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Comparison of STarT Back Screening Tool and Simmonds Physical Performance Based Tests Battery in Prediction of Disability Risks Among Patients with Chronic Low-Back Pain

Porównanie Metody Przesiewowej STarTBack oraz Baterii Testów Opartych na Sprawności Fizycznej Simmonds'a w przewidywaniu ryzyka niepełnosprawności wśród pacjentów z przewlekłym bólem dolnego odcinka kręgosłupa.

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Key words
STarT Back, Simmonds physical performance tests battery, disability, prediction

Abstract
Objectives: This study identified disability sub-groups of patients with chronic low back pain (LBP) using the Subgroup for Targeted Treatment (or STarT) Back Screening Tool (SBST) and Simmonds Physical Performance Tests Battery (SPPTB). In addition, the study investigated the divergent validity of SBST, and compared the predictive validity of SBST and SPPTB among the patients with the aim to enhance quick and accurate prediction of disability risks among patients with chronic LBP.
Methods: This exploratory cross-sectional study involved 70 (52.0% female and 47.1% male) consenting patients with chronic non-specific LBP attending out-patient physiotherapy and Orthopedic Clinics at the Obafemi Awolowo University Teaching Hospitals, Ile-Ife and Ladoke Akintola University of Technology Teaching Hospital, Osogbo, Nigeria. Disability risk subgrouping and prediction was carried out using the SBST and SPPTB (comprising six functional tasks of repeated trunk flexion, sit-to-stand, 360-degree rollover, Sorenson fatigue test, unloaded reach test, and 50 foot walk test). Pain intensity was assessed using the Quadruple Visual Analogue Scale. Data on age, sex, height, weight and BMI were also collected. Descriptive and inferential statistics were used to analyze data at $p<0.05$ Alpha level.
Results: The mean age, weight, height and body mass index of the participants were 51.4±8.78 years, 1.61±0.76 m and 26.6±3.18 kg/m^2 respectively. The mean pain intensity and duration were 5.37±1.37 and 21.2±6.68 respectively. The divergent validity of SBST with percentage overall pain intensity was r = 0.732; p = 0.001. Under SBST sub-grouping the majority of participants were rated as having medium disability risk (76%), whilst SPPTB sub-grouped the majority as having high disability risk (71.4%). There was a significant difference in disability risk subgrouping between SBST and SPPTB (χ^2=12.334; p=0.015). SBST had no floor and ceiling effects, as less than 15% of the participants reached the lowest (2.9%) or highest (1.4%) possible score. Conversely, SPPBT showed both floor and ceiling effects, as it was unable to detect '1' and '9', the lowest and highest obtainable scores. The 'Area Under Curve' for sensitivity (0.83) and specificity (0.23) of the SBST to predict 'high-disability risk' was 0.51. The estimated prevalence for 'high-disability risk' prediction of SBST was 0.76. The estimate for true positive, false positive, true negative and false negative for prediction of 'high-disability risk' for SBST were 0.77, 0.23, 0.31, and 0.69 respectively.

The individual division of this paper was as follows: A – research work project; B – data collection; C – statistical analysis; D – data interpretation; E – manuscript compilation; F – publication search

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Conclusion: The StartBack screening tool is able to identify the proportion of patients with low back pain with moderate disability risks, while the Simmonds Physical Performance Tests Battery is better able to identify high disability risks. Thus, SBST as a self-report measure may not adequately substitute physical performance assessment based disability risks prediction. However, SBST has good divergent predictive validity with pain intensity. In contrast to SPBBT, SBST exhibited no floor or ceiling effects in our tests, and demonstrated high sensitivity but low specificity in predicting 'high-disability risk'.

Słowa kluczowe
STarT Back, bateria testów sprawności fizycznej Simmonds'a, ból dolnego odcinka kręgosłupa, niepełnosprawność

