Comparison of the upper extremity physical performance tests between asymptomatic adults with and without scapular dyskinesis

Comparação dos testes de desempenho físico de membros superiores entre adultos assintomáticos com e sem discinesia escapular

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Abstract

Introduction: Physical performance tests (PPTs) are screening tools widely available, easy to apply, and that can be performed in different environments and contexts. Scapular dyskinesis can be related to changes in glenohumeral angulation, acromioclavicular joint strain, subacromial space dimension, shoulder muscle strength/activation and humeral position/motion. Few studies were developed to understand the influence of aspects such as strength, stability mobility, and scapular dyskinesis on the scores of the upper extremity PPTs. **Objective:** To compare the performance in the Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST), Seated Medicine Ball Throw Test (SMBT) and Upper Quarter Y Balance Test (UQYBT) between asymptomatic adults with and without scapular dyskinesis. **Methods:** Cross-sectional study with 20 asymptomatic individuals: 10 with scapular dyskinesis and 10 without scapular dyskinesis. The average number of touches, number of touches normalized by height, and power score in the CKCUEST, distance covered by the ball in the SMBT, reach in the medial, inferolateral, and superolateral directions, total excursion and composite score of the UQYBT were compared between both groups. **Results:** No significant differences were found for all variables ($p > 0.05$). Small to moderate effect sizes were found for the scores of the CKCUEST ($d = 0.16$-0.78), a small effect size was found for the distance in the SBMT ($d = 0.12$), and small to moderate effect sizes were found for the scores of the UQYBT ($d = 0.02$-0.43). The scapular dyskinesis group presented better performance in all tests. **Conclusion:** The presence of scapular dyskinesis in asymptomatic individuals is not a factor related to worse scores in upper extremity physical performance tests.

Keywords: Physical performance tests. Scapular dyskinesis. Screening. Shoulder.

Resumo

Introdução: *Os testes de desempenho físico (PPTs) são instrumentos de triagem amplamente disponíveis, de fácil aplicação e que podem ser realizados em diferentes ambientes e contextos. A discinesia escapular pode estar relacionada a alterações na angulação glenoumeral, tensão na articulação acromioclavicular, dimensão do espaço subacromial, força/ativação muscular do ombro e posição/movimento umeral. Poucos estudos foram desenvolvidos para entender a influência de aspectos como força, estabilidade, mobilidade e discinese escapular nos escores dos PPTs de membros superiores.* ***Objetivo:*** *Comparar o desempenho no Teste de Estabilidade de Extremidade Superior de Cadeia Cinética Fechada (CKCUEST), Teste de Arremesso de Medicine Ball Sentada (SMBT) e Teste de Equilíbrio em Y do Quarto Superior (UQYBT) entre adultos assintomáticos com e sem discinesia escapular.* ***Métodos:*** *Estudo transversal com amostra de 20 indivíduos assintomáticos: 10 com discinesia escapular e 10 sem discinesia escapular. Comparou-se o número médio de toques, número de toques normalizados pela altura e pontuação de potência no CKCUEST, distância percorrida pela bola no SMBT, alcance nas direções medial, inferolateral e superolateral, excursão total e escore composto do UQYBT entre ambos os grupos.* ***Resultados:*** *Não foram encontradas diferenças significativas para todas as variáveis (p > 0,05). Tamanho de efeito pequeno a moderado foi encontrado para os escores do CKCUEST (d = 0,16-0,78), tamanho de efeito pequeno foi encontrado para a distância no SBMT (d = 0,12) e tamanho de efeito pequeno a moderado foi encontrado para as pontuações do UQYBT (d = 0,02-0,43). O grupo com discinesia escapular apresentou melhor desempenho em todos os testes.* ***Conclusão:*** *A presença de discinesia escapular em indivíduos assintomáticos não é um fator relacionado a piores escores em testes de desempenho físico de membros superiores.*

Palavras-chave: *Testes de desempenho físico. Discinesia escapular. Triagem. Ombro.*

Introduction

Physical performance tests (PPTs) are screening tools widely available, easy to apply, and that can be performed in different environments and contexts.[1] Among the upper extremity PPTs, the Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST), the Seated Medicine Ball Throw Test (SMBT), and the Upper Quarter Y Balance Test (UQYBT) are frequently used since they present good to excellent reliability, validity with isokinetic dynamometry, and reference values in overhead athletes, healthy volunteers, adolescents, older adults, and subjects with shoulder impingement syndrome.[2-8] Also, the CKCUEST was capable to predict shoulder injuries in football players.[9]

The scapular dyskinesis is defined as an alteration of normal scapular kinematics and can be clinically observed as the prominence of the medial border or inferior angle or early scapular elevation or shrugging during arm elevation, and/or rapid downward rotation during arm lowering.[10,11] It is presented mainly in overhead athletes (61%), when compared to nonoverhead athletes (33%),[12] and a recent systematic review with metanalysis of prospective studies concluded that the presence of scapular dyskinesis in asymptomatic overhead athletes may increase the risk of developing nonspecific pain in the shoulder by 43%.[13]

Scapular dyskinesis can be related to changes in glenohumeral angulation, acromioclavicular joint strain, subacromial space dimension, shoulder muscle strength/activation and humeral position/motion.[10,11] The shoulder muscle strength and activation deficits are the most studied. It is believed that scapulothoracic muscle weaknesses or muscular imbalance represented as excessive activation of the upper trapezius, combined with decreased control of the lower trapezius and the serratus anterior, contribute to abnormal scapular motion, and these alterations are commonly seen in subjects with impingement symptoms.[14-17]

Few studies were developed to understand the influence of aspects such as strength, stability and mobility of the upper quarter on the scores of the upper extremity PPTs,[2,3,5] and none of these studies assessed the influence of scapular positioning. Considering the prevalence in asymptomatic (33-61%) and symptomatic individuals (67-100%),[12,18] the aspects related to this dysfunction (especially shoulder strength and activation deficits),[14-17] and that the role of the dyskinesis in creating or exacerbating shoulder dysfunction is not clearly defined,[11] it is important to verify its influence on upper extremity performance.

