

Research Article

Psychometric Properties of the 10-Item Active Movement Scale (AMS) for Assessing Musculoskeletal Function in Adults

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Abstract

Objective: A movement screen is an efficient tool to evaluate movement patterns, detect potential dysfunctions and justify interventions aimed at improving musculoskeletal health. This study aimed to examine the reliability and validity of the 10-item Active Movement Scale (AMS) for assessing musculoskeletal function in adults.

Methods: This is a cross-sectional measurement study. Fifty-five subjects receiving outpatient orthopedic physical therapy attended two sessions. Concurrently, participants underwent self-reported questionnaires and performance-based tests. Inter-rater reliability, test-retest reliability, concurrent validity and floor/ceiling effect of the AMS were assessed using weighted Kappa, percentage of agreement, Intraclass Correlation Coefficient (ICC) and Pearson correlation.

Results: Inter-rater reliability was excellent (ICC range: 0.90 to 0.93). Test-retest reliability was good (ICC range: 0.82 to 0.87). Inter-rater agreement (weighted kappa) ranged from 0.57 to 0.92. Test-retest agreement (kappa) ranged from 0.53 to 0.77. There were no floor effects, but mild ceiling effects were observed. AMST correlated highly with Lifestyle Physical Function Screen (LPFS) ($r = 0.73$) and moderately with PROMIS Physical Function-10a (PFF) ($r = 0.61$) surveys. AMS (upper body subscale) had a low correlation with Grooved Pegboard Placing (GPP) ($r = 0.49$), WorkAbility Rate of Manipulation Placing (WRMP) ($r = 0.51$). AMS (lower body subscale) correlated moderately with 10-Meter Walk at Fast pace (GSF) ($r = 0.52$) and Two Square Agility Test (TSAT) ($r = 0.43$).

Conclusion: This study provides evidence of the reliability and validity of AMS in adults with musculoskeletal disorders and identifies potential gaps for future improvement and development.

Keywords: Motor Activity; Movement Disorders; Psychometrics; Disability Evaluation; Movement; Dyskinesias; Musculoskeletal Diseases

Abbreviation

AMS: Active Movement Scale; AMST: Active Movement Scale Total score; AMSU: Active Movement Scale Upper Body subscale; AMSL: Active Movement Scale Lower Body subscale; WtH: Waist-to-Height ratio; BMI: Body Mass Index; PFF: PROMIS Physical Function 10a Survey (PFF); LPFS: Lifestyle Physical Function Screen; CAL: Cardio Activity Level; TSAT: Two Square Agility Test; GSU: 10-Meter Walk at Usual pace; GSF: 10-Meter Walk at Fast pace ; GS: Grip Strength; GPP: Grooved Pegboard Placing test; WRMT: WorkAbility Rate of Manipulation Turning test; WRMP: WorkAbility Rate of Manipulation Placing test

Introduction

Prevalent musculoskeletal conditions include low back pain, neck pain, shoulder, knee disorders and arthritis, impose a significant burden on nonfatal health diseases [1-4]. Affected individuals often suffer chronic pain and disability, leading to participation restrictions in daily activities and decreased quality of life. This results in a considerable number of annual healthcare visits and substantial costs for musculoskeletal conditions, exceeding \$1 trillion in 2018 [5]. This cost burden includes

healthcare costs and productivity losses due to sick days, disability and reduced work efficiency. Notably, while individuals aged 65 and over incurred the highest mean per-person costs, persons aged 45-64 in the workforce accounted for the largest share of aggregate costs due to the large size of this cohort [5].

The American Physical Therapy Association (APTA) advocates for greater access to physical therapy professionals as a strategic approach to transform society by optimizing movement to improve the human experience. This involves leveraging knowledge and expertise in the movement system to optimize movement, promote health and wellness, mitigate the progression of impairments and prevent additional disability. An endorsed strategy involves the implementation of a functional movement screen in various settings to detect movement impairments to guide the selection of additional tests and measures to include in the patient and client examination.

Typically, a movement screening tool is an observed, performance-based assessment that possesses specific characteristics. Firstly, it comprises a series of functional tasks to concurrently assess joint mobility, stability and body asymmetry through predetermined movements. Secondly, the assessment aims to be simple, practical and cost-effective to allow for completion within five to ten minutes. Thirdly, the assessment must use movement patterns of the trunk, upper extremities and lower extremities that are essential to perform daily activities. Thirdly, the assessment relies on movement patterns of the trunk, upper extremities and lower extremities that are essential to perform daily activities. Fourthly, these tools are versatile, applicable across various populations and settings. Lastly, they are designed to identify motion deficits, serve as a pre-participation functional assessment and predict injury risks within the assessed population [6].

