International Journal of Gerontology 7 (2013) 158–161

Contents lists available at SciVerse ScienceDirect

International Journal of Gerontology

journal homepage: www.ijge-online.com

Original Article

Factor Structure and Correlates of Functional Fitness of Older Adults in Taiwan☆

Li-An Ho [1], Huey-June Wu [2]*, Tracey D. Matthews [3], Jasson Chiang [2], Ying-Ju Lin [2]

[1] *Department of Physical Education, Chinese Culture University,* [2] *Graduate Institute of Sports Coaching Science, Chinese Culture University, Taipei, Taiwan, ROC,*
[3] *Department of Exercise Science and Sport Study, Springfield College, Springfield, MA, USA*

ARTICLE INFO

Article history:
Received 28 July 2011
Received in revised form
24 March 2012
Accepted 3 September 2012
Available online 14 December 2012

Keywords:
flexibility,
latent factor,
physical power,
structural equation modeling

SUMMARY

Background: The purposes of the study were to test the factor structure of the models of functional fitness for older adults, in which the latent factor flexibility represents scores in chair sit-and-reach and back scratch, and the latent factor Physical Power represents scores in chair stand, arm curl, 8-foot up-and-go, and 2-minute step. Correlates of the latent factors including age, sex, and physical activity level were also investigated.
Methods: Functional fitness tests were administered to 94 older adults (age: 73.61 ± 5.77 years). Demographic data were collected and physical activity level was measured by using the Physical Activity Scale for Elderly (PASE). The structural equation modeling technique was used to investigate the factor structure of flexibility model and physical power model as well as the contribution of the correlates.
Results: The goodness-of-fit indices were excellent for the flexibility model (χ^2-square = 4.725, df = 5, p = 0.451, comparative fit index [CFI] = 1.00, Root mean square error of approximation [RMSEA] = 0.001, standardized root mean square of residuals [SRMR] = 0.0646) and physical power model (χ^2-square = 17.962, df = 14, p = 0.209, CFI = 0.981, RMSEA = 0.055, SRMR = 0.0651). Age and sex were significant predictors to flexibility and physical power ($p < 0.05$). Physical activity level was a significant predictor of flexibility ($p < 0.05$).
Conclusion: Flexibility and physical power decline with advanced age. Males have higher physical power, and females have better flexibility. A higher level of physical activity, as measured by PASE, relates to better flexibility but not physical power.

1. Introduction

Taiwan is an aging society. The population of adults age 65 years and older reached 2,457,000 in 2009, which accounts for 10.63% of the total population[1]. It is expected that the older population in Taiwan will exceed 14% by 2017, and 25% by 2025[2]. With the increase in the older population, functional fitness is an important issue related to quality of life for older adults. According to the Functional Ability Framework by Rikli and Jones[3], functional limitation results from physical impairment, and leads to reduced ability or disability. Aging accompanies loss of bodily function and inactivity, which would exacerbate the quality of life for older adults.

Testing functional fitness is a way to detect functional limitation before disability occurs. Many different tests were designed for older adults[3,4]. One of the widely used[5–10] test batteries is designed by Rikli and Jones[3], which includes the 30-second chair stand (lower body strength), arm curl (upper body strength), chair sit-and-reach (lower body flexibility), back scratch (upper flexibility), 6-minute walk (aerobic endurance), 2-minute step (aerobic endurance, alternative of 6-minute walk) and 8-foot up-and-go (power, speed, agility, and dynamic balance).

Although the tests in the test battery were designed to evaluate different aspects of functional fitness, they can be represented by several latent factors. Based on the physiologic characteristics and correlation among the six tests, Konopack et al[11] proposed two latent factor models including the flexibility model, which represented chair sit-and-reach and back scratch (χ^2 = 0.80, df = 2, p = 0.67, SRMR = 0.01, CFI = 1.00), and physical power model, which represented 30-second chair stand, arm curl, 8-foot up-and-

☆ All contributing authors declare no conflicts of interest.
* Correspondence to: Professor Huey-June Wu, Graduate Institute of Sports Coaching Science, Chinese Culture University, 12F.-3, Number 31, Minzu Road, Danshui District, New Taipei City 251, Taiwan, ROC.
E-mail address: wuhc0123@gmail.com (H.-J. Wu).

