Autoreferát disertační práce

Evaluation of functional fitness status and examination of its underlying structure in older adults

Kateřina Macháčová

Vědní obor: Kinantropologie

Školící pracoviště: Laboratoř sportovní motoriky

Školitel: Prof. Ing. Václav Bunc, CSc.

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INTRODUCTION

The goal of gerontologists and applied health scientists is to change the shape of the human survival curve so that most individuals can live longer lives. However, most people would agree that a long life without health and physical independency is undesirable, yet many live their terminal years in a state of morbidity, or complete physical dependence and poor health. Discussions of extending the life span should always be entangled with issues of quality of life. Quality of life in advanced age depends to a large degree on the ability to do the things one wants to do independently, safely, without undue pain, and for as long as needed (Rikli & Jones, 2001; Spirduso, 2005). This physical ability is strongly pre-determined by a level of actual functional fitness thus preserving functional fitness becomes an issue of high interest.

In order to maintain certain functional fitness status, attention to physical activity levels is one of the easiest ways to offset physical dependency or postpone impairment. The beneficial effects of physical activity on various functional fitness components such as aerobic endurance, muscle strength, flexibility, and balance in older adults have been well established (Baker, Atlantis, & Fiatarone Singh, 2007; Brown et al., 2000; Buchman, Boyle, Wilson, Bienias, & Bennett, 2007; Cao, Maeda, Shima, Kurata, & Nishizono, 2007; Capodaglio, Capodaglio Edda, Facioli, & Saibene, 2007; Conn, Minor, Burks, Rantz, & Pomeroy, 2003; DiBrezzo, Shadden, Raybon, & Powers, 2005; Frankel, Bean, & Frontera, 2006; Haskell et al., 2007; Hauer, Becker, Lindemann, & Beyer, 2006; Judge, Lindsey, Underwood, & Winsemius, 1993; Paterson, Jones, & Rice, 2007; Stewart, 2005). **The ability to measure those components is needed for an early detection of potential decline which is crucial for planning effective and successful preventive programs. An accurate assessment of initial functional status is also important for predicting risk factors for functional dependence, institutional discharge planning, or documenting and evaluating those preventive strategies.**

Functional fitness is defined as having a physical capacity to perform normal everyday activities of daily living safely and independently without undue fatigue (Rikli & Jones, 2001). But having the adequate physical capacity does not ensure independency itself. There are other factors that play an important role such as health status (number of chronic conditions), cognitive functioning, sensomotoric functioning, motor control, or environment. As illustrated in Figure 1,

the combination of all those factors determines the general ability to function independently. However, this study is restricted to only one factor – functional fitness with a special attention targeted on measurement issues.

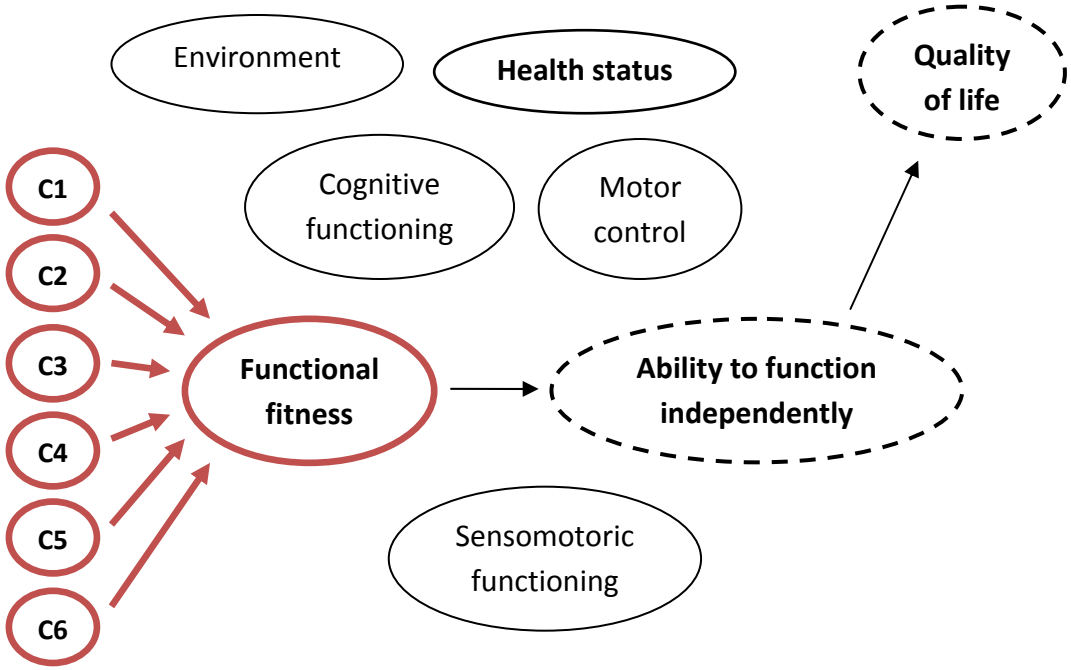


Figure 1 Diagram illustrating the focus of this study – how functional fitness contributes to the quality of life (C1 – C6 represents individual functional fitness components)