Streszczenie
Cele: W badaniu tym zidentyfikowano podgrupy niepełnosprawności pacjentów z przewlekłym bólem dolnego odcinka kręgosłupa (Chronic Low Back Pain, LBP) używając Podgrupy do Ukierunkowanego Leczenia (Subgroup for Targeted Treatment lub StarT), Narzędzia Przesiewowego Badania Pleców (Back Screening Tool, SBST) oraz Baterii Testów Simmondsa oceniających Sprawność Fizyczną (Simmonds Physical Performance Test Battery, SPPTB). Ponadto, aby przyspieszyć i dokładniej przewidzieć ryzyko niepełnosprawności wśród pacjentów z przewlekłym LBP, w badaniu zbadano trafność różnicową SBST i porównano przewidywalną trafność SBST i SPPTB u pacjentów.
Metody: To przekrojowe badanie poznawcze obejmowało 70 (52,0% kobiet i 47,1% mężczyzn) pacjentów z przewlekłym niespecyficznym LBT, którzy wyrazili zgodę i uczestniczyli w fizjoterapii ambulatoryjnej, przy udziale Kliniki Ortopedycznej w Obafemi Awolowo University Teaching Hospital, ile-Ife i Ladoke Akintola University of Technology Teaching Hospital, Osogbo, w Nigerii. Podgrupowanie ryzyka niepełnosprawności i prognozowanie przeprowadzono przy użyciu SBST i SPPTB (składającego się z sześciu zadań funkcjonalnych: wielokrotnego zginania tułowia, wstawania z pozycji siedzącej, 360-stopniowego przewrotu, testu zmęczenia Sorenson'a, testu zasięgu bez obciążenia i test chodu na odległość 50 stóp). Intensywność bólu oceniano za pomocą poczwórnej wizualnej skali analogowej (ang. Quadruple Visual Analogue Scale – QVAS). Zebrano również dane dotyczące wieku, płci, wzrostu, masy ciała i BMI. Do analizy danych użyto statystyki opisowe i inferencyjne na poziomie istotności statystyczej Alpha $p < 0,05$
Wyniki: Średni wiek, masa ciała, wzrost i wskaźnik masy ciała uczestników wynosiły odpowiednio 51,4 ±8,78 lat, 1,61 ±0,76 m i 26,6 ±3,18 kg/m^2. Średnia intensywność bólu i czas trwania wyniosły odpowiednio 5,37 ±1,37 i 21,2 ±6,68. Trafność różnicowa SBST z procentem ogólnej intensywności bólu wynosiła r = 0,732; p = 0,001 w. W podrupowaniu zgodnie z SBST, większość uczestników oceniono jako ze średnim ryzykiem niepełnosprawności (76%), podczas gdy SPPTB podrupowało większość jako mających wysokie ryzyko niepełnosprawności (71,4%). Stwierdzono istotną różnicę w ocenie ryzyka niepełnosprawności między grupami poddanymi SBST i SPPTB (χ^2 = 12,334; p = 0,015). SBST nie miał efektów podłogowych ani sufitowych, ponieważ mniej niż 15% uczestników osiągnęło najniższy (2,9%) lub najwyższy (1,4%) możliwy wynik. Natomiast SPPBT pokazał zarówno efekty podłogowe, jak i sufitowe, ponieważ nie był w stanie wykryć „1" i „9", najniższego i najwyższego osiągalnego wyniku. „Obszar Pod Krzywą" dla czułości (0,83) i swoistości (0,23) SBST do przewidywania „wysokiego ryzyka niepełnosprawności" wynosił 0,51. Szacunkowa przewaga prognozowania wysokiego ryzyka niepełnosprawności" przy zastosowaniu SBST wynosiła 0,76. Szacunkowe dane dla wyników prawdziwie dodatnich, fałszywie dodatnich, prawdziwie ujemnych i fałszywe ujemnych dla przewidywania „wysokiego ryzykaa niepełnosprawności" w przypadku SBST wyniosły odpowiednio 0,77, 0,23, 0,31, i 0,69.
Wnioski: Narzędzie przesiewowe StartBack jest w stanie lepiej zidentyfikować odsetek pacjentów z bólem dolnego odcinka kręgosłupa znajdujących się w grupie średniego zagrożenia niepełnosprawnością, podczas gdy Bateria Testów Sprawności Fizycznej Simmonds'a jest w stanie lepiej zidentyfikować wysokie ryzyko niepełnosprawności. Tym samym SBST jako środek samodzielnego raportowania nie może w wystarczającym stopniu zastępować przewidywania ryzyka niepełnosprawności w oparciu o ocenę sprawności fizycznej. Jednakże SBST ma dobrą trafność różnicową przewidywań w kwestii intensywności bólu. W przeciwieństwie do SPBBT, SBST nie wykazywał w naszych testach żadnych efektów podłogowych ani sufitowych i wykazał się wysoką czułością, ale niską swoistością w przewidywaniu „wysokiego ryzyka niepełnosprawności".

BACKGROUND

Low back pain (LBP) is one the most prevalent musculoskeletal condition, and among the most common causes of disability in developed nations[1]. Out of all 291 conditions studied in the Global Burden of Disease 2010 Study, LBP ranked highest in terms of Years lived with disability (YLDs), and sixth in terms of overall burden (Disability-Adjusted Life Year (DALY))[2] and is the greatest contributor to disability worldwide[3]. Disability related to chronic LBP is a complex and multidimensional phenomenon[4]. LBP-related disability can manifest, with symptoms that are self-limiting, within a few weeks, and becomes recalcitrant in some patients[5-7]. As such, about 23% of patients with LBP experience persistent symptoms, and about 11-12% of these patients report substantial levels of disability[8]. Henschke et al.[9] submit that nearly 40% of people presenting to primary care with LBP are at high risk of developing chronic disability. Pain and disability resulting from chronic LBP account for the vast majority of the socioeconomic impact of LBP[10].

Traditionally, physiotherapy assessment methods for disability among individuals with chronic LBP have been carried out using clinical tests of impairment[11-14] and other tests involving complex and expensive isometric and isokinetic devices[12,14]. These tests have been shown to possess variable psychometric and clinimetric properties, ranging from poor to good[15,16], while at times the appropriateness of these tests in disability assessment, particularly in the case of chronic pain, is questionable[14].

The need to develop appropriate tools for assessing disability or functional capability among patients was advocated by the International Task Force on Back Pain as a priority for research in 2000[17]. Consequently, several self-report disability scales have been developed for individuals with chronic LBP[14]. These scales are

cheap, quick and easy to administer but demonstrate skewed psychometric properties ranging from poor to excellent[18,19]. One such scale is the Orebro Musculoskeletal Pain Questionnaire (ÖMPSQ)[20,] developed to predict long term disability and failure to return to work[21,22]. Despite the evolution of disability scales, some studies have shown that there is often discrepancy between self-report disability scales and performance-based measures of disability[23-32], suggesting that these measures might describe different aspects of functional capacity or disability[32]. Hence the need for a rigorously developed algorithm or tool that will demonstrate clinical prediction capabilities and improved outcomes with a stratified care approach in chronic LBP[28].

The STarT Back Screening Tool (SBST) was developed and validated to identify subgroups of patients with chronic LBP and to guide the initial decision making in primary care by physiotherapists[33]. The tool has comparable clinimetric properties to OMPSQ, which is the current reference standard screening tool[34]. The SBST is based on the presence of potentially modifiable physical and psychological indicators for persistent, disabling symptoms, identified through nine questions. Patients are classified as 'low risk' of future disabling LBP if they score positively on fewer than four questions. The remainder are then subdivided into "medium risk" (physical and psychosocial indicators of poor outcome, but without high levels of psychological indicators) and "high risk" (high levels of psychological prognostic indicators with or without physical indicators).

The SBST has shown inconsistent predictive validity between physiotherapy and chiropractic[35,36] which lead to further research by Sturgeon and Zautra[37] that looked into the 'resilience' factors which may have a unique predictive ability for chronic pain. Prospective validation studies in different cultural and clinical settings that will make SBST more appealing to physiotherapists have been advocated[35]. Furthermore, the criterion and predictive validity of the SBST compared with performance-based test batteries in the primary care setting have not been established. The SBST is designed to stratify patients with LBP according to their risk of future physical disability, in order that prognostic subgroups can receive matched treatment[33], and is being validated for disability risk subgrouping. SBST and other similar instruments have potential to give valuable information to practitioners about how to treat patients and who is in the most need of treatment. However, the clinical usability of SBST as a self-report method of disability risk assessment compared with psychometrically sound tests batteries such as SPPTB has not yet been adequately established in evidence. There is critical lack of empirical research into the overlap between SBST and SPPTB for disability risk prediction. Therefore, the overarching objective of this study was to compare the predictive validity of SBST and SPPTB among patients with chronic non-specific LBP.

