

Ability of five times sit-to-stand to determine functional limitation in people with knee osteoarthritis

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KEYWORDS

Sit-to-stand;
Clinical measure;
Muscle strength;
Mobility;
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ABSTRACT

Knee osteoarthritis (KOA), the most common form of arthritis, affects the ability to fully use the lower extremities due to pain, muscle weakness, and deformity. With the ability of the five times sit-to-stand test (FTSST) to reflect functional lower limb strength, the researchers hypothesized that outcomes of the test could detect functional limitation in these individuals. Thus, this study explored the ability of the FTSST to determine functional limitation in individuals with KOA. Ninety-three participants with KOA were cross-sectionally assessed for their health status, KOA information, FTSST, and functional limitation using a standard measure, namely the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) questionnaire. The findings indicated that 64 participants were those with non-functional limitation, and the rest of them (n = 29) were those with functional limitation according to the data of WOMAC. Furthermore, outcomes of the FTSST ≥ 15 seconds could excellently determine those with functional limitation (sensitivity=79%, specificity=71%, and area under the curve=0.838). As being a practical measure of the FTSST, the present findings offer an alternative strategy to detect and monitor individuals with KOA who have functional limitation, as well as indicate treatment effectiveness for these individuals.

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Introduction

Knee osteoarthritis (KOA) is a progressive degenerative joint disease that is caused by degeneration of articular cartilage and changes in subchondral bone⁽¹⁾. Major clinical signs and symptoms of KOA include chronic joint pain, morning stiffness over a short period, limited range of motion, crepitus, tenderness, joint effusion, malalignment or deformity of the knee joint, and bony enlargement^(2,3). These consequences further affect muscular functions around the joints, induce mobility restriction, disability, as well as quality of life of the individuals⁽⁴⁻¹¹⁾. Therefore, the ability of early detection for functional limitations among individuals with KOA is crucial for the initiation of appropriate treatments and monitoring for treatment effectiveness.

Currently, clinical measurements for functional limitation in people with KOA are executed using a test battery, namely the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)^(12,13). Such test batteries commonly have low sensitivity to detect change and are time-consuming to complete all items in the test, i.e., approximately 10 to 15 minutes⁽¹³⁾. Therefore, the use of a practical measure relating to the impairments due to KOA may offer an alternative strategy to detect a crucial consequence, i.e., functional limitation, among these individuals. From literature review, the researchers found the five times sit-to-stand test (FTSST) which is commonly used to assess functional lower extremity motor strength and balance ability while changing postures^(14,15). Previously, some studies have reported the use of FTSST to detect problems of individuals with KOA⁽¹⁶⁻¹⁸⁾. Master et al⁽¹⁷⁾ reported that the ability to complete FTSST of longer than 12 seconds could determine inadequate ability to walk at least 6,000 steps/day in people with KOA (with 80%-95% specificity). Another study also indicated that the time to complete FTSST of more than 7.9 seconds could detect fall risk probability in these individuals⁽¹⁸⁾. However, to the best of the researchers' knowledge,

there is no target value indicating functional limitation, a common consequence of KOA, using the FTSST. Thus, this study investigated the possibility of using the FTSST to determine functional limitation in people with KOA. The findings would offer specific target value indicating functional limitation using practical measure that can be applied for early screening with periodic follow-up of these people in various settings.

Materials and methods

Study design and participants

This cross-sectional study was conducted in people with KOA from several communities in Northeast and southern areas of Thailand. The sample size was estimated using the data from 30 pilot cases with the sensitivity of FTSST being 83%, while the prevalence of Thai frailty people with KOA was around 69.1%⁽¹⁹⁾. The α error and the precision of the estimation were set at 0.05 and 10% (0.1), respectively. Thus, this study required at least 77 participants. The research protocol of this study was approved by the Khon Kean University Ethics Committee for Human Research (HE652028). Participants needed to sign an informed consent document prior to the participation in the study.

The inclusion criteria were aged between 50 and 79 years, both males and females with unilateral or bilateral KOA as determined using the criteria from the American College of Rheumatology (ACR) classification⁽²⁰⁾. The ACR's criteria consists of having knee pain (≤ 7 out of 10), with the addition of 3 out of 6 criteria, including the age of 50 years and over, crepitus on motion, morning stiffness, bony enlargement, bony tenderness, and no palpable warmth⁽²¹⁾. Moreover, the eligible participants needed the ability to perform the test, and understand the command and protocol of the study^(22,23). These individuals were excluded if they had a history of lower extremity joint replacement surgery, with any neurological impairments and residual defect involving mobility, as well as any signs and symptoms affecting the ability to complete the test^(16,22,24).