Based on the previous text much of the usual age-related decline in functional fitness is preventable and even reversible through proper attention to physical activity. Especially important is the early detection of physical weaknesses and establishment of desired changes in physical activity habits. Until recently, however, most instruments to evaluate physical functioning were developed either for young individuals or for more frail elderly to determine the amount of care or assistance needed with activities of daily living. Instruments appropriate for frail individuals are too easy and not sufficiently challenging to evaluate fitness in healthier older adults (Rikli & Jones, 2001) and, vice-versa, instruments for younger individuals are usually too demanding hence unsafe and inappropriate for the majority of the older population. The primary goal was to be able to accurately monitor the functional fitness of a wide range of

ability levels in older adults so that evolving weakness might be identified and treated before resulting in impairment leading to limitations in functional behavior.

STATEMENT OF THE PROBLEM AND GENERAL AIMS

Assessing the functional fitness in older adults is challenging because many conditions make this population difficult to test. Furthermore, factors such as pain, impairment, or changes in medical status and medications increase within-subject variance in measurement. However, the assessment of functional fitness is extremely important in later life.

In the Czech Republic there is a lack of relevant information about older adults' physical functioning measured by performance tests. This particular dissertation has been conducted to fill the gap and to gain experience with performance testing in older Czech adults. The overall goal was to describe in detail their functional fitness status and to provide pilot data needed for future research conducted to develop normative standards for the Czech population over the age of 60 years.

Because many different instruments assessing physical functioning appropriate for older adults were developed in past few decades, an already existing battery standardized to measure functional fitness in older adults was selected and tested for the use in the older Czech population. Additionally, the use of already existing battery ensures important advantages such as comparability across studies or nations and the ability to accumulate findings.

Therefore, **the first general aim** of this study was to summarize and organize existing instruments developed to measure physical functioning among older adults.

The second general aim was to apply the most sufficient battery and to provide detailed information about functional fitness status of older Czech adults. The main goal was to make sure that the battery will be accepted by the majority of older adults (both lower and higher functioning), that it will suffer from minimal ceiling and floor effects, and that it will be sensitive enough to detect even small yet clinically important changes.

The third general aim was to develop a single score representing an Overall Functional Fitness. So called composite measurement scores (CMS) are practical and important for both research

and clinical purposes because multiple evaluations are not always satisfactory or even desirable. Functional fitness is a typical example of a latent construct therefore the development of a single score requires special attention and proper methodology. The essential aspect is to verify unidimensionality which in other words means to verify that all components are measuring a single underlying trait. In addition, an individual contribution of those components to the overall construct was investigated.

The presented dissertation was divided into three independent studies (1-3) conducted to address each of the above mentioned general aims.

STUDY 1: METHODS OF MEASURING FUNCTIONAL FITNESS AND AVAILABLE INSTRUMENTS

Evaluation of physical functioning plays a valuable role in clinical geriatrics as well as in aging research. In the 90's, physical functioning had generally been assessed through self- or interviewer-reported assessments (so called subjective methods). An important addition was the use of performance-based measures (so called objective methods) of physical function, which have become very popular among clinicians and researchers during last few decades.

Both self-report and performance-based instruments capture unique and important information about physical functioning. But because self-reported instruments assess more limitations than actual status, the answers may not reflect true ability at the time of assessment, especially if bedridden. In contrast, performance-based instrument only simulate a given activity so they do not reflect adaptations older adults make to facilitate routine day-to-day performance. Investigators have suggested that the choice of the measure should be determined by research objectives and a study population. All available methods of physical functioning evaluation were organized as presented in Figure 2.