METHODS

A total of 108 patients with non-specific LBP were initially recruited into this exploratory cross-sectional study. As some patients were then excluded or dropped out for various reasons, 70 (male (n=37), female (n= 33)) participants completed both the SBST and SPPTB evaluations. The flowchart of inclusion of participants in the study is in Figure 1. Eli-

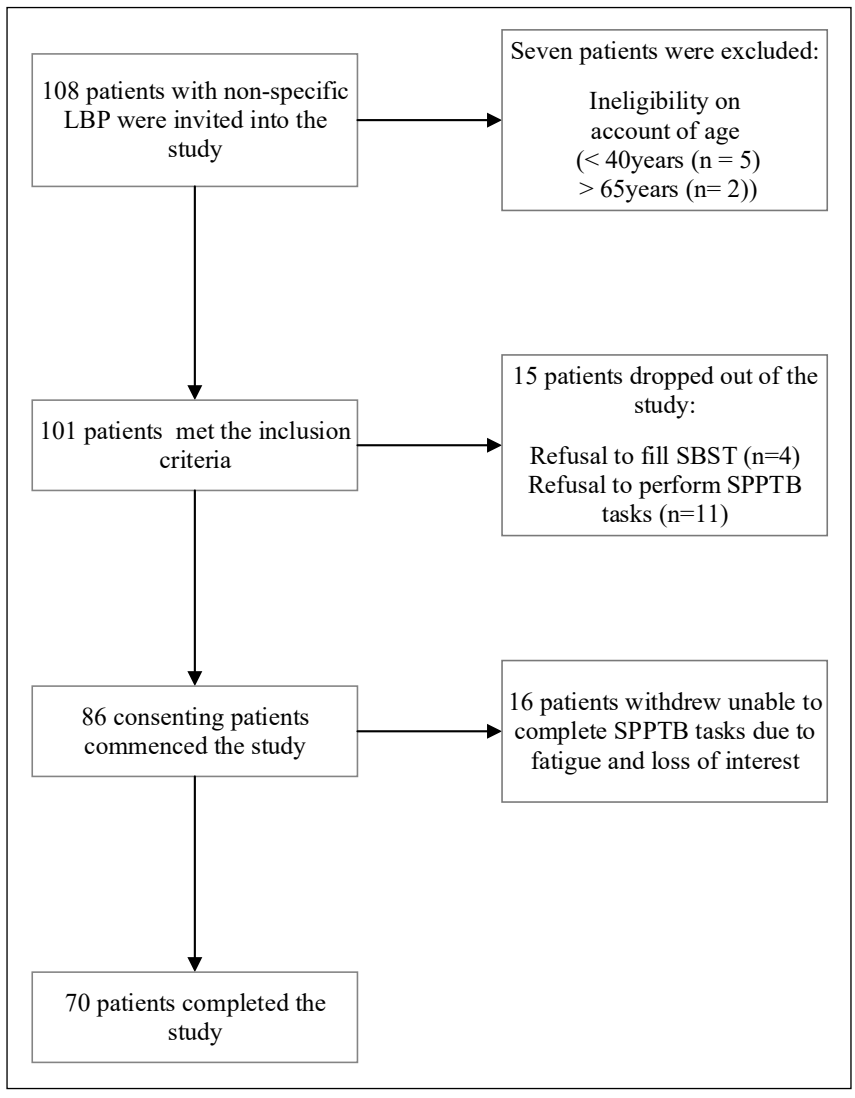

Figure 1
Flow chart of patients' progression in the study

gible participants for this study were – i) patients with clinical diagnosis of chronic LBP (>3months) who were within the ages of 40 and 65 years, ii) patients without any obvious deformities affecting the trunk, upper or lower limbs; and, iii) patients who were literate in the English or Yoruba language. Excluded from the study were i) patients with serious spinal pathology (including fractures, tumours, and inflammatory diseases) or any obvious spinal deformity or neurological disease, ii) patients with a reported history of cardiovascular disease contra-indicated to exercise; or individuals who were with elevated blood pressure (>140/90 mmHg), iii) patients who were pregnant or have had a previous back surgery; and iv) patients with previous experience of assessment with SPPTB.

Ethical Approval for this study was granted by the Health Research Ethics Committee of the Institute of Public Health, Obafemi Awolowo University, Ile-Ife, Nigeria (IPHO-AU/12/831). Permission for data collection was also granted by the Heads of the selected Physiotherapy Departments. Each participant gave their signed, informed consent following full disclosure of the purpose and procedure of the study.

Instrument

STarT Back Screening Tool (SBST)

The primary assessment tool of interest for this study is the SBST developed by Hill et al.[33], a prognostic self-assessment questionnaire with items related to physical and psychosocial factors that have been identified as strong independent predictors for persistent disabling LBP. This is a 9-item screening measure used to identify subgroups of patients with LBP in primary care settings based on the presence of physical or modifiable psychosocial prognostic factors (or both), which may be useful in matching patients with targeted interventions.

The SBST has demonstrated predictive validity for long-term disability outcomes for patients with LBP in primary care settings[33]. It was designed as a screening tool and has previously been implemented in both primary care[33] and outpatient physical therapy[35] settings. Its usefulness for treatment monitoring, however, has only recently been evaluated in primary care settings[38]. The SBST overall scores (ranging from 0 to 9) are determined by summing all positive responses. A score of 3 or less low risk. Those with a score of 4 or more are further stratified according to a sub-score (from items 5-9), with 3 or less classified as medium risk and 4 and above as high risk[33]. Both English and Yoruba language versions of the SBST were used.

