Chulalongkorn Medical Journal

Volume 59
Issue 1 *January 2015*

Article 2

1-1-2015

Reliability and validity of a modified instrumentfor functional reach test

Kanokporn Pooranawatthanakul

Anchalee Foongchomcheay

Chula Med J Vol. 59 No. 1 January-February 2015

Reliability and validity of a modified instrument for functional reach test

Kanokporn Pooranawatthanakul*

Anchalee Foongchomcheay**

Pooranawatthanakul K, Foongchomcheay A. Reliability and validity of a modified instrument for functional reach test. Chula Med J 2015 Jan – Feb; 59(1): 13 - 22

Background : *Functional reach test (FRT), a clinical balance measurement, is used to detect the limit of stability. Performing FRT measure could be in expedient due to the needs to obtain accurate reach distance and cautiousness of high susceptibility to fall. To overcome these occurrences a modified instrument which was easy to read value, adjustable, foldable, and movable has been developed*

Objective : *To investigate the validity, intra- and inter-rater reliability of the modified instrument for FRT.*

Setting : *Phranungklao Hospital Elderly Club, National Stadium.*

Population sample : *Fifteen elderly and 15 young adults; all were healthy volunteers.*

Research Methodology : *Participants were randomized to perform both the traditional FRT and the modified FRT instrument on the same day. Data were obtained by having the participants complete the protocol. Each participant was asked to perform three trials in one session, for two sessions. Mean reaching distance of the three trials was analyzed. Intra-class correlation-coefficient (ICC) was used to evaluate intra-and inter-rater reliability. Mean reaching distance of three trials was analyzed. The modified FRT instrument was correlated with traditional FRT using Pearson r correlation.*

* Master of Science Program in Physical Therapy, Faculty of Allied Health Science, Chulalongkorn University

** Department of Physical Therapy, Faculty of Allied Health Sciences, Chulalongkorn University

Results : *This study demonstrates high inter-rater- reliability (ICC $_{2, 3}$ = 0.78 - 0.94) and high intra-rater (ICC $_{3, 2}$ = 0.77-0.97), with high correlation (Pearson r = 0.79). The standard error of measurement was 0.42 - 0.46 inches*

Conclusions : *The modified instrument more comfortable use of measuring method for accurate results and allows measurer to be cautious only on susceptibility to fall.*

Keywords : *Functional reach test, elderly, balance.*

Reprint request: Foongchomcheay A. Department of Physical Therapy, Faculty of Allied Health Sciences, Chulalongkorn University, Bangkok 10330, Thailand.

Received for publication. March 6, 2014.

กนกพร ปูรณวัฒนกุล, อัญชลี ฝูงชมเชย. ความเที่ยงตรงของเครื่องมือประยุกต์สำหรับทดสอบความสามารถในการเอื้อมมือ. จุฬาลงกรณ์เวชสาร 2558 ม.ค. – ก.พ.; 59(1): 13 – 22

เหตุผลของการทำวิจัย : *แบบประเมินความสามารถในการทรงตัวโดยวิธีการเอื้อมมือ (FRT) เป็นแบบประเมินทางคลินิก ซึ่งใช้วัดระยะจำกัดของเขตความมั่นคงในการทรงท่าของร่างกาย โดยวัดจากระยะของการเอื้อมมือที่สามารถเอื้อมไปได้ไกลมากที่สุดการวัดโดยใช้ FRT แบบดั้งเดิมนั้นอาจไม่สะดวก เนื่องจากการวัดต้องการทั้งความแม่นยำของการอ่านค่าระยะการเอื้อมมือ และการระมัดระวังการล้มที่อาจจะเกิดขึ้นได้ ดังนั้นเพื่อที่จะให้เกิดความสะดวกในการประเมินเครื่องมือที่สามารถอ่านค่าระยะทางที่เอื้อมมือได้ง่าย เคลื่อนย้ายได้ และสามารถพับรวมถึงสามารถปรับได้ทั้งระดับความสูง และปรับใช้ได้ทั้งแขนซ้ายและแขน ขวาจึงถูกประดิษฐ์ขึ้น*