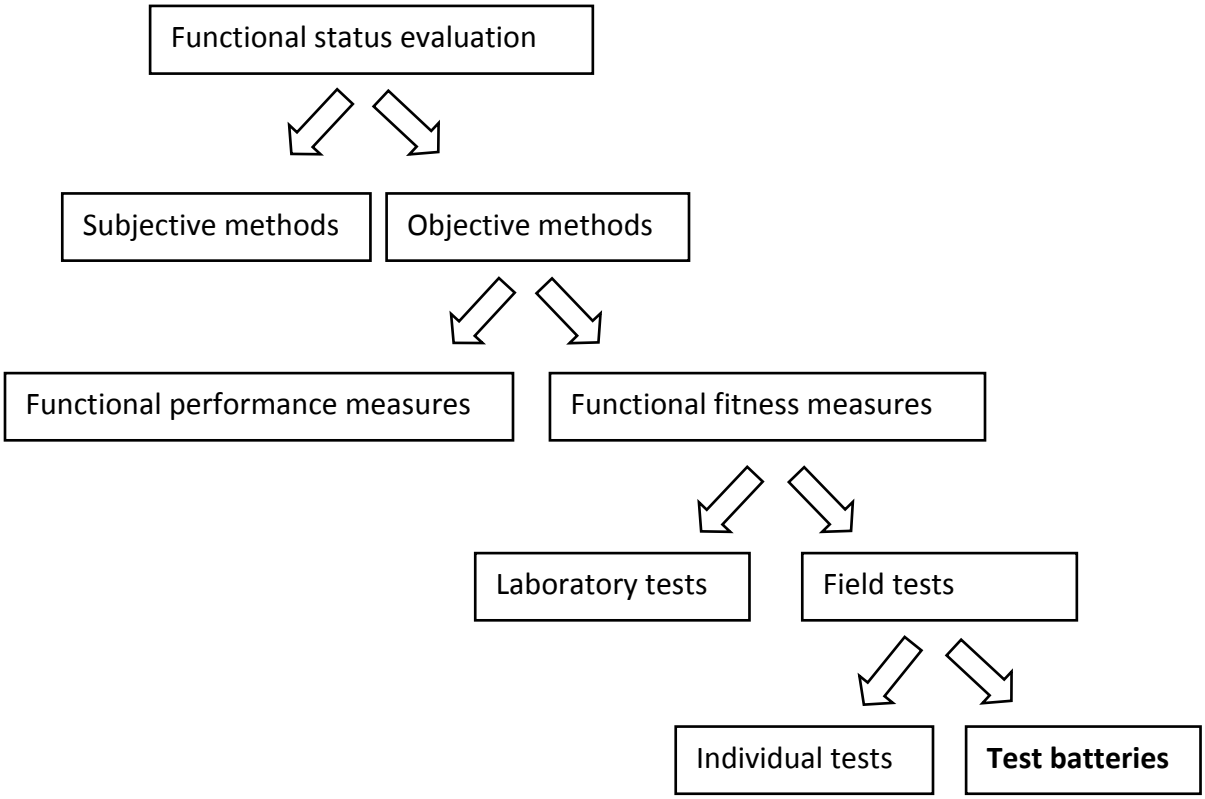


Figure 2 Diagram illustrating the tree of available measurement methods

In this study, each method of testing was described including examples of available standardized instruments. Then the most relevant instruments for the purposes of the present dissertation were described in more detail (see original manuscript). This study also addressed the process of instrument selection which might be helpful for decision making. The extensive review may be used as a starting point by anybody who is interested in measuring fitness among older adults either for research or clinical purposes.

But the most importantly, this study was used for the selection of the most appropriate instrument for this dissertation. The selection criteria or requirements were established as follows: the first requirement was that the instrument must be standardized for use among older adults; the second requirement was that the instrument must be able to accurately measure all components that are related to daily functioning; the third requirement was that the instrument was developed to be administered in field settings and the priority was given to a quick-and-easy to administer one without a need of special equipment and space

requirements. Based on these requirements, the Senior Fitness Test (Rikli & Jones, 2001) appeared to be the most appropriate instrument for the purposes of this dissertation.

The Senior Fitness Test (SFT) was developed to assess all known components of functional fitness, specifically: strength (upper-body and lower-body), endurance, balance, and flexibility (upper-body and lower-body). The battery includes seven tests assessing the six earlier mentioned components (there are two alternative tests for the aerobic endurance component): 30-second chair stand test measuring **lower-body strength**; 30-second arm curl test measuring **upper-body strength**; 2-minute step test or 6-minute walk test measuring **aerobic endurance**; chair sit-and-reach test measuring **lower-body flexibility**; back-scratch test measuring **upper-body flexibility;** and 8-foot up-and-go test measuring **dynamic balance or agility**. Each test is scored separately described in detail in the original manuscript. For those studies conducted within the U.S., results can be compared with normative standards that were developed from a national study of 7000 independently living men and women aged between 60-94 years. Additionally, results may be compared with threshold scores indicating the risk of independency loss. Advantages of the SFT are summarized as follows:

- The SFT is comprehensive. The tests reflect a cross section of all major fitness components associated with independent functioning in later life, whereas other test batteries for older adults focus mostly on selected aspects of fitness.
- The SFT provides continuous-scale measures which helps to sensitively assess a wide range of the population. A common limitation in other test batteries is that some items tend to be either too easy or too difficult for a large portion of older adults.
- The SFT is usable in the field setting and all tests have minimal equipment and space requirements hence the entire battery can be administered in most clinical and community settings as well as in peoples' homes.
- The SFT is very well standardized. Rikli and Jones have shown that for community dwelling adults over 60 years of age, this battery has content validity established through literature review and expert opinion; criterion validity correlation coefficients

ranging from r = 0.73 to r = 0.83 when comparing each test item with an earlier established criterion measure; and high test-retest reliability with correlation coefficients ranging from r = 0.80 to r = 0.98.

