# ความเที่ยงตรงของเครื่องมือประยุกต์สำหรับทดสอบความสามารถในการเอื้อมมือ

# Reliability and Validity of a Modified Instrument for Functional Reach Test

Kanokporn Pooranawatthanakul(ปูรณวัฒนกุล กนกพร) * Dr.Anchalee Foongchomcheay (ดร(อัญชลี ฝุ่งชมเชย.**

**ABSTRACT**

The purposes of this study were to investigate validity, intra- and inter-rater reliability of a modified instrument for Functional Reach Test. Fifteen elderly (mean age=69.75±6.29 yr.) and fifteen young adult (mean age=17.67±1.45 yr.) participated into this study. Mean reaching distance of three trials was analyzed. Results from this study demonstrated 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's r*= 0.79). The standard error of measurement was 0.42-0.46 inches. It can be concluded that the modified instrument provided more comfortable use of measuring method for accurate results and allowed measurers to be cautious only on susceptibility to fall.

**บทคัดย่อ**

จุดประสงค์ของการศึกษานี้เพื่อทดสอบ ความเที่ยงตรงของเครื่องมือประยุกต์สำหรับแบบทดสอบความสามารถ ในการเอื้อมมือ โดยผู้เข้าร่วมการศึกษามีผู้สูงอายุ 15 คน (69.75±6.29 ปี) และวัยรุ่น 15 คน (17.67±1.45 ปี) การวิเคราะห์ผล ใช้ค่าเฉลี่ยของระยะการเอื้อมมือมาคำนวณ โดยที่ความตรงของเครื่องมือนั้น อยู่ระดับสูง ($r$ = 0.79) เมื่อใช้สถิติสัมประสิทธ์ สหสัมพันธ์เพียร์สัน ในการหาความสัมพันธ์กับ เครื่องมือประยุกต์สำหรับแบบทดสอบความสามารถในการเอื้อมมือ กับ แบบทดสอบความสามารถในการเอื้อมมือแบบดั้งเดิมและผลการศึกษาของค่าความเที่ยงเมื่อใช้ สถิติสัมประสิทธ์ สหสัมพันธ์ภายในชั้น ค่าความเที่ยงอยู่ในระดับสูง ทั้งในบุคคลเดียว (ICC $_{(3, 2)}$ = 0.77-0.97) และระหว่างบุคคล (ICC $_{(2, 2)}$ = 0.78-0.94) และค่าเบี่ยงเบนมาตรฐานของการวัด มีค่าน้อยกว่า ค่าที่ได้จากการศึกษาก่อนหน้า (SEM=0.42-0.45 นิ้ว) ซึ่งสามารถสรุปได้ว่า เครื่องมือประยุกต์สำหรับแบบทดสอบความสามารถในการเอื้อมมือ มีความเที่ยงตรงในการประเมิน การทดสอบความสามารถในการเอื้อมมือได้ อีกทั้งยังสะดวกต่อการอ่านค่าที่ได้จากการเอื้อมมือ

**Key Words:** Functional Reach Test, Elderly, Balance

**คำสำคัญ:** แบบทดสอบความสามารถในการเอื้อมมือ ผู้สูงอายุ การทรงตัว

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

** *Lecturer, Department of Physical Therapy, Faculty of Allied Health Science, Chulalongkorn Universit*

**Introduction**

Approximately one third of people aged 65 years and over who live in community fall at least once a year. In community dwelling, falls in older adults are results of various risk factors including history of falls and balance deficit (Lord et al., 2001).

Balance is an ability to maintain center of mass within a base of support to remain upright and prevent from fall (Maki and McIlroy, 1996). This ability plays a critical role in how individuals perform their function in their everyday live. If any deficit of balance is found during activities and mobility, further testing to identify cause of falling would be needed. Common tests used in clinic to assess deficiency of balance and to determine risks of fall include Romberg stance (Woollacott and Shumway, 2007), Timed-Up-and-Go (TUG) (Podsiadlo and Richardson, 1991), Berg Balance Scale (BBS) (Berg et al., 1992), and Functional Reach Test (FRT) (Duncan et al., 1990). Evaluation of abilities to maintain balance by multi testing methods may be needed to give a more complete picture of an individual to maintain 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 (Thapa et al., 1994).

