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Convergent Validity and Test-Retest Reliability of the 1-Minute Sit-to-Stand Test Compared with the 6-Minute Walk Test in Adults with Cardiovascular Disease: A Systematic Review and Correlation Meta-Analysis

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Abstrak:

Pendahuluan: Penyakit kardiovaskular merupakan penyebab kematian terbesar di dunia. 6-Minute Walk Test (6MWT) merupakan uji kapasitas fungsional kardiorespirasi yang paling sering digunakan, akan tetapi memerlukan koridor lurus minimal 30 meter sehingga kurang memungkinkan untuk telehealth, dan pada setting dengan sumber daya terbatas. Disisi lain 1-Minute Sit-to-Stand Test (1-MSTST) hanya memerlukan kursi standar dan ruang kecil. Penelitian ini bertujuan untuk melakukan tinjauan sistematis dan meta-analisis untuk menilai validitas konvergen serta reliabilitas uji-ulang 1-MSTST terhadap 6MWT pada populasi dewasa dengan penyakit kardiovaskular. **Metode:** Tinjauan ini mengikuti pedoman PRISMA 2020 dan telah diregistrasikan di Prospero (CRD420261378362) dan OSF. Tujuh basis data ditelusuri sampai Maret 2026. Studi yang membandingkan 1-MSTST dan 6MWT pada pasien dewasa dengan CVD dimasukkan. Risiko bias dinilai dengan COSMIN, dan kepastian bukti dengan GRADE yang dimodifikasi. Koefisien korelasi disatukan menggunakan transformasi z Fisher dengan model efek acak (estimator REML, penyesuaian Knapp-Hartung). **Hasil:** Enam studi dengan 400 pasien memenuhi kriteria meta-analisis (penyakit arteri koroner, gagal jantung, fibrilasi atrium, hipertensi pulmonal, dan hipertensi arteri pulmonal terkait penyakit jantung bawaan). Korelasi gabungan 1-MSTST dengan 6MWT adalah $r = 0,70$ (IK 95%: 0,61–0,78; $I^2 = 60,5\%$), menunjukkan validitas konvergen sedang hingga kuat. Reliabilitas uji-ulang konsisten sangat baik (ICC 0,93–0,98). Dua studi melaporkan nilai batas diskriminatif (AUC 0,80–0,94). Penilaian bias publikasi formal tidak dilakukan karena jumlah studi terlalu sedikit ($k < 10$). **Kesimpulan:** 1-MSTST memiliki validitas konvergen baik dan reliabilitas tinggi terhadap 6MWT, sehingga berpotensi sebagai uji fungsional pelengkap ketika 6MWT tidak dapat dilakukan.

Kata kunci: *kapasitas fungsional; meta-analisis korelasi; penyakit kardiovaskular; rehabilitasi jantung; uji duduk-berdiri 1 menit; uji jalan 6 menit; validitas konvergen.*

Abstract:

Introduction: Cardiovascular disease (CVD) is the leading cause of mortality globally. The 6-Minute Walk Test (6MWT) is widely used but requires a corridor of at least 30 meters, limiting its use in telehealth and resource-limited settings. The 1-Minute Sit-to-Stand Test (1-MSTST), requiring only a standard chair and minimal space, offers a practical alternative. This study evaluated the convergent validity and test-retest reliability of the 1-MSTST versus the 6MWT in adults with CVD. **Methods:** Following PRISMA 2020 guidelines and registered in PROSPERO (CRD420261378362) and OSF, seven electronic databases were searched through March 2026. Eligible studies compared the 1-MSTST and 6MWT in adults with CVD. Risk of bias was assessed using COSMIN, evidence certainty using modified GRADE, and correlation coefficients were pooled via Fisher's z transformation in a random-effects model (REML estimator, Knapp-Hartung adjustment). **Results:** Six studies ($n = 400$) were included (coronary artery disease, heart failure, atrial fibrillation, pulmonary hypertension, and pulmonary arterial hypertension associated with congenital heart disease). The pooled correlation was $r = 0.70$ (95% CI: 0.61–0.78; $I^2 = 60.5\%$), indicating moderate-to-strong convergent validity. Test-retest reliability was excellent (ICC 0.93–0.98), and two studies reported discriminative cut-offs with AUCs of 0.80–0.94. Publication-bias testing was omitted due to fewer than ten pooled studies. **Conclusion:** The 1-MSTST shows good convergent validity and high test-retest reliability compared with the 6MWT, supporting its use as a complementary functional assessment when the 6MWT is not feasible.

Keywords: *1-minute sit-to-stand test; 6-minute walk test; cardiovascular disease; cardiac rehabilitation; convergent validity; correlation meta-analysis; functional capacity.*

1. Introduction

Cardiovascular disease (CVD) continues to dominate global mortality figures, with roughly 17.9 million deaths attributed to it each year (1). This burden is distributed unequally, as more than four out of five of these deaths occur in low- and middle-income countries (2). In Indonesia, CVD is responsible for nearly 35% of all deaths, and national health surveys conducted in 2018 estimated the prevalence of heart failure at around 1.5% (3). Against this backdrop, cardiac rehabilitation has established itself as a cornerstone of secondary prevention, with evidence linking program participation to approximately 20–27% reductions in cardiovascular mortality and roughly 18% fewer rehospitalisations (4,5). Accurate assessment of functional exercise capacity underpins the entire rehabilitation process, informing both the design of initial programming and the evaluation of treatment response (6).