STUDY 2: FUNCTIONAL FITNESS AMONG OLDER CZECH ADULTS

Summary and hypothesis

It has been proven that older adults, both men and women, can benefit from physical activity and that the measurement issue is a key factor for planning preventive physical activity programs. Therefore, the assessment of all components related to independent living becomes essential. Based on the extensive literature review, the SFT fulfilled our requirements, and therefore has been selected for the present dissertation. Importantly, the SFT has been widely used in many studies both within and outside of the United States (Alexander, Phillips, & Wagner, 2008; Beck, Damkjaer, & Beyer, 2008; Carvalho, Marques, & Mota, 2008; Cyarto, Brown, Marshall, & Trost, 2008; DiBrezzo et al., 2005; Dobek, White, & Gunter, 2006; Garatachea et al., 2008; Mahrova, Bunc, & Fischerova, 2006; Thompson, Cobb, & Blackwell, 2007; Toraman, 2005; Toraman & Ayceman, 2005). The general aim of this particular study was to gain an experience with performance testing among older adults living in the Czech Republic and to provide knowledge of their physical capacities, both of which are needed for future research conducted to develop normative standards. Four hypothesis-driven specific aims were addressed in this study:

*Specific aim 1***:** to provide the evidence that the Senior Fitness Test is applicable for the majority of older adults living in the Czech Republic.

Specific aim 2: to provide the evidence that the Senior Fitness Test is sensitive enough to detect differences between higher functioning and lower functioning older adults.

Specific aim 3: to provide the evidence that the Senior Fitness Test is sensitive enough to detect differences between age groups.

Specific aim 4: to examine the possibility to successfully identify older adults who are at-risk of independency loss using threshold scores developed in the U.S.

Hypothesis

H1 The Senior Fitness Test is applicable for independently living older adults as well as for residents from Residential Care Facilities.

H2 Older adults living independently in the community perform significantly better compared to older adults living in Residential Care Facilities in all tests.

H3a All the components of functional fitness decline significantly with age.

H3b The relative age-related decline in functional fitness components is consistent for all tests.

H4a All older adults living in community will perform above threshold scores in all tests.

H4b More than 50% of older adults living in Residential Care Facilities will perform bellow threshold scores in all tests.

Methods

Ninety three older adults (> 60 years) were included in the study. In order to confirm that the SFT is acceptable for a wide range of older adults, participants were recruited from two different backgrounds. Fifteen participants who were considered to be higher functioning lived actively in the community (9 women and 2 men; mean age 73.7; SD 5.95) and seventy eight participants who were considered to be lower functioning were permanent residents of Residential Care Facilities (RCF) (69 women and 9 men; mean age 81.9; SD 9.31). Functional fitness was assessed by six SFT tests measuring major components of functional fitness among older adults. Means and standard deviations were performed to describe both sub-samples. Independent-samples *t*-test and one-way ANOVA were used to determine the differences of means between and within sub-samples.

Results and conclusions

Applicability of Senior Fitness Test in the Czech Republic

All participants from community settings completed all tests included in the SFT battery without any problems. However, participants living in Residential Care Facilities experienced some difficulties with completing some of the tests. It appeared that the most difficult test was the 8-

foot up-and-go test (22% participants found it too difficult to perform) followed by the 2-minute step test (21% participants found it too difficult to perform). Conversely, the easiest test was the 30-second arm curl test (only 1 participant was not able perform this test). Both of the flexibility tests (the chair sit-and-reach test and the back scratch test), and the 30-second chair stand test happened to have medium difficulty (12%, 8%, and 6% participants found it too difficult to perform). Women had more problems compared to men, but it could have been caused by an unequal sample size. When we divided women into three different age categories as recommended by Holmerova & Juraskova (2003), it appeared that difficulty performing individual tests increases with age. 80% of the women in the youngest category [60-74 years] were able to independently complete the entire SFT compared to just 55% of the women in the middle category [75-89 years]. The oldest category [over 90 years] experienced even more difficulties when compared to the middle one. Only 50% of them were able to complete the SFT battery. But despite the fact that some older adults, especially those in advanced old age living in RCFs, experienced some difficulties it did not cause either floor or ceiling effects (see Histograms illustrating the data distribution in the original manuscript). Therefore, the SFT can be considered as an appropriate instrument measuring functional fitness even among lower functioning. **The hypothesis H1 was accepted**.

Differences between older adults living in Residential Care Facilities and those living in community settings

Differences in performances between sub-samples were observed for each test within the SFT battery. Independent *t*-tests were performed to examine whether means for both sub-samples were significantly different from zero. Except for the chair sit-and-reach test (t (82) = -1.64, p = .104), all of the differences in mean performance were highly statistically significant: 30-second stand test (t (86) = -5.05, p ≤ .000); 30-second arm curl test (t (90) = -5.24, p ≤ .000); and 2-minutes step test (t (75) = -6.57, p ≤ .000). The differences in the last two tests were also statistically significant, but because of observed inequality of variances, Welsh's *t*-test statistic was run. The Levene's test of homogeneity of variance was used to verify equal variance assumption. The null hypothesis for the Levene's test is that the variances are homogeneous. For this set of data the Levene's test was not significant for most of the tests, indicating that the

null hypothesis cannot be rejected, that is, the variances are homogeneous, except for the back scratch test (F = -2.009, p = .011) and the 8-foot up-and-go test (F = 6.405, p = .014). Thus the Welsh's t-test statistic for non equal variances was used instead. The differences in mean performance were also highly statistically significant: back scratch test (t (66) = -3.56, p ≤ .000) and 8-foot up-and-go test (t (62) = 4.95, p = .001). According to the results **the hypothesis H2 was accepted**.

