteria included the following: age over 60 years old, local residents or non-local residents who have lived for more than half a year, and willingness to participate in this survey. Exclusion criteria were cognitive decline and a history of illness within this month.

Participants

We surveyed 800 elderly people in total, and 80 of them were asked to participate in the retest at 24 hours to 1 week intervals. In the first test, 777 valid questionnaires (male, 50.8%) were returned, with effective response rate of 97.13%. 74 valid questionnaires were retested and returned, with effective recovery rate of 92.50%. All participants have signed the informed consent.

Ethical approval

This study was approved by the Ethics Committee of Nanfang Hospital of Southern Medical University (No. NFEC-2020-288).

Healthy fitness assessment

Healthy fitness was the adaptability outcome analyzed in this study. This was measured using the Health Measurement Scale version 1.0 (HFMS V1.0), which had been previously developed by our research group. This scale conforms to operational definition of healthy fitness and has been analyzed and confirmed by the expert and field investigation [31]. HFMS V1.0 consists of three subscales: physical fitness status (PF), mental fitness status (MF), and social fitness status (SF). PF consists of 14 items that comprises three factors: organic function, motor function and physical adaptive capacity. MF consists of 11 items that comprises three factors: psychological cognition, resilience and stress response. SF consists of 9 items that comprises two factors: role adaptation and social resource and social support. Forward scoring must be adopted for the 1-5, 16-17, 28-36 with the score equal to the original score, while reverse scoring (6-1) must be adopted for the items 6-14, 18-26, and items 15, 27, 37, and 38 were the overall evaluation items and not calculated. All items were assessed using Likert's five-level scoring, ranging from 1 (very poor) to 5 (very good). The original score of each dimension was computed as the sum of the scores of each subordinate items, and the original score of each subscale was computed as the sum of the scores of each subordinate dimensions. The gross score of the scale was computed by the sum of the scores of the three subscales. For better analysis, comparison, and popularization, the raw scores are converted to percentile value with formula as follows. The higher the conversion score, the higher the fitness level.

$$Conversion\ \ score = \frac{Original\ \ score - Theoretica\ l\ Minimum}{Theoretica\ l\ Maximum - Theoretica\ l\ Minimum} * 100$$

Quality control

The uniformly trained investigators sent out the questionnaire to the subjects, and introduced the filling method and precautions. The subjects were required to respond independently and completed the questionnaire by themselves based on their own healthy fitness in the past month. If the participants have trouble in reading the questionnaires, the investigator may provide appropriate assistance to them without any inducing prompts. In order to ensure the quality of the questionnaires, all questionnaires were collected on the spot, and those with more than 6 missing items, inconsistent answers, regular answers, or highly repeated answers were excluded.

Statistical analysis

All data were processed by IBM SPSS 25.0 software and AMOS 21.0 software. Quantitative data were described as (`X±S) and count data were described as percentage. Reliability of the questionnaire as internal consistency was determined using split-half method and Cronbach's alpha coefficient. Cronbach's alpha coefficient of 0.81 to 1.00 indicates almost perfect agreement, 0.61 to 0.80 indicates agreement, 0.41 to 0.60 indicates moderate agreement [41]. Split-half method reliability was assessed by calculating the 34 odd- and even-numbered items after removing 4 overall items not involved in scoring, with its coefficient over 0.70 considered satisfactory [42]. The intraclass correlation coefficient (ICC) was calculated for evaluating test-retest reliability with values less than 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and greater than 0.90 indicative of poor, moderate, good, and excellent reliability, respectively [43]. Validity was evaluated using convergent and discriminant validity, as well as factor analysis consisting of exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). Examination of convergent and discriminant construct validity included evaluation of spearman's correlation coefficient [44]. In general, great convergent and discriminant validity is characterized by the correlation coefficient between each dimension value and the total value higher than that between each dimension; and the coefficient between each item and its dimension higher than that between each item and other dimensions; correlation coefficient < 0.3 indicates weak relationship, correlation coefficient = 0.3-0.7 allows moderate, and coefficient > 0.7 allows strong relationship [45]. For EFA, we used the Kaiser-Meyer-Olkin (KMO) test and Bartlett’s test of sphericity to measure the adequacy of samples when determining whether KMO value is between 0.5 and 1[46]. Principal components analysis (PCA) was used to obtain common factors. In order to determine the factor structure, the orthogonal rotation axis was performed by the varimax rotation. CFA was performed to assess the measurement model. Good model fit [47] included chi-square (CMIN/DF) < 3.00, root mean square error of approximation (RMSEA) < 0.05, incremental fit index (IFI) > 0.900, Tucker-Lewis index (TLI) > 0.900, comparative fit index (CFI) > 0.900. The missing data were replaced by the mean value of the respondents. * $p < 0.05$ indicates significant difference.