Among available field tests, the 6-Minute Walk Test (6MWT) has long occupied a central role in cardiac assessment. First standardised by the American Thoracic Society in 2002 (7), the test underwent further refinements in the 2014 ATS/ERS technical update, addressing corridor layout, verbal encouragement, and safety supervision protocols (8). The test carries well-established prognostic value, one study found that each 104-meter gain in walk distance corresponded to a 55% lower likelihood of all-cause death risk among patient with stable coronary disease (9). Associations with peak oxygen uptake ($\text{VO}_{2\text{peak}}$) in heart failure populations have also been documented, with correlations typically between $r = 0.58$ and 0.66 (10). Despite these advantages, the 6MWT carries notable practical constraints. Administration requires a straight 30-meter corridor, staff trained in basic life support, and a total session time of up to 30–40 minutes when rest periods are factored in. These demands can pose significant barriers in telehealth environments, home-based rehabilitation programs, and smaller clinical facilities (11). The COVID-19 pandemic further exposed these vulnerabilities; cardiac rehabilitation attendance in the United States declined by approximately 94% during the early phase of the pandemic, and the need for a shorter, space-efficient alternative has remained considerable ever since (12).

Against this background, the 1-Minute Sit-to-Stand Test (1-MSTST) has attracted growing interest as a bedside measure of functional capacity. The test requires only a standard armless chair (seat height 45–48 cm), approximately 1–2 m² of space, and a stopwatch. Participants are instructed to complete as many full sit-to-stand repetitions as possible within 60 seconds, keeping their hands on the hips and achieving full knee extension at each stand (13). Normative reference data from a large Swiss cohort ($n = 6,926$) were reported by Strassmann et al. (14). Crook et al. subsequently validated the test in chronic obstructive pulmonary disease (COPD) patients, reporting correlations with 6-minute walk distance between $r = 0.59$ and 0.68 and identifying a minimal important difference of approximately three repetitions (15). A previous systematic review by Bohannon and Crouch (2019) included 17 studies across pulmonary, renal, neurological, and other populations, but did not incorporate cardiac cohorts (16). More recent evidence has emerged from cardiac-specific studies encompassing coronary artery disease (17), chronic heart failure (18–21), atrial fibrillation (22), and various forms of pulmonary hypertension (23–25).

Despite this growing literature, evidence on how the 1-MSTST performs specifically in CVD populations remains scattered. A narrative review by Kaur and colleagues summarized 10 studies across cardiorespiratory conditions, however, it did not include meta-analytic pooling or a formal quality appraisal (26). An editorial by Calik Kutukcu in the International Journal of Cardiology further emphasized the need for comprehensive evidence synthesis on this topic (27). Furthermore, no PROSPERO registration for a cardiac-specific systematic review was identified. Therefore, the aim of this study was to conduct a systematic review and correlation meta-analysis evaluating the convergent validity and test-retest reliability of the 1-MSTST compared to the 6MWT in adults with cardiovascular disease, with the goal of informing clinical decision-making regarding the complementary role of the 1-MSTST in functional capacity assessment within cardiac rehabilitation settings.

2. Method

2.1. Protocol and Eligibility Criteria

The protocol for this review was established prior to study screening, data extraction, and analysis. The review was conducted in accordance with the PRISMA 2020 guidelines. To ensure transparency, the protocol was prospectively registered in PROSPERO (CRD420261378362) and the Open Science Framework (OSF). Eligibility criteria were defined using the PICOS framework (Population, Intervention, Comparator, Outcomes, and Study design), as summarised in **Table 1**. Studies were excluded if: (a) the population was exclusively non-cardiac (e.g., COPD-only or neurological); (b) the STS test used a protocol other than 1-minute (e.g., 30-second or 5-repetition); (c) the STS and 6MWT were used as separate outcomes without direct comparison; (d) the publication type was a review, editorial, case report, or conference abstract without full numeric data; or (e) cardiac patients could not be separated from mixed populations.

Table 1. PICOS Component of this study

Component of PICOS	Description
Population	Adults (≥ 18 years) with any cardiovascular disease, including coronary artery disease (CAD), heart failure (HF, including HFrEF and HFpEF), atrial fibrillation (AF), pulmonary hypertension (PH) or pulmonary arterial hypertension (PAH), valvular heart disease, cardiomyopathy, or patients undergoing cardiac surgery
Intervention	1-Minute Sit-to-Stand Test (1-MSTST), number of repetitions in 60 seconds
Comparator	6-Minute Walk Test (6MWT), with distance walked (6MWD) as the primary outcome
Outcomes	Measures of agreement and validity between 1-MSTST and 6MWT, including: 1) Correlation coefficients (Pearson r / Spearman ρ) 2) Intraclass Correlation Coefficient (ICC) 3) Bland-Altman limits of agreement 4) ROC/AUC where available
Study design	Cross-sectional, prospective cohort, or validation studies

2.2. Search Strategy

Seven electronic databases were queried from their inception through March 2026, encompassing PubMed, Cochrane CENTRAL, Embase, CINAHL, Scopus, Web of Science, and PEDro. Search terms were constructed around sit-to-stand testing vocabulary ("sit-to-stand" OR "chair stand" OR "STST" OR "1-MSTST" OR "60-second sit-to-stand"), walk test terminology ("6MWT" OR "6-minute walk" OR "six-minute walk"), and cardiovascular disease terms using both MeSH headings and free-text keywords. Bibliography lists of eligible studies and pertinent reviews underwent manual checking, no language restrictions applied, and Google Scholar was consulted to identify additional records.

2.3. Study Selection and Data Extraction

Title and abstract screening was performed independently by two reviewers, followed by full-text evaluation of potentially eligible records. Any disagreements were resolved through discussion, where necessary, adjudication by a third reviewer. Data extraction was conducted independently from including study identifiers (author, year, country, journal), study design, population characteristics (diagnosis, sample size, age, sex, disease severity), details of the 1-MSTST protocol (chair height, encouragement, number of trials), details of the 6MWT protocol, and reported outcomes (correlation coefficients with confidence intervals, ICC values, means and standard deviations, ROC/AUC data, and Bland-Altman statistics where available).