Numerous studies have substantiated the reliability of movement screening tools (Table 1) [8-24]. In the context of known-groups validity, studies demonstrated that individuals with a documented history of musculoskeletal injury exhibit lower scores on movement screens compared to those without such antecedents [25,26]. Nevertheless, establishing a definitive association between a score falling below a cut-off threshold and an elevated risk of injury remains ambiguous. This uncertainty is likely attributable to the multifaceted nature of injury causation and the inherent challenges associated with monitoring subsequent injury occurrences [7,28-30]. Currently, the development of movement screening tools that are not only reliable and valid but also sensitive to change and effective in predicting injury risk is still limited.

Developed by Wickstrom, et al., the Active Movement Scale (AMS) was designed for movement screening to improve physical examinations [31]. It establishes a graded observational rating system for individual movements, aiding in the triage of individuals for subsequent fitness or therapeutic interventions. The initial version, AMS version 1 (v1), comprises 14 items and could be administered in about five minutes. After field testing, four items were removed and the original five-point rating scale (0 = unable/unwilling to attempt; 1 = poor; 2 = fair; 3 = guarded; 4 = normal) was reconfigured to a four-point scale (0 to 3) by merging the 'fair' and 'guarded' categories. This modification was made as clinicians identified that these two categories often represented similar levels of movement quality, making it challenging to reliably differentiate between them during assessments. The consolidation aimed to enhance consistency in scoring and improve the scale's overall applicability in clinical practice. The revised AMS, known as version 2 (v2), consists of 10 items with a 4-point scale. This study aimed to evaluate the reliability and validity of AMS v2 at both the scale and item levels. Specifically, assessments encompass inter-rater reliability, test-retest reliability, concurrent validity and floor/ceiling effect of the AMS for evaluating musculoskeletal function in adults.

Material and Methods

Study Sample

A convenience sample of adults diagnosed with musculoskeletal disorders was prospectively recruited within a two-week period of discharge from an outpatient physical therapy clinic in Newark, OH, from January 2021 to January 2023. Inclusion criteria were: (1) age 18 or older, (2) presence of upper or lower body musculoskeletal ailment persisting for more than two weeks, (3) independent ambulation capacity with or without assistive aids, (4) capability to perform a functional pinch grasp to pick up a pencil and (5) self-reported pain at rest rated at 6/10 or below. Exclusion criteria were: (1) recent musculoskeletal surgery within the past three months, (2) current pregnancy and (3) inability to comprehend written or spoken instructions in English.

This prospective cohort study utilized an adapted COSMIN checklist to assess the methodological rigor of health status measurements [31]. Approval for the study was granted by the Institutional Review Board of the University of Wisconsin-Milwaukee. All participants completed written informed consent before study participation.

Test Protocol

Participants attended two sessions within a 3-week timeframe. During the initial session, participants provided demographic information and underwent separate AMS assessments administered by two evaluators: an experienced Physical Therapist (PT) (rater 1) with over 30 years of clinical expertise and a Physical Therapy Assistant (PTA) (rater 2) with over 20 years of clinical experience. The sequence of evaluators was randomized using an Excel-generated random list. Both assessors received in-person training from the developer, reviewed manuals and engaged in collaborative practice.

In the second session, in addition to a repeated AMS assessment by rater 2 (PTA), participants underwent anthropometric measurements (waist girth, height and weight). Additionally, they completed self-report surveys and performance-based evaluations of physical function. The self-report surveys included the PROMIS Physical Function 10a Survey (PFF), Lifestyle Physical Function Screen (LPFS) and Cardio Activity Level (CAL). Performance-based assessments were conducted in a randomized sequence and encompassed the Two Square Agility Test (TSAT), 10-Meter Walk at Usual (GSU) and Fast (GSF) pace, Grip Strength (GS), Grooved Pegboard Placing (GPP) and WorkAbility Rate of Manipulation Turning (WRMT) and Placing (WRMP) tests.

Instruments and Variables

Anthropometric variables: Waist-to-height ratio (WtH) was computed by dividing the waist circumference (cm) by the height (cm). Body Mass Index (BMI) was determined by dividing an individual's weight in kilograms by the square of their height in meters.

