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Development and Validation of a Modified Five-Times Sit-to-Stand Test in Hospitalized Patients

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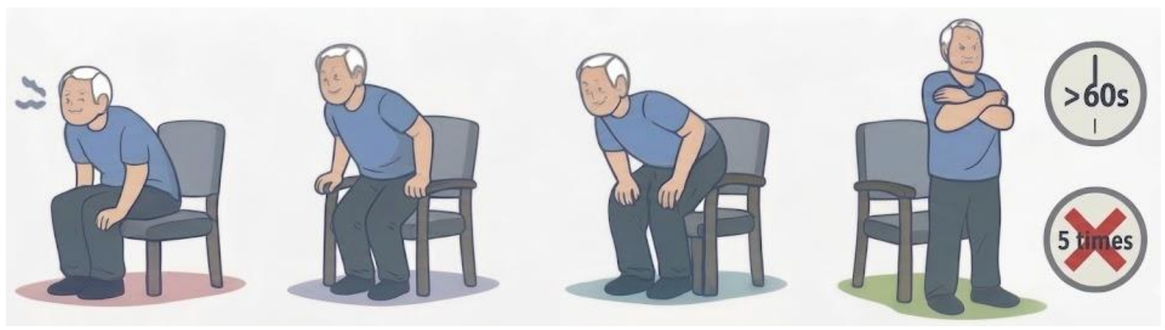
Introduction

- The five-times sit-to-stand test (5TSTS) assesses functional lower-extremity strength and mobility and is incorporated into the Short Physical Performance Battery (SPPB) chair-stand component by converting completion time into an ordinal score (0–4).
- However, many hospitalized patients with low baseline functional capacity cannot complete the 5TSTS, resulting in a pronounced floor effect that limits discrimination among low-functioning individuals.
- In our clinical practice, we have routinely used and recorded a modified 5TSTS to better stratify functional ability among low-functioning individuals, and evaluated its clinical utility in this study.

Table 1. Scoring Criteria for the Modified and Conventional Five-Times Sit-to-Stand Tests

Modified Five-Times Sit-to-Stand Test (modified 5TSTS)		Five-Times Sit-to-Stand Test (5TSTS)	
0	Unable to rise from the chair	0	Unable to complete 5 repetitions with arms folded or requires ≥ 60 seconds
1	Able to stand using armrest support		
2	Able to stand using hands-on-knees support		
3	Able to stand with arms folded but unable to complete 5 repetitions or requires ≥ 60 seconds		
4	Able to complete 5 repetitions with arms folded in 16.7–60 seconds	1	Able to complete 5 repetitions with arms folded in 16.7–60 seconds
5	Able to complete 5 repetitions with arms folded in 13.7–16.69 seconds	2	Able to complete 5 repetitions with arms folded in 13.7–16.69 seconds
6	Able to complete 5 repetitions with arms folded in 11.2–13.69 seconds	3	Able to complete 5 repetitions with arms folded in 11.2–13.69 seconds
7	Able to complete 5 repetitions with arms folded in ≤ 11.19 seconds	4	Able to complete 5 repetitions with arms folded in ≤ 11.19 seconds

Figure 1. Illustration of the 0-3 Categories of the Modified Five-Times Sit-to-Stand Tests



Methods

Design
- A single center retrospective observational study

Participant
- Hospitalized adults with a recorded modified 5TSTS

Clinical Data
- Modified 5TSTS, conventional 5TSTS
- Handgrip strength, knee extensor strength
- Functional Ambulation Category (FAC), ICU Mobility Scale (ICU-MS)
- For patients with repeated assessments, all measurement occasions were included and each assessment was analyzed as an independent observation.