The systematic search identified 847 records across seven databases, with 512 records remaining after duplicate removal. Following title and abstract screening, 49 full-text articles were assessed for eligibility. A total of

11 studies were included in the qualitative synthesis, of which 8 provided extractable correlation data. After a further eligibility refinement requiring directly reported correlation coefficients for meta-analytic inclusion, six studies were retained for quantitative pooling. Primary reasons for full-text exclusion included use of non-1-minute STS protocols, absence of direct correlation data between STS and 6MWT, non-cardiovascular populations, duplicate cohorts, and insufficient data from conference abstracts. The PRISMA flow diagram is presented in **Figure 1**.

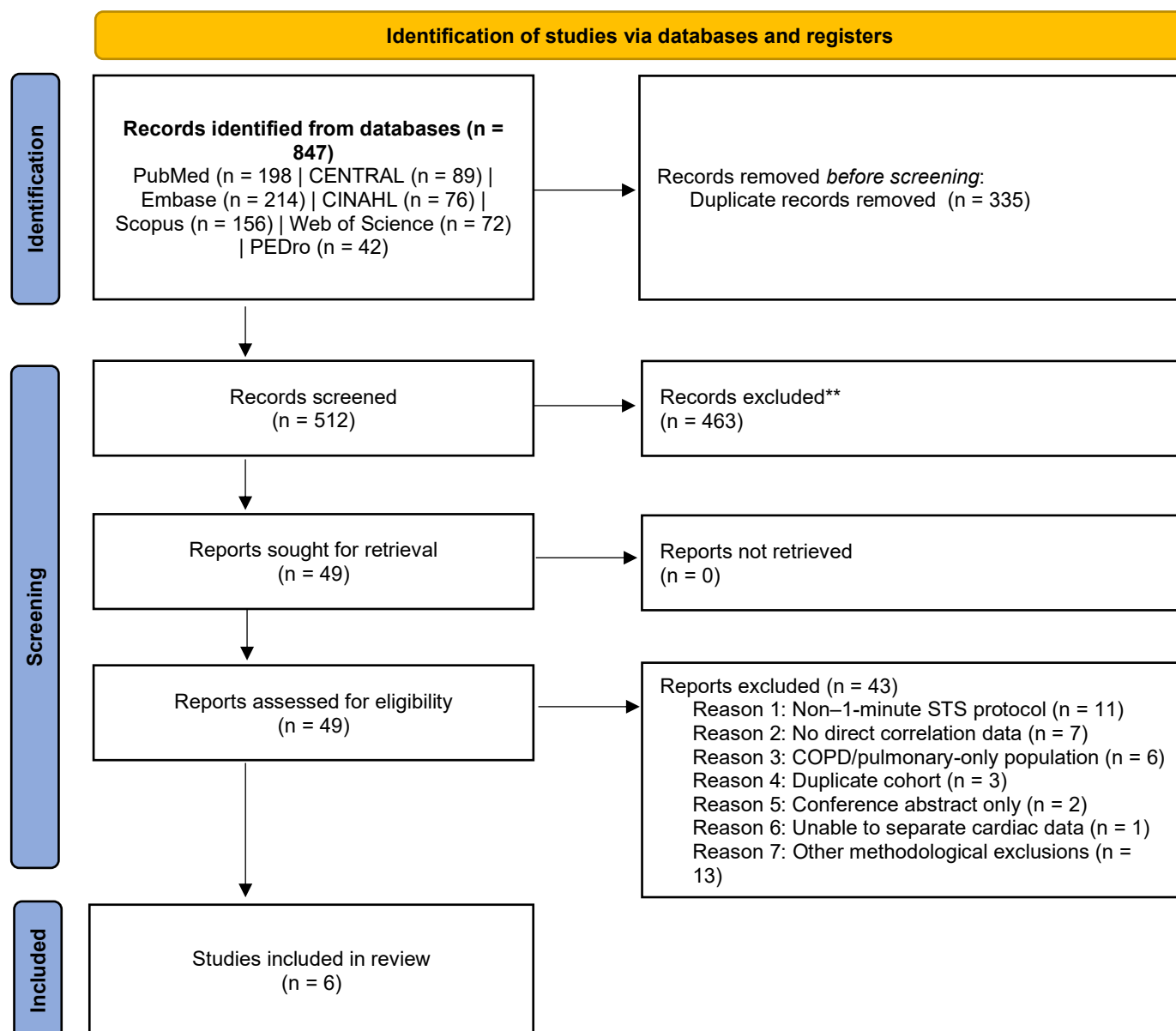


Figure 1. PRISMA Flowchart for study selection.

2. 4. Risk of Bias Assessment

Methodological quality was evaluated using the COSMIN Risk of Bias checklist, a tool developed specifically for studies examining measurement properties (25). This approach was selected in place of QUADAS-2, as neither the 1-MSTST nor the 6MWT represents a true diagnostic reference standard; both are submaximal field tests. Accordingly, the present synthesis was framed as an agreement analysis rather than a diagnostic accuracy evaluation (26,30). Each COSMIN domain was rated on a four-level scale (very good, adequate, doubtful, or inadequate), with overall study ratings determined by the worst-score-counts principle (26). Evidence certainty was subsequently graded using a modified GRADE framework consistent with COSMIN recommendations (27).