Active Movement Scale (AMS): The AMS v2 is a 10-item screen for quantifying musculoskeletal risks, triaging physical activity or classifying clients for interventions [31]. Each item is rated on a 4-point ordinal scale (0 to 3). Upper extremity tasks are seated, while lower extremity tasks are standing. Movement tasks include: (1) Extend wrists, (2) Flex elbows back, (3) Elevate shoulders, (4) Rotate head down, (5) Extend head back, (6) Forward bend over, (7) Rotate torso, (8) Step up and over, (9) Active squat down and (10) Lunge backwards. Items 1, 2, 3, 4, 7, 8 and 10 are evaluated independently for the left and right sides and the lower score between the two sides is used to calculate the total score (AMST) and two sub-scores: upper body (AMSU) and lower body (AMSL). AMST is the cumulative sum, AMSU is items 1-5 and AMSL is items 6-10. Scores were converted to a percent (0-100%), with higher scores indicating better movement function. Item descriptions and detailed administration instructions are in Appendix 1.

PROMIS Physical Function 10a Survey (PPF): PPF is a self-reported assessment consisting of 10 items that gauge an individual's current physical function status, such as limitations in walking over a mile [32]. Raw scores were obtained by summing item points and transformed into T-scores with a mean of 50 and a standard deviation of 10, where a higher T-score signifies enhanced physical function.

Lifestyle Physical Function Screen (LPFS): LPFS is a tailored 20-item self-reported physical function survey. LPFS integrates 11 items from PROMIS Item Bank v2.0 – Physical Function and 9 items co-developed by the authors with the PROMIS team. Responses employ a 5-point ordinal scale, ranging from “no difficulty” to “cannot do”. Aggregate LPF scores were transformed into a percentage scale (0-100%), with higher scores reflecting superior physical function.

Cardio Activity Level (CAL): CAL is a 10-level rating scale designed to categorize physical activity using levels that are consistent with categories of recommended physical activity for moderate or vigorous aerobic activity [33,34].

Two Square Agility Test (TSAT): TSAT is a functional mobility assessment designed to evaluate participants' agility. In this test, individuals step back and forth across a marked line as quickly as safety permits for a designated number of cycles. TSAT speed (cycles per second), was determined by dividing the fixed number of cycles (5) by the best (lowest) completion time recorded across three trials [35].

10-Meter Walk at Usual (GSU) and Fast (GSF) pace: 10MWT evaluates the walking gait speed (meters per second) and was computed by dividing the measured walk distance by the best (lowest) time recorded across trials [36]. Participants undergo walking assessments in two distinct modes, yielding measures denoted as usual pace (GSU) and fast pace (GSF).

Grip Strength (GS): GS was assessed using a Jamar dynamometer with a standardized protocol at position 2 handle span with arm against the side of the trunk and elbow bent at 90°C [37]. Three trials were collected for the right and left hands by alternating between sides. The study used the average of the best result (highest) for the right and left hands.

Grooved Pegboard Placing (GPP): GPP evaluates finger dexterity of placing and removing pegs using the Lafayette Instrument Company's Grooved Pegboard [38]. The study used the best result (lowest time) from each hand's two trials, averaged for both right and left hands. Time was then transformed into dexterity speed (pegs/minute) using the formula: $\text{Speed} = 25 \text{ pegs/Time (sec)} * 60 \text{ sec/minute}$.

WorkAbility Rate of Manipulation Turning (WRMT) and Placing (WRMP): WRMT and WRMP assess hand dexterity of turning and placing 20 disks [39]. The study calculated the average of the best (fastest) three trials for each hand and converted this time to dexterity speed (disks per minute) using the formula: $\text{Dexterity Speed} = 20 \text{ disks/Time (sec)} * 60 \text{ sec/minute}$. The conversion of the best trial times to speed in disks per minute was undertaken to facilitate score interpretation, where elevated scores denote superior performance.

Statistical Analyses

Data were analyzed using SPSS statistical package version 29 (Armonk, NY: IBM Corp). Descriptive statistics, including mean + SD and frequency counts, were utilized for data depiction. Inter-rater and test-retest reliability for AMST, AMSU and AMSL scores were assessed at the item level using intraclass correlation coefficient (ICC) (model 2,1). ICC reliability values were categorized as poor (less than 0.5), moderate (0.5 to less than 0.75), good (0.75 to less than 0.9) and excellent (0.9 to 1.00) [40]. Individual AMS item agreement was evaluated using percentage of agreement and weighted Kappa, with guidelines indicating slight agreement (0.0 to 0.2), fair agreement (0.2 to 0.4), moderate agreement (0.4 to 0.6), substantial agreement (0.6 to 0.8) and almost perfect agreement (0.8 to 1.0) [41]. Concurrent validity was assessed through Pearson correlations between AMST, AMSU and AMSL scores and 1) anthropometric variables, 2) self-report surveys and 3) performance-based physical functioning tests. The strength of correlations was categorized as negligible (less than 0.3), low (0.30 to less than 0.5), moderate (0.5 to less than 0.7), high (0.7 to less than 0.9) and very high (0.9 to 1.0) [42]. Floor and ceiling effects were determined by calculating the proportion of individuals exhibiting the worst (floor) and best (ceiling) scores for AMST, AMSU and AMSL.