Procedure

Simmonds Physical Performance Tests Battery (SPPTB)

The SPPTB involves the performance of tasks that are fundamental components of day-to-day physical activities that are commonly compromised by LBP[12]. It is a simple and standard battery of performance tests used to complement standard routine clinical tests for patients with LBP. Prior to our main study, a pilot study for familiarization in executing the SPPTB was conducted. Participants in the pilot study were not part of the main study. The physical tasks were performed by the participants in random order. The tests are: repeated sit-to-stand, repeated trunk flexion, unloaded reach, 50 - foot walk, 360-degree roll over and Sorensen Fatigue Test.

i. Repeated Sit to Stand: The participants were asked to sit on a seat of height 17 inches (43.3 cm) placed against a wall to prevent it from moving. The participant sat in the middle of the chair, back straight, feet approximately shoulder width apart and placed on the floor at an angle slightly back from the knees with one foot slightly in front of the other to help maintain balance. (Plate IV). At the signal "GO", the participant was asked to rise to a full stand (body erect and straight) then return back to the initial seated position. While monitoring the participant's performance to ensure proper form, a researcher recorded the time spent performing the task.
ii. Repeated Trunk Flexion: The participant was in supine position on a treatment table with arms stretched towards the knees. While the researcher stood beside the participant stabilizing the knee joints, the participant was asked to tuck in their chin and lift their head and shoulders off the table in a sit-up. The degree of motion the participant was able to achieve was rated (see table 1).
iii. Unloaded Reach Test: The participant was instructed to stand close to a wall, facing at 90 degrees to it, and position the arm that is closer to the wall straight out in front at 90 degrees of shoulder flexion with a closed fist. A researcher recorded the starting position of the 3rd metacarpal head (i.e. the most protruding knuckle joint) using a yardstick attached to the wall. The participant was instructed to reach forward as far as possible without taking a step. The measurement was then taken again and a score determined by assessing the difference between the start and end measurements.
iv. 50 Foot Walk Test: Upon the command "Go", the participant was instructed to walk to a 25 foot mark and back. The walk, however, must be completed within 15 seconds and the performance time is recorded.
v. 360 Degree Roll Over Test: With the participant in supine position on a mat, he/she was instructed to roll over 360 degrees as fast as possible. After a brief pause, the participant was instructed to roll over 360 degrees in the opposite direction. The time taken to complete the task in both directions was recorded.
vi. Sorensen Fatigue Test: The participant was instructed to lay prone on a treatment table with the upper edge of the iliac crests (i.e. top of the hip bones) in alignment with the edge of the table. Straps were placed across the waistline and posterior thigh to stabilize the participant. With arms flat against the body they hold the position for

Table 1

Simmonds Physical Performance Tests Battery Scoring Method			
SN	Tests	Task/Movement/ Categories of Performance/Interpretation	Score
1	Trunk Flexion Test		
		The patient completes range of motion and raises trunk until scapulae are off the table	2
		The patient completes partial range of motion and the examiner must be able to detect contractile activity.	1
		The patient is unable to lift the shoulders from the table and no or very limited activity is visible.	0
2	Sits to stand Test		
		Those who cannot complete 30seconds	0
		Those who stand greater than 30seconds	1
		Those who can stand more than 20minutes	2
3	50-feet Walk Test		
		15 seconds or less	4
		15.5-20 seconds	3
		20.5-25 seconds	2
		more than 25 seconds	1
		Unable	0
4	Unloaded Reach Test		
		Unable to reach	0
		Reach ≤ 6inches	1
		Reach ≥ 6 but ≤ 10 inches	2
		Reach ≥ 10 inches	3
5	Sorensen Test	<90.0 secs holding time for male or <67.0 sec. for female,	0
		90-193 secs or 67-170 secs., for female	1
		>193 secs and > 170 sec. for female	2
6	360 roll test		
		Able to roll 360 degrees safely in 4 sec or less	4
		Able to roll 360 degrees safely only in 4sec or less	3
		Able to roll 360 degrees safely but slowly	2
		Need close supervision or verbal cueing	1
		Need assistance while turning	0

as long as possible, with time taken to fatigue recorded.

Quadruple Visual Analogue Scale (QVAS)

The QVAS was used to assess pain intensity experienced by the participants at the time of assessment, typical or average pain, pain at its best and pain at its worst[39]. A Yoruba translated version of the QVAS was used for participants who preferred the Yoruba version. The translation was made at the department of linguistics and African languages of Obafemi Awolowo University, Ile Ife. Pearson product moment correlation coefficient (r) of 0.88 was obtained for reliability of the back translation of the Yoruba version. The Total QVAS can be calculated with the equation below:

Questions (1+2+4)/3*10 = Total QVAS. Scores were classified as low intensity of pain where total QVAS </= 50 or high intensity of pain where total QVAS > 50).

Weighing Scale

Body weight in light clothes was measured to the nearest 0.1 kg using a weighing scale (ISO 9001:2000 Mod BR9011) calibrated from 0–120 kg, with the participant standing with minimal movement with hands by their sides. Shoes and excess clothing were removed.

Stadiometer

The RGZ480 model stadiometer, made in South Korea, was used to measure the height of the participants. Standing height is the measurement of the maximum distance from the floor to the highest point of the head, when the subject is facing directly ahead. Footwear is removed, feet together, and arms by the sides. Heels, buttocks and upper back should be in contact with a wall when the measurement is made.

Stop watch
A stop watch (Uniquely clock, China, MR0954) was used to measure the duration of activities or tests in seconds.

All assessments were carried out between 10:00 am and 12:00 pm daily for a period of six months. Assessments were conducted before patients received any physiotherapeutic treatment.

Data Analysis

Descriptive statistics of mean and standard deviation, frequency and percentages were used to summarize the data. Inferential statistical analysis using Chi-square tests was performed to compare the proportion of disability sub-groups obtained from the SBST and SPPTB. Spearman rank correlation coefficient (r) was used to determine the concurrent validity of SBST and SPPTB.

Two by two contingency tables were constructed and sensitivity and specificity with 95% confidence intervals. Sensitivity, specificity, positive predictive value and negative predictive value were calculated using standardized methods[40]. Likelihood ratios were calculated using the score method[40]. Receiver Operator Characteristic (ROC) curve is an overall measure of the diagnostic efficacy and the curves' combined sensitivity and specificity. Alpha level was set at $p < 0.05$. SPSS version 20.0 (SPSS Inc, Chicago, Illinois) was used for the analysis.