Results

Description of sample

The demographics of all participants are shown in Table 1. Of the 777 participants, males accounted for a larger proportion (50.8%) with most in the 65-69 age group (26.1%). Education of the most participants was junior high school and above (76.2%), and most of the participants were married (79.9%). Their pre-retirement occupations were mainly heads of state agencies, party organizations, enterprises, and institutions (34.2%), and a majority participated in public medical insurance (57.1%).

Table1 Participant’s demographic characteristics (n=777)

Characteristic	N	%
Gender		
Male	395	50.8
Female	382	49.2
Age (years old)		
60-64	164	21.1
65-69	203	26.1
70-74	139	17.9
75-79	108	13.9
80-	163	21.0
Education		
Uneducated	43	5.5
Primary school diploma	142	18.3
Junior high school diploma	132	17.0
High school/technical secondary school/vocational high school diploma	207	26.6
College degree	174	22.4
Bachelor degree and above	79	10.2
Marital status		
Single	14	1.8
Married	621	79.9
Divorced	35	4.5
Widowed	101	13.0
others	6	0.8
Household monthly income per person (yuan)		
<3000	95	12.2
3000-6000	262	33.7
6000-9000	187	24.1
9000-12000	133	17.1
>12,000	100	12.9
Personal monthly income (yuan)		
<2000	55	7.1
2000-4000	124	16.0
4000-6000	239	30.8
6000-8000	137	17.6
>8000	222	28.6
Pre-retirement occupation		
Heads of state agencies, party organizations, enterprises, and institutions	266	34.2
Professional technicians (teachers, doctors, etc.)	113	14.5
Clerks and related personnel	127	16.3
Commercial and service personnel	71	9.1

Production personnel in agriculture, forestry, animal husbandry, fishery and water conservancy	59	7.6
Production, transport and equipment operators and related occupations	39	5.0
Soldier	4	0.5
Other practitioners	98	12.6
Participation in insurance		
Self pay	25	3.2
Public medical insurance	402	51.7
Medical insurance for urban and rural residents	189	24.3
Urban employee medical insurance	235	30.2
Commercial medical insurance	50	6.4

Reliability

The Cronbach's alpha of HFMS V1.0 scale was 0.920, and the Guttman coefficients of the HFMS V1.0 total scale was 0.946. Three subscales reliability results, means and standard deviations are provided in Table 2. The highest and lowest scores accounted for very low proportions in the HFMS V1.0 total scale and the three subscales of PF, MF, and SF, without ceiling and floor effect.

Table 2 Internal consistency reliability results, means and standard deviation (SD), floor and ceiling effects of the HFMS V1.0 (N=777).

Scale	Cronbach's alpha	Guttman coefficient	Mean	SD	Floor (%)	Ceiling (%)
HFMS V1.0	0.920	0.946	57.40	11.02	15.44(0.13%)	91.91(0.13%)
PF	0.869	0.883	53.38	13.37	12.50(0.13%)	92.86(0.13%)
MF	0.866	0.893	61.08	13.03	13.64(0.13%)	100.00(0.13%)
SF	0.832	0.882	59.13	13.49	19.44(0.26%)	94.44(0.37%)

Table 3 shows the test-retest reliability statistics in older adults from Guangzhou for the HFMS V1.0 and three subscale: PF, MF, and SF. The ICC values ranged from 0.752 (SF) to 0.837 (MF), and the ICC of HFMS V1.0 was 0.878.

Table 3 Test–retest (24 hours to 1 week apart) reliability of the HFMS V1.0 among older adults in Guangzhou (n = 75).