Figure 3 Mean performances in Z-scores for each SFT test for all participants (both women and men) living in Residential Care Facilities settings (blue) and community settings (red)

The role of age on the performance of older women living in Residential Care Facilities

Three age categories for older adults recommended by Holmerova & Juraskova (2003) were used: the youngest category (60-74 years – category 1); the middle category (75-89 years – category 2); and the oldest category (90 years and over – category 3). The number of women in each category varied from ten in the youngest and the oldest category to forty nine in the middle one. We can certify that physical fitness declines with age and that this decline is considerably obvious (Figure 4). To examine the statistical significance of this decline, we performed a one-way ANOVA. This approach is recommended when there is a need to test differences between more than two groups. It appeared that only the difference for the 30-second chair stand (F (63) = 4.85; p = .011) was statistically significant. Otherwise the observed

decline was not statistically significant but may be considered as clinically significant because the performance between the youngest and the oldest age category decreased at the minimum of 15%. The *F*-test statistics were: for the 30-second arm curl test $F(67) = 0.95$, $p = .393$; for the 2-minute step test $F(54) = 1.43$, $p = .249$; for the chair sit-and-reach test $F(59) = 1.00$, $p = .374$; for the back scratch test $F(62) = 1.54$, $p = .222$; and finally for the 8-foot up-and-go test $F(52) = 0.91$, $p = .408$. Because the decline was considered clinically significant for all tests **the hypothesis H3a was accepted.** Additionally, it appeared that this decline is inconsistent across age groups for all tests except for the 2-minute step test suggesting that it slows down with increasing age**.** Therefore, **the hypothesis H3b was accepted only for test 3 and rejected for the rest of the tests**.

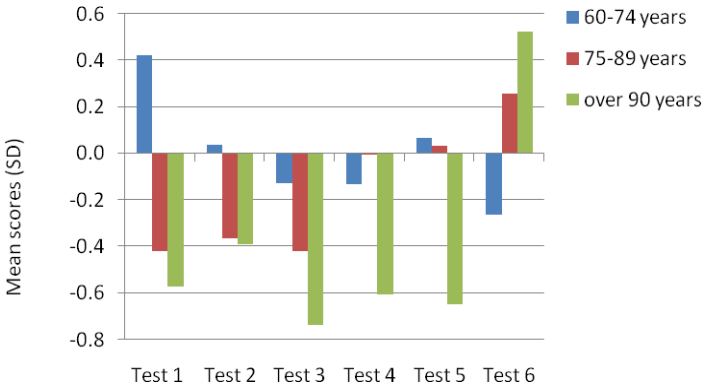


Figure 4 Mean performance in Z-scores for each SFT test for women living in Residential Care Facilities divided into three different age categories (60-74 years in blue, 75-89 years in red, 90 years and over in green)

Physical fitness performance and the risk of independency loss

As indicated in Table 1, women were more at risk of independency loss compared to men. As expected, residents for RCFs were mostly at risk compared to those living independently in community settings. It appeared that the older Czech adults had the most problems with the completion of the 2-minute step test and one of the two flexibility tests - the back scratch test suggesting that especially these two threshold scores might be too strict for the Czech population.

Table 1 Threshold scores and total percentage (number) of participants of both sub-samples who performed on or under threshold scores associated with being at risk for losing one's ability to function independently

	Threshold scores for each fitness component		Community living sub-sample		RCFs sub-sample	
	Wo-men	Men	Women (N = 13) N (%)	Men (N = 2) N (%)	Women (N = 69) N (%)	Men (N = 9) N (%)
30-second chair stand test [number of repetitions]	8.4	8.3	3 (23%)	0 (0%)	40 (58%)	1 (11%)
30-second arm curl test [number of repetitions]	11.0	10.8	1 (8%)	0 (0%)	33 (48%)	1 (11%)
2-minute step test [number of repetitions]	65	65	5 (38%)	0 (0%)	67 (97%)	7 (78%)
chair sit-and-reach test [cm]	-4.8	-6.3	3 (23%)	1 (50%)	31 (45%)	3 (33%)
back scratch test [cm]	-11.4	-20.3	6 (46%)	0 (0%)	50 (72%)	6 (67%)
8-foot up-and-go test [seconds]	8.8	8.9	0 (0%)	0 (0%)	58 (84%)	7 (78%)

It was expected that all participants from the higher functioning sub-sample will score above the threshold level in all tests while more than 50% of the RCFs residents will score below. Therefore, **the hypothesis H4a was rejected and the hypothesis H4b was accepted**.