The FRT developed by Duncan et al in 1990 (Duncan et al., 1990) was a well-known clinical measure of balance, and has been tested for both validity and reliability. FRT measured 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 (Duncan et al., 1990). FRT was used in patients with diagnoses as different as stroke, Parkinson, multiple sclerosis and hip fractures. Reach distance of FRT at less than or equal to 14 inches, has reported to be associated with increased risk of fall in elderly. In using FRT a 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 value obtained from the device and a gold standard measure (Duncan et al., 1990)

FRT was reported to be a quick and simple, single-task dynamic test and evaluate the margin of stability as well as ability to maintain balance during a functional task (Duncan et al., 1990). Conventional FRT was used by placing a yardstick or tape measure on a wall, parallel to the floor, at the height of the acromion of the participant's dominant arm. The participants were instructed to stand with the feet a comfortable distance apart, make a fist, and forward flex the dominant arm to approximately 90 degrees. The participants were asked to reach forward as far as possible without taking a step or touching the wall. Scores were determined by assessing the difference between the start and end position of reaching distance, usually measured in inches.

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 was developed. Our purpose in this study was to test the validity and reliability of the modified instrument for measure functional reach test (figure 1) and to demonstrate whether it produce less measurement error than the conventional one.

the core track to make its height adjustable therefore the use for any shoulder height of participants (figure 1A).

**The second part was the measurement value track. It** made from an aluminum runner rail.

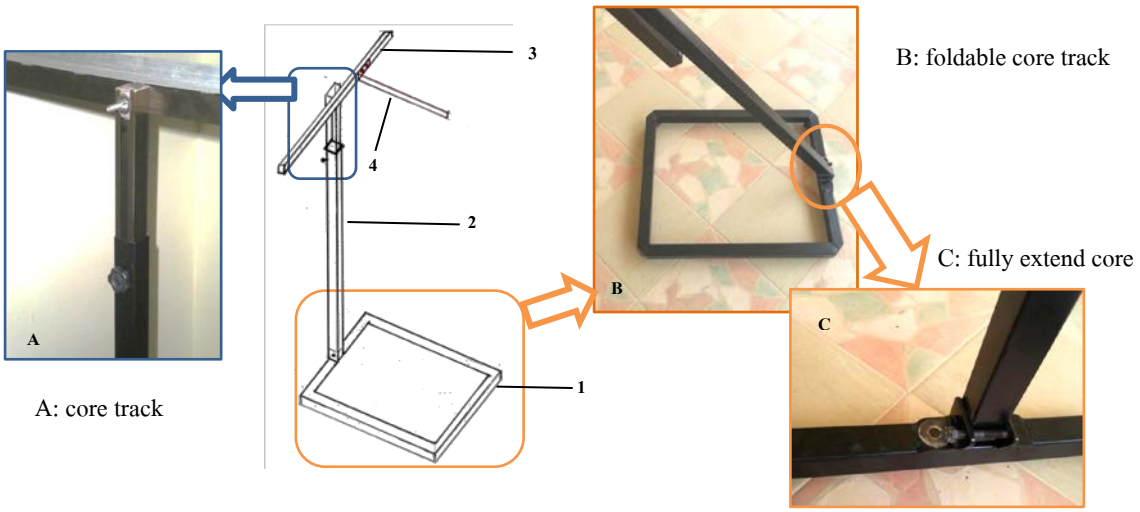


**Figure 1** A modified instrument for FRT and partly of a modified instrument 1) base 2) core track 3) measurement value track 4) slide handle bar

**Method**

**Instrumentation**

The modified instrument for FRT in this study were divided into 3 main parts

**The first part was the base and core track.** The base was welded from steel square pipes (figure 1). At the 4 corners of this base, and adjustable foot was attached for leveling the equipment on uneven surface. The core track (figure 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 (figure 1B, C). In addition an aluminum runner rail was inserted inside

Reading value was provided using a yardstick which was attached on rectangular aluminum (figure 2). The measurement value track can 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 (figure 2D), were attached to keep the slide handle bar remain on the track.


