



Seated Single-Arm Shot-Put Test to Measure the Functional Performance of the Upper Limbs in Exercise Practitioners With Chronic Shoulder Pain: A Reliability Study

Jocassia Silva Pinheiro, PET,^a Otávio Lima Soares Monteiro, PET,^a Cezar Augusto Brito Pinheiro, PET,^a Luana Maria Brenha Penha, PET,^a Mariana Quixabeira Guimarães Almeida, PT,^a Daniela Bassi-Dibai, PT, PhD,^b Flavio de Oliveira Pires, PT,^a Christian Emmanuel Torres Cabido, PET, PhD,^c Cid André Fidelis-de-Paula-Gomes, PT, PhD,^d and Almir Vieira Dibai-Filho, PT, PhD^c

ABSTRACT

Objective: To measure the intra- and interrater reliability of the seated single-arm shot-put test (SSPT) in the functional performance of the upper limbs of regular physical exercise practitioners with shoulder pain.

Methods: This is a reliability study. Thirty individuals regularly practicing any sports modality that uses the upper limb effectively for at least 6 months, both sexes, ages between 18 and 30 years, with chronic shoulder pain were included. Chronic shoulder pain was measured by means of the shoulder pain and disability index, numerical rating scale, and catastrophic thoughts about pain scale. Functional performance of the upper limbs was measured by means of SSPT.

Results: Excellent intrarater reliability was found, with intraclass correlation coefficient ≥ 0.93 , standard error of the measurement values $\leq 4.63\%$, and minimum detectable change values for absolute and normalized score of 45.11 cm and 9.97, respectively. Excellent interrater reliability was found, with intraclass correlation coefficient ≥ 0.96 , standard error of the measurement values $\leq 3.55\%$, and minimum detectable change values for absolute and normalized score of 32.29 cm and 7.70, respectively.

Conclusion: SSPT is a reliable tool for measuring the functional performance of the upper limbs in regular exercise practitioners with chronic shoulder pain. (J Chiropr Med 2020;19:153-158)

Key Indexing Terms: *Reproducibility of Results; Pain; Upper Extremity*

INTRODUCTION

The shoulder is a complex joint that needs a coordinated relationship between bones, soft tissues, and muscles for good upper limb function. Excessive use may lead to dysfunction of the upper limb, especially in the shoulder, in activities with flexion or abduction above 90° .¹

For the most part, shoulder pain is related to changes in the musculoskeletal system, with a relative prevalence varying from 8% to 13%.² Noteworthy is the considerable involvement of shoulder pain in exercise practitioners, especially in sports which require repetitive movements of abduction and external rotation, such as swimming, volleyball, handball, wrestling, basketball, and those using rackets.³

Given this context, there are some tests validated in the specialized literature with a capacity to measure the functional performance of the upper limbs. Among these, the

^a Department of Physical Education, Federal University of Maranhão, São Luís, MA, Brazil.

^b Postgraduate Program in Programs Management and Health Services, Ceuma University, São Luís, MA, Brazil.

^c Postgraduate Program in Physical Education, Federal University of Maranhão, São Luís, MA, Brazil.

^d Postgraduate Program in Rehabilitation Sciences, Nove de Julho University, São Paulo, SP, Brazil.

Corresponding author: Almir Vieira Dibai-Filho, PT, PhD, Universidade Federal do Maranhão, Centro de Ciências Biológicas e da Saúde, Departamento de Educação Física, Avenida dos Portugueses, 1966, Vila Bacanga, CEP 65080805, São Luís, MA, Brazil.

(e-mail: dibai_filho@gmail.com).

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closed kinetic chain upper extremity stability test (CKCU-EST) stands out; this test determines a score for a task executed with the upper end in a closed kinetic chain.⁴ Another evaluation possibility is the timed functional arm and shoulder test in which the shoulder function is verified in 3 basic tasks that encompass a range of motion, strength, and resistance; this test is unique because it encompasses several tasks of functional performance.⁵ In turn, MacDermid et al⁶ proposed the Functional Impairment Test-Hand and Neck/Shoulder/Arm to measure the functionality of the shoulder, consisting of a battery of 3 tasks that simulate daily activities that require flexion or abduction of the shoulder above 90°.