Research protocol

The eligible participants were assessed for their functional limitation using WOMAC questionnaire and FTSST. Details of the tests are as follows.

WOMAC questionnaire

This questionnaire contains 24 items, which are divided into three subscales, including pain (5 items), stiffness (2 items), and physical function (17 items), with four scales of each item. Thus, the maximum WOMAC score is 96. Among these items, the level of functional limitation was considered using the physical function subscale. Participants with the score at least 28 out of 68 were classified as having functional limitation⁽¹³⁾.

FTSST

Participants were asked to cross their arms on their chest and sat with their back against the backrest of the chair (43 cm chair height). The participants were instructed to stand up and sit down for five times as quickly as they could do safely. Timing began with the command “Go” and stopped when the participant’s back touched the chair on the fifth repetition. They were asked to perform three trials; then the average time was recorded in seconds⁽²⁵⁾.

Before the tests, participants were asked to wear sandal shoes and safety belt for their safety prepared by the researchers. A researcher was at their side without interruption to provide the assistance as needed and accuracy of the outcomes. Participants were able to take a period of rest between the trials as needed until their vital signs returned to their usual data.

Statistical analysis

The data were analyzed using the SPSS for Windows, version 22.0 (SPSS Statistics version

17.0; IBM Corporation, Armonk, NY, USA; serial number: 5068054). The descriptive statistics (mean, standard deviation, and percent) were applied to explain demographic characteristics of the participants. If the data were normally distributed, the independent samples t-test and Chi-square test were used to compare the findings between the groups (non-functional limitation and functional limitation groups) for continuous and categorical variables, respectively. However, if the data were non-normally distributed, the Mann-Whitney U Test and Fisher's Exact test were applied for the same objectives. Then, the Receiver Operator Characteristic (ROC) curve was applied to determine an optimal sensitivity and specificity for functional limitation of the participants. A level of significant difference was set at less than 0.05⁽²⁶⁾.

Results

Demographic characteristics of the participants

One hundred and thirty-two individuals with KOA were interested to participate the study. However, 26 individuals were excluded because of missing the inclusion criteria (Figure 1). Thus, a total of 106 participants completed the study, and were divided into non-functional limitation (n = 68, 64.1% and functional limitation (n = 38, 35.9%) groups based on their WOMAC (functional part) scores. All demographic characteristics of the participants were shown in table 1. However, 13 participants were unable to perform FTSST due to exhaustion, increased knee pain, and requiring upper limb contribution for standing up. Thus, 93 participants were able to complete the FTSST.