2. 6. Statistical Analysis

Correlation coefficients were converted to Fisher's z scores ($z = \text{arctanh}(r)$; variance = $1/(n - 3)$) and synthesized within a random-effects model using the restricted maximum likelihood (REML) estimator with Knapp–Hartung confidence interval adjustment (28,31). Pooled estimates were back-transformed to the correlation metric. Heterogeneity was quantified using I^2 , τ^2 , and a 95% prediction interval (29). Pre-specified subgroup analyses were planned according to cardiac diagnosis and disease severity when data allowed. Sensitivity analyses comprised leave-one-out pooling and influence diagnostics including Cook's distance and DFBETAS (31). Publication bias assessment through funnel plot asymmetry, Egger's regression, and trim-and-fill was pre-specified only when at least ten studies were available, consistent with recommendations discouraging these procedures in underpowered syntheses (30). ICC data for test-retest reliability were narratively summarised given their availability in only a subset of studies. All computations were carried out in R (v4.3.2) with the metafor package (31).

3. Result

3.1 Study selection and characteristics

49 full-text articles assessed for eligibility, six satisfied all criteria for correlation meta-analysis (**Figure 1**). Publication dates spanned 2022 to 2025, reflecting how recent this line of evidence is. The combined sample totalled 400 participants distributed across five distinct cardiovascular subpopulations: coronary artery disease ($n = 112$) (17), chronic heart failure with reduced ejection fraction ($n = 43$) (18), atrial fibrillation ($n = 45$) (19), pulmonary hypertension of mixed aetiology (two cohorts, $n = 106$ and $n = 54$) (20,21), and pulmonary arterial hypertension linked to congenital heart disease ($n = 40$) (22). The studies were conducted in five countries, China, Turkey, Austria, the United Kingdom, and Slovenia, spanning three continents, and applied either cross-sectional or prospective study designs. Detailed characteristics, protocol specifications, and outcome data are presented in **Tables 2–4**.

Table 2. Characteristics of included studies — population, design, and participant demographics.

Study	Country	Design	Population / Diagnosis	N	Age (y) mean $\pm$ SD	Sex% male	BMI(kg/m ²) mean $\pm$ SD
Pavsic et al. (2024) (22)	Slovenia	Prospective cross-sectional, single-center	Pulmonary arterial hypertension associated with congenital heart disease (PAH-CHD); Eisenmenger syndrome 72.5%; Down syndrome 35%	40	42.9 $\pm$ 15.1	50%	25.8 $\pm$ 4.3
Wang et al. (2022) (17)	China	Cross-sectional (ChiCTR: 2000037435)	Coronary artery disease (CAD): atherosclerosis 30%, post-PCI 27%, post-acute MI 43%	112	63.9 $\pm$ 8.8	69%	24.6 $\pm$ 3.5
Kronberger et al. (2023) (20)	Austria	Prospective cross-sectional, single-center	Pulmonary hypertension (PH) mixed groups (mPAP $\geq$ 20 mmHg); WHO-FC III: 49%	106	66 $\pm$ 15	43%	28 $\pm$ 6.8
Stubbs et al. (2023) (21)	UK	Prospective cohort (PHRET study)	PH mixed (incident diagnosis): PAH 33.9%, CTEPH 35.6%, left heart disease 10.2%	54	63 $\pm$ 13	44%	29.2 $\pm$ 6.5
Bozdemir Özel et al. (2025) (19)	Turkey	Cross-sectional, prospective, single-center	Atrial fibrillation (AF): paroxysmal 20%, persistent 20%, permanent 60%; EHRA III: 73.3%	45	66.6 $\pm$ 9.8	48.9%	27.2 $\pm$ 6.3
Tanriverdi et al. (2023) (18)	Turkey	Cross-sectional, two-visit design	Chronic heart failure — HFrEF (NYHA II–III); ischaemic CM 72%; non-ischaemic 28%	43	60.3 $\pm$ 6.9	83.7%	28.4 $\pm$ 3.8

PAH-CHD: pulmonary arterial hypertension associated with congenital heart disease; PH: pulmonary hypertension; CAD: coronary artery disease; CHF: chronic heart failure — reduced ejection fraction (HFrEF); AF: atrial fibrillation; CTEPH: chronic thromboembolic pulmonary hypertension; post-PCI: post-percutaneous coronary intervention; post-AMI: post-acute myocardial infarction; CM: cardiomyopathy; NYHA: New York Heart Association; EHRA: European Heart Rhythm Association; N: total sample for validity analysis; BMI: body mass index; y: years; NR: not reported.

Table 3. Protocol details for the 1-MSTST and 6MWT across included studies.

Study	Chair height (cm)	Arm position	Standardized instructions	1-MSTST (reps) mean $\pm$ SD	6MWT corridor (m)	6MWT distance (m) mean $\pm$ SD	Test order	Rest between tests (min)
Pavsic et al. (2024) (22)	46	Not allowed; hands on hips	Yes (demonstration)	21 $\pm$ 6	NR (ATS)	385 $\pm$ 89	6MWT first (nurse), then 1-MSTST (physician)	$\geq$ 30
Wang et al. (2022) (17)	46	Arms crossed, hands on shoulders	Yes	24.7 $\pm$ 6.7	30	431–480 *	Randomized (sealed envelope)	30 (6MWT $\leftrightarrow$ STS) 5 (STS $\leftrightarrow$ STS)
Kronberger et al. (2023) (20)	45	NR (standard protocol)	Yes	17 $\pm$ 7	NR (ATS)	351 $\pm$ 137	Randomized (46% STST first, 54% 6MWT first)	15
Stubbs et al. (2023) (21)	NR	NR	Yes (verbal + written)	NR	30	340 $\pm$ 13	6MWT first, STS after rest	$\geq$ 30
Bozdemir Özel et al. (2025) (19)	46	Arms crossed over chest	Yes (Furlanetto protocol); few trials before	15.4 $\pm$ 6.1	30	258 $\pm$ 115	Randomized (computer-generated); all 3 tests same day	30
Tanriverdi et al. (2023) (18)	46	Arms crossed over chest	Yes; familiarization before 1STS trials	19.5 $\pm$ 5.2	20	434.6 $\pm$ 84.8	6MWT at Visit 1 ($\times$ 2); 1STS at Visit 2 (within 1 week)	30

* Post-AMI group: 431.5 $\pm$ 64.6 m; Non-MI group: 480.3 $\pm$ 57.3 m. 1-MSTST: 1-minute sit-to-stand test; 6MWT: 6-minute walk test; ATS: American Thoracic Society; NR: not reported; STS: sit-to-stand; reps: repetitions; CM: cardiomyopathy.