In conclusion, the SFT was well accepted by all tested older adults. Even though a few participants experienced difficulty with some of the tests, it caused neither floor effects among lower functioning participants, nor ceiling effects among higher functioning participants. Thus the SFT battery was considered as a suitable instrument measuring functional fitness among older Czech adults and it is recommended for future use. As expected, independently living older adults performed significantly better as compared to those living in RCFs providing the evidence that the SFT is sensitive enough to detect small but important differences in fitness status. It also appeared that all functional components decline with age as illustrated in women from the RCF sub-sample (Figure 4). This may also be considered as additional evidence for

reasonable sensitivity. Furthermore, it was found that the age-related decline in the same sub-sample slows down with increasing age except for aerobic endurance where the decline was consistent between all three groups and for flexibility tests where the decline did not follow this trend. Nevertheless, because of low number of participants more extensive research on the larger or representative sample is needed to support our findings.

STUDY 3: OVERALL FUNCTIONAL FITNESS MODEL FOR OLDER ADULTS

Summary and hypothesis

Physicians and medical researchers are faced with the necessity of measuring complex phenomena or constructs such as disease risk or severity, physical disability, functional fitness, or quality of life. The development and psychometric evaluation of scales which measure unobservable, or latent, constructs continues to be an issue of high interest among many researchers because the multiple evaluations are not always satisfactory or even desirable. Composite measurement scores are practical and important for both research and clinical purposes. However, a review of the current practice of constructing evaluative composite measurement scores showed serious flaws. Most of the published approaches did not consider basic measurement properties, and even more importantly, they did not examine if the structure of a measured construct is unidimensional. Only three articles investigating the structure of physical fitness among older adults were found.

Given the lack of a sufficient process regarding adequate methodology in creating composite measurement scores, this study focused specifically on a theoretical and statistical testing of an Overall Functional Fitness score. This study will carry on in Nagasaki and his colleagues' studies (Nagasaki, Itoh, & Furuna, 1995a, 1995b) in order to confirm and extend their findings. The general aim of the present study was to further the understanding of the structure of functional fitness among older adults. Findings from this study provide a baseline data that will help to accurately evaluate older adults' Overall Functional Fitness status, which is an important factor of quality of life in old age. Three hypothesis-driven specific aims were addressed in this study:

Specific aim 1: to provide the theoretical model of the Overall Functional Fitness and operationalize the construct.

Specific aim 2: to empirically examine the theoretical model of Overall Functional Fitness using structural equation modeling. Performance tests previously validated to measure each functional fitness component will serve as manifest variables for the statistical model.

Specific aim 3: to investigate the contribution of individual components to the overall construct.

Hypothesis

H1 The Overall Functional Fitness among older adults is a unidimensional construct consisting of six individual components.

H2a Each component has its unique contribution to the Overall Functional Fitness scrore.

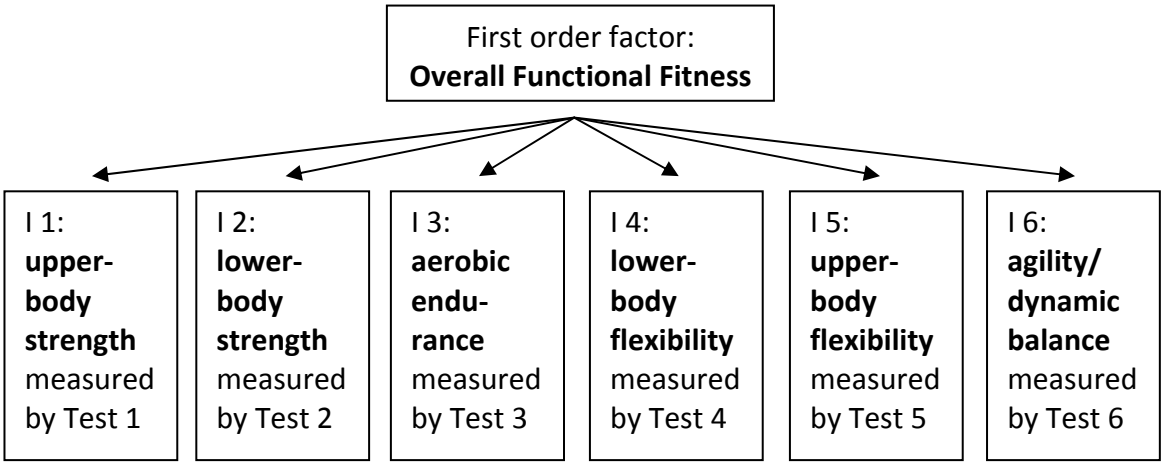
H2b The most important components are those related to mobility.

Methods

A 6-test performance battery (Senior Fitness Test - SFT) was administered to seventy eight participants (69 women and 9 men; mean age 82.0; SD 8.8). A single level structure model of Overall Functional Fitness was tested. Six indicators represented by the 30-second chair stand test, the 30-second arm curl test, the 2-minute step test, the chair sit-and-reach test, the back scratch test, and the 8-foot up-and-go test were hypothesized to have loadings on the first-order factor represented by the Overall Functional Fitness. The structural equation modeling using Lisrel statistical package was performed to test the hypothesis.