Scale	Test mean (SD)	Re-test mean (SD)	ICC	95% CI	α
HFMS V1.0	60.79(9.10)	59.59(8.73)	0.878	0.807-0.923	0.881
PF	57.48(10.14)	56.20(10.22)	0.797	0.679-0.871	0.798
MF	63.88(10.83)	61.22(13.11)	0.837	0.735-0.899	0.847
SF	62.16(12.51)	62.89(8.73)	0.752	0.608-0.844	0.751

Notes: SD=standard deviation. α =Cronbach's alpha

Validity

Convergent and discriminant validity

In order to verify the structural validity of the HFMS V1.0, we conducted a Spearman's correlation analysis between each item and dimensions, each dimension and its subscales, each subscale and the HFMS V1.0. As shown in Table 4 and Table 5, the correlation coefficient between each item of HFMS V1.0 and the corresponding dimension ranged from 0.528 to 0.836, significantly greater than that between the item and other dimensions (-0.039-0.561) (p <0.001). The correlation coefficient between each dimension and the corresponding subscale was 0.601-0.888, greater than that between the dimension and other subscales (0.261-0.574) (p < 0.001). Importantly, the results indicated strong the correlation between PF, MF, SF subscales and HFMS V1.0 scale (p < 0.001) with their coefficients 0.852, 0.866 and 0.709, respectively.

Table 4 Spearman's correlation between items and dimensions in HFMS V1.0								
Item	Organ function	Motor function	Physical adaptive capacity	Psychological cognition	Resilience	Stress response	Role adaptation	Resource and social support
HF1	**.528****	.339**	.203**	.178**	.189**	.157**	.242**	.149**
HF2	**.662****	.288**	.288**	.296**	.265**	.248**	.210**	.209**
HF3	**.727****	.371**	.372**	.361**	.332**	.348**	.330**	.263**
HF4	**.662****	.256**	.345**	.219**	.262**	.344**	.175**	.097*
HF5	**.644****	.343**	.389**	.283**	.315**	.503**	.381**	.126**
HF6	.356**	**.745****	.424**	.353**	.353**	.286**	.252**	.158**
HF7	.374**	**.820****	.492**	.340**	.367**	.314**	.447**	.234**
HF8	.394**	**.715****	.425**	.272**	.313**	.236**	.206**	.172**
HF9	.456**	**.737****	.561**	.361**	.400**	.335**	.371**	.235**
HF10	.306**	**.781****	.488**	.322**	.294**	.189**	.168**	.096*
HF11	.391**	.515**	**.715****	.310**	.363**	.287**	.260**	.113*
HF12	.326**	.389**	**.697****	.225**	.311**	.353**	.154**	.077*
HF13	.390**	.453**	**.765****	.329**	.428**	.385**	.303**	.150**
HF14	.350**	.496**	**.725****	.330**	.403**	.413**	.380**	.197**
HF16	.306**	.355**	.336**	**.829****	.413**	.297**	.413**	.313**
HF17	.355**	.335**	.325**	**.820****	.346**	.284**	.191**	.183**
HF18	.320**	.372**	.390**	.355**	**.729****	.367**	.375**	.326**
HF19	.297**	.303**	.355**	.347**	**.762****	.375**	.265**	.191**
HF20	.377**	.376**	.436**	.360**	**.797****	.471**	.427**	.351**
HF21	.367**	.306**	.388**	.353**	**.752****	.545**	.352**	.244**
HF22	.421**	.350**	.429**	.276**	.552**	**.745****	.484**	.312**
HF23	.382**	.319**	.389**	.263**	.443**	**.806****	.455**	.257**
HF24	.348**	.209**	.303**	.243**	.404**	**.758****	.274**	.177**
HF25	.428**	.256**	.432**	.295**	.432**	**.832****	.362**	.205**
HF26	.346**	.206**	.320**	.274**	.363**	**.752****	.383**	.162**
HF28	.305**	.201**	.239**	.246**	.313**	.372**	**.728****	.418**
HF29	.367**	.401**	.367**	.356**	.431**	.461**	**.810****	.423**
HF30	.353**	.334**	.306**	.296**	.342**	.414**	**.836****	.420**
HF31	.278**	.259**	.225**	.282**	.317**	.348**	**.763****	.461**
HF32	.231**	.265**	.222**	.271**	.343**	.299**	.513**	**.714****
HF33	.177**	.119**	.081*	.176**	.178**	.201**	.423**	**.680****
HF34	.063	.005	-.039	.091*	.093**	-.002	.116**	**.593****