Table 4. Convergent validity and test–retest reliability outcomes, with Fisher’s z values used in the meta-analysis.

Study	Correlation type	r	p-value	ICC (95% CI)(reliability subsample)	SEM(reps)	MDC ₉₅ (reps)	Fisher's z(for meta-analysis)	SE1/√(n-3)	Additional clinical correlates
Pavsic et al. (2024) (22)	Spearman	0.807	< 0.001	NR	NR	NR	1.119	0.164	WHO-FC (p < 0.001); Eisenmenger syndrome subgroup r = 0.844; Down syndrome subgroup r = 0.850; RDW r = -0.556 (Eisenmenger only)
Wang et al. (2022) (17)	Pearson	0.550	< 0.001	0.96 (0.91–0.98)n = 30	1.39	3.86	0.618	0.096	LVEF r = 0.27 (weak, p = 0.004); post-AMI vs non-MI: MD -3.4 reps (p = 0.006); ROC cut-off ≤ 23 reps (AUC = 0.80, sensitivity 71.4%, specificity 73.8%)
Kronberger et al. (2023) (20)	Spearman	0.711	< 0.001	NR	NR	NR	0.888	0.098	NT-proBNP r = -0.405; WHO-FC r = -0.591; mPAP r = -0.280 (all p < 0.001); Bland-Altman LoA: +1.47 to -1.47 z-scores; 6.6% outliers
Stubbs et al. (2023) (21)	Spearman	0.710	< 0.001	NR	NR	NR	0.887	0.141	95% CI for r: 0.54–0.82; concordance of directional change at follow-up: 66% (STS vs 6MWT); all feasible as home-based remote test
Bozdemir Özel et al. (2025) (19)	Pearson	0.809	< 0.001	0.975 (0.954–0.986)n = 45	1.96	3.88	1.124	0.154	Age r = -0.519; EHRA score r = -0.303; AF-QoL r = -0.402 (all p < 0.05); ROC cut-off ≤ 13 reps (AUC = 0.94, sensitivity 100%, specificity 84.6%)
Tanriverdi et al. (2023) (18)	Pearson / Spearman	0.612	< 0.001	0.932 (0.874–0.963)n = 43	1.36	3.79	0.712	0.158	NYHA class r = -0.640; quadriceps strength r = 0.567; IPAQ-SF r = 0.523; FEV ₁ r = 0.476; FVC r = 0.432; age r = -0.472 (all p < 0.05)

ICC: intraclass correlation coefficient; SEM: standard error of measurement; MDC₉₅: minimal detectable change at 95% confidence interval; SE: standard error; r: Pearson correlation coefficient; p: Spearman rank correlation coefficient; reps: repetitions; WHO-FC: World Health Organization functional class; LVEF: left ventricular ejection fraction; NT-proBNP: N-terminal pro-brain natriuretic peptide; mPAP: mean pulmonary arterial pressure; EHRA: European Heart Rhythm Association; AF: atrial fibrillation; QoL: quality of life; NYHA: New York Heart Association; IPAQ-SF: International Physical Activity Questionnaire – Short Form; FEV₁: forced expiratory volume in 1 second; FVC: forced vital capacity; AUC: area under the curve; ROC: receiver operating characteristic; RDW: red cell distribution width; LoA: limits of agreement; NR: not reported.

† Tanriverdi et al. applied either Pearson's or Spearman's correlation based on normality of distribution; figure caption reports p = 0.612. Fisher's z calculated using same formula. Green shading indicates r ≥ 0.70 (strong convergent validity). Fisher's z computed as $z = 0.5 \times \ln[(1+r)/(1-r)]$; SE = $1/\sqrt{n-3}$.

3.2. Convergent validity: pooled correlation

The pooled Pearson correlation coefficient between 1-MSTST repetitions and 6MWD across six cardiovascular studies (total n = 400) was r = 0.703 (95% CI: 0.609–0.777), indicating moderate-to-strong convergent validity **Figure 2**. Moderate heterogeneity was observed ($I^2 = 60.5\%$; $\tau^2 = 0.0252$; Cochran's Q = 12.65, df = 5, p = 0.027; $\tau = 0.1586$). Individual study correlations ranged from r = 0.550 coronary artery disease (16) to r = 0.809 in atrial fibrillation (19). Four of six studies (67%) demonstrated correlations at or above r = 0.70, meeting the COSMIN threshold for sufficient criterion validity (32).

