

ORIGINAL ARTICLE

Minimal Detectable Change for Motor Function Tests in Patients with Knee Osteoarthritis

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Objective: Improvement in a subject's motor function is clinically evaluated by comparing measurements of the motor function tests taken before and after an intervention. Consequently, it is important to increase the accuracy of the determination of the intervention effect by confirming the minimal detectable change (MDC), which is an index representing the limits of measurement errors in motor function tests. This study aimed to examine the MDC of the five-time sit-to-stand test (FTSST) and the 5-m walk test (5mWT) in patients with knee osteoarthritis (OA). **Methods:** In this cross-sectional study, 83 patients (63 women and 20 men, mean age: 73.7±8.0 years) with knee OA were subjected to two trials of the FTSST and 5mWT. The maximum walking speed was calculated using the walking time in the 5mWT, and the intraclass correlation coefficients (ICCs) were determined. **Results:** The ICCs (1,1) of the FTSST, the walking time in the 5mWT, and the walking speed were 0.90, 0.83, and 0.81, respectively. The MDC₉₅ for the FTSST time, walking time in the 5mWT, and walking speed were 1.71 s, 0.99 s, and 0.36 m/s, respectively. **Conclusion:** If the observed changes in the motor function tests exceed 1.71 s for FTSST time, 0.99 s for walking time in the 5mWT, or 0.36 m/s for walking speed, then an improvement in function is indicated. Such an improvement would reflect the effectiveness of the intervention. These findings may aid in clinical decision making when using motor function tests in patients with knee OA.

Key Words: evaluation criteria; knee osteoarthritis; rehabilitation; sit-to-stand test; walk test

INTRODUCTION

Knee osteoarthritis (OA) is one of the most common joint disorders. It is a degenerative disease characterized by knee muscle weakness or atrophy, reduced range of motion (ROM) of the knee joint, and knee pain, and consequently can undermine independence in activities of daily living (ADL).^{1,2)} Because standing and walking are important motions in ADL, decreased activity is highly likely in patients with OA.^{3,4)} Therefore, exercise therapy for improving motor functions, such as standing and walking, is a major element of rehabilitation in patients with knee OA.

Conservative therapy is generally effective and is the first-choice treatment for knee OA. In rehabilitation, which is the core of conservative therapy, the effectiveness of exercise therapy (e.g., muscle strengthening and ROM exercises) is recognized.⁵⁻⁷⁾ In the clinical setting, whether the motor

function (e.g., standing and walking) of the subjects has improved is evaluated by comparing the measured values of the motor function tests taken before and after the intervention. Therefore, these motor function tests should be reliable in a clinical setting. Moreover, it is important to increase the accuracy of evaluating the intervention effect by clarifying the minimal detectable change (MDC), which is an index representing the limits of measurement error in motor function tests.

Relevant motor function tests include the sit-to-stand test (SST) to evaluate the standing ability and the walk test (WT) to evaluate the walking ability. Both are frequently used in clinical practice because they do not require a lot of space or special equipment. The MDC in the SST has been studied in patients with Parkinson's disease,⁸⁾ those undergoing hemodialysis,⁹⁾ and those with end-stage renal disease.¹⁰⁾ Moreover, the MDC in the WT has been investigated in patients

Received: August 21, 2018, Accepted: December 3, 2018, Published online: December 22, 2018

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with stroke,¹¹⁾ Parkinson's disease,¹²⁾ spinal cord injury,¹³⁾ femoral neck fracture,¹⁴⁾ and chronic obstructive pulmonary diseases.¹⁵⁾ The MDC can be used in clinical decision making when interpreting the improvement in standing and walking abilities in patients with the above-mentioned diseases. However, the MDCs for the SST and WT in patients with knee OA have never been studied. Therefore, the purpose of this research was to examine the MDC of the SST and WT in patients with knee OA.

METHODS

Study Design

This was a cross-sectional study. The protocol was approved by the Institutional Review Board (approval no. 08–14).

Participants

The inclusion criteria for participant selection were (1) a diagnosis of knee OA, (2) undergoing conservative intervention as an outpatient in a clinic, (3) the ability to stand from a chair without assistance or the use of upper extremity support, and (4) the ability to walk 11 m or more without assistive devices. The exclusion criteria were (1) patients with a history of knee surgery and (2) patients with restricted abilities to sit, stand, or walk because of other joint conditions. The participants were given an explanation of the study and its procedures; they subsequently gave written informed consent for participation.