HF35	.156**	.155**	.120**	.234**	.277**	.212**	.374**	**.756****
HF36	.273**	.253**	.233**	.288**	.352**	.311**	.466**	**.785****
Note:**= significant, $p<0.001$, * = significant, $p<0.05$. The bold correlation coefficient is the correlation coefficient between each item and the corresponding dimension								

Table 5 Spearman's correlation between dimensions and subscales, subscales and HFMS V1.0 scale

	Physical fitness	Mental fitness	Social fitness
Organ function	**.760****	.548**	.355**
Motor function	**.883****	.475**	.322**
Physical adaptive capacity	**.811****	.574**	.281**
Psychological cognition	.472**	**.601****	.360**
Resilience	.547**	**.836****	.439**
Stress response	.513**	**.886****	.435**
Role adaptation	.446**	.556**	**.847****
Social resource and social support	.261**	.370**	**.888****
HFMS V1.0	.852**	.866**	.709**
Note:**= significant, $p<0.001$. The bold correlation coefficient is the correlation coefficient between each dimension and the corresponding subscale			

Exploratory factor analysis

A KMO test was used in research to determine whether the sampling adequacy of data are to be used for factor analysis. As a consequence, the data of high KMO value (0.927) demonstrated that a factor analysis may be useful; meanwhile the approximate chi-square distribution of Bartlett test was 10710.343, the degree of freedom was 561, ($p < 0.001$), refuting the hypothesis that the correlation matrix is not an identity matrix. This indicates that 34 items have common factors and therefore are suitable for factor analysis[48]. In the PCA, 11 factors were extracted (Table 6), and the cumulative contribution rate reached 68.09%. After the orthogonal rotation axis is performed by the varimax rotation, the item distribution of the 11 factors was roughly in line with the theory of scale compilation with the factor loads higher than 0.4 (factor 1: Motor function; factor 2: Stress response; factor 3: Role adaptation; factor 4: Resilience; factor 5, factor 9 and factor 11: Organ function; factor 6: Physical adaptive capacity; factor 7 and factor8 : Social resource and social support; factor10: Psychological cognition).

Table 6 Factor loading matrix and contribution rate of each factor											
	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10	Factor11
HF10	0.792										
HF6	0.763										
HF7	0.745										
HF8	0.647										
HF9	0.635										
HF24		0.784									
HF25		0.769									
HF26		0.737									
HF23		0.727									
HF22		0.481		0.422							
HF30			0.797								
HF31			0.757								
HF29			0.705								
HF28			0.509								
HF32			0.494								
HF19				0.776							
HF18				0.682							
HF20				0.660							
HF21		0.422		0.618							
HF2					0.790						
HF3					0.711						
HF13						0.692					
HF11						0.613					
HF12						0.592					
HF14						0.434					
HF35							0.828				
HF36							0.704				
HF34								0.833			
HF33			0.428					0.669			
HF4									0.743		
HF5									0.631		
HF16										0.706	
HF17										0.622	
HF1											0.857
Contribution rate (%)	28.679	8.500	6.421	4.464	4.009	3.263	2.862	2.685	2.581	2.351	2.279
Note: Factor loading� 0.4.											

Confirmatory factor analysis

Combined with the secondary structure of the HFMS V1.0 scale, a second order CFA structure was modeled, as shown in Figure 1. The correlation coefficients among the three subscales of PF, MF, and SF were 0.59, 0.86, 0.75, and the standardized path coefficients between the dimensions and the subscales ranged from 0.79 to 0.94. The path coefficients of most items over 0.60 indicated that HFMS V1.0 has a large effect with great path association. The initial model was not well fitted (CMIN/DF=3.625, RMSEA=0.058, IFI =0.868, TLI=0.856, CFI=0.867.), so covariation relationship between the error variables was established in turn by combining the Modification Indices and Estimated parameter change for covariance. After the correction, the model showed good fit: CMIN/DF=2.773, RMSEA=0.048, IFI =0.915, TLI=0.904, CFI=0.915.

Discussion

The increase in life expectancy and the decline in fertility are facilitating the aging of the world's population [32]. In order to promote healthy aging, the WHO has released the *World report on ageing and health*, emphasizing that fitness is related to health, which hinges on the intrinsic capacity of the individual and environmental characteristics[49]. However, the current assessment of fitness is mostly limited to a certain dimension of physiology, psychology and society, and there is a lack of comprehensive healthy fitness measurement approaches. In this study, we aimed to assess the reliability and validity of the HFMS V1.0 for measuring the healthy fitness of the elderly.