Computation

The STarT Back Screening Tool was administered to assess the disability level of the same participants. The SBST overall scores (ranging from 0 to 9) are determined by summing all positive responses: Scores of 3 or less indicate low risk; scores of 4 or more are stratified according to a subscore (from questionnaire items 5-9), where 3 or less indicates medium risk and 4 and above indicates high risk. All assessments were undertaken during each session.

Total Score possible on Simmonds Physical Performance Battery was 17. Performance was classified as low (=/>12), medium (=/>7 and <12) or high (<7) risk for disability.

RESULTS

Seventy (37 females (52.9%) and 33 males (47.1%)) patients with chronic non-specific LBP participated in this study. The mean age, height, and body mass index of the participants were 51.4 ±8.78 years, 1.61 ±0.76m and 26.60 ±3.98 kg/m^2 respectively (Table 2). The pain characteristic of the participants are also presented in Table 2; the mean QVAS total pain score of the participants was 53.47 ±13.2 (out of a total of 100). The mean pain duration (in weeks) of the participants was 21.2 ±6.68.

STarT Back Screening Tool disability risk and distress sub-scale sub-groupings of the participants are shown in Table 3. Based on their SBST assessment outcome, participants were categorized as low, medium or high risk. A majority (76%) of the participants were assigned to the medium risk group. More male participants were in the 'high risk' category (8.5% vs. 5.7%). Based on the distress subscale of the SBST, a majority of the participants (86.0%) were in the medium risk category with a higher female preponderance (83.8% vs. 66.7%). There was also a higher proportion of males in the high distress subscale category (18.2% vs. 10.8%).

The SBST demonstrated moderate to strong divergent validity against different pain intensity measures (the correlation co-efficients between SBST score and each of current pain, average pain, worst pain, and least pain were 0.718, 0.694, 0.594, and 0.669 respectively). Thus, the divergent validity of SBST against percentage overall pain intensity score was $r = 0.732$; $p = 0.001$) (Table 4). The divergent validity of the SBST and percentage overall pain intensi-

Table 2

General and Pain Characteristics of Participants

Variable	All participants	Male (n =33)	Female (n = 37)		
	Mean ± *SD*	Mean ± *SD*	Mean ± *SD*	t-cal	*p*-value
General characteristics					
Age (years)	51.42±8.78	52.72±9.45	50.25±8.08	1.172	0.046
Weight (kg)	68.57±11.60	68.89±11.79	68.29±11.59	0.208	0.733
Height (m)	1.61± 0.76	1.64± 0.07	1.58± 0.07	3.206	0.377
BMI (kg/m^2)	26.60±3.92	25.84±3.76	27.28±3.99	-1.550	0.526
Pain characteristics					
Current pain	4.78±1.67	4.72±1.66	4.83±1.69	-0.275	0.512
Average pain	4.61± 1.29	4.54±1.22	4.67± 1.35	-0.420	0.806
Worst pain	6.64± 1.37	6.48±1.25	6.78±1.47	-0.908	0.750
Least pain	3.65± 1.42	3.51±1.27	3.78± 1.55	-0.786	0.577
QVAS Total %	53.47± 13.2	52.52±12.63	54.32± 13.85	-0.565	0.886
Pain duration	21.2± 6.67	21.9±6.96	20.5±6.43	0.874	0.385

Table 3

STarT Back Screening Tool Disability Risk Subgrouping by Gender

Risk Group	All participants (n = 70)	Male (n = 33)	Female (n = 37)		
	n (%)	n (%)	n (%)	χ^2	*p*-value
SBST Risk group					
Low Risk	7 (10.0)	5 (15.1)	2 (5.4)	2.995	0.224
Medium Risk	53 (76.0)	22 (66.7)	31 (83.8)		
High Risk	10 (14.0)	6 (18.2)	4 (10.8)		
Distress Subscale Risk Group					
Low Risk	0 (0)	0 (0)	0 (0)	0.774	0.379
Medium risk	60 (86.0)	27 (81.8)	33 (89.2)		
High risk	10 (14.0)	6 (18.2)	4 (10.8)		

Table 4

Correlation Between Pain Characteristics and STarT Back Screening Tool Scores (n = 70)

Pain Characteristics	r	*p*-values
Current Pain	0.718	0.001*
Average Pain	0.694	0.001*
Worst Pain	0.594	0.001*
Least Pain	0.669	0.001*
QVAS total score	0.732	0.001*

QVAS: Quadruple Visual Analogue Scale
* level of significance

ty score is depicted as a scatter plot in Figure 2.

Table 5 shows the disability risk subgroupings of the participants using the SPPTB. 71.4% of the participants had high disability risk, while the rate for low disability risk was 5.71%. There was no significant association between disability risk subgroups and gender. (χ^2=1.857; p=0.395).

Chi-squared statistical analysis revealed a significant difference in disability risk subgrouping between SBST and SPPTB (χ^2= 12.334; p=0.015), as depicted in Table 6. There was no significant relationship between SBST and SPPTB disability risk subgrouping (r = 0.023; p= 0.280). SBST had a positive Kurtosis value of 0.300 indicating a distribution curve with heavier tails and a sharper peak than the normal distribution (Table 7). SPPTB had a negative Kurtosis value of -0.210 meaning the distribution had lighter tails and a flatter peak than the normal distribution. Both SBST and SPBBT Kurtosis values deviated largely from 0, indicating the data are not normally distributed (Table 7). Analysis for skewness showed SBST has negative skewed value of -0.135, indicating the "tail" of the distribution points to the left while SPPTB has positive skewed value of 0.169 which indicates the "tail" of the distribution points to the right (Table 7).

SBST showed no floor and ceiling effects; less than 15% of the participants reach the lowest or highest possible score. 2.9% of the participants scored '0', and 1.4% scored '9', the lowest and highest obtainable scores on SBST. Conversely, SPBBT demonstrated floor and ceiling effects, being unable to detect '0' and '9', the lowest and highest obtainable scores. We found that 2.9% and 4.3% of participants had, respectively, '2' and '7', the lowest and highest recorded scores.