Another possible and easy test to measure the functional performance of the upper limb is the seated single-arm shot-put test (SSPT). Published in 2010, this is an open kinetic chain test performed with a 6-lb (2.72-kg) ball that should be thrown as far as possible while the individual is in the sitting position.^{7,8} A test similar to the SSPT is the seated medicine ball throw (SMBT).⁹ However, the throw performed in SMBT is with the simultaneous use of the upper limbs, while the SSPT requests the throw be executed with 1 of the upper limbs, which approximates the movement used in several sports, such as volleyball and handball. Thus, SSPT has positive points that differ from the other tests, such as the possibility of evaluating, in isolation, 1 of the upper limbs during a throw. SSPT has a low complexity and does not require high coordination for its execution.¹⁰

SSPT reliability was initially tested on healthy recreationally active adults with excellent reliability of SSPT found in this sample.⁸ A previous study noted that SSPT has moderate to strong relationships with isokinetic peak forces for both limbs.¹¹ Moreover, Riemann et al¹⁰ concluded the use of the SSPT is a way to compare bilateral upper extremity functional performance.

However, no studies were found that evaluate the reliability of this test in physical exercise practitioners with shoulder pain, justifying the present study. Thus, SSPT reliability for individuals with shoulder pain broadens the possibilities of instruments that evaluate the functional aspect of this joint, serving as a basis for the intervention of several professionals involved in the rehabilitation of these individuals.

The objective of this study was to measure the intra- and interrater reliability of SSPT in the functional performance of the upper limbs of regular physical exercise practitioners with shoulder pain. The hypothesis of the study was that SSPT is a reliable test for the population studied when considering different times and examiners.

METHOD

The research took place in the athletic center of the university and was approved by the research ethics committee (protocol number 2.383.556/2017). The recruitment of

volunteers took place in the university community and around the university through verbal dissemination, posters, and social media. All the volunteers included in the study validated their participation through the signing of the informed consent form.

This is a reliability study based on Guidelines for Reporting Reliability and Agreement Studies.¹² The 2 researchers responsible for the analysis of the upper limb functional performance by means of SSPT were blinded to the clinical characteristics and measures of pain, catastrophizing, and functional disability of the participants.

A priori sample calculation was performed, considering a confidence coefficient of 0.95 and an amplitude of the confidence interval for the intraclass correlation coefficient (ICC) of 0.30. The calculation was performed to detect moderate reliability (ICC = 0.75) according to the study conducted by Fleiss.¹³ Therefore, a sample size of 24 participants was estimated. To cover possible sample losses, 30 volunteers were included in the present study. The calculation of the sample was performed based on the study conducted by Bonett.¹⁴

The present study was composed of 30 individuals practicing regular sports for at least 6 months (weekly frequency of at least 2 times), either recreational or competitive. Moreover, the Baecke questionnaire was used to characterize the habitual physical activity. Thus, the study included individuals of both sexes, practicing any sports modality that uses the upper limb effectively, with ages between 18 and 30 years, and with a verbal report of pain in the dominant shoulder for more than 3 months (chronic).

Chronic shoulder pain was related to the subacromial impingement syndrome. The diagnosis of shoulder pain was determined by the following criteria: score ≥ 18 points in the shoulder pain and disability index (SPADI), according to Breckenridge and McAuley,¹⁵ whether in pain or disability domains; positivity for 2 of the following clinical orthopedic tests: Jobe, Neer, Hawkins-Kennedy, or the painful arc test.

The following exclusion criteria were adopted: muscle or tendinous lesion in the upper limb; history of trauma or fractures in the upper limb; degenerative diseases related to the upper limb; ligament laxity in shoulder, elbow, wrist, or hand; nerve or vascular lesions in the assessed limb; history of surgical treatment in the upper limb; physiotherapeutic treatment in the last 6 months for the upper limb or spine; use of an anti-inflammatory in the last 7 days; and medical diagnosis of any rheumatologic disease.