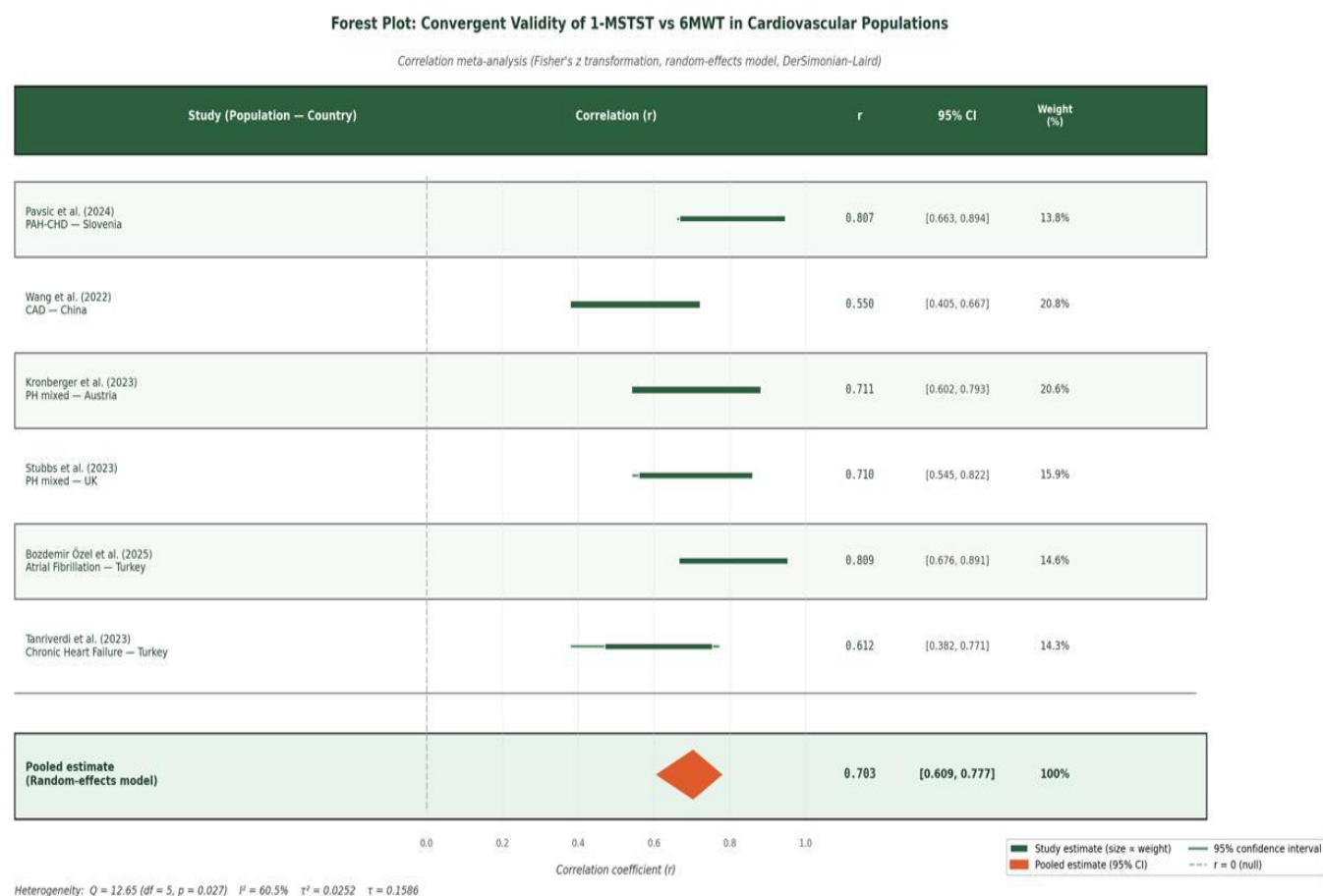


Figure 2. Forest plot of convergent validity: correlation meta-analysis of 1-MSTST repetitions versus 6MWT distance in cardiovascular populations. Random-effects model with Fisher's z transformation. Study estimates are represented by green rectangles (size proportional to weight), with horizontal lines indicating 95% confidence intervals. The pooled estimate (orange diamond) indicates moderate-to-strong convergent validity ($r = 0.703$; 95% CI: 0.609–0.777). Heterogeneity statistics: $Q = 12.65$ ($df = 5$, $p = 0.027$); $I^2 = 60.5\%$; $\tau^2 = 0.0252$; $\tau = 0.1586$.

3.3. Variation across cardiovascular subpopulations

Exploratory analysis revealed notable variation in correlation strength across cardiovascular subpopulations. The strongest association was observed in the atrial fibrillation cohort ($r = 0.81$) (19), where preserved left ventricular systolic function may allow functional performance to depend more on peripheral muscle capacity. In pulmonary hypertension, two studies reported highly similar estimates (both $r = 0.71$) despite differences in subtype composition between cohorts from Austria and the United Kingdom (20,21). A similarly high correlation ($r = 0.81$) was identified in the PAH-CHD cohort, which notably included 35% of participants with Down syndrome (35%), suggesting that the 1-MSTST remains applicable in clinically diverse populations (22). By contrast, lower correlations were reported in coronary artery disease ($r = 0.55$) (17) and chronic heart failure ($r = 0.61$) (18). These weaker associations may reflect the influence of deconditioning, musculoskeletal constraints, and pharmacological factors, such as beta-blocker use reducing chronotropic response, which can attenuate the relationship between lower-limb strength and walking performance in these groups.

3.4. Sensitivity analysis

Leave-one-out analysis demonstrated that the pooled estimate was robust to the removal of any single study. Excluding the study with the lowest reported correlation, $r = 0.550$ (17) increased the pooled estimate to $r = 0.735$, whereas removing the study with the highest correlation, $r = 0.81$ (19), decreased it to $r = 0.672$. The direction and statistical significance of the pooled estimate remained unchanged across all iterations, supporting the stability of the overall finding. With only six studies, formal assessment of publication bias using Egger's test was not performed, as recommended for $k < 10$ (30).