1873-9598/$ – see front matter Copyright © 2012, Taiwan Society of Geriatric Emergency & Critical Care Medicine. Published by Elsevier Taiwan LLC. All rights reserved.
http://dx.doi.org/10.1016/j.ijge.2012.11.009

go and VO_{2max} ($\chi^2 = 0.31.73$, $df = 11$, $p < 0.001$, SRMR = 0.05, CFI = 0.90). With the structural equation modeling technique, Konopack et al[11] also found that age, sex, and exercise self-efficacy were significant correlates of physical power, and sex was a significant correlate of flexibility.

The success in identifying the factor structures of the functional fitness battery for older adults leads to several in-depth questions. First, Konopack et al[11] used VO_{2max} as the measurement of aerobic capacity, which is different from the aerobic tests (6-minute walk and 2-minute step tests) in the test battery of Rikli and Jones[3]. Whether the factor structure fits the scores from 6-minute walk or 2-minute step tests is not known. Second, Konopack et al[11] stated that the individuals in the study were rather homogeneous, and therefore more information is needed for a more diverse population in terms of ethnicity and education. In addition, the individuals in the study by Konopack et al[11] were sedentary; whether the factor structures fit more active older adults is not known.

In response to these questions, the purposes of the current study were to re-investigate the factor structures proposed by Konopack et al[11] using a different ethnic group, with different levels of physical activity and using exclusively the functional fitness test battery designed by Rikli and Jones[3]. In addition, instead of measuring exercise self-efficacy, levels of physical activity were used as one of the three predictors of the two latent factors of functional fitness. The reason to use level of physical activity is that instead of assuming physical impairment as a result of disease and pathology, lifestyle and inactivity were also found to be responsible for physical impairment[12,13]. Thus, it is plausible to involve levels of physical activity in the models as a predictor of functional fitness. It was hypothesized that the factor structure of the flexibility model and physical power model would fit the older adults in Taiwan. It was also hypothesized that age, sex, and physical activity level would be significant predictors of performance in functional fitness.

2. Methods

2.1. Patients

A convenient sample of 94 older adults recruited from indoor or outdoor facilities such as a public park or community center (female $n = 52$, age: 72.96 ± 6.01 years; male, $n = 42$, age: 74.40 ± 5.43 years) participated in the current study. Although there is no gold standard in determining adequate sample size in structural equation models, researchers had proposed several practical rules, including five observations per measured variable[14] or 10 observations per measured variable[15–17]. Others proposed a 5:1 ratio[18] or 10:1 ratio[19] of sample size to free parameters. According to the aforementioned rules, adequate sample size should be 25–100 or more for flexibility model and 35–140 or more for physical power model. Thus, the sample size of the current study was relatively small but adequate[20]. The patients were required to be able to answer the questionnaire (Physical Activity Scale for Elderly; PASE[3]) either on paper or verbally. Patients who had physical conditions that would increase the risk of participating in physical activity were not included in the study for safety concerns. Approval from the institutional review board (IRB) of Chinese Culture University was obtained and all patients signed informed consent before participating in the study.

2.2. Measurement

Demographic information including age, sex, height, and weight were collected before the tests. Six functional fitness tests including the 30-second chair stand, arm curl, chair sit-and-reach, back scratch, 2-minute step, and 8-foot up-and-go were carried out. Details of functional fitness tests can be found in the study by Rikli and Jones[21]. Levels of physical activity were measuring by PASE[3]. A Chinese version of PASE[22] was used because of the language preference of the patients. Concurrent validity and test–retest reliability of the PASE Chinese version had been evaluated, and the scores obtained from PASE were significantly correlated with cardiovascular endurance. The test–retest reliability was satisfactory over a 3-week period[22].