Estimation of Sample Size

Power analysis was performed using G*Power 3.1.9.2 (Heinrich-Heine University, Düsseldorf, Germany). The α error was set at 0.05, the power was set at 0.80, the effect size ρ was set at 0.30, and a two-tailed test was selected. The power analysis indicated a sample size of more than 82 participants.

Measurements

In this study, the five-time sit-to-stand test (FTSST)¹⁶⁾ was used as the SST, and the 5-m walk test (5mWT)¹⁷⁾ was used as the WT. We measured the MDC twice on the same day without any interventions between the test and retest because we wished to avoid the influence of any interventions on the MDC. The two tests were performed at different times of the day. Furthermore, the participants were allowed to practice until the motions became familiar before measurements were recorded.

FTSST

The participants were asked to sit with their arms folded across their chests and with their backs against the chair. A stopwatch and a standard chair (43-cm high) were used. The participants were asked to do five repetitions of standing from seated and then sitting on the chair as quickly as they could. Timing began at "Go" and ended when the patients sat on the chair after the fifth repetition.

5mWT

In the 5mWT, the time taken to walk 5-m of an 11-m track was recorded. The timed 5-m distance covered the middle of the track, denoted by markers 3-m from both ends of the track. The resulting three zones were the initial 3-m acceleration zone, the central 5-m timed zone, and the final 3-m deceleration zone. The participants were asked to walk on the 11-m track as fast as they could without using an assistive device. Moreover, walking speed (m/s) was calculated as the distance (5-m) divided by the walking time (s).

Analysis

The intraclass correlation coefficients (ICCs) of the FTSST and 5mWT walking time and walking speed were calculated. Then, using ICC (1,1), the standard error of measurement (SEM) and MDC₉₅ were calculated using the following formulas:

$$\text{SEM} = \text{standard deviation of measurements} \times \sqrt{1 - \text{ICC}}$$

$$\text{MDC}_{95} = \text{SEM} \times 1.96 \times \sqrt{2}$$

SPSS Statistics version 22 (IBM Japan Co., Tokyo Japan) was used to analyze the collected data, and statistical significance was set at $P < 0.05$.

RESULTS

We enrolled 83 outpatients with knee OA (63 women and 20 men, mean age: 73.7±8.0 years) who met the inclusion criteria and provided consent. The characteristics of the participants are shown in **Table 1**. In total, 43 participants (51.8%) had grade II knee OA according to the Kellgren-Lawrence (K-L) classification. The findings of the motor function tests are listed in **Table 2**. Our results showed that the ICC (1,1) of the FTSST, the walking time in the 5mWT, and the walking speed were 0.90, 0.83, and 0.81, respectively. The MDC₉₅ of the FTSST time, walking time in the 5mWT, and walking

Table 1. Characteristics of participants (n=83)

Basic attributes	Sex	Women: 63 (75.9), Men: 20 (24.1)
	Age (years)	73.7±8.0
	Height (cm)	153.2±8.0
	Weight (kg)	56.5±10.1
	BMI (kg/m ²)	24.1±3.8
Medical characteristics	K-L grades	I: 17 (20.5), II: 43 (51.8), III: 12 (14.5), IV: 11 (13.2)
	Lesion	Bilateral knee OA: 58 (69.9), Unilateral knee OA: 25 (30.1)

Data are presented as means ± standard deviations or n (%). BMI: body mass index, K-L grades: Kellgren-Lawrence grades.

Table 2. Summary of motor function test results

	Test session 1	Test session 2
Five-time sit-to-stand test (s)	8.95±2.03	8.28±2.06
Walking time in 5mWT (s)	3.89±0.90	3.52±0.81
Walking speed (m/s)	1.35±0.28	1.48±0.29

Data are presented as mean ± standard deviation.

Table 3. Reliability of the five-time sit-to-stand test and 5-m walk test

	ICC (1,1)	95% CI	P-value	SEM	MDC ₉₅
Five-time sit-to-stand test (s)	0.90	0.85–0.94	<0.001	0.62	1.71
Walking time in 5mWT (s)	0.83	0.75–0.89	<0.001	0.36	0.99
Walking speed (m/s)	0.81	0.72–0.87	<0.001	0.13	0.36

CI: confidence interval.

speed were 1.71 s, 0.99 s, and 0.36 m/s, respectively (**Table 3**).