วัตถุประสงค์ : *เพื่อทดสอบความตรงและความเที่ยงของเครื่องมือใหม่ที่ประดิษฐ์ขึ้นทั้งในบุคคลคนเดียวกัน และระหว่างบุคคล*

สถานที่ทำการศึกษา : *ชมรมผู้สูงอายุ โรงพยาบาลพระนั่งเกล้า และ สนามกีฬาแห่งชาติ*

ประชากร : *15 ผู้สูงอายุ และ15 วัยรุ่นที่สุขภาพดี*

วิธีการศึกษา : *ผู้เข้าร่วมการศึกษาถูกสุ่มให้ทดสอบความสามารถในการทรงตัว โดยวิธีการเอื้อมมือทั้งแบบดั้งเดิมและใช้เครื่องมือมือที่ประดิษฐ์ใหม่ ซึ่งข้อมูลได้จากผู้เข้าร่วมการศึกษาที่ผ่านกระบวนการอย่างสมบูรณ์ โดยผู้เข้าร่วมการศึกษา จะถูกให้ทำการทดสอบ 3 ครั้ง ใน 1 รอบ และทำ 2 รอบ โดยนำค่าระยะทาง เอื้อมมือที่ได้ถูกนำมาเฉลี่ย และวิเคราะห์ผล โดยที่ความตรงของเครื่องมือนั้นอยู่ระดับสูง (r = 0.79) เมื่อใช้สถิติสัมประสิทธ์สหสัมพันธ์เพียร์สันในการหาความสัมพันธ์กับ FRT แบบดั้งเดิม และผลการศึกษาของค่าความเที่ยงเมื่อใช้สถิติสัมประสิทธ์สหสัมพันธ์ภายในชั้นค่าความเที่ยงอยู่ในระดับสูงทั้งในบุคคลเดียว (ICC (3, 2) = 0.77 - 0.97) และระหว่างบุคคล (ICC (2, 2) = 0.78 - 0.94) และค่าเบี่ยงเบนมาตรฐานของการวัดมีค่าน้อยกว่าค่าที่ได้จากการศึกษาก่อนหน้า (SEM = 0.42 - 0.45 นิ้ว)*

สรุป : *เครื่องมือใหม่ที่สามารถประเมิน FRT มีความตรงและเที่ยงในการประเมิน FRT ได้อีกทั้งยังสะดวกต่อการอ่านค่าที่ได้จากการเอื้อมมือ*

คำสำคัญ : *การประเมินความสามารถในการทรงตัวโดยวิธีการเอื้อมมือ, ผู้สูงอายุ, การทรงตัว.*

Approximately, one-third of people aged 65 years and over who live in acommunity fall at least once a year. In community dwelling, falls in older adults are results of various risk factor including history of falls and balance deficit.[1]

Balance is an ability to maintain the center of mass within a base of support to remain upright and prevent from fall.[2] This ability plays a critical role ashow individuals perform their function in their everyday living. If any deficit of balance is found during activities and mobility, further testing to identify the cause of fall would be needed. Common tests used in clinic to assess deficiency of balance and to determine the risk of fall include Romberg stance.[3] Timed-Up-and-Go (TUG)[4], Berg Balance Scale (BBS) [5], and Functional Reach Test (FRT).[6] Evaluation of abilities to maintain balance by multi-testing methods may be needed to give a more complete picture of an individual to maintain their balance. This evaluation is also used to establish a baseline of balance performance for a plan of care. Moreover, balance assessment tools chosen for a clinical examination should be simple without being redundant with the information obtained.[7]