3.5. Test-retest reliability

Three studies reported intraclass correlation coefficients for test–retest reliability. All values exceeded the COSMIN sufficiency threshold of $ICC \geq 0.70$: 0.96 (95% CI: 0.91–0.98; $n = 30$) (17), 0.975 (95% CI: 0.954–0.986; $n = 45$) (19), and 0.932 (95% CI: 0.874–0.963; $n = 43$) (18). The standard error of measurement ranged from 1.36 to 1.96 repetitions, and the minimal detectable change (MDC_{95}) clustered narrowly between 3.79 and 3.88 repetitions, broadly in line with COPD benchmarks of 2.2–3.9 repetitions (14,16). No study reported a clinically meaningful learning effect, suggesting that a single administration is sufficient for most clinical purposes, although larger confirmatory reliability studies would strengthen this conclusion.

3.6. Clinical cut-offs and diagnostic accuracy

Two studies provided ROC-derived cut-offs with potential clinical relevance. A threshold of ≤ 13 repetitions identified functional impairment in atrial fibrillation, with sensitivity of 100% and specificity of 84.6% ($AUC = 0.94$) (19). In coronary artery disease, a cut-off of ≤ 23 repetitions was associated with higher cardiovascular event risk, yielding sensitivity of 71.4% and specificity of 73.8% ($AUC = 0.80$) (17). In a separate prognostic analysis of pulmonary hypertension ($n = 114$), a threshold of ≤ 14 repetitions corresponded to a 6MWT distance of < 165 m ($AUC = 0.90$), with values below this level associated with worse long-term survival (37,38). These cut-offs should be interpreted as population-specific signals that require external validation rather than universal decision thresholds.

3.7. Risk of bias assessment

COSMIN Risk of Bias assessment revealed that two studies (17,18) achieved an overall “adequate” rating, while four studies were rated “doubtful” primarily due to unclear blinding of assessors and, in some cases, small sample sizes for validity analysis **Figure 3**. No study received an “inadequate” rating on any domain. Reliability was reported by only three of six studies, representing a gap in the evidence base. Construct validity methodology was very good or adequate in all studies. The 1-MSTST protocol was well-standardized across studies, with chair heights of 45–46 cm and arms-crossed positioning, though test order randomization was reported in only three studies (17,19,20). Applying the modified GRADE approach, the overall certainty of evidence for convergent validity was rated as “moderate,” downgraded one level for risk of bias concerns related to incomplete blinding and small sample sizes in some studies.

	Reliability (test-retest)	Measurement error	Construct validity	Sample size	Blinding assessors	STS protocol standardization	6MWT protocol standardization	Overall rating
Pavsic et al. (2024) PAH-CHD, Slovenia	--	--	V	D	D	A	A	D
Wang et al. (2022) CAD, China	V	V	V	V	A	V	V	A
Kronberger et al. (2023) PH, Austria	--	--	V	V	D	A	A	D
Stubbs et al. (2023) PH mixed, UK	--	--	A	A	D	D	A	D
Bozdemir Özel et al. (2025) AF, Turkey	V	A	V	A	A	V	V	A
Tanriverdi et al. (2023) CHF, Turkey	V	V	A	D	A	V	D	D

V = Very good A = Adequate D = Doubtful I = Inadequate -- = Not reported

Figure 3. COSMIN Risk of Bias assessment summary. Overall rating determined by “worst score counts” principle (Terwee et al., 2012). V = very good; A = adequate; D = doubtful; I = inadequate; -- = not reported/not applicable.

Figure 3. COSMIN Risk of Bias assessment summary. Domains assessed include hypothesis testing (comparator instrument, statistical method, sample size, design flaws) and reliability (time interval, test conditions, statistical method, sample size). Overall rating determined by “worst score counts” principle (Terwee et al., 2012). V = very good; A = adequate; D = doubtful; I = inadequate; -- = not reported/not applicable.

4. Discussion

4.1. Principal findings

This systematic review and correlation meta-analysis provides the first pooled estimate of convergent validity between the 1-MSTST and the 6MWT in cardiovascular populations. A pooled correlation of $r = 0.703$ (95% CI: 0.609–0.777) indicates moderate-to-strong convergent validity, aligning with the COSMIN criterion validity threshold of $r \geq 0.70$ (32). This finding suggests that the 1-MSTST captures a clinically meaningful proportion of the variance in functional exercise capacity measured by the 6MWT. Based on the current evidence, the 1-MSTST should be considered a useful complementary functional assessment rather than a direct substitute for the 6MWT. Establishing it as a fully interchangeable measure would require head-to-head comparison with a recognised gold standard, such as cardiopulmonary exercise testing (CPET) or peak VO_2 , which is not yet available in the existing cardiac literature.

4.2 Comparison with existing evidence

The pooled estimate aligns with validation studies conducted in COPD populations, where correlations between the 1-MSTST and 6MWT have been reported ranging from $r = 0.57$ to 0.89 (14,33–35). It also compares favorably with the relationship between 6-minute walk distance and peak VO_2 in heart failure, for which a meta-analysis of 20 studies yielded a pooled r of 0.62 (10). The degree of heterogeneity observed ($I^2 = 60.5\%$) is anticipated given the considerable clinical diversity across included populations, which spanned from stable coronary artery disease with preserved ejection fraction to decompensated pulmonary hypertension. This level of heterogeneity is broadly comparable to that reported in the 6MWT- VO_2 literature ($I^2 = 57\%$) (10).

Differences in correlation strength across subpopulations shed light on factors that may influence the 1-MSTST-6MWT relationship. Higher correlations in atrial fibrillation ($r = 0.809$) and PAH-CHD ($r = 0.807$) likely reflect conditions in which functional capacity is predominantly governed by a combination of limited cardiac output and peripheral muscle performance. By contrast, weaker correlations in CAD ($r = 0.550$) and CHF ($r = 0.612$) suggest that confounding variables, including physical deconditioning, musculoskeletal constraints, or medication-related effects, may introduce discrepancies between sit-to-stand performance and walking endurance. From a mechanistic standpoint, the 1-MSTST places greater demand on lower-extremity muscle strength, while the 6MWT additionally captures cardiovascular endurance and gait efficiency (15,17).