DISCUSSION

Because the ICC (1,1) values were greater than 0.8, indicating almost perfect agreement, this study showed the high reliability of the FTSST and 5mWT in our participants with knee OA.¹⁸⁾ While these high reliabilities were found in both the FTSST and 5mWT in our study participants with knee OA,¹⁹⁾ the same high reliabilities were also found in patients with other diseases.^{8,11)} In Japanese studies, the 30-s chair-stand test (30CST)²⁰⁾ might be used more commonly than the FTSST; however, the FTSST has been shown to be as reliable as the 30CST.^{21,22)} The 10-m walk test (10mWT)²³⁾ might also be more common than the 5mWT. However, the 5mWT is more convenient than the 10mWT, because the 5mWT does not require a long indoor walking path. Therefore, the motor function tests used in this study were shown to be convenient and useful indices in the clinical setting.

This study determined that changes exceeding 1.71 s in the FTSST time are changes in clinically meaningful that

exceed the measurement error. Master et al.²⁴⁾ reported 10.5±2.9 s as the FTSST time for 1925 patients with knee OA (1065 women, mean age 65.1±9.1 years), and Bohannon et al.²⁵⁾ showed that FTSST times in community-dwelling elderly people were 8.1±3.1 s in individuals aged 60–69 years, 10.0±3.1 s in individuals aged 70–79 years, and 10.6±3.4 s in individuals aged 80–89 years, and these times are used as reference values. It is important to interpret these values by comparing them with the reference values in previous studies to accurately grasp the decline in the standing ability of patients with knee OA. However, the MDC₉₅, rather than the above reference values, should be taken into account when evaluating the change in the FTSST time and the effects of interventions. Given that we could compare the measured FTSST times taken before and after the intervention on the basis of our study results, we consider that FTSST times constitute a useful index for clinical decision making.

Our MDC₉₅ results for the 5mWT showed that the limits of measurement error for walking time and walking speed were 0.99 s and 0.36 m/s, respectively, which are important to take into account when using the 5mWT in patients with knee OA in a clinical setting. In previous studies, the MDCs

of the WTs were shown in terms of speed (m/s) rather than in terms of time (s).^{11–14} If the MDCs of WTs are evaluated using speed rather than time, it can take some time to derive the walking speed (m/s), reducing the usefulness of the WTs. In clinical settings, the walking time (s) may be more useful than the walking speed (m/s), because no calculation is involved when dealing with times. As mentioned above, a decrease in the 5mWT walking time of more than 0.99 s after the intervention indicates that the walking ability has improved, thereby indicating the effectiveness of the intervention.

Our study clarified that a change in the maximum walking speed exceeding 0.36 m/s indicates a meaningful change in a clinical setting. Watanabe et al.²⁶ assessed 30 participants with knee OA (21 women, 9 men, mean age: 76.0 years) and concluded that the maximum walking speed increased significantly from 0.63±0.26 m/s to 0.70±0.19 m/s after three weeks of body-weight-supported treadmill training. Homma et al.²⁷ assessed seven participants with knee OA (five women, two men, mean age: 79.3 years) and concluded that the maximal walking speed increased significantly from 1.24±0.18 m/s to 1.32±0.18 m/s after static stretching of the popliteal region. However, the results of those studies did not consider the limits of measurement errors using the 95% confidence interval or MDC₉₅. Although the maximum walking speed improved significantly after the intervention in those studies, the change appears to be within the limits of measurement errors derived from our present study, thereby undermining the meaningfulness of the findings.

Several limitations to the present study should be acknowledged. First, because participants with other joint dysfunctions, such as those in the hip or lower back, were excluded, the results of our study should not be extended to such populations. Second, we did not consider inter-rater reliability in this study, and the corresponding findings were not included. Third, we did not investigate the FTSST and 5mWT findings from the onset of knee OA, and, moreover, we did not conduct the assessments on the first day of conservative therapy. Therefore, the influence of these factors remains unknown.

CONCLUSION

The results of this study showed for the first time that, for patients with knee OA, the MDC₉₅ values of the FTSST time, the walking time in the 5mWT, and the walking speed are 1.71 s, 0.99 s, and 0.36 m/s, respectively. If changes in motor function tests exceeding these MDC₉₅ values are observed,

this indicates that the motor function has improved, thereby indicating the effectiveness of the intervention. Therefore, these findings may aid in clinical decision making when using motor function tests in patients with knee OA.

CONFLICTS OF INTEREST

The authors declare that there are no conflict of interests.

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