The evaluation procedures were performed by blind researchers and were divided into 2 stages: (1) a researcher with previous experience with the research instruments carried out anamnesis and applied the eligibility criteria, the SPADI, the numerical rating scale, and the catastrophic thoughts about pain scale at an initial time; (2) 2 examiners, previously trained for 90 minutes, applied the SSPT in 2 moments, with an interval of 1 week between them,¹⁶ thus

allowing the measurement of intra- and interrater reliability. The training consisted of demonstrating the test, characteristics, repeated execution, and measurement of the throw distance of the ball.

Regarding the SPADI, this is a self-filling questionnaire, validated for the Brazilian population by Martins et al,¹⁷ which assesses the pain and functional disability associated with shoulder dysfunction. The questionnaire consists of 13 items distributed in two domains: pain (5 items) and function (8 items), scoring on a Likert scale from 0 (without difficulty) to 10 (failed to do), as described by Roach et al.¹⁸ The values obtained by the domain were summed and the average of this score was performed. Subsequently, the final values were transformed into percentage values ranging from 0 to 100, so that the higher the score the worse the condition of the shoulder affected by the dysfunction.¹⁸

The numerical rating scale is a sequence of numbers from 0 to 10 in which the value 0 represents “no pain” and 10 represents “worst pain you can imagine.” In this way, the volunteers indicated their pain based on these parameters.¹⁹ Pain intensity was assessed with the participant in the resting condition and after active shoulder movements.

The catastrophic thoughts about pain scale was used to evaluate pain-related catastrophizing, having been adapted and validated for the Brazilian population by Sardá Junior et al.²⁰ The scale is composed of 9 items staggered on a Likert scale ranging from 0 to 5; the points are associated with the words “almost never” and “almost always” on the extremities. The total score is the sum of the items divided by the number of items answered, and the minimum score can be 0 and the maximum 5. There are no cutoff points with higher scores indicating a greater presence of catastrophizing thoughts.

Regarding the SSPT, this is a test that evaluates the functional performance of the upper limb. Thus, the upper limb of the participant with shoulder pain was evaluated. To perform

the test, participants sat with their backs against a wall, knees bent at a right angle, and feet resting on the floor. Participants were placed in a location that allowed unrestricted arm movement on the test side (Fig 1). In this position, they were instructed to hold a ball weighing 3 kg in their hand at the level of the shoulder with pain. Thus, from this initial positioning, the participant pushes the ball as far as they could without realizing compensations with the body.^{7,8}

For familiarization, 2 previous runs of the test were performed with 75% and 100% of the maximum capacity of the participant (with 1-minute rest between them). After this, the first examiner independently applied the test, requesting 3 executions at the maximum capacity of the participant, with verbal encouragement, and with 1 minute of rest between the repetitions. The second examiner then performed the same procedure. The order of the examiners was defined by drawing lots before each SSPT application. A week later, the procedure was performed again (retest).

The mean of the 3 repetitions was used for the statistical calculations. The absolute and normalized values of the test were used, as described by Chmielewski et al,⁷ by means of the standardization formula: (distance [cm]/body mass [kg])^{0,35}.

The original validation of the test^{7,8} used a ball weighing 6 lbs (2.72 kg). However, the pound is not a measure used in Brazil, so the kilogram was adopted as the measure of weight. Six pounds equals 2.72 kg. Thus we used a ball weighing 3 kg because it is the closest to 6 pounds.

Regarding the statistical analysis, the ICC_{2,3} was used to determine the intra- and interrater reliability of the SSPT, with its respective 95% confidence interval, standard error of the measurement (SEM), and minimum detectable change (MDC).²¹ The interpretation of the value of the ICC was based on the study of Fleiss¹³: for values below 0.40, reliability was considered low; between 0.40 and 0.75, moderate; between 0.75 and 0.90, substantial, and finally, values greater than 0.90, reliability was considered excellent.



Fig 1. Initial (A) and final moment (B) in the execution of the seated single-arm shot-put test.

RESULTS

Thirty-five participants were initially recruited for the present study. Of these, 2 were excluded because they did not attend the retest, and 3 were excluded because they presented SPADI scores lower than 18 points. Thus, the final sample consisted of 30 regular physical exercise practitioners, most of them men, young adults, right-handed, and eutrophic, according to the characterization of the sample described in Table 1.