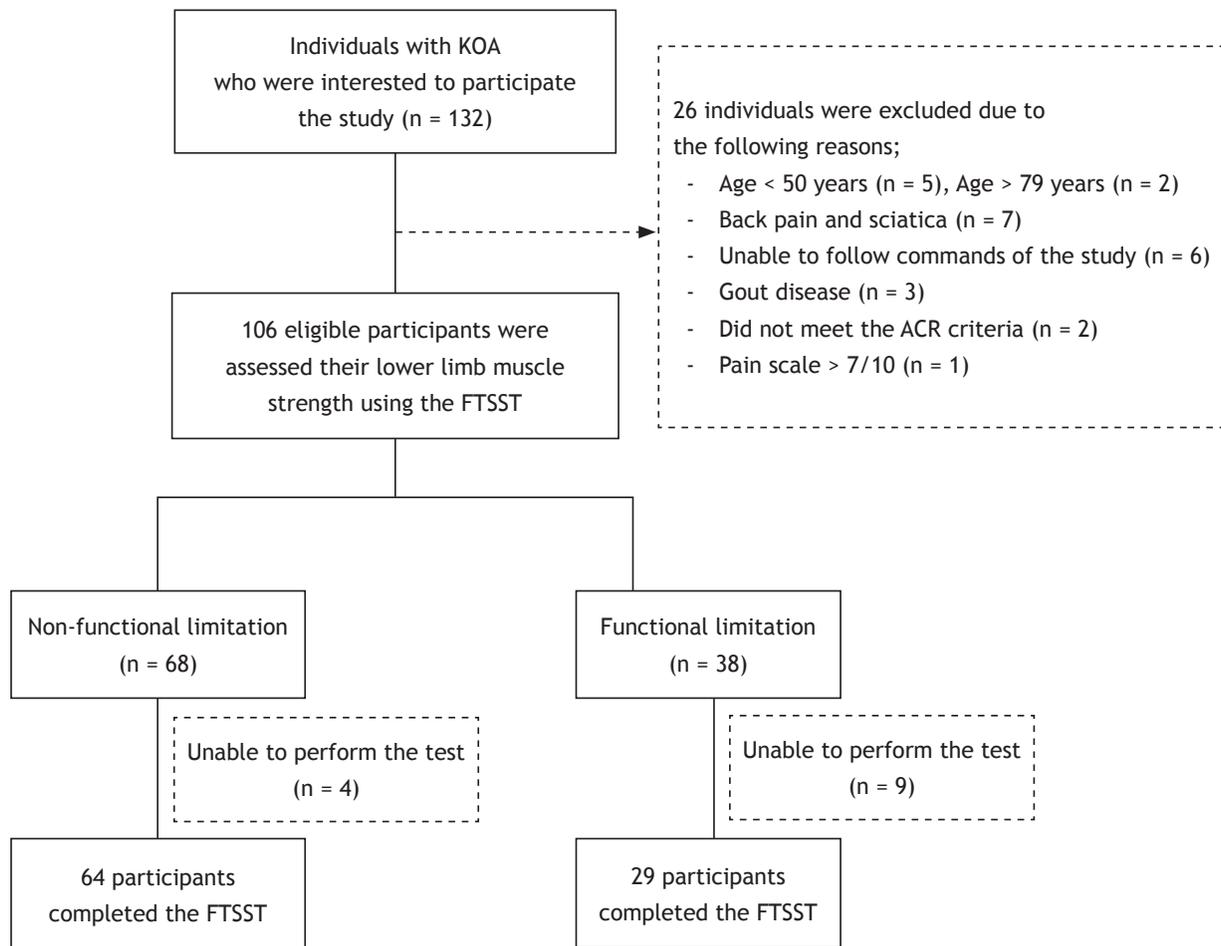


Figure 1 Participation flowchart.

Abbreviations: KOA, knee osteoarthritis; ACR, American College of Rheumatology; FTSST, five times sit-to-stand test.

FTSST data

Table 2 presents the FTSST data. All participants could complete the FTSST in approximately 15s, whereby those with functional limitation group used time to

complete the test significantly longer than those in the non-functional limitation group (p -value < 0.001). The duration to complete the FTSST 15s and over could excellently determine those with functional limitation (Table 3).

Table 1 Demographic characteristics of the participants

Variable	All (n = 106)			Non-functional limitation (n = 68)			Functional limitation (n = 38)			p-value
	Mean ± SD (95%CI)	Median	Min - Max	Mean ± SD (95%CI)	Median	Min - Max	Mean ± SD (95%CI)	Median	Min - Max	
Sex: female, n(%) ^a		83 (78.3)			47 (69.1)			36 (94.7)		0.002 ^a .
Age (years)	61.77 ± 8.04 (60.33 - 63.35)	61	50 - 79	25.60 ± 4.07 (24.62 - 26.59)	59	50 - 79	26.69 ± 4.75 (25.13 - 28.25)	65.5	50 - 79	<0.001 ^{d,*}
BMI (kg/m ²)	25.99 ± 4.33 (25.16 - 26.83)	25.64	16.23 - 37.38	3.87 ± 1.23 (3.57 - 4.17)	25.11	17.22 - 37.38	5.16 ± 1.08 (4.80 - 5.51)	26.33	16.23 - 35.00	0.21 ^{6c}
NRS (score)	4.33 ± 1.33 (4.08 - 4.59)	4	2 - 7		4	2 - 6		5	2 - 7	<0.001 ^{d,*}
ACR items										
Average ACR score	5.19 ± 0.83 (5.04 - 5.36)	5	3 - 6	4.99 ± 0.85 (4.78 - 5.18)	5	3 - 6	5.58 ± 0.64 (5.35 - 5.77)	6	5 - 6	<0.001 ^{d,*}
ACR classification, n(%) ^a										<0.001 ^{b,*}
Age ≥ 50 years		106 (100)			68 (100)			38 (100)		
Morning stiffness		97 (91.5)			59 (86.8)			38 (100)		
Crepitus		91 (85.8)			54 (79.4)			37 (97.4)		
Bony tenderness		101 (95.3)			64 (94.1)			37 (97.4)		
Bony enlargement		56 (52.8)			27 (39.7)			29 (76.3)		
No palpable warmth		106 (100)			68 (100)			38 (100)		
Type of KOA lesion, n(%) ^a										
Unilateral : Bilateral	52 (49.1) : 54 (50.9)			38 (55.9) : 30 (44.1)			14 (36.8) : 24 (63.2)			0.060 ^a
Knee deformity [Yes, n(%)] ^f	43 (40.6)			21 (30.9)			22 (57.9)			0.007 ^{b,*}
WOMAC Index (score)	31.43 ± 16.78 (28.12 - 34.74)	28.50	7 - 87	21.50 ± 9.00 (19.36 - 23.66)	21	7 - 41	49.21 ± 12.12 (45.51 - 53.06)	44.5	36 - 87	<0.001 ^{d,*}
WOMAC (Pain)	5.74 ± 3.25 (4.08 - 4.59)	5	1 - 20	4.12 ± 1.99 (3.62 - 4.61)	4	1 - 10	8.63 ± 3.07 (7.74 - 9.71)	8	2 - 20	<0.001 ^{d,*}
WOMAC (Stiffness)	2.52 ± 1.35 (2.28 - 2.76)	2	0 - 8	2.22 ± 1.26 (12.95 - 2.54)	2	0 - 8	3.05 ± 1.37 (2.66 - 3.52)	2	2 - 8	0.002 ^{c,*}
WOMAC (Functional)	23.15 ± 13.12 (20.58 - 25.74)	21	5 - 59	15.18 ± 6.82 (13.54 - 16.80)	15	5 - 28	37.42 ± 8.87 (34.62 - 40.07)	34	29 - 59	<0.001 ^{d,*}