The functional reach test (FRT), developed by Duncan *et al.* in 1992[6] is a well-known clinical measureof balance and has been tested bothfor validity and reliability.[6] FRT measures the distance between the length of the arm and a maximal forward reach in a standing position, while maintaining a fixed base of support. It has been developed as a dynamic measure of balance with no attempt to control movement strategies.[6] FRT was used in patients diagnosed as stroke, Parkinson, multiple sclerosis and hip fractures. Reach distance of FRT at less than or equal to 14 inches, has been reported to be associated with increased risk of fall in the elderly.[7] In using FRT, the researcher must be confident that the measurement has both high reliability and validity. The accuracy or validity of the measurements provided by an instrument can be determined by comparing the reading values obtained from the device witha gold standard measure.[6]

FRT is a quick and simple, single-task dynamic test that evaluates the margin of stability as well as ability to maintain balance during a functional task.[6] Traditional FRT is used by placing a yardstick or tape measure on awall, parallel to the floor, at the height of the acromion of the participant's dominant arm. The participant is instructed to stand with the feet ata comfortable distance apart, makinga fist, and forwardly flex the dominant arm to approximately 90 degrees. The participants are asked to reach forward as far as possible without taking a step or touching the wall. Scores are determined by assessing the difference between the start and end position of reaching distance, usually measured in inches.

Conventional FRT, there are limitations of the test. First, conventional FRT need the wall for placing a yardstick or tape measure. Second, the FRT itself reproduces a risk of fall. Cautious of safety is crucial to be taken in account considering the conventional FRT interest, precaution need to be given measure may involve conscious of participants reaching distance and safety of anticipate of participants. This must be done two tasks at the same time. So could cause errors in the readings value of measurement and safety during testing. Accuracy of reach distance and cautiousness of high susceptibility to fall

were needed to obtain during performing FRT measure. To overcome these occurrences, a modified instrument which was foldable, movable and adjustable has been developed. The purpose of this study is to test the validity and reliability of the modified instrument for measuring functional reach test (Fig. 1) and to demonstrate whether it produce less measurement error than the traditional one.

Research Methodology

Instrumentation

The modified FRT instrument in this study was divided into 3 main parts:

The first part was the base and core track. The base was welded from steel square pipes (Fig. 1). At the 4 corners of this base, and adjustable foot was attached for leveling the equipment on uneven surface. The core track (Fig.1A) was consisted of one steel square pipe and one aluminum runner rail. The connection between base and the core track was foldable base make it easy to move (Fig.1B, C). In addition an aluminum runner rail was inserted inside the core track to make its height adjustable therefore the use for any shoulder height of participants (Fig.1A).

The second part was the measurement of the value track. It made from an aluminum runner rail. Reading value was provided using a yardstick which was attached on rectangular aluminum (Fig. 2). The measurement value track could be rotated to position the slide handle bar either for left or right dominant's hand of participants. At both ends of the measurement value track, 2 stop-breakers (Fig. 2D), were attached to keep the slide handle bar remain on the track.

The last part was the slide handle bar. (Fig.3E, F) It made from a rectangular aluminum attached perpendicularly to the measurement value track via 2 rollers. These 2 rollers were used to decrease fiction during movement of the slide handle bar along the measurement value track. A solid card was attached the slide handle bar to guide direction of fist of participants during reaching out of participants. At the final reaching distance a measurer move the slide handle bar so that the solid card touched the third metacarpal of participants.