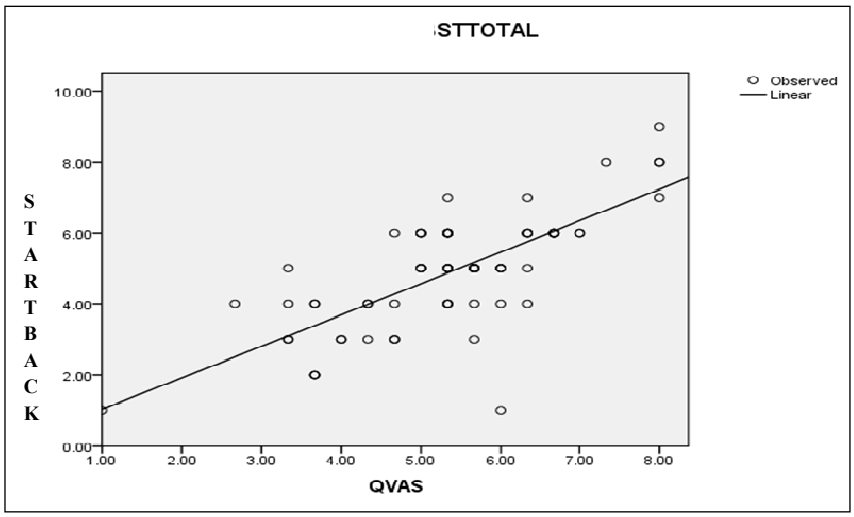

Figure 2

Divergent validity of the STarT Back screening tool

Table 5

Simmonds Physical Performance Tests Battery: Disability Risk Subgrouping by Gender

	All participants (n = 70)	**Male** (n = 33)	**Female** (n = 37)		
	n (%)	n (%)	n (%)	χ^2	*p*-value
SBST Risk subgroup					
Low Risk	4 (5.71)	3 (4.30)	1 (1.42)	1.857	0.395
Medium risk	16 (22.9)	6 (8.57)	10 (14.3)		
High risk	50 (71.4)	24 (34.3)	26 (37.1)		

Table 6

Comparison of STarT Back Screening Tool and Simmonds Physical Performance Tests Battery Disability Risk Groupings

SBST risk	SPPTB risk Subgrouping					
Subgrouping	All participants	Low Risk	Medium Risk	High risk		
	n (%)	n (%)	n (%)	n (%)	χ^2	*p*-value
Low Risk	7 (10.0)	2 (2.85)	3 (4.3)	2 (2.9)	12.334	0.015
Medium risk	53 (75.7)	1 (1.42)	10 (14.3)	42 (60.0)		
High risk	10 (14.3)	1 (1.40)	3 (4.3)	6 (8.6)		

Table 7

Skewness and Kurtosis Scores: STarT Back Screening Tool and Simmonds Physical Performance Test Battery

	SBST	**SPPTB**
Skewness	-0.135	0.169
Std. Error of Skewness	0.287	0.287
Kurtosis	0.300	-0.210
Std. Error of Kurtosis	0.566	0.566

Receiver operating curves (ROC) were used to test the sensitivity and specificity of the SBST. The area under curve was found to be 0.51. The estimated prevalence for high disability risk prediction of SBST was 0.76. The sensitivity and specificity of SBST was 0.83 and 0.23 respectively. Positive and negative predictive values of SBST were 0.81 and 0.19 respectively. Estimates for true positive, false positive, true negative and false negative for prediction of high disability risk were 0.77, 0.23, 0.31, and 0.69 respectively. Table 8 shows the estimates of population prevalence, sensitivity, specificity, predictive values, and likelihood ratios of SBST to predict high disability risk.

DISCUSSION

This study assessed the comparative predictive validity of SPPTB and SBST to assist clinicians and patients to quickly and accurately predict disability risks among sufferers of chronic non-specific LBP. Traditionally, to predict disability and treatment outcomes, physiotherapy relies on specific tests such as range of motion, resistance testing, neuro-assessment tests, manual muscle tests[41] and batteries of tests such as the SPPBT (i.e. repeated sit-to-stand, repeated trunk flexion, unloaded reach, 50 foot walk, 360-degree roll over and Sorensen Fatigue Test)[12], or the Short Physical Performance Battery[42].

Concerns about the clinical usability of psychometrically sound test batteries such as SPPTB have contributed to the development of self-report tools as an alternative means of assessment. Self-report tools for predicting disability risks such as the ÖMPSQ and SBST[33] are gaining increasing use in clinical and research settings. This study aims to address the dearth of evidence concerning the overlap between psychometrically sound test batteries such as SPPTB and self-report tools such as SBST for disability risks prediction.

The mean age of the patients in this study was 51.4 ±8.78 years, which is within the age bracket in which LBP is most prevalent[43,44]. A systematic review by Meucci et al.[44] posits that chronic LBP prevalence varies according to age range and was around three to four times higher in individuals aged over 50 compared to those aged 18 to 30. Another systematic review by Hoy et al.[43] found that the overall prevalence of LBP increases with age until the 60-65 year age group and then gradually declines.