Results

A total of 55 participants (mean age: 61.3 ± 15.3 years, 64% female) attended two sessions spaced 8.9 ± 4.1 days apart (range: 3 to 21 days). Regarding the injured body part, 27 (49.1%) reported musculoskeletal impairments in the upper body, while 45 (81.8%) reported conditions in the lower body. Of these, 21 (38.2%) patients came to the clinic for back pain, 13 (23.6%) due to joint injury and replacement, 10 (18.2%) for trauma injuries and 8 (14.5%) for arthritis. The mean scores of AMST, AMSU and AMSL in the first session were 80.1 (11.0), 85.0 (11.8) and 75.3 (14.9) respectively and in the second session, they were 78.4 (12.4), 82.4 (12.9) and 74.3 (17.1).

The overall inter-rater reliability of AMST, AMSU and AMSL subscales was good to excellent, with ICC values of 0.92 [95% CI: (0.86, 0.96)], 0.90 [95% CI: (0.79, 0.95)] and 0.93 [95% CI: (0.88, 0.96)], respectively. The test-retest reliability of the AMST, AMSU and AMSL subscales was good, with ICC values of 0.87 [95% CI: (0.77, 0.92)], 0.82 [95% CI: (0.71, 0.89)] and 0.85 [95% CI: (0.75, 0.91)], respectively.

Table 2 presents inter-rater reliability of individual movement tasks assessed by the AMS. Inter-rater reliability for individual items exhibited a range from 0.57 (rotate head down) to 0.92 (flex elbow back), with absolute agreement spanning 70.9% to 96.4%, indicating moderate to almost perfect agreement.

Table 3 presents test-retest reliability of individual movement tasks assessed by the AMS. Test-retest reliability for individual items varied from 0.53 (step up and over) to 0.77 (flex elbow back, extend head back), with absolute agreement ranging from

69.1% to 90.9%.

Table 4 illustrates the concurrent validity of AMS. AMST exhibited a high correlation with AMSU ($r = 0.80$) and AMSL ($r = 0.88$), while AMSU had a low correlation with AMSL ($r = 0.43$). The AMSL displayed a negative low correlation with anthropometric variables: WtH ($r = -0.35$) and BMI ($r = -0.40$). AMSU was not significantly correlated with anthropometric variables for WtH ($r = -0.10$) and BMI ($r = -0.05$). Concerning self-report surveys, AMST showed a moderate correlation with PFF ($r = 0.61$), a high correlation with LPFS ($r = 0.73$) and a low correlation with CAL ($r = 0.40$). Regarding performance-based physical functioning tests, AMSU exhibited a moderate correlation with GPP ($r = 0.49$) and WRMP ($r = 0.51$), but lower correlations with GS ($r = 0.20$) and WRMT ($r = 0.42$). AMSL displayed a moderate correlation with GSF ($r = 0.52$) and lower correlations with TSAT ($r = 0.43$) and GSU ($r = 0.45$).

No floor effects were observed for the AMST, AMSU and AMSL scales. However, mild ceiling effects were noted. In the initial session, 1 participant (1.8%), 9 participants (16.4%) and 3 participants (5.5%) attained the maximum score for the AMST, AMSU and AMSL scales, respectively. In the subsequent session, 2 participants (3.6%), 11 participants (20.0%) and 9 participants (16.4%) achieved the maximum score for the AMST, AMSU and AMSL scales, respectively.