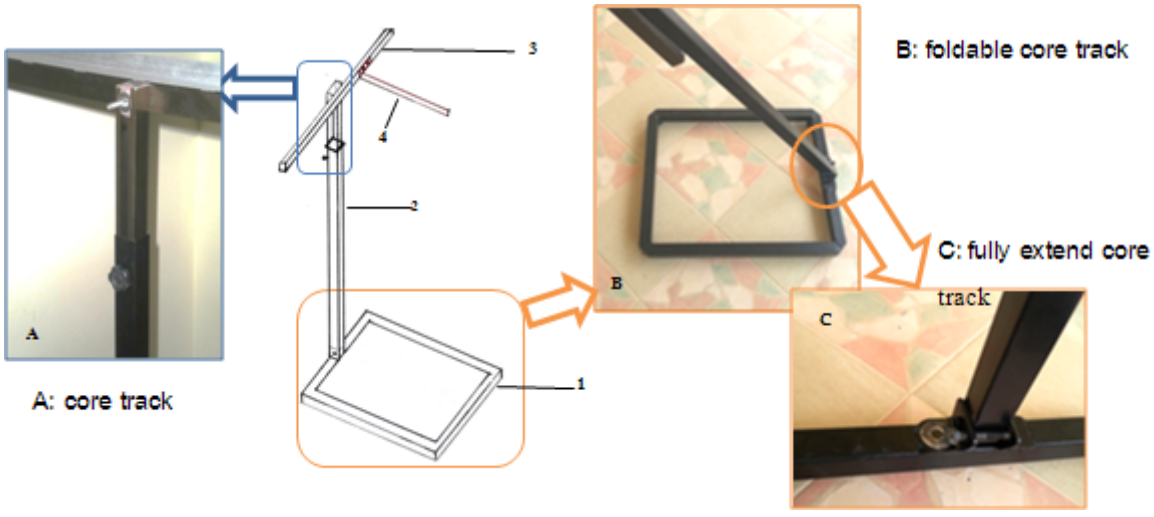

Figure 1. A modified FRT instrument and partly of a modified instrument 1) base 2) core track 3) measurement value track 4) slide handle bar.

Figure 2. Measurement value track.

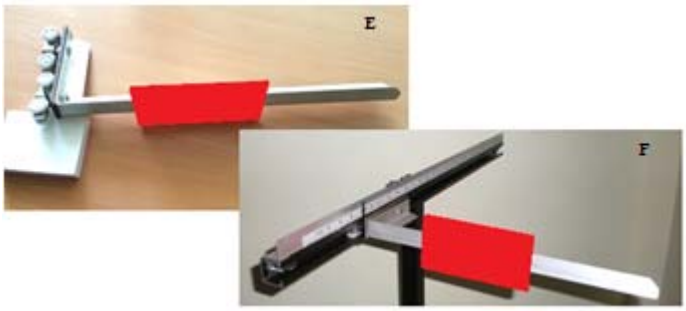

Figure 3. Slide handle bar, roller system and solid card.

Participants

Healthy volunteers participated in the study. Those who were able to maintain standing position for 1 minute and had no problem in balance standing were included. Those who had problems in these conditions such as shoulder pain, shoulder or elbow joint limitation, fracture of the upper extremity within the past year were excluded. Fifteen elderly and 15 young adults were recruited in this study.

Experimental Procedure

All participants were randomized to perform on both the traditional FRT and the modified FRT instrument on the same day. Each participant was asked to stand on the line, marked for positioning of the feet placement for starting position.

The traditional FRT was tested by placing a tape measure on the wall, parallel to the fall, at the height of the acromion of the participant's dominant arm. The participants were asked to stand on the line with the feet a comfortable distance apart, make a fist, and lean forward.

The modified FRT instrument was done by setting participants to stand on the line, as in the traditional FRT but the measurer could adjust the acromion height by moving the core track and rotated the measurement value track for the dominant hand.

After a measurer assessed distance when participants maximally lean forwarded while holding and upright posture. Each participant was asked to perform three trials in 1 session, for two sessions. Mean reach distance of three trials was analyzed.

All participants were explained to ensure their understanding of the tests. They were asked to stand so that their shoulders were perpendicular to the floor, make a fist and reach their arm, and then participants were asked to lean forward as far as they could without taking a step or losing their balance. Participants were asked to maintain their shoulder position in forward flexion, without shoulder abduction and adduction. A measurer slid the slide handle bar to touch the fist on the third metacarpal to determine reach distances.