Our results demonstrated that HFMS V1.0 scale exhibits acceptable internal consistency (Cronbach's alpha coefficient = 0.920, split-half coefficient = 0.946 > 0.70), which is consistent with data of previous findings (Cronbach's alpha coefficient = 0.920, split-half coefficient = 0.763) [31]. This indicates that all items in the HFMS V1.0 scale have good correlation with similar feature. The test-retest reliability of HFMS V1.0 scale was evaluated through examination of ICC value, as the result of ICC = 0.878 confirms the scale stability over time. In the study, the highest and lowest scores accounted for very low proportions in the HFMS V1.0 total scale and the three subscales of PF, MF, and SF. No ceiling effect or floor effect was observed in the HFMS V1.0, indicating that these aggregate scores sensitively reflect the changes in the healthy fitness of the Chinese elderly.

The test on convergent validity of the HFMS V1.0 scale indicates the strong correlation (r = 0.528-0.888) between each item and the dimension, each dimension and subscales. In the test on discriminant validity, the correlation coefficient between each dimension value and the total value was higher than that between each dimension; and the coefficient between each item and its dimension was also higher than that between each item and other dimensions, which indicates great convergent and discriminant validity of the HFMS V1.0 scale.

Besides, the results from EFA and CFA further depict the construct validity of the HFMS V1.0 scale. In the EFA, the extracted 11 factors are responsible 68.09% of the variability. Among the 11 factors, factor 1 (motor function) accounts for 28.68% of the variability, suggesting that individual's motor function should deserve more attention. Different from our conclusion, a previous study by Lijie Jiang[31] points out stress response as the main impact factor responsible for 9.485% of the variability. Such difference may be due to the compositions of the subjects; the subjects of our study were retired elderly while Li's research focused on civil servants, most of whom were under 30 years old (47.5%). Physical fitness is related to age. The decline in function activity of skeletal muscle [50] affects the balance and walking ability of the elderly[51]. It is noted that physical fitness reaches a peak at the age of 20 [52]. Civil servants are more available to mental disorders. According to relevant data, 33.8% of civil servants suffers from high work pressure[53], while some 47% of compensatory mental disorders are triggered by work pressure[54]. Individuals under long-term stress are prone to psychological discomfort and negative emotional reactions[55]. The stress response is significantly related to psychological health[56].

In the CFA, we set up a second-order factor model to examine the scale fitness based on theoretical structure of the HFMS V1.0 scale. The standardized path coefficients between the dimensions and the subscales ranged from 0.79 to 0.94 indicating HFMS V1.0 has great path association. The initial model failed to indicate acceptable fitness. But after adjustment of fixed parameters and establishment of covariation relationship between the error terms based on the MI value and the estimated parameter change, the overall model of the scale indicated good fitness (CMIN/DF=2.773, RMSEA=0.048, IFI =0.915, TLI=0.904, CFI=0.915).

The main advantage of HFMS V1.0 scale is comprehensive evaluation of healthy fitness with systematic structure as the scale involves examinations of physical, mental fitness, and social fitness. Our study first confirms the reliability and validity of HFMS V1.0 in the Chinese elderly population through EFA and CFA, when describing the operational definition of healthy fitness. However, this study has certain limitations. Firstly, since many of our cognitive abilities start to decline during aging, there existed certain understanding obstacles. Secondly, the self-report method was adopted in which the participants made an evaluation of their healthy fitness in the past month, but there may be a recall bias. Besides, the survey sampling was limited to the city of Guangzhou, which is not representative enough. Additional tests in different population cohorts in other regions will be conducted to further verify the reliability and validity of the HFMS V1.0 scale in the future.

Conclusion

This study confirms that the HFMS V1.0 scale has acceptable reliability and validity in the assessment of the healthy fitness of the elderly in Guangzhou, and it can be used as an effective and reliable quantitative measurement of the healthy fitness level of the elderly in other regions of China. These evidences might lay a good foundation for further research on the healthy fitness norms of the elderly and their related factors.

Declarations

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Authors' contributions

QL and HZ conducted the analyses, interpreted the results, and participated in developing the first draft. HQ, CH, LJ, GJ, WW, ZH and JX analyzed the data and drafted the manuscript. All authors read and approved the final version to be submitted.

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Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

Data are available upon reasonable request. Readers can contact Xu Jun (drugstat@163.com) to submit raw data access requirements.