Author (year)	Study sample	Measure / sample size	Number of raters	Time between sessions	Results
Sanchez-Lastra (2022) [8]	Adults from residential and day care center over 18 years old, with intellectual disability	FMS n = 30	3 raters	14 days	Composite score: - Test-retest reliability (ICC) = 0.89 trained rater - Test-retest reliability (ICC): 0.60 to 0.76 novice rater - Inter-rater reliability (ICC): 0.71 to 0.80
Alkhathami (2021) [9]	Young adults 18 and 40 years old with low back pain	FMS n = 22	4 raters	6 weeks	Composite score: - Inter-rater reliability = 0.96 to 0.99 - Intra-rater reliability = 0.97 to 0.98 - Minimal Detectable Change (MDC95) = 0.90 to 1.05
Harper (2021) [10]	Healthy adults without physical activity restrictions	FMS n = 16	5 raters	4 days	Composite Score: - Inter-rater reliability (composite score) = ICC 0.79 to 0.84 Individual movement scores: - Inter-rater reliability (item) = Kappa -0.03 to 0.96 - Poor reliability for hurdle step, inline lunge, and rotator stability.
Smith (2013) [11]	Healthy, injury-free, and physically active adults (22 to 44 years old)	FMS n = 20	4 raters	1 week	Composite score: - Inter-rater reliability (ICC) = 0.87 to 0.89 (good) Individual movement scores: - Inter-rater reliability (ICC) = 0.30 to 0.98, poor for hurdle step. - Intra-rater reliability (ICC): 0.81 to 0.91
Shultz (2013) [12]	National Collegiate Athletic Association Division IA varsity athletes	FMS n = 21	6 raters	1 week	Composite score: - Test-retest reliability Live Session (ICC) = 0.60 (good) - Live-Versus-Video Session Reliability (ICC) = 0.92 (excellent) - Inter-rater reliability (Krippendorff α) = 0.38 (poor) Individual movement scores: - Interrater reliability: 0.25 to 0.95, mean 0.47 - Poor reliability for in-line lunge, trunk stability, rotatory stability, and overhead squat
Onate (2012) [13]	Convenient healthy adults from the University and	FMS n = 19	2 raters (in person)	1 week	Composite Score: - Inter-session reliability (ICC) = 0.92 - Inter-rater reliability (ICC) = 0.98 Individual movement scores:

Author (year)	Study sample	Measure / sample size	Number of raters	Time between sessions	Results
	surrounding area				- Inter-session agreement (kappa) = 0.16 to 1.00 (mean 0.55), with hurdle step poor - Inter-rater agreement (kappa) = 0.31 to 1.00, mean 0.82, with hurdle step poor
Gribble (2013) [14]	Convenient healthy adults from University's athletic training clinical staff and academic programs	FMS n = 3	38 raters (video)	1 week	Composite score: - Intra-rater reliability (all) (ICC) = 0.75 (moderate) - Intra-rater reliability (athletic training students) (ICC) = 0.37 - Intra-rater reliability (athletic trainer) (ICC) = 0.76 (moderate) - Intra-rater reliability (ATs with at least 6 months of experience) (ICC) = 0.95 (excellent)
Teyhen (2012) [15]	Active-duty service members	FMS n = 64	2 raters (n person)	48 to 72 hours	Composite score: - Test-retest reliability (ICC) = 0.76 (moderate) - Inter-rater reliability (ICC) = 0.74 (moderate) - Minimal detectable change (MDC95) = 2.1 to 2.5 points (on the 21-point scale) Individual movements: - Inter-rater agreement (kappa) = 0.45 to 0.82, mean 0.69 - Intra-rater agreement (kappa) = 0.29 to 0.76, mean 0.61, rotary stability least reliable
Morgan (2023) [16]	Healthy, active physical therapy students	FMS n = 45	4 raters (video review)	n/a	Composite Score: - Inter-rater reliability (ICC) = 0.95 - Individual movements: Inter-rater reliability (ICC) = 0.78 to 0.96
Leeder (2016) [17]	Healthy, elite squash athletes	FMS n=5	20 novice raters (video)	n/a	Composite Score: Inter-rater reliability (ICC) = 0.91
Minick (2010) [18]	Healthy college students	FMS n = 40	4 raters (video)	n/a	Individual movement scores: Inter-rater agreement (kappa) = 0.74 to 1.00, mean 0.92
Aghi (2023) [19]	Healthy young athletes	SFMA n = 28	2 raters (video)	60 days	Individual movement scores: - Intra-rater reliability (kappa) = 0.49 (moderate) - Inter-rater reliability (kappa) = 0.60 to 0.62 (substantial)
Stanek (2019) [20]	Physically active participants	SFMA n = 25	3 raters (in person)	2 to 7 days	Individual movement scores: - Intra-rater reliability (kappa) = 0.21 to 1.00 - Intra-rater reliability (% agreement) = 0.64 to 1.00 - Inter-rater reliability (kappa) = 0.11 to 0.89 - Inter-rater reliability (% agreement) = 0.52 to 0.96
Glaws (2014) [21]	Healthy students from physical therapy program and University Club Rugby team	SFMA n = 35	3 raters (video)	7 to 14 days	Composite Score: - Intra-rater reliability (ICC) = 0.26 to 0.52 - Inter-rater reliability (ICC) = 0.43 Individual movement scores: - Intra-rater reliability (kappa) = 0.72 to 0.83 - Intra-rater reliability ((% agreement) = 0.85 to 0.91 - Inter-rater reliability (kappa) = 0.41 to 0.69 - Inter-rater reliability (% agreement) = 0.61 to 0.79
Dolbeer (2017) [22]	Subjects with a current history of axial, lower body, or upper quarter pain >2 weeks	SFMA n = 49	3 raters (video)	n/a	Composite Score: - Inter-rater reliability (ICC) = 0.61 Individual movement scores: - Inter-rater reliability (kappa) = 0.07 to 0.85 - Inter-rater reliability (% agreement) = 0.57 to 0.96
Harper	Healthy	SFMA	2 raters	n/a	Composite Score:

Author (year)	Study sample	Measure / sample size	Number of raters	Time between sessions	Results
(2023) [23]	volunteers	n = 25	(In person)		- Inter-rater reliability (ICC) = 0.55 to 0.78 Individual movement scores: - Inter-rater reliability (kappa) = 0.01 to 0.70
Holm (2008) [24]	Patients with rheumatoid arthritis (RA)	KFT n = 20	2 raters (in person)	1 week	Composite Score: - Intra-rater reliability (ICC) = 0.90 to 0.95 - Inter-rater reliability (ICC) = 0.92 to 0.99
* ICC = Intraclass correlation coefficient; FMS = Functional Movement Screen; SFMA = Selective Functional Movement Assessment; KFT = Keitel Functional Test					

Table 1: Previous studies examining reliability of functional movement screen.

	Inter-rater reliability (rater 1 vs. 2)	
	Weighted Kappa	Agree (%)
Extend wrists	0.75	89.1
Flex elbow back	0.92	96.4
Elevate shoulders	0.83	89.1
Rotate head down	0.57	70.9
Extend head back	0.73	85.5
Forward bend over	0.89	94.5
Rotate torso	0.64	76.4
Step up and over	0.70	81.8
Active squat down	0.91	94.5
Lunge backward	0.84	83.6
Mean	0.78	0.86
SD	0.12	0.08

Table 2: Inter-rater reliability of the categorical scoring of AMS individual movement tasks presented as Kappa coefficient and agreement (%).

	Test-retest reliability (rater 2)	
	Weighted Kappa	Agree
Extend wrists	0.67	87.3
Flex elbows back	0.77	90.9
Elevate shoulders	0.70	80.0
Rotate head down	0.55	70.9
Extend head back	0.77	89.1
Forward bend over	0.75	87.3
Rotate torso	0.54	70.9
Step up and over	0.53	72.7
Deep squat down	0.62	76.4
Lunge backward	0.73	69.1
Mean	0.66	0.80
SD	0.10	0.09

Table 3: Test-retest reliability of the categorical scoring of AMS individual movement tasks presented as Kappa coefficient and agreement (%).

	AMST	AMSU	AMSL	WtH	BMI	PFF	LPFS	CAL	TSAT	GSU	GSF	GS	GPP	WRMT
AMST	1													
AMSU	0.80**	1												
AMSL	0.88**	0.43**	1											
WtH	-0.28*	-0.10	-0.35**	1										
BMI	-0.29*	-0.05	-0.40**	0.87**	1									
PFF	0.61**	0.40**	0.61**	-0.12	-0.19	1								
LPFS	0.73**	0.50**	0.71**	-0.12	-0.15	0.88**	1							
CAL	0.40**	0.29*	0.38**	-0.11	-0.08	0.55**	0.56**	1						
TSAT	0.42**	0.26	0.43**	-0.24	-0.25	0.37**	0.42**	0.18	1					
GSU	0.43**	0.25	0.45**	-0.16	-0.28*	0.32*	0.32*	0.28*	0.50**	1				
GSF	0.47**	0.25	0.52**	-0.18	-0.24	0.34*	0.41**	0.30*	0.52**	0.81**	1			
GS	0.18	0.20	0.11	-0.05	0.06	0.12	0.27*	0.25	0.19	0.01	0.12	1		
GPP	0.58**	0.49**	0.48**	-0.32*	-0.23	0.44**	0.46**	0.15	0.50**	0.24	0.31*	0.25	1	
WRMT	0.46**	0.42**	0.37**	-0.27*	-0.23	0.32*	0.29*	0.19	0.37**	0.29*	0.31*	0.17	0.74**	1
WRMP	0.60**	0.51**	0.51**	-0.29*	-0.28*	0.47**	0.52**	0.18	0.64**	0.37**	0.49**	0.20	0.79**	0.71**

AMS = Active Movement Scale; AMSU = Active Movement Scale Upper; AMSL = Active Movement Scale Lower; WtH = Waist-to-height ratio; BMI = Body mass index; PFF = PROMIS Physical Function 10a Survey (PFF); LPFS = Lifestyle Physical Function Screen; CAL = Cardio Activity Level; TSAT = Two Square Agility Test; GSU = 10-Meter Walk at Usual pace; GSF = 10-Meter Walk at Fast pace; GS = Grip Strength; GPP = Grooved Pegboard Placing test; WRMT = WorkAbility Rate of Manipulation Turning test; WRMP = WorkAbility Rate of Manipulation Placing test.