2.3. Statistical analysis

Two stages of statistical analyses were carried out for each of the two models as proposed by Konopack et al[11]. The first stage was to confirm the factor structure of the models, in which the latent factor Flexibility represented the scores in chair sit-and-reach and back scratch, and the latent factor physical power represented the chair stand, arm curl, 8-foot up-and-go, and 2-minute Step. The second stage was to investigate the contribution of age, sex, and physical activity level to flexibility and physical power (Figs. 1 and 2). Sex, as categorical data, was dummy coded with male being 1 and female being 0. Scores for 8-foot up-and-go were recalculated by subtracting the time of completion in seconds from 20 in order to make the direction of the scores consistent with other tests so that higher scores represent better performance[11]. Structural equation modeling with SPSS AMOS 19 software (IBM) was used to perform the analyses.

Several goodness-of-fit indices were used to test the models. Chi-square was used to test the fit of the models to the data[23], with a nonsignificant chi-square indicating good fit. Root mean square error of approximation (RMSEA), as stated by Browne and Cudeck[24], measures "how well the model, with unknown but optimally chosen parameter values, fit the population covariance matrix if it were available"[24]. RMSEA values less than 0.05 represents good fit, 0.05–0.08 indicates reasonable fit, 0.08–0.10 indicates mediocre fit, and greater than 0.10 indicates poor fit[25]. The comparative fit index (CFI) is derived from the comparison between the hypothesized model and independence model, with CFI greater than 0.90 indicating good fit[26]. Standardized root mean square of residuals (SRMR) represents the average value of the standardized residual, which ranges from 0 to 1, with values less than 0.05 indicating a good fit[27]. When using the goodness-of-fit indices in combination, Hu and Bentler[28] suggested the criteria of CFI approximates of greater than 0.95, SRMR less than 0.08, and RMSEA less than 0.06 being of good fit.

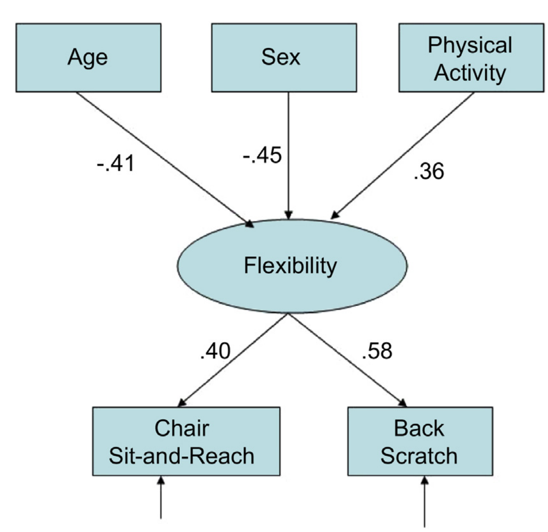

Fig. 1. Model of flexibility.

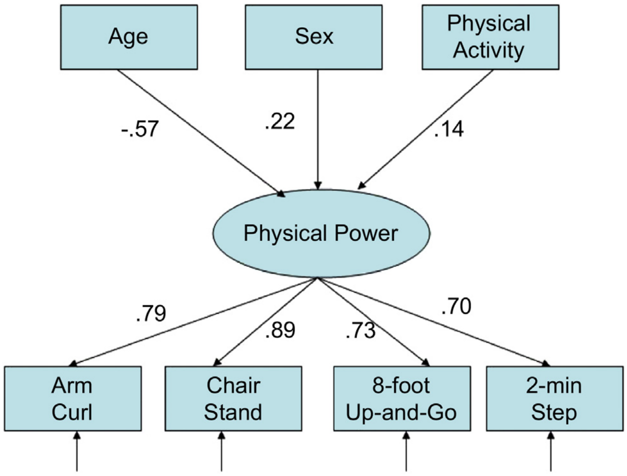

Fig. 2. Model of physical power.

3. Results

3.1. Descriptive statistics

Mean and standard deviations for all measured variables are shown in Table 1.

3.2. Factor structures of the latent factors

3.2.1. Flexibility

The flexibility model (Fig. 1) revealed good fit (χ^2-square = 4.725, df = 5, p = 0.451, CFI = 1.00, RMSEA = 0.001, SRMS = 0.0646) with the standardized coefficient ranging from −0.41 to 0.58. All three predictor variables (age, sex, and physical activity) were significant predictors to flexibility ($p < 0.05$). Age, sex, and physical activity accounted for 49.3% of the variation of flexibility.