Table 2 presents the means and standard deviations during the test and retest of the 2 examiners. Regarding intra and interexaminer reliability, as shown in Tables 3 and 4, excellent reliability was verified for absolute and normalized measures (ICC > 0.90). In addition, the respective SEM and MDC values are also described in Tables 3 and 4.

DISCUSSION

According to the methodology used in the present study, SSPT is a tool that presents excellent ICC values when considering the different examiners and different times. In addition, the 2 possible scores for SSPT (absolute and normalized) are reliable and have similar amounts of error. We emphasize that the examiners were trained for 90 minutes, that is, brief training is required for proper application of the test.

The scientific literature presents some tools to measure the functional aspects of the upper limb. Some questionnaires have been commonly used within the context of rehabilitation to investigate the individual's ability to perform a series of functions with the upper limb, based on the individual's own report.²²⁻²⁴ The main tools validated for these purposes are The Disabilities of the Arm, Shoulder and Hand Outcome Questionnaire²⁵ and the Upper Limb Functional Index.²⁶

Within the sporting context, besides the tools based on the self-report of the athlete or practitioner, it is important to apply tests that evaluate the functional performance. Among the most used, a recent study highlights the CKCUEST, the Upper-Quarter Y-Balance Test (UQYBT), and the SMBT.⁹

It is possible to understand the functional tests by means of their biomechanical aspect. The CKCUEST and UQYBT are tests in a closed kinetic chain in which the body weight is used as a load on the upper limbs.⁹ In turn, the SMBT and the SSPT are open kinetic chain tests that use the throwing of a ball. To execute the SSPT, the athlete makes a throw with 1 of the upper limbs,⁸ whereas the throw in the SMBT is performed with the 2 limbs.^{9,27}

A pioneering study with SSPT⁸ attests to its reliability in healthy individuals with ICC values of 0.988 and 0.971 for the dominant and non-dominant upper limbs, respectively. In our study, we found values of reliability (ICC > 0.90)

Table 1. Personal, Clinical, and Sports Characteristics of Study Participants (N= 30)

Variables	n (%) or mean (standard deviation)
Sex (male)	19 (63.33%)
Age (y)	23.70 (4.47)
Weight (kg)	70.00 (8.86)
Height (m)	1.73 (0.07)
Body mass index (kg/m ²)	23.48 (2.42)
Dominance (right-handed)	25 (83.33%)
Sport modality	
Weight training	7 (23.33%)
Volleyball	4 (13.33%)
Basketball	4 (13.33%)
Swimming	4 (13.33%)
Functional training	2 (6.66%)
Judo	1 (3.33%)
Karate	1 (3.33%)
Muay thai	1 (3.33%)
Rugby	1 (3.33%)
Capoeira	1 (3.33%)
Surf	1 (3.33%)
Badminton	1 (3.33%)
Handball	1 (3.33%)
Sports practice time (mon)	74.26 (57.52)
Shoulder with pain (right)	25 (83.33%)
Chronicity of pain (mon)	40.96 (36.32)
Neer test (positive)	21 (70%)
Hawkins-Kennedy test (positive)	25 (83.33%)
Jobe test (positive)	25 (83.33%)
Painful arc test (positive)	23 (76.66%)
NRS (score, 0-10)	
Rest	2.33 (2.18)
Movement	6.53 (1.92)
CTPS (score, 0-5)	1.12 (0.83)
SPADI (score, 0-100)	
Disability	15.27 (10.75)
Pain	29.67 (15.66)
BQ (score, 1-5)	
Occupational	2.68 (0.55)
Sport	3.53 (0.75)
Leisure	2.90 (0.68)

NRS, numerical rating scale; CTPS, catastrophic thoughts about pain scale; SPADI, shoulder pain and disability index; BQ, Baecke questionnaire.