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4: Concurrent validity of AMS percent scores with physical function measures.

Discussion

This study explored the reliability and validity of AMS v2 in a clinical cohort with musculoskeletal disorders. The findings indicated that, overall, AMS v2 exhibits good inter-rater reliability and test-retest reliability, a slight ceiling effect, satisfactory concurrent validity and adequate construct validity. The APTA advocates for expanded access to physical therapists as an entry-point to healthcare, covering physical activity, wellness and health assessments. Concerns persist about limited Return On Investment (ROI) in traditional workplace wellness strategies that predominantly target cardiovascular risks, while often neglecting biometrics for musculoskeletal risks. Thonon, et al., reviewed the ROI of workplace-based prevention and intervention studies and reported fewer positive results for high quality studies, with only 12.3% of interventions targeting risks for musculoskeletal disorders [43]. Early utilization of the AMS presents a strategic opportunity for physical therapists to seamlessly integrate movement screening into wellness programs, empowering clinicians to prescribe cost-effective interventions that target significant movement deficits, contributing to improved movement health across the lifespan.

Movement screening tools have undergone extensive investigation across various populations, including school sports teams, specific occupational groups (e.g. fire-fighters, emergency medical responders, health center employees), military personnel and collegiate athletes [7,25-27,46-52]. Many reliability studies were conducted in healthy, physically active adults collegiate athletes and active-duty service members with fewer studies focusing on individuals with musculoskeletal impairments [9,22,24]. The strengths of this study included recruiting patients seeking orthopedic outpatient physical therapy care and employing a PT/PTA team as assessors. Demonstrated reliability and validity by the PT/PTA team in clinical settings suggest AMS could help bridge gaps that exist between healthcare and fitness programs.

This study identifies areas for future improvement and development. Specifically, the reliability analysis identified three items ("rotate head down," "step up and over," and "rotate torso") as having the lowest weighted kappa scores and agreement. These findings suggest need to further investigate administration protocols for these tasks, with potential revisions to either the instructions or the AMS protocol to enhance consistency and clarity. Additionally, the presence of a mild ceiling effect suggests that the current assessment may not fully capture the upper limits of participants' fitness for participation in more vigorous physical activities. To address this, it is recommended that the AMS be supplemented with more challenging performance-based items, requiring greater strength and muscle power, be incorporated into the assessment to better differentiate high-performing individuals and extend the tool's sensitivity. For example, grip strength may be useful measure to supplement the AMS Upper Body movement outcome, given the availability of normative data for individuals across the lifespan and association of low grip strength with sedentary work and increased risk of cardiovascular disease, stroke, hospitalization and overall mortality [38,51].

Our findings are pivotal as they lay the groundwork for subsequent research endeavors. Further research should focus on advancing the AMS, addressing its current limitations due to the lack of normative reference values and a cut-off score for score interpretation. Our research team is dedicated to exploring the clinical applications of the AMS, including the integration of smartphone apps for video capture and kinematic analysis of joint angles to enhance observed movement ratings and provide immediate feedback.

This study is subject to several limitations, including the use of only two raters, the absence of blinding during the protocol and a wider time interval between test-retest sessions compared to previous studies. Future studies should incorporate additional raters with diverse health professional backgrounds. Participants in this study exhibited heterogeneous musculoskeletal impairments. While the study sample mirrors a subset of patients seeking outpatient rehabilitation, a larger sample size with a more homogeneous patient composition would enhance generalizability.

Conclusion

This study provides evidence of the reliability and validity of AMS in adults with musculoskeletal disorders and potential gaps for future improvement and development.

Key Points

- The American Physical Therapy Association (APTA) has advocated leveraging knowledge and expertise in the movement system to optimize movement, promote health and wellness, mitigate the progression of impairments and prevent additional disability
- The AMS introduces an efficient and quantitative framework for movement screening that rated based on observed performance, extending beyond the mere identification of movement dysfunctions or symptom complaints
- The AMS presents a strategic opportunity for physical therapists, physical therapist assistants or other health practitioners to seamlessly integrate movement screening into wellness programs, empowering clinicians to prescribe appropriate physical activity by identifying significant movement deficits and enabling direction to self-administered exercises for individuals with minor deficits

Conflict of Interest

The authors declare that they have no conflict of interest in this paper.

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Authors' Contributions

All authors contributed equally in this paper.