3.2.2. Physical power

The physical power model (Fig. 2) revealed good fit (χ^2-square = 17.962, df = 14, p = 0.209, CFI = 0.981, RMSEA = 0.055, SRMR = 0.0651) with the standardized coefficient ranging from −0.57 to 0.89. Among the three predictor variables, only age and sex were significant predictors of physical power ($p < 0.05$). Physical activity level was not a significant predictor of physical power (p = 0.114). Age, sex, and physical activity accounted for 39.0% of the variation in physical power.

4. Discussion

There were two purposes for the current study. The first was to test the factor structure of functional fitness for older adults as proposed by Konopack et al[11], in which the functional fitness tests were the function of two independent latent factors. The second was to investigate the predictors of functional fitness including age, sex, and levels of physical activity.

In the model of flexibility, the latent factor flexibility well represented the testing scores in back scratch and chair sit-and-reach. Sex was found to be a significant predictor of flexibility, with females having significantly better flexibility than males. This confirmed the findings of Konopack et al[11].

Age was a significant predictor to flexibility ($p < 0.05$), which was consistent with the finding in the study of Rikli and Jones[29]. Rikli and Jones[29] indicated a significant decline in the performance of chair sit-and-reach and back scratch from age 60 to 94 years in both sexes. It is noticeable that Konopack et al[11] found that age was not a significant predictor of flexibility, and the result was consistent with the finding of Roach and Miles[30]. A possible explanation to the inconsistencies between the current study and the findings of Konopack et al[11] and Roach and Miles[30] was the age difference in the patients, because the mean and range of the age of the patients in both of these studies seemed to be lower than the current study and the study by Rikli and Jones[29].

Self-efficacy was not assessed in the current study. Instead, the levels of physical activity were evaluated by PASE[21]. The level of physical activity was a significant predictor of flexibility. A higher level of physical activity related to better flexibility. It is well known that increased flexibility and range of motion are the benefits of regular exercise[31]. Although PASE measures the overall level of physical activity, not exercise programs designed specifically to improve flexibility, older adults who engage in higher levels of physical activity have a better chance to move their limbs with a larger range of motion, which would be beneficial in terms of maintaining or improving flexibility.

Although the goodness-of-fit of factor structure of physical power in the study by Konopack et al[11] was only acceptable, our data showed an excellent fit. The latent factor physical power well represented the four functional fitness tests, including the 30-second chair stand, arm curl, 2-minute step, and 8-foot up-and-go. Age and sex were significant predictors of physical power, which is consistent with the findings of Konopack et al[11] and Rikli and Jones[29]. The results indicate that physical power declines with advanced age, and men have higher physical power than women.

To our surprise, physical activity level was not a significant predictor of physical power. A possible explanation is that the PASE measures the overall level of physical activity. Although different weights were used for physical activities with different intensities in PASE when calculating physical activity level, the result does not specify the intensity. It is known that to improve fitness, moderate to vigorous cardiovascular exercise as well as resistance training are needed[32]. In PASE, however, the same score could be derived from a lower volume of higher intensity activity or higher volume of lower intensity activity. The lack of indication of exercise intensity in PASE might contribute to the insignificance of physical activity as a predictor of physical power.

Although the purpose of the study was to confirm the factor structure of functional fitness tests for older adults as proposed by Konopack et al[11], there is another more parsimonious way to test the factor structure. Because the source variables of age, sex, and physical activity level were identical for the unrelated latent factors physical power and flexibility, the two independent models can be combined as one (Fig. 3). With our data, the goodness-of-fit of the combined model was not desirable (χ^2-square = 44.21, df = 24, p = 0.007, CFI = 0.919, RMSEA = 0.095, SRMR = 0.101). Physical power was a significant predictor of 30-second chair stand, arm curl, 2-minute step, and 8-foot up-and-go, and flexibility was a significant predictor of back scratch and chair sit-and-reach. Age, sex, and physical activity level were significant predictors of

Table 1
Descriptive statistics.