**Figure 2** Measurement value track

**The last part was the slide handle bar.** (figure 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.

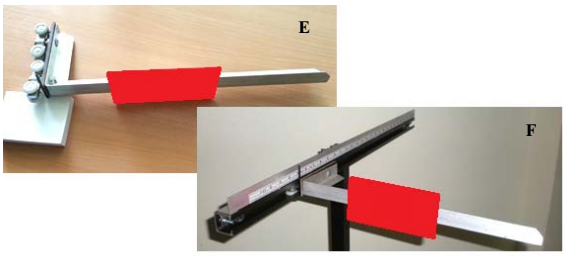


**Figure 3** Slide handle bar, roller system and solid card

**Participants**

Healthy individuals volunteered to participate. 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 upper extremity within the past year were excluded. Fifteen elderly and 15 young adults were included in this study.

**Test Procedures**

All participants were randomly to perform both conventional FRT and the modified instrument for FRT on the same day. Participants were asked to stand on the line, marked for positioning of the feet placement for starting position

The conventional FRT was tested by placing a tape measure on the wall, parallel to the floor, 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 instrument for FRT was done by setting participants to stand on the line same as in the conventional FRT but the measurer can adjust acromion height by moving the core track and rotated the measurement value track for 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 given explanation 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 third metacarpal for 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. A mixed model ANOVA was used to calculate intraclass correlation coefficients (ICC $_{(3, 2)}$) and ICC $_{(2, 2)}$ (Portney, 2000) 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 (Portney, 2000). 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 x SEM x √2 (Portney, 2000).

**Results**

Fifteen elderly (mean age=69.75±6.29 yr.) and 15 young adults (mean age=17.67±1.45 yr.) were completed the procedure. Analysis of criterion validity and reliability used mean reach distance obtained from both measurers. The modified instrument for FRT was demonstrated a high relationship with conventional FRT (*Pearson's r* = 0.79). Intraclass correlation coefficient (ICC) was used to evaluate intra- and inter-rater reliability. Mean reach distance and standard deviation were presented in table 1. The results indicated the modified instrument for FRT 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).

The SEM and MDC of the intra rater and inter

rater measurement were reported in table 3. The SEMs were smaller when the modified instrument FRT was used across in both groups and across intra rater and inter rater measures than when the conventional FRT was used. The SEMs were 0.42 - 0.46 inches and MDC were 0.89 - 2.38 inches

**Discussion**

Results from this study indicated that the modified instrument for FRT 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 conventional FRT was one of the most tools in clinical practice by doctors, physiotherapists and other clinicians. This is simple easy and minimum time 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 assess.

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

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

Considering implementation for clinical use, the modified instrument for FRT gave more benefit due to reduce the complicated secure safety of participants during evaluation, and the instrument was foldable, mobile 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.

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

| Group | Rater | Mean ± SD (modified FRT) | | Mean ± SD (conventional FRT) | |
|---|---|---|---|---|---|
| | | Session1 | Session2 | Session1 | Session2 |
| **Young adults (n=15)** | Rater 1 | 16.17 ± 0.90 | 16.25 ± 1.11 | 14.17 ± 2.60 | 14.68 ± 2.56 |
| | Rater 2 | 16.78 ± 1.35 | 16.76 ± 1.32 | 14.70 ± 2.65 | 14.23 ± 2.61 |
| **Elderly (n=15)** | Rater 1 | 14.17 ± 2.60 | 14.68 ± 2.56 | 9.36 ± 2.07 | 9.84 ± 1.71 |
| | 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 = Intraclass 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 (n=15)** | Rater 1<br>Rater 2 | 0.78 | 0.36 – 0.93 | 0.11 |
| **Elderly (n=15)** | Rater 1<br>Rater 2 | 0.94 | 0.83 - 0.98 | 0.07 |

**CI =** Confidence Interval, SD = Standard Deviation, ICC = Intraclass 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 | 95%CI | |
| **Young adults (n=15)** | Rater 1 (S1)<br>Rater 1 (S2) | 0.87 | 0.61 – 0.96 | 0.236 |
| | Rater 2 (S1)<br>Rater 2 (S2) | 0.97 | 0.91 - 0.99 | 0.438 |
| **Elderly (n=15)** | Rater 1 (S1)<br>Rater 1 (S2) | 0.89 | 0.68 - 0.96 | 0.29 |
| | Rater 2 (S1)<br>Rater 2 (S2) | 0.77 | 0.31 - 0.92 | 0.35 |

**CI =** Confidence Interval, SD = Standard Deviation, ICC = Intraclass correlation coefficient, S1 = session 1, S2 = session 2

**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 |