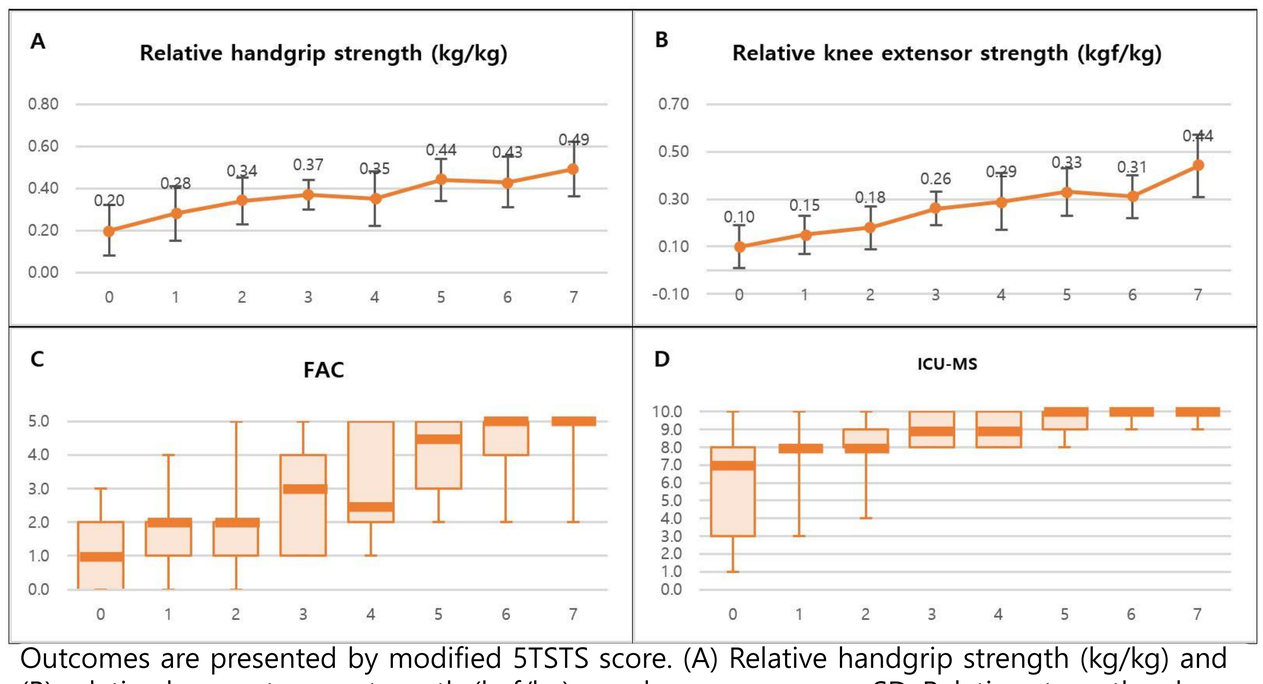
Results

Table 2. Patient-Level Baseline Characteristics

Variables		Patent N = 187 (Assessment N = 291)
Age (year)	Mean±SD	58.6±14.9
Sex		
Male	N (%)	109 (58.3)
Female	N (%)	78 (41.7)
BMI (kg/m^2)	Mean±SD	21.80±4.14
Handgrip strength (kg)	Mean±SD	23.19±11.20
	Median (IQR)	22.25 (15.78-30.73)
Normalized handgrip strength (kg/kg)	Mean±SD	0.39±0.16
	Median (IQR)	0.40 (0.29-0.51)
Knee extensor strength (kgf)	Mean±SD	20.61±11.27
	Median (IQR)	19.80 (11.63-27.63)
Normalized knee extensor strength (kgf/kg)	Mean±SD	0.34±0.16
	Median (IQR)	0.33 (0.22-0.44)
FAC	Median (IQR)	4 (2-5)
ICU-MS	Median (IQR)	9 (8-10)

Handgrip strength and knee extensor strength were normalized to body weight and are presented as kg/kg and kgf/kg, respectively./kg.
Abbreviations: N, number; SD, standard deviation; IQR, interquartile range; BW, body weight; FAC, Functional Ambulation Category; ICU-MS, Intensive Care Unit Mobility Scale.

Figure 1. Muscle strength and functional status across performance levels of the modified Five-Times Sit-to-Stand Test (modified 5TSTS)



Outcomes are presented by modified 5TSTS score. (A) Relative handgrip strength (kg/kg) and (B) relative knee extensor strength (kgf/kg) are shown as mean ± SD. Relative strength values are normalized to body weight. (C) Functional Ambulation Category (FAC) and (D) ICU Mobility Scale (ICU-MS) are displayed as box-and-whisker plots (median, interquartile range, and range).

- The modified 5TSTS showed a positive association with muscle strength and functional status, with a consistent stepwise gradient, particularly within the newly defined 0–3 levels that further stratified the original floor category.

Table 3. Monotonic Trends in Muscle Strength and Functional Outcomes within Lower Modified Five-Times Sit-to-Stand Test Categories (0-3)

Outcome variables	N	Jonckheere-Terpstra statistic	p-value
Handgrip strength	159	6278.0	<0.001*
Relative handgrip strength	159	6290.0	<0.001*
Knee extensor strength	59	786.5	<0.001*
Relative knee extensor strength	59	753.5	0.001*
FAC	159	5936.5	<0.001*
ICU-MS	159	6186.5	<0.001*

When the analysis was extended to participants with modified sit-to-stand scores of 0–7, significant monotonic increases were still observed across all measures (all $p < 0.05$).

- Jonckheere–Terpstra tests showed significant monotonic trends across scores 0–7 and 0–3 (all $p \leq 0.001$), confirming ordinal validity and improved discrimination within the lower range.

Table 4. Comparison of Spearman Correlations Between the Modified and the Conventional Five-Times Sit-to-Stand Test Scores with Muscle Strength and Functional Measures

		Modified 5TSTS		Conventional 5TSTS	
Measures	N	Spearman's ρ (95% CI)	p-value	Spearman's ρ (95% CI)	p-value
Handgrip strength	290	0.721 [0.654–0.774]	<0.001*	0.669 [0.594–0.726]	<0.001*
Relative handgrip strength	290	0.680 [0.603–0.740]	<0.001*	0.621 [0.542–0.688]	<0.001*
Knee extensor strength	180	0.769 [0.698–0.821]	<0.001*	0.755 [0.680–0.810]	<0.001*
Relative knee extensor strength	180	0.726 [0.644–0.790]	<0.001*	0.713 [0.630–0.781]	<0.001*
FAC	289	0.816 [0.768–0.852]	<0.001*	0.802 [0.756–0.838]	<0.001*
ICU-MS	254	0.801 [0.741–0.845]	<0.001*	0.760 [0.699–0.805]	<0.001*

ρ, Spearman's rank correlation coefficient.; CI, confidence interval obtained using bias-corrected and accelerated (BCa) bootstrap with 5,000 resamples.

- Spearman correlations between the modified 5TSTS and strength/mobility measures were moderate-to-strong (ρ=0.68–0.82) and were generally higher than those for the SPPB 5TSTS.7

- The floor effect was 55.0% for the conventional 5TSTS versus 23.0% for the modified 5TSTS.
- Among the conventional 5TSTS score 0 assessments, 58.1% were reclassified to modified scores 1–3 in modified 5TSTS.

Conclusion

- The modified 5TSTS provides a biomechanically plausible stepwise hierarchy by grading levels of assistance within the conventional "unable-to-perform" category.
- The modified 5TSTS reduced floor effects while maintaining ordered associations with strength and mobility measures, supporting construct validity and enabling more effective functional assessment of low-functioning patients than the conventional SPPB.

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