	Mean	Standard deviation
Age (y)	73.61	5.77
Physical activity level (points)	97.88	55.95
Chair sit-and-reach (cm)	7.27	12.92
Back-scratch (cm)	−8.62	15.63
Chair stand (repetition)	17.26	7.41
Arm curl (repetition)	23.86	7.59
8-foot up-and-go (s)	6.55	2.54
2-min step (step)	120.29	32.66

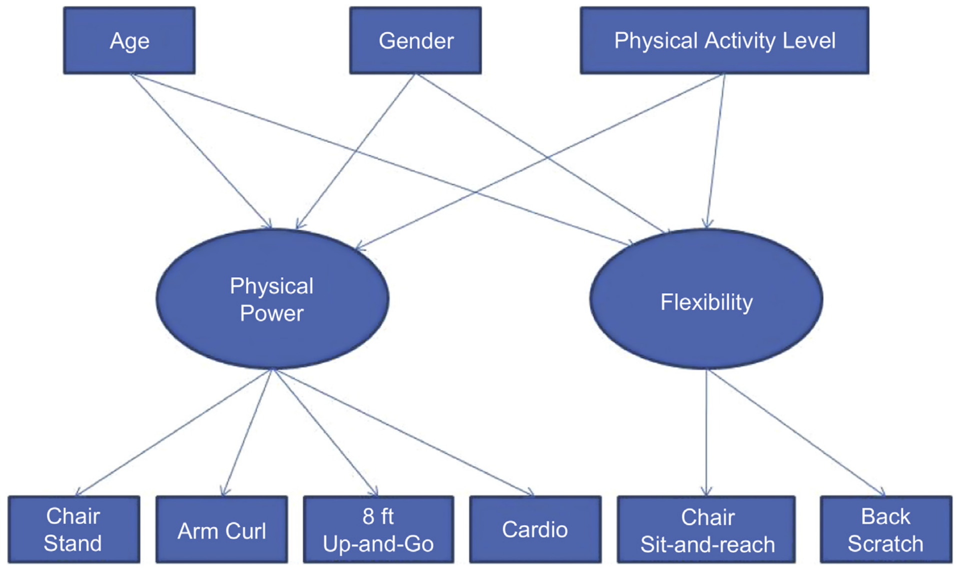

Fig. 3. Model of functional fitness for older adults.

physical power and flexibility except that physical activity level was not a significant predictor of physical power. The result is similar to the two separate models as proposed by Konopack et al[11]. The result of the combined model, however, should not be viewed as discouraging because the sample size was smaller than the minimum requirement[20]. Hu and Bentler indicated that when the sample size is less than 250, most of the combination of goodness-of-fit indices tends to overreject[28]. It is suggested that a larger sample size can be used to reinvestigate the factor structure of the combined model in future studies.

The current study confirmed the factor structure of the models proposed by Konopack et al[11] and provided evidence about the relationship between the correlates such as age, sex, and physical activity levels and the latent factor of functional fitness. It is suggested that the intensity of physical activity should be measured to determine the relationship between physical activity level and physical power. It is also suggested that future studies could focus on the effect of functional fitness on psychologic factors such as affective states, self-esteem, and quality of life using these latent factor models. It is suggested that increasing physical activity level may help maintain or improve flexibility; however, higher intensity or more specific exercises may be needed to improve muscular strength and cardiovascular fitness.