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Appendix

Instructions for Active Movement Scale (AMS) v2

Setup: Materials needed for AMS include an armless chair, a 7-inch step, and a sturdy table.

Rating scale: 0 = Unable to perform/unwilling to attempt; 1 = Poor (major deficits); 2 = Fair (mild deficits); 3 = Good (good movement/requires no physical assistance)

Verbal instructions:

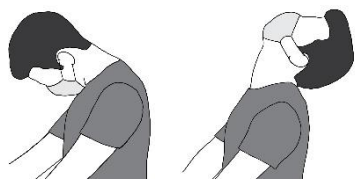
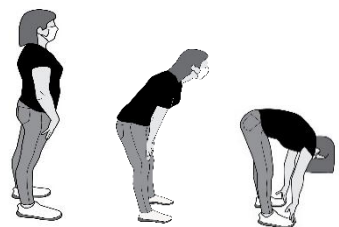
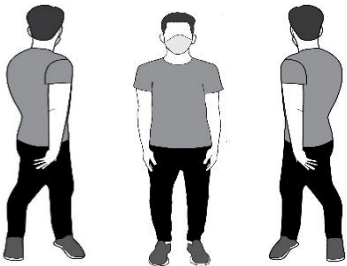
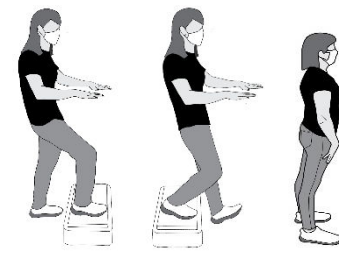
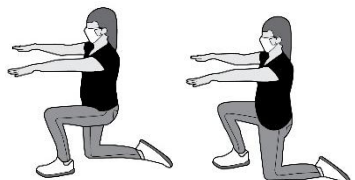
- Perform each movement demonstrated to the extent that you safely can.
- You may skip any movements that you feel may be unsafe.
- Begin sitting upright with palms facing up without leaning against the backrest.



Scoring:

- For movements 1 to 4 and 7 to 9, use lowest for right or left scores as the **Movement Score**.
- AMS Total Body Score (AMST) is the sum of scores for all 10 movements.
- AMS Upper Body Score (AMSU) is the sum of scores for movements 1 to 5.
- AMSL Lower Body Score (AMSL) is the sum of items 6 to 10.

#		Movement Description	Score
1		Extend Wrists Curl fingers to make tight fists with thumbs touching. Place palms together with thumbs against chest. Slide hands down as far as you can while keeping palms together.	Left ____
			Right ____
			Movement Score ____
2		Flex Elbows Back Extend elbows back with palms facing up. Keep elbows back as you flex elbows and wrists as far as you can to touch the top of shoulders.	Left ____
			Right ____
			Movement Score ____
3		Elevate Shoulders Extend elbows back with palms facing up while sitting upright. Raise only the left arm next to the side of head. Then raise only the left arm next to the side of head.	Left ____
			Right ____
			Movement Score ____
4		Rotate Head Down Turn your head as far as you can to the left, pause, and then try to touch chin to shoulder. Then turn your head as far as you can to the right, pause, and try to touch chin to shoulder.	Left ____
			Right ____
			Movement Score ____

5		Extend Head Back Sit sideways in chair and grasp knees with arms extended. Bend head down and try to touch chin to chest without moving trunk. Then extend head back as far as you can to look up without moving trunk.	Movement Score_____
6		Forward Bend Over Stand feet even and apart. Bend over at the waist as far as you can without bending knees. Slide your hands down your legs as far as you can to try to touch your toes.	Movement Score_____
7		Rotate Torso Face forward, with feet even and shoulder width apart. Keep feet in place and arms near your side as you rotate your shoulders and hips to the right as far as you can. Then rotate your torso to the left as far as you can.	Left _____ Right _____ Movement Score_____
8	 Right side shown	Step Up and Over Place only your right foot on the step and step up and over the step slowly to finish with feet even on the other side. You may hold the table for balance or support if you need to for safety. Turn around and perform this movement with only your left foot on step.	Left _____ Right _____ Movement Score_____
9		Active Squat Down Turn sideways, with your arms in front and feet even at a comfortable distance apart. Squat down to lower your bottom as close to the ground as you can without using your arms to help.	Movement Score_____
10	 Left side Right side	Lunge Backwards Next, lunge backward to kneel behind your right foot, pause with your trunk upright before standing up. Then lunge backward to kneel behind your left foot. You may hold onto the chair or floor to get up or down if needed for safety.	Left _____ Right _____ Movement Score_____

Appendix 1: Instructions for Active Movement Scale (AMS) v2.