Data analysis

All data were analyzed using SPSS software, version 17.0 for windows. Descriptive statistics was presented as mean, standard deviation and median (minimum, maximum). Percentages (as appropriate) were used to test baseline characteristic data. Pearson's correlation was used to correlate both instruments that were demonstrated criterion validity. Mixed model ANOVA was used to calculate intra-class correlation coefficients ($ICC_{(3, 2)}$) and $ICC_{(2, 2)}$[8] to determine test-retest reliability of the modified for instrument of functional reach test. The SEM was defined as a standard error of measurement which was calculated as SD /$\sqrt{}$ (1-ICC) where SD was the variance of the difference score.[8] The minimal detectable change (MDC) was used for contemplating on amount of error that associated with repeated measurements. It indicated the error in the unit of the measurement. MDC was calculated as $1.96 \times SEM \times \sqrt{2}$.[8]

Result

Fifteen elderly (mean age = 69.75 ± 6.29 yr.) and 15 young adults (mean age = 17.67 ± 1.45 yr.) completed the protocol. Analysis of thecriterion validity and reliability used mean reach distance obtained from both measurers. The modified FRT instrument is useful to evaluate the dynamic balance from a high relationship with the traditional FRT (*Pearson's r* = 0.79). Intra-class correlation coefficient (ICC) was used to evaluate intra- and inter-rater reliability. Mean reach distance and standard deviation are shown in table 1. The results indicated the modified FRT instrument provided high reliability of both intra and inter-rater reliability of the modified instrument ($ICC_{(2, 3)}$ = 0.78 - 0.94) and ($ICC_{(3, 2)}$ = 0.77 - 0.97) respectively (Table 2 and 3).

Table 1. Mean ± Standard deviations of reach distance in each group of the instrument (n = 30).

Group	Rater	Mean ± SD (modified FRT)		Mean ± SD (traditional FRT)	
		Session 1	Session 2	Session 1	Session 2
Young adults	Rater 1	16.17 ± 0.90	16.25 ± 1.11	14.17 ± 2.60	14.68 ± 2.56
(n=15)	Rater 2	16.78 ± 1.35	16.76 ± 1.32	14.70 ± 2.65	14.23 ± 2.61
Elderly	Rater 1	14.17 ± 2.60	14.68 ± 2.56	9.36 ± 2.07	9.84 ± 1.71
(n=15)	Rater 2	14.70 ± 2.65	14.23 ± 2.60	10.14 ± 2.01	10.00 ± 2.11

CI = Confidence Interval, **FRT** = Functional Reach Test, **ICC** = Intra-class Correlation Coefficient and **SD** = Standard Deviation,

Table 2. The Inter-rater reliability ($ICC_{(2,2)}$) of the FRT instrument and p-value.

Group	Rater	Inter rater reliability		p-value
		$ICC_{(2,2)}$	95%CI	
Young adults	Rater 1	0.78	0.36 – 0.93	0.11
(n = 15)	Rater 2			
Elderly	Rater 1	0.94	0.83 - 0.98	0.07
(n = 15)	Rater 2			

CI = Confidence Interval, SD = Standard Deviation, ICC = Intra-class Correlation Coefficient

Table 3. Intra rater reliability ($ICC_{(3,2)}$) of the FRT instrument and p-value.

Group	Rater	Intra rater reliability		p-value
		$ICC_{(3,2)}$	95%CI	
Young adults	Rater 1 (S1)	0.87	0.61 – 0.96	0.236
(n = 15)	Rater 1 (S2)			
	Rater 2 (S1)	0.97	0.91 - 0.99	0.438
	Rater 2 (S2)			
Elderly	Rater 1 (S1)	0.89	0.68 - 0.96	0.29
(n = 15)	Rater 1 (S2)			
	Rater 2 (S1)	0.77	0.31 - 0.92	0.35
	Rater 2 (S2)			

CI = Confidence Interval, SD = Standard Deviation, ICC = Intra-class correlation coefficient, S1 = session 1, S2 = session 2

The SEM and MDC of the intra rater and interrater measurement were reported in table 4. The SEMs were smaller when the modified FRT instrument was used in both groups and in the across intra- rater and inter- rater measures than when the traditional FRT was used. The SEMs were 0.42 - 0.46 inches and MDC were 0.89 - 2.38 inches.