Consent for publication

Not applicable.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Nanfang Hospital of Southern Medical University (No. NFEC-2020-288). All protocols are carried out in accordance with relevant guidelines and regulations. At the beginning of this study, participants were informed about the purpose of this study and their right to voluntarily participate. All participants provided written consent to participate in the study.

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Figures

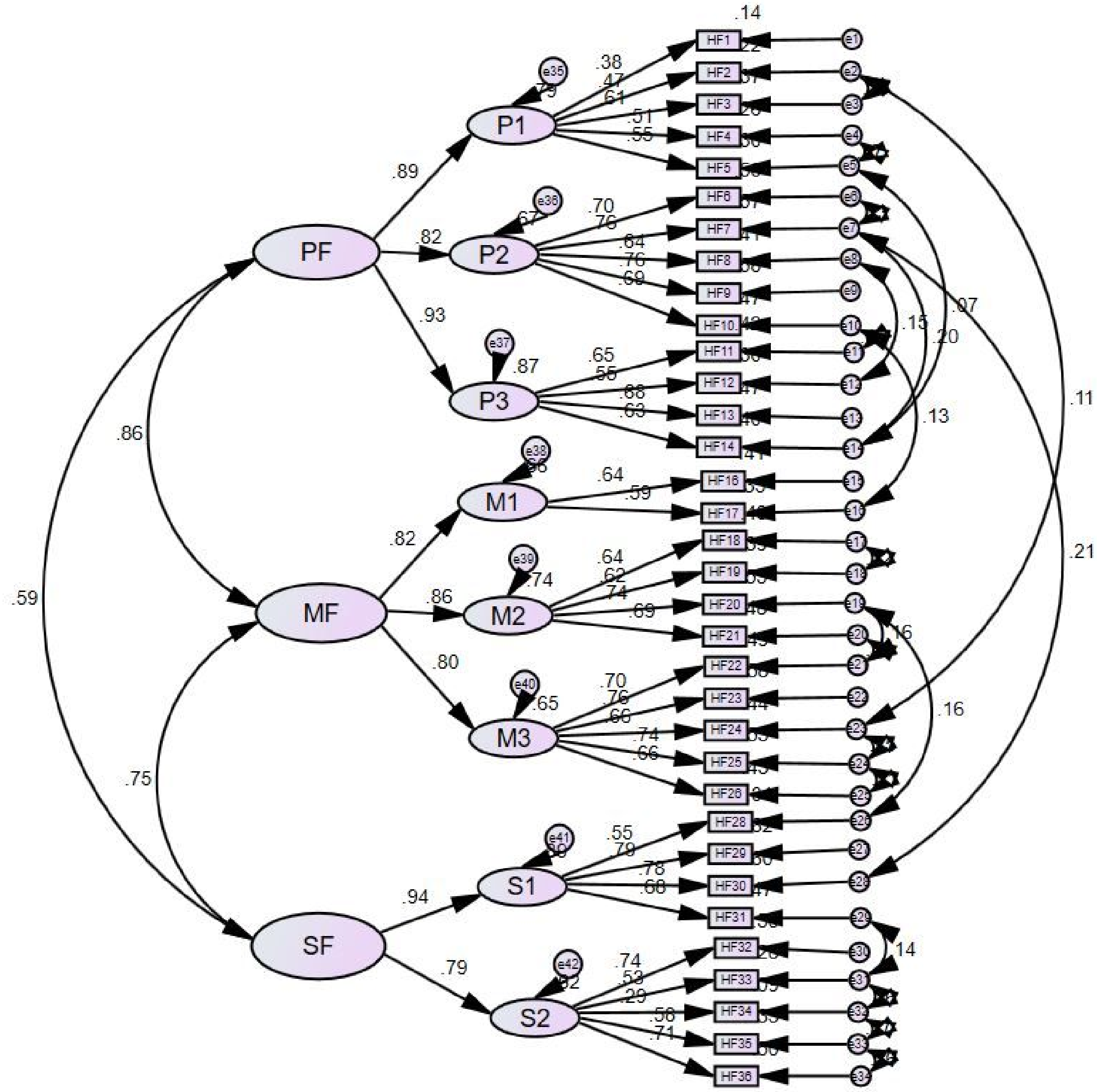

Figure 1

The revised overall model of HFMS V1.0