Within this study, both the intensity and duration of pain of the patients were assessed. Pain is a multidimensional experience that is a prominent feature of many musculoskeletal disorders[45]. This study utilized the QVAS for pain assessment. The Visual

Table 8

Estimates of Population Prevalence, Sensitivity, Specificity, Predictive Values, and Likelihood Ratios of STarT Back Screening Tool to Predict High Disability Risk

	Estimated	95% Confidence interval	
	Values	low limit	upper limit
Prevalence	0.757143	0.637378	0.848318
Sensitivity	0.830189	0.697037	0.914788
Specificity	0.235294	0.078231	0.502383
Positive test result	0.814286	0.699768	0.893648
Negative test result	0.185714	0.106352	0.300232
True positive predictive value	0.77193	0.6384	0.868448
False positive predictive value	0.22807	0.131552	0.36157
True negative predictive value	0.307692	0.0103585	0.611151
False negative predictive value	0.692308	0.388849	0.896415
Positive likelihood ratio (C)	1.085631	0.811983	1.451502
Negative likelihood ratio (C)	0.721698	0.721698	1.90374
Positive likelihood ratio (W)	3.384615	2.056963	5.569192
Negative likelihood ratio (W)	2.25	1.115508	4.538292

Analogue Scale (VAS) is also widely used in research studies, primarily due to its ample clinimetric and psychometric properties[46]. However, an inherent limitation that leaves patients with no ability to quantify worsening pain[47] constitutes a significant shortcoming in the use of the VAS. QVAS is used to assess pain experienced over an extended period of time, and help define how severe the symptoms are within specific timeframes[39]. Based on the QVAS scores obtained in this study, the current, average, least and worst pain levels of the patients were 4.78 ±1.67, 4.61 ±1.29, 3.65 ±1.42 and 6.64 ±1.37 respectively. The mean QVAS total pain score of the patients was 53.47 ±13.2, from a possible total of 100. As such, the patients in this study can be said to have, on average, pain intensity of a moderate level. Of course, pain intensity in the chronic LBP population varies[48]. Sribastav et al.[49], for example, reported that some of the patients under consideration with chronic LBP have mild to moderate pain intensity while others suffer with severe pain.

We found no significant gender difference in the pain characteristics of the patients. It is well accepted that gender is a relevant factor in the modulation of pain, and there is a considerable body of evidence suggesting that women have more frequent LBP[50], higher levels of disability[51], and a higher number of comorbidities[52] than men. The pain duration of the participants in this study was 21.2 ±6.67 weeks. However, Kongsted et al.[53] underlined that LBP is typically characterized by an episodic course, and accurately reporting the duration of symptoms may therefore be difficult.

The study also aimed to identify the disability sub-groups of patients with chronic LBP using SBST and SPPTB respectively. Identifying subgroups of patients with LBP and matching them with targeted therapies has been recommended by various panels on LBP management[54]. The SBST is one of the tools designed to stratify patients with LBP according to their risk of future physical disability, in order that prognostic subgroups can receive matched treatment[33].

We validated the tool for disability risk sub grouping. In accordance with the SBST, patients in this study were categorized as low, medium or high risk respectively. In our study sample, a majority (76%) of the patients were classified as medium risk. This outcome is similar to a study by Robinson and Dagfinrod[55], which reported the majority of the patients recruited were categorized as medium risk. However, Fritz et al.[35], concluded from their research that the baseline SBST risk category was associated with a patient's baseline pain and disability levels, with the high-risk category having the highest scores and the low-risk category having the lowest scores. Their result imply that patients categorized by the SBST as being at medium risk are those with predominantly physical prognostic factors.

The expectation is that these medium risk patients are most likely to benefit from referral to physical therapists[56]. However, our participants were also categorized into disability risk subgroups using SPPTB, with the majority of the patients being classified as high risk (72.7%). There is a very marked discrepancy between the disability risks subgroupings from the two tools, with SPPTB determining that close to three quarters of the patients are at high risk whilst SBST puts just above three quarters of those same patients as at medium risk.

Physical functioning presents potentially useful assessment opportunities since, unlike some domains, it can be assessed both indirectly by self-report and directly by observational methods in a performance context[57]. Bombardier[58] and Grotle et al.[59] argued that self-reported disability questionnaires are cheap, quick and easy to administer and demon-

strate good levels of reliability and responsiveness, unlike physical performance measures in which the administration can be burdensome for both patient and clinician, and requires a significant amount of time if administered to an entire group of participants[11]. It is possible, however, physical performance measures may provide unique and useful information about patient functioning over and above that which self-report measures[57] can. Denison et al.[60] suggested that self-reported disability assessment may be influenced by patients' psychological state to a greater degree than a performance-based assessment. Self-reported measures may capture not what the patient can do, but what they think they can do and these two things might not always be the same, particularly in those patients with poorer psychological functioning[61].

A higher percentage of males in our study were assigned to the high risk subgroup (8.5% vs. 5.7% for females). This is contrary to Robinson and Dagfinrod[55] where there was a greater preponderance of females than males (62% vs 38%). In the 'distress' subscale of the SBST, a majority of their participants (86.0%) were in the medium risk category, again with a higher female preponderance (47.1%) than male (38.7%). Such findings are further supported by Leijon et al.[62], who identified a gender gap concerning self-reported LBP and psychosocial distress, with greater prevalence amongst females.

A significant relationship was found between different levels of pain characteristics and SBST, similar to the findings of Hill et al.[33] who developed and validated the SBST against back pain[28]. The study subsequently established that a relationship exist between pain intensity and SBST. Moreover, studies by Hill et al.[22], Hay et al.[56] and Yasmeen[63] demonstrate that SBST has the ability to detect multiple predictors of persistent disabling back pain and the tool was initially created to inform clinical care pathways and referral routes for patients with LBP seeking care from primary care clinicians[64].

SBST was validated for determining the severity of back pain through measurement of pain intensity. The correlation coefficient between SBST score and the total pain score of QVAS was (r = 0.732), similar to the findings of Forsbrand et al.[65] who demonstrated moderately strong correlations between the SBST and total pain scores for individuals with back and/or neck pain with short duration. Higher correlations have been reported when comparing the SBST for patients with pain in an English population[66] and in a French population[67] but lower correlations have also been found in a Finnish population[68].

The concurrent validity of the SBST in this study was r = 0.5. The SBST has been shown to have concurrent validity with a similar screening tool[33] and has been validated as predictive of future disability for patients with LBP within a primary care setting[66]. Robinson and Dagfinrod[69] also described SBST as a validated instrument measuring performance of activities. Sharafi et al.[70] further established that the Persian version of ÖMPSQ was a valid and reliable instrument and also a good cross- cultural equivalent to the original English version. The ÖMPSQ-short has earlier been compared with the SBST for patients with LBP[68,71,72] but not yet for a population with patients applying for physiotherapy treatment due to back pain.