Results and conclusions

According to the theory, a theoretical structural model of the Overall Functional Fitness was constructed (as illustrated in Figure 5), applied to the results from the SFT battery, and empirically tested in Lisrel. The model was defined as a first-order covariance structure in which the Overall Functional Fitness was the only latent variable – a first-order factor. Six fitness components were represented by six performance tests which were previously validated to measure corresponding components (see Figure 5).



Note. Test 1 – 30-second chair stand test
Test 2 – 30-second arm curl test
Test 3 – 2-minute step test
Test 4 – Chair sit-and-reach test
Test 5 – Back scratch test
Test 6 – 8-foot up-and-go test

Figure 5 Schematic covariance structure model of Overall Functional Fitness

Before actual modeling in Lisrel, the structure of Functional Fitness was visually examined (correlation matrix) and also pre-determined by using factor analysis (single factor explained 54.480 % of total variance). In addition, the measure of internal consistency, Cronbach's alpha, was computed ($\alpha = 0.8312$). The presented evidence was considered sufficient and supportive for further testing in Lisrel.

Goodness-of-fit indices (chi-square = 7.64 [$p = .57$], degrees of freedom = 9, RMSEA = 0.00, 90% CI for RMSEA = 0.0; 0.11, GFI = 0.97, RMR = 0.038) indicated that the theoretical model fits very well. The findings also revealed hierarchical structure of functional fitness. The most important components were those related to mobility. The factor score representing a relative importance of lower-body muscle strength was 0.32, of aerobic endurance 0.24, of agility -0.19, and of lower-body flexibility 0.19. Even though upper-body functioning might seem minor, it is also a very important component within the construct and cannot be eliminated. Upper body strength gained the factor score of 0.15 and upper-body performance gained the factor score of 0.12. As a result, the most accurate estimation of the Overall Functional Fitness would be a

weighted sum of each fitness component measured by relevant manifest variables. The goodness-of-fit indices provided the sufficient evidence for the construct validity thus the **hypothesis H1 was accepted**. Also according to the results, both of the hypotheses 2, specifically, **the hypothesis H2a and the hypothesis H2b were accepted**.

In conclusion, findings demonstrate that the structure of functional fitness is unidimensional construct and contributions of its individual components are hierarchical in nature. Therefore, an accurate estimation of Overall Functional Fitness considers the weighted sum, rather than a simple sum, of all identified components. This study was proposed as a framework to help investigators in their efforts to estimate the Overall Functional Fitness in older adults more accurately and with the confidence that the summary score is reasonable. But the process itself, as applied in this study, may be used as an inspiration and guide for any other composite measurement score development in relevant areas of behavioral research and beyond.

GENERAL DISCUSSION

Evaluation of physical functioning plays a valuable role in clinical geriatrics as well as in aging research. The present dissertation was conducted to fill the gap and to gain an experience with performance-based measures of functional fitness in older adults living in the Czech Republic and to examine the structure of functional fitness among older adults.

The first general aim of this dissertation was to review available methods of physical functioning assessment and to provide the most commonly used instruments. This issue was addressed in the Study 1 (Chapter 2 in the original manuscript). The detailed review of available instruments helped to select the most appropriate instrument for the present dissertation. In addition, this review might be very helpful and a valuable source of information for anybody who is interested in measuring physical functioning in older adults. Based on objectives of the research study and pre-defined requirements, the Senior Fitness Test (Rikli & Jones, 2001) appeared to be the best instrument for use in the present dissertation.

The Study 2 (Chapter 3 in the original manuscript) addressed the second general aim which was targeted on an application of the SFT battery on older Czech population. In order to make sure that the SFT will be accepted by the majority of the targeted population, participants were

recruited from two completely different backgrounds. The priority was to test both higher and lower functioning older individuals who were still capable of performing activities of daily living. The higher functioning sub-sample served for pilot testing purposes. As expected, nobody from this sub-sample experienced any difficulty with any of tests and all participants accepted performance testing very well. But more important for us was the reaction of the lower functioning sub-sample. Even though some participants, especially those in advanced old age, experienced difficulty with performing some of the tests but in general everybody accepted performance testing well. It seemed that most of older adults living in Residential Care Facilities appreciated the attention and even the challenge of testing. Many of them were competitive so they motivated those who were not very confident at the beginning. Also, many older adults realized that they were still able to accomplish some of the tasks they already believed were impossible. Further, because it has been proven that functional fitness may be improved by physical activity even among low functioning older adults, it is crucial to be able to accurately assess baseline levels in this population despite the fact that some of them might not be able to complete all of the tests. For instance, in the 30-second chair stand test, an improvement from score 0 to 3 reflects a great accomplishment and may be clinically even more important than an improvement from score 7 to 10. The application of the performance testing even in Residential Care Facilities was considered very successful and promising for the future. Although the SFT was developed on community dwelling older adults this battery seems to be very useful for testing also lower functioning older adults as it has been previously documented by Beck (2008). It seems that this battery suffers from minimum ceiling and floor effects. The preliminary results of this study were already published (Machacova, Bunc, Vankova, Holmerova, & Veleta, 2007).