References

1. Directorate-General of Budget, Account and Statistics, Executive Yuan, R.O.C. http://eng.dgbas.gov.tw/mp.asp?mp=2 2010. Accessed 11.11.2012.
2. Council for Economic Planning and Development. http://www.cepd.gov.tw/encontent/ 2010. Accessed 11.11.2012.
3. Rikli RE, Jones CJ. Development and validation of a functional fitness test for community-residing older adults. *J Aging Phys Act*. 1999;7:129–161.
4. Osness WH, Adrian M, Clark B, et al. *Functional Fitness Assessment for Adults Over 60 Years (A Field Based Assessment)*. Reston, VA: American Alliance for Health, Physical Education Recreation and Dance (AAHPRED); 1990.
5. Tuna HD, Edeer AO, Malkoc M, et al. Effect of age and physical activity level on functional fitness in older adults. *Eur Rev Aging Phys Activ*. 2009;6:99–106.
6. Islam MM, Takeshima N, Rogers ME, et al. Decline of functional fitness in free living Japanese older adults. *Asian J Exerc Sport Sci*. 2005;2:9–15.
7. Islam MM, Takeshima N, Rogers ME, et al. Relationship between balance, functional fitness, and daily physical activity in older adults. *Asian J Exerc Sport Sci*. 2004;1:9–18.
8. Jiang XX, Cooper JJ, Porter MM, et al. Adoption of Canada's physical Activity guide and handbook for older adults: impact on functional fitness and energy expenditure. *Can J Appl Physiol*. 2004;29:395–410.
9. Toraman NF, Erman A, Agyar E. Effects of multicomponent training on functional fitness in older adults. *J Aging Phys Act*. 2004;12:538–553.
10. Wilkin LD, Haddock BL. Health-related variables and functional fitness among older adults. *Int J Aging Hum Dev*. 2010;70:107–118.
11. Konopack JF, Marquez DX, Hu L, et al. Correlates of functional fitness in older adults. *Int J Behav Med*. 2008;15:311–318.
12. Nagi SZ. Disability concepts revisited: implication for prevention. In: Pope AM, Tarlow AR, eds. *Disability in American: Toward a National Agenda for Prevention*. Washington, DC: National Academy Press; 1991:309–327.
13. Chandler JM, Hadley EC. Exercise to improve physiologic and functional performance in old age. *Clin Geriatr Med*. 1996;12:761–784.
14. Gorsuch RL. *Factor Analysis*. 2nd ed. Hillsdale, NJ: Erbaum; 1983.
15. Nunnally JC. *Psychometric Theory*. New York, NY: McGraw-Hill; 1967:355.
16. Barclay DW, Higgins C, Thompson R. The partial least squares (PLS) approach to causal modeling: personal computer adaptation and use as an illustration. *Technology Studies*. 1995;2:285–309.
17. Chin WW. The partial least squares approach to structural equation modeling. In: Marcoulides GA, ed. *Modern Methods for Business Research*. Mahwah, NJ: Lawrence Erlbaum Associates; 1998:295–336.
18. Bentler PM. *EQS, Structural Equations, Program Manual, Program Version 3.0*. Los Angeles, CA: BMDP Statistical Software, Inc.; 1989:6.
19. Kline RB. *Principles and Practice of Structural Equation Modeling*. 2nd ed. NY: Guilford Press; 2005:105.
20. Bentler PM, Chou CP. Practical issues in structural modeling. *Sociol Methods Res*. 1987;16:78–117.
21. Washburn RA, Smith KW, Jette AM, et al. The physical activity scale for the elderly (PASE): development and evaluation. *J Clin Epidemiol*. 1993;46:153–162.
22. Wu CY. *A Correlational Study Among Sleep Quality, Physical Activity, and Depression of Community-Dwelling Elders*. Unpublished Master Thesis.
23. Bollen KA. *Structural Equations with Latent Variables*. Oxford, England: John Wiley & Sons; 1989.
24. Browne MW, Cudeck R. Single sample cross-validation indexes for covariance-structures. *Multivar Behav Res*. 1989;24:445–455.
25. MacCallum RC, Browne MW, Sugawara HM. Power analysis and determination of sample size for covariance structure modeling. *Psychol Methods*. 1996;1:130–149.
26. Bentler PM. On the fit of models to covariances and methodology to the Bulletin. *Psychol Bull*. 1992;112:400–404.
27. Hu L, Bentler PM. Evaluating model fit. In: Hoyle RH, ed. *Structural Equation Modeling: Concepts, Issues, and Applications*. Thousand Oaks, CA: Sage Publications, Inc.; 1995:76–99.
28. Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus. *Struct Equ Modeling*. 1999;6:1.
29. Rikli RE, Jones CJ. Functional fitness normative scores for community-residing older adults, ages 60–94. *J Aging Phys Act*. 1999;7:162–181.
30. Roach KE, Miles TP. Normal hip and knee active range of motion: the relationship to age. *Phys Ther*. 1991;71:656–665.
31. Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, et al. American College of Sports Medicine position stand. Exercise and physical activity for older adults. *Med Sci Sports Exerc*. 2009;41:1510–1530.
32. Paterson DH, Jones GR, Rice CL. Ageing and physical activity: evidence to develop exercise recommendations for older adults. *Can J Public Health*. 2007;98:S69–S108.