4.3 Reliability and clinical cut-offs

Across three studies, the 1-MSTST demonstrated consistently high test-retest reliability (ICC = 0.932–0.975), meeting COSMIN criteria and in some cases exceeding values reported for the 6MWT (ICC = 0.90–0.97) (8,36). The estimated minimal detectable change (MDC_{95}) of approximately four repetitions provides a practical benchmark, indicating that smaller changes are unlikely to reflect meaningful clinical improvement. The absence of a clear learning effect supports the use of a single administration in most settings, although repeated testing remains recommended for the 6MWT (8). Proposed cut-off values (≤ 13 repetitions in atrial fibrillation, ≤ 23 in coronary artery disease, and ≤ 14 in pulmonary hypertension) offer preliminary guidance for interpretation. However, as these thresholds are derived from single-centre cohorts, further validation is needed before routine clinical use.

4.4. Relevance for low- and middle-income countries

The minimal equipment demands of the 1-MSTST are particularly relevant in the context of cardiac rehabilitation access across LMICs (39,40). Indonesia presents a clear example: despite bearing one of the heaviest CVD burdens in Southeast Asia, participation in structured cardiac rehabilitation programs remains remarkably low (39,40). The 1-MSTST, a test that needs only a standard chair and ninety seconds of patient time most of which is the test itself plus brief setup, has clear advantages in primary care clinics, puskesmas, and home-visit settings where a 30-meter corridor and trained supervisors are often not available. A recent study from Universitas Brawijaya published the first Indonesian validation data for a sit-to-stand test in systolic heart failure, using a 30-second variant, providing regional support for this type of assessment (41). The consistent validity of the 1-MSTST across diverse cardiac diagnoses observed in this meta-analysis further supports its potential integration into Indonesian

cardiac care. The feasibility of remote 1-MSTST delivery shown in the PHRET cohort is also directly relevant given Indonesia's archipelagic geography and growing telerehabilitation needs (21).

From a clinical perspective, the 1-MSTST should be considered a complementary tool rather than a direct replacement for the 6MWT. The 6MWT retains unique value as a window onto haemodynamic responses during continuous ambulation, encompassing heart rate recovery trajectories, blood pressure dynamics, and exercise-induced desaturation (7,8). However, evidence of comparable physiological stress responses between the two tests (17,18) supports the use of the 1-MSTST as a valid alternative when the 6MWT is impractical due to space, time, or resource constraints.

4.5. Strengths and limitations

This review was underpinned by prospective protocol registration, a structured PICOS eligibility framework (24), and dual-reviewer screening and extraction throughout. Methodological quality was assessed using the COSMIN risk-of-bias tool, and statistical synthesis applied a conservative approach based on Fisher's *z* transformation with Knapp–Hartung adjustment. The interpretation was also carefully aligned with the limits of correlation-based evidence, avoiding overstatement regarding interchangeability with the 6MWT.

Several limitations should be considered. The relatively small number of included studies (*n* = 6) restricts the precision of subgroup analyses and precludes formal assessment of publication bias, which is generally unreliable with fewer than 10 studies (30). Furthermore, many studies were rated as “doubtful” in at least one COSMIN domain, often due to unclear reporting or limited sample size. It is also important to note that the 6MWT itself is a submaximal field test rather than a criterion standard, therefore, a strong correlation does not establish the 1-MSTST as a definitive substitute for functional capacity assessment. Evidence on responsiveness, whether the 1-MSTST can capture meaningful clinical change over time or predict cardiovascular outcomes, remains limited. Furthermore, no included study originated from Southeast Asia or Indonesia, which restricts the direct applicability of these findings in those settings despite the practical advantages of the test.

5. Conclusions

Evidence drawn from six cardiovascular studies totalling 400 participants reveals that the 1-MSTST shares a moderate-to-strong convergent relationship with the 6MWT and demonstrates highly consistent reproducibility across test occasions. Such results point toward a meaningful adjunctive function for the 1-MSTST in functional capacity evaluation among cardiac patients, with particular utility in telehealth delivery, home-based rehabilitation programs, and clinical environments where corridor-based walking tests cannot be administered. Before the 1-MSTST can be positioned as a full alternative to the 6MWT, however, further validation is required, most importantly against recognised functional-capacity gold standards such as cardiopulmonary exercise testing, alongside longitudinal responsiveness studies, derivation of cardiac-specific minimal important differences, and prospective validation in low- and middle-income settings including Indonesia.

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Supplementary Materials: The following is not mandatory but may be added if supplementary materials exist. The following are available online <https://journal.uny.ac.id/publications/jomassh>

List of Abbreviations

1-MSTST	1-Minute Sit-to-Stand Test
6MWT	6-Minute Walk Test
6MWD	6-Minute Walk Distance
AF	Atrial Fibrillation
AUC	Area Under the Curve
CAD	Coronary Artery Disease
CPET	Cardiopulmonary Exercise Testing
COSMIN	COnsensus-based Standards for the selection of health Measurement Instruments
CVD	Cardiovascular Disease
GRADE	Grading of Recommendations, Assessment, Development and Evaluation
HFREF	Heart Failure with Reduced Ejection Fraction
ICC	Intraclass Correlation Coefficient
LMIC	Low- and Middle-Income Country
MDC	Minimal Detectable Change
PAH-CHD	Pulmonary Arterial Hypertension associated with Congenital Heart Disease
PH	Pulmonary Hypertension
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
REML	Restricted Maximum Likelihood
ROC	Receiver Operating Characteristic
SEM	Standard Error of Measurement
VO ₂ peak	Peak Oxygen Uptake

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