We found SBST and SPPTB to be significantly associated. There was also a significant difference in the predictive validity for disability risk between SBST and SPPTB. Guildford et al.[57] found significant association between self-report and physical performance measures in people with chronic pain. Simmonds et al.[12] also found performance on the test battery and self-report of disability were moderately associated. However, in our study there was no significant relationship between the raw scores of SBST and SPPTB.

The study considered further analysis involving checking the floor and ceiling effects, as well as the sensitivity and specificity of both tools. Skewness is a measure of symmetry, or more precisely, lack of symmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the center point. Skewness can range from minus infinity to positive infinity. Absolute values above 0.2 indicate great skewness[73]. Normal distributions have zero skewness.

Kurtosis characterizes the relative peakedness or flatness of a distribution compared to the normal distribution, where Positive Kurtosis indicates a relatively peaked distribution and Negative Kurtosis a relatively flat distribution". Kurtosis is actually more influenced by scores in the tails of the distribution than scores in the center of a distribution[74]. Accordingly, it is often appropriate to describe a leptokurtic distribution as "fat in the tails" and a platykurtic distribution as "thin in the tails." A uniform distribution certainly has a flat top. The SBST results had a positive Kurtosis value of 0.300 which indicate that the distribution has heavier tails and a sharper peak than a normal distribution. By contrast, the SPPTB results displayed a negative Kurtosis value of -0.210, which means the distribution has lighter tails and a flatter peak than the normal distribution. Both SBST and SPPTB Kurtosis values deviate greatly from 0 which indicates that the data are not normally distributed. The result on skewness shows that SBST has negative skewed value of -0.135 which indicate the "tail" of the distribution points to the left while SPPTB has positive skewed value of 0.169 which indicate the "tail" of the distribution points to the right. Skewness refers to the asymmetry of the distribution.

The SBST results obtained had no floor and ceiling effects, as less than 15% of the participants reach the lowest or highest possible score. The result show that 2.9% and 1.4% of the participants had '0' and '9' which is the lowest and highest obtainable scores on SBST. Conversely, SPPTB showed both floor and ceiling effects, as it was unable to detect '0' and '9' which are the lowest and highest obtainable scores on SPPTB; 2.9% and 4.3% of participants had '2' and '7' as their lowest and highest scores. According to Terwee et al.[75], outcome measures with floor or ceiling effects

are typically unable to detect extreme scores in their low or upper ends. Furthermore, such scales are unable to discriminate between patients with lowest and highest possible scores, thus compromising the reliability of the scale. As changes in health status cannot be measured in these groups of patients with extreme scores using a scale with floor or ceiling effects, the responsiveness of such an instrument is reduced.

The ceiling effect occurred when the score distribution was asymmetric and was determined by the percentage of the population that scored the highest levels of the measure, harming the detection of change in health status in situations of improvement. Likewise, the floor effect was observed when a percentage of the individuals scores at the lowest level of the measure, which may impair the detection of change in situations of deteriorating health condition[76]. The presence of floor and ceiling effects can influence sensitivity and responsiveness, important psychometric properties of the instruments of measurement[77].

In signal detection a receiver operating characteristic (ROC) curve graphically illustrates the performance of a binary classifier system by plotting the True Positive Rate (TPR) versus the False Positives Rate (FPR), at various thresholds. TPR is also referred to as Sensitivity and is a measure of how rarely a tool overlooks what it is intended to find. Calculated as 1-FPR is the True Negative Rate. Also known as Specificity, it is a measure of how rarely a tool misidentifies anything else as that which it is intended to find.

ROC was used to assess the sensitivity and specificity of the SBST, with the area under curve found to be 0.51. The Area Under the Curve (AUC) is a summary measure of achieved discrimination, with perfect discrimination represented by an AUC of 1.0, and scores equal to or less than 0.5 are equivalent to or worse than can be expected by random chance. The closer the AUC approaches 1.0, the better discriminatory power the diagnostic test has in relation to the criterion or reference standard. Having cross-classified the participants according to SBBPT (whether a high-risk for disability is present or absent), and whether SBST (designed to indicate the presence of high-disability risk) proves positive or negative, SBST sensitivity (conditional probability that the test will be positive if the condition is present), SBST specificity (conditional probability that the test will be negative if the condition is absent), predictive values of SBST (probabilities for true positive, true negative, false positive, and false negative), and positive and negative likelihood ratios of SBST were calculated, alongside the 95% confidence intervals.

The prediction for disability risk was taken as the case (problem) while low disability risk was used as the referent (absence of high-disability risk). The estimated prevalence for high disability risk prediction of SBST is 0.76. The sensitivity and specificity of SBST is 0.83 and 0.23 respectively. Positive and negative predictive values of SBST are 0.81 and 0.19 respectively. The estimates for true positive, false positive, true negative and false negative for prediction of high disability risk are 0.77, 0.23, 0.31, and 0.69 respectively. This study gave estimates of population Prevalence, Sensitivity, Specificity, Predictive Values, and Likelihood Ratios of SBST to predict high disability risk.

The study has potential limitations associated with nature of both self-report and physical performance means of assessment. The use of self-report tools is believed to be fraught by recall bias[78], prolong pain forgotten memory problem[79], mood and memory bias[67], and comes with ethnic and cultural considerations[67,80]. Physical performance tests can bring their own potential limitations, such as the inability to regulate participants' motivation[81]. However, the results supported the use of SBST as a prognostic tool that can predict the likelihood of potential disability and suggest treatment interventions for a patient. Considering also that SBST's psychometric properties have been tested in several countries and it is now used in a number of different international settings[33,35,67,68,82-84,] SBST is recommended for use in physiotherapy settings as a valid and reliable tool for subgrouping of patients into risk-groups depending on the severity of their back problems[69].

CONCLUSION

The STarT Back Screening Tool is better able to identify patients with low-back pain with moderate disability risks, while The Simmonds Physical Performance Test Battery is better able to identify high disability risks. As such SBST as a self-report measure may not adequately substitute physical performance-based disability risks prediction. However, SBST has good divergent predictive validity with pain intensity. Unlike SPPBT, SBST had no floor and ceiling effects, and demonstrated high sensitivity but low specificity in predicting 'high-disability risk'.

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Competing interests
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