Finally, the last study (Chapter 4 in the original manuscript) was focused on a theoretical approach of development of a composite measurement score of functional fitness. The psychometric evaluation of scales which measures unobservable or latent constructs continues to be an issue of high interest among many researchers. Because functional fitness is a latent construct consisting of specific components essential for independent functioning (muscle strength, aerobic endurance, flexibility, and agility) the psychometric evaluation should follow

specific procedures including both theoretical and statistical approaches. Even though many different composite measurement scores of physical functioning have been published (Avila-Funes, Gray-Donald, & Payette, 2006; Buchman, Boyle et al., 2007; Buchman, Wilson, Boyle, Bienias, & Bennett, 2007; Dobek et al., 2006), most of them except for three studies (Kinugasa & Nagasaki, 1998; Nagasaki et al., 1995a, 1995b) did not consider examination of the structure of a measured construct which is essential to any meaningful composite score computation. According to previous findings, the structure of functional fitness in older adults is a unidimensional construct (Guralnik, Seeman, Tinetti, Nevitt, & Berkman, 1994; Nagasaki et al., 1995a, 1995b). This, in other words, means that all tests measure a single underlying common factor so the single score of Overall Functional Fitness may be constructed. Our findings supported, to some extent, results presented by Nagasaki and his colleagues and extended their work by analyzing the contribution of individual components. As expected, it appeared that each component of functional fitness has a different contribution to the overall score and that the structure is hierarchical. The most important components are those related to mobility as proposed by Guralnik (2000) and the least, but also important, are upper-body performances:

6. Upper body flexibility

5. Upper-body strength

3. - 4. Agility and Lower-body flexibility

2. Aerobic endurance

1. Lower-body strength

The findings of this last study are crucial in order to evaluate the Overall Functional Fitness more accurately as a weighted sum of all relevant components compared to a simple summary score proposed by Dobek (2006).

These findings might help to create more effective intervention programs. It is evident that interventions created to maintain independent functioning should include stressing of all identified components needed for performing daily activities with special attention to the lower body functioning and aerobic endurance because those appeared to be the most important

ones. In addition, this study may be used as a guide through the process of composite measurement score development in any other area of behavioral research and beyond.

In the end, three possible ways of interpretation of the data are proposed. Each of the interpretations may be useful for different purposes or needs. Firstly, the results of functional fitness evaluation may be interpreted in original units. Those scores contain full information and are very important for research purposes and for those who are closely interested in physical functioning thus require as accurate data as possible.

But the information about functional fitness status may be also highly relevant for others who are working with older adults on daily basis but might not be as familiar with physical functioning as physical specialists, thus they might not know what original scores actually mean from a practical point of view. For instance, a nurse in a Residential Care Facility or a caregiver might find it helpful and useful to know what to expect from patients but the score 10 in test 1 would not necessarily provide them with a proper idea of what fitness level this score actually reflects. Therefore, an alternative method of data collapsed into categories may be more appropriate. This way of interpretation would provide a more accurate idea about the actual capabilities of patients for health providers, caregivers, family members or even older adults themselves but loses some of original information.

This proposed process may be applied on the Overall Functional Fitness score but one condition should remain. According to the findings from the last study, categories should be created from an already existing composite score rather than just be computed as a mean of scores already collapsed into categories as proposed by Buchman and his colleagues (Buchman, Boyle et al., 2007; Buchman, Wilson et al., 2007) and others. This novel approach ensures that less of the original information is lost and that the results are more accurate.

Two major limitations should be mentioned. First, our sample was too small and additional research is needed to support our findings and to be able to generalize on the population, and second, our sample consisted of mostly women so we were not able to explore whether some of our findings may apply to both genders.

CONCLUSIONS

1. The SFT is appropriate for measuring functional fitness among older Czech adults.
   - The SFT was well accepted by both higher and lower functioning older adults.
   - The SFT suffers from minimal ceiling and floor effects.
   - The SFT was sensitive to detect small yet clinically important changes between both lower and higher functioning and younger and older participants.
2. The threshold scores indicating the risk of independency loss developed in the U.S. appeared to be too strict for the use in the Czech Republic.
3. Functional fitness among older adults is a unidimensional construct consisting of six major components (lower- and upper-body strength, aerobic endurance, lower- and upper-body flexibility, and balance/agility).
4. Furthermore, findings demonstrate that the contributions of its individual components are hierarchical in nature.

⇨ Therefore, an accurate estimation of Overall Functional Fitness considers the weighted sum, rather than a simple sum, of all identified components

FUTURE RESEARCH DIRECTIONS

- To translate the Senior Fitness Test manual into the Czech language.
- To collect data from a large sample in order to develop normative standards for the older Czech population.
- To develop the threshold scores indicating the risk of dependency loss in older Czech adults.
- To provide additional evidence that age-related decline in functional fitness slows down with increasing age.
- To replicate the statistical approach from the last study in order to confirm the proposed structure of functional fitness.

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