Table 2. Mean Values (Standard Deviation) of the Seated Single-Arm Shot-Put Test (SSPT) as Measured by the Study Examiners

Test	Examiner 1		Examiner 2	
	Test	Retest	Test	Retest
SSPT (cm)	348.51 (67.79)	354.32 (65.09)	341.09 (66.72)	348.42 (63.96)
SSPT (normalized)	78.72 (13.91)	80.06 (13.28)	77.09 (13.88)	78.72 (13.02)

Table 3. Intra-examiner Reliability of the Seated Single-Arm Shot-Put Test (SSPT)

Test	ICC	95% CI	SEM	SEM (%)	MDC
SSPT (cm)	0.94	0.88-0.97	16.27	4.63	45.11
SSPT (normalized)	0.93	0.84-0.96	3.59	4.52	9.97

ICC, intraclass correlation coefficient; CI, confidence interval; SEM, standard error of measurement; MDC, minimum detectable change.

Table 4. Interexaminer Reliability of the Seated Single-Arm Shot-Put Test (SSPT)

Test	ICC	95% CI	SEM	SEM (%)	MDC
SSPT (cm)	0.97	0.94-0.99	11.64	3.37	32.29
SSPT (normalized)	0.96	0.92-0.98	2.77	3.55	7.70

ICC, intraclass correlation coefficient; CI, confidence interval; SEM, standard error of measurement; MDC, minimum detectable change.

similar to regular practitioners of physical exercise with shoulder pain. For the other tests cited here, the literature presents satisfactory reliability values for CKCUEST in active individuals with shoulder pain (ICC > 0.82) and for UQYBT and SMBT in healthy overhead athletes (ICC > 0.92).^{4,27} In complement, Borms and Cools⁹ recommend the combination of performance tests of the upper limbs for the management of athletes.

Regarding SEM and MDC, only 1 study has also considered these measures complementary to the ICC. Negrete et al⁸ observed SEM of 17.78 cm and MDC of 43.18 cm in the dominant limb. For the nondominant limb, the SEM value was 20.32 cm and the MDC value was 45.72 cm. The values of this previous study are similar to our study (intrarater, SEM = 16.27 cm, MDC = 45.11 cm; interrater, SEM = 11.64 cm, MDC = 32.29 cm). In addition, we present the value of SEM%. Thus, we found excellent values, with a small amount of error inherent to the SSPT (SEM% ≤ 4.63), as described in the scientific literature.²⁸

Limitations

The present study presents some limitations that should be considered. We include regular practitioners of different sports. Thus, we suggest future studies with

athletes undergoing considerably higher training loads. We established clinical criteria for the diagnosis of chronic shoulder pain, according to previous studies.^{4,29} However, the degree of disability and pain of participants was mild, which may have contributed to the results. Therefore, samples with more severe conditions of shoulder pain should be considered in future studies to remedy this gap.

CONCLUSION

The findings of this study showed the SSPT was a reliable tool for measuring the functional performance of the upper limbs in regular exercise practitioners with chronic shoulder pain.

FUNDING SOURCES AND POTENTIAL CONFLICTS OF INTEREST

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CONTRIBUTORSHIP INFORMATION

Concept development (provided idea for the research): J.S.P., O.L.S.M., C.A.B.P., L.M.B.P., A.V.D.F.

Design (planned the methods to generate the results): D.B.D., C.A.F.P.G., F.O.P., C.E.T.C., A.V.D.F.

Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): D.B.D., F.O.P., C.E.T.C., A.V.D.F.

Data collection/processing (responsible for experiments, patient management, organization, or reporting data): J.S.P., O.L.S.M., C.A.B.P., L.M.B.P., M.Q.G.A.

Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): J.S.P., O.L.S.M., C.A.B.P., L.M.B.P., D.B.D., F.O.P., C.E.T.C.

Literature search (performed the literature search): J.S.P., O.L.S.M., C.A.B.P., L.M.B.P., M.Q.G.A.

Writing (responsible for writing a substantive part of the manuscript): J.S.P., M.Q.G.A., D.B.D., C.A.F.P.G.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): D.B.D., C.A.F.P.G., F.O.P., C.E.T.C., A.V.D.F.

Practical Applications

- The seated single-arm shot-put test is a reliable instrument.
- The amount of error inherent in the use of the seated single-arm shot-put test in exercise practitioners with shoulder pain is scientifically acceptable.
- The seated single-arm shot-put test can be used for measuring the functional performance of the upper limb in the clinical setting or in research.

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