Table 4. The standard error of measurement (SEM) and the minimal detectable change (MDC) (n = 30) (inches).

Reliability	SEM based on means of Trial 1 (inches)		MDC based on means of Trial 1 (inches)	
	Young adult	Elderly	Young adult	Elderly
Intra-rater	0.32	0.86	0.89	2.38
Inter-rater	0.42	0.45	1.16	1.25

Discussion

Results from this study indicated that the modified FRT instrument had high reliability. In this study, measurement of functional reach test has demonstrated high reliability with ICC of 0.94 in line with the result shown by Duncan *et al*, 1990 used the yard stick (Duncan *et al*., 1990). The traditional FRT was one of the most commontools in clinical practice by doctors, physiotherapists and other clinicians. This is simple easy and minimum timeis required to administrate. In addition, it provided an accurate measure to assess balance in elderly, However, the test was susceptibility to fall enhanced by reach task during assessment.

The modified FRT instrument was invented by the authors and considered to be more convenient and practical to be used by older adults participants. This modified FRT instrument is easy to be mobilized and assembled in any place. In addition, this modified FRT instrument can be set on uneven surface by utilizing the adjustable feet. Also, it provides convenience to determine reading values of reach distance as well as enhanced capability of measurer to perform measurement safely.

It was consistently reported that traditional FRT were inconvenient in height adjustment. So Duncan *et al*, 1990 shown that the height of participantswas contributed to the reach value and accuracy of FRT rather than gender. Given that the height of this modified FRT instrument was adjustable therefore, it helps to reduce the individual variation of acromion height at the starting position.

Considering implementation for clinical use, the modified FRT instrument give more benefit due to the reduce complicated secure safety of participants during evaluation, and the instrument was foldable, easily mobilized and suitable for various heights of participants. Considering implementation for research, further study may emphasize on a digital system for developing measurement value track from yard stick to digital system.

Acknowledgements

This study was partially supported by grants from the Faculty of Allied Health Science, Chulalongkorn University. The success of this study can be attributed to assistance from measurers, namely, Perin Wan-Aroh and Nudcharin Manoratch. I wish to thank academic staff members in neurological area in the Department of Physical Therapy, the Faculty of Allied Health Science, Chulalongkorn University for providing suggestions for development of the research instrument.

References

1. Lord SR, Clark RD, Webster IW. Physiological factors associated with falls in an elderly population. J Am Geriatr Soc 1991 Dec; 39(12): 1194 - 200
2. Maki BE, McIlroy WE. Postural control in the older adult. Clin Geriatr Med 1996 Nov; 12(4): 635 - 58
3. Woollacott MH, Shumway-Cook A. Motor Control: Translating Research into Clinical Practice. Philadelphia: Lippincott Williams & Wilkins, 2007
4. Podsiadlo D, Richardson S. The timed “Up & Go”: a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 1991 Feb; 39(2):142 - 8

5. Berg KO, Maki BE, Williams JI, Holliday PJ, Wood-Dauphinee SL. Clinical and laboratory measures of postural balance in an elderly population. Arch Phys Med Rehabil 1992 Nov; 73(11): 1073 - 80

6. Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. J Gerontol 1990 Nov; 45(6): M192-7

7. Thapa PB, Gideon P, Fought RL, Kormicki M, Ray WA. Comparison of clinical and biomechanical measures of balance and mobility in elderly nursing home residents. J Am Geriatr Soc 1994 May; 42(5): 493 - 500

8. Portney LG, Watkins MP. Foundations of Clinical Research: Applications to Practice. 2nd ed. Upper Saddle River, NJ: Prentice Hall, 2000