Note: The data were compared using independent t-test, *Indicated significant difference (p-value < 0.001).

Abbreviations: FTSST, five times sit-to-stand test; SD, standard deviation; CI, confidence interval.

Table 1 Demographic characteristics of the participants (Cont.)

Variable	All (n = 106)			Non-functional limitation (n = 68)			Functional limitation (n = 38)			p-value
	Mean ± SD (95%CI)	Median	Min - Max	Mean ± SD (95%CI)	Median	Min - Max	Mean ± SD (95%CI)	Median	Min - Max	
KOA duration (month)	39.88 ± 45.77 (31.05 - 49.35)	24	1 - 228	29.82 ± 39.53 (21.55 - 40.02)	12	1 - 228	57.88 ± 50.95 (42.94 - 73.06)	36	4 - 216	<0.001 ^{d,*}
Underlying disease [Yes, n(%)] ^f	70 (66)			44 (64.7)			26 (68.4)			0.699 ^a
Level of education, n(%) ^g										<0.001 ^{b,*}
Under elementary school		14 (13.2)			4 (5.9)			10 (26.3)		
Elementary school		65 (61.3)			39 (57.4)			26 (68.4)		
Secondary school		11 (10.4)			9 (13.2)			2 (5.3)		
College		16 (15.1)			16 (23.5)			0 (0)		

Note: ^fThe data are presented using the number (percent of total participants). ^aData were compared using Chi-square test, ^bFisher's Exact test, ^cIndependent samples t-test, and ^dMann-Whitney U Test, ^eIndicated significant differences (p-value < 0.05).

Abbreviations: BMI, body mass index; NRS, numeric rating scale; ACR, American College of Rheumatology; KOA, knee osteoarthritis; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

Table 2 Comparison of the FTSST between non-functional limitation and functional limitation groups

Test	All (n = 93)			Non-functional limitation (n = 64)			Functional limitation (n = 29)			Mean difference (95%CI)	p-value
	Mean ± SD (95%CI)	Min - Max	Mean ± SD (95%CI)	Min - Max	Mean ± SD (95%CI)	Min - Max					
FTSST (s)	15.35 ± 4.95 (14.36 - 16.44)	8.93 - 33.49	13.35 ± 2.63 (12.71 - 13.99)	8.93 - 19.82	19.77 ± 5.96 (17.59 - 21.97)	10.05 - 33.49 (4.66 - 8.19)	6.42			<0.001 [*]	

Note: The data were compared using independent t-test, ^{*}Indicated significant difference (p-value < 0.001).

Abbreviations: FTSST, five times sit-to-stand test; SD, standard deviation; CI, confidence interval.

Table 3 Cut-off scores of FTSST to determine functional limitation

Test	n	Cut-off score	Sensitivity (%)	Specificity (%)	AUC	95%CI of AUC
FTSST (s)	93	≥ 15.00	0.79	0.71	0.838	0.74 - 0.93

Abbreviations: FTSST, five times sit-to-stand test; AUC, area under the curve; CI, confidence interval.

Discussion

The study compared the FTSST data between participants with functional limitation and non-functional limitation. In addition, the study explored the specific cut-off score of the FTSST to indicate functional limitation in people with KOA. The findings indicated that approximately one-third of the participants with KOA had functional limitation. Participants with functional limitation used the time to complete the FTSST significantly longer than those with non-functional limitation (Table 2). The FTSST ≥ 15 seconds could excellently indicate functional limitation in people with KOA (Table 3).

To the best of the researchers' knowledge, there were no data on functional limitation in individuals with KOA available. The current findings indicated that more than one-third (35.9%) of participants with KOA experienced functional limitation. These individuals had significantly poorer ability to perform FTSST as compared to those without functional limitation (p -value < 0.001). These findings may reflect their natural characteristics, whereby they were older with significantly greater number of females and those with knee deformity (p -value < 0.01 , table 1). In addition, they had significantly longer duration after having KOA, higher pain severity with low level of education as compared to those without functional limitation (p -value < 0.01 , table 1). These findings associated with previous reports that individual factors including severity of KOA, knee deformity, level of pain and joint stiffness, and a long duration after KOA significantly induced functional limitation^(27,28). Having such characteristics crucially affect the ability to complete the FTSST. Eriksrud et al⁽²⁹⁾ reported that, apart from lower-extremity range of motion and balance ability, the FTSST is crucially affected by lower-extremity muscle force. Wretenberg and Aborelius⁽³⁰⁾ found that the knee extensors contribute 72% of the concentric force at the hip and the knee joint while completing a sit-to-stand task. As a demanding activity for

lower limb muscles and motion, participants with functional limitation who had greater pain severity and the higher number of those with knee deformity completed the FTSST using significantly longer duration than those with non-functional limitation (Table 2). Furthermore, the high demanding limited the ability of 13 participants with KOA, regardless of functional limitation to complete the test (Figure 1).

The findings further suggested that the ability to complete the FTSST ≥ 15 seconds (79% sensitivity, 71% specificity) could indicate functional limitation in people with KOA (Table 3), which was longer than that of the another event in individuals with KOA⁽¹⁸⁾. Amano and Suzuki⁽¹⁸⁾ found that the time to complete the FTSST of greater than 7.9 seconds (92% sensitivity, 58% specificity, and AUC=0.79) could detect the possibility of fall in people with KOA⁽¹⁸⁾. Although they applied the same protocol of FTSST of the present study, KOA condition was diagnosed using the radiography. Even though the radiography is a standard method, the participants with asymptomatic KOA without any pain were included into their study. Therefore, using the ACR criteria to diagnose KOA condition help to recruit people with symptomatic KOA, who are more likely to have functional limitation. Additionally, the elderly women who completed the FTSST more than 13 seconds (85.7% sensitivity and 53.2% specificity, and AUC=0.72) indicated the highest probability to have sarcopenia⁽³¹⁾. They included the participants focusing on muscle strength and performance. The findings from previous report may imply that although KOA participants in the present study (mean score of FTSST as 13.35 ± 2.63 seconds) had no functional limitation, they might have a chance to develop poor performance and sarcopenia.

The present findings offer evidence supporting the use of a practical and demanding measure, namely the FTSST, to screen and monitor functional limitation of individuals with KOA. The present study applied the FTSST because it is a test specifically demanding for the knees. Therefore,

clinical application of the test should be used with caution as it might aggravate pain severity of the individuals. A further study may apply other indirect practical measures relating to KOA to offer practical measure to be used in all individuals with KOA.

Conclusion

The study compared the outcomes of FTSST between participants with KOA who had functional limitation and non-functional limitation, and explored the specific cut-off score of the FTSST to indicate functional limitation in these individuals. The findings indicated that approximately one-third of the participants with KOA had functional limitation, whereby they could complete the FTSST significantly longer than those with non-functional limitation. The FTSST ≥ 15 seconds could excellently indicate functional limitation in people with KOA. The findings suggest the use of FTSST as a practical and demanding measure to screen and monitor functional limitation of individuals with KOA.

Take home messages

More than one-third of people with KOA had functional limitations. The use of FTSST and its target value of ≥ 15 seconds might help to screen and monitor individuals with KOA to minimize the possibility of having functional limitation in these individuals.

Conflicts of interest

The authors declare no conflict of interest.

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