Therefore, the primary objective of this study was to compare the performance in the CKCUEST, SMBT and UQYBT between asymptomatic adults with and without scapular dyskinesis. As it is considered a movement

dysfunction, our initial hypothesis was that the participants with scapular dyskinesis would have worse performance in these tests compared to asymptomatic adults without scapular dyskinesis.

Methods

A cross-sectional analytical study was carried out according to the recommendations of the STROBE (Strengthening the Reporting of Observational studies in Epidemiology). This study was approved by the Ethics Committee on Research with Humans (CAAE: 39143820.2.0000.5076). Informed consent was obtained in accordance with the Helsinki Declaration and local resolution.

Participants

Participants were recruited using advertisements within the Evangelical Faculty of Ceres community. The study was conducted at the Evangelical Faculty of Ceres. The inclusion criteria for the study were: male and age between 18 and 30 years. The exclusion criteria were: presence of previous injuries in the upper limbs; history of previous surgeries in the upper limbs; presence of self-reported cardiovascular, orthopedic, neurological, or rheumatologic diseases that prevented the performance of the physical performance tests. In G*Power software,[19] a sample size was calculated based on CKCUEST score of the first five individuals of each of the two groups (with and without scapular dyskinesis). Calculations were made using difference between two independent means, $\alpha = 0.05$, $\beta = 0.20$, allocation ratio N2/N1= 1 and effect size (d) = 1.26. The effect size was taken from a previous study.[20] Based on these criteria, at least nine individuals per group were required in each group. Therefore, a sample of 20 individuals completed the study, being 10 in each group.

Outcomes

The average number of touches, number of touches normalized by height, and power score in the CKCUEST, distance covered by the ball in the SMBT, reach in the medial, inferolateral, and superolateral directions, total excursion, and composite score of the UQYBT were compared between both groups.

Procedures

Data collection began with a questionnaire to obtain identification data and general information such as age, weight, height, body mass index, and length of the upper limbs. The length of the upper limbs was assessed with the participant standing, ninety-degree shoulder abduction, elbow extended, and wrist/hand in a neutral position. The measurement was made from the spinous process of C7 to the distal phalanx of the third finger.[4] After this measurement, the scapular dyskinesis test was performed and then the CKCUEST, SMBT and UQYBT were performed in a randomized order. Before the tests were carried out, the participants received information about how they were to be performed. A two-minute interval has been provided between the tests.

For the scapular dyskinesis test, a portable tripod was positioned perpendicular to the frontal plane at a height of 1.5 meters and a distance of 2.0 meters from the participant. The scapular dyskinesis was assessed through digital videos using an Iphone X sampling at 60 frames per second. Individuals were asked to simultaneously elevate their arms to a 3-second count using the "thumbs up" position, and then lower to a 3-second count.[21] At first, each individual performed five repetitions of arm elevation.[21] Scapular dyskinesis was considered present when the proeminence of medial scapular border, superior scapular border, inferior angle, or rapid scapular downward rotation[10,11,21] could be observed in 3/5 trials of arm elevation in the sagittal and/or frontal plane.[21] Scapular dyskinesis was absent when there were no abnormalities in scapular motion during elevation of the arm. Patterns of the scapular motion were rated independently by two trained raters, and dyskinesis was classified as present or absent. Data from both upper limbs were collected and the participant was classified as "present" when one upper limb demonstrated a scapular dyskinesis. A good interrater reliability was found for the classification in presence or absence of scapular dyskinesis (Kw = 0.90).

For the CKCUEST, participants were positioned in the push up position with the perpendicular arms spread at 92 centimeters. Participants performed alternate touches on the opposite hand as quickly as possible for a period of 15 seconds. Four attempts were allowed with an interval of 30 seconds between them, the first being for practice, and the average of the last three for analysis. The number of touches on the opposite hand

was recorded by the examiners. If the participant did not reach the predetermined mark or left the support position, the repetition was not valid. Normalized score was obtained dividing the number of touches by subject height, and power score was obtained by multiplying the average number of touches by 68% of subject's body weight in kilograms (percentage that corresponds to the weight of the arms, head and trunk) divided by 15 (elapsed test time in seconds).[8]

For the SMBT, participants were seated on the floor, supporting their backs against a wall and keeping their legs extended over a distance of 60 centimeters between them. A measuring tape was placed on the floor and extended at 10 meters. A 2 kg medicine ball was then delivered to the participants, and they were instructed to hold it with both hands close to the midline at chest height, and then to throw it horizontally as far as possible in relation to the tape measure placed on the floor. The distance (centimeters) covered by the ball was marked with the same measuring tape. Four attempts were allowed with an interval of one minute between them. If the participant moved their back off the wall or launched the ball in a non-horizontal trajectory, the repetition was not valid.[7]

For the UQYBT, participants were positioned in the push up position with the upper limbs extended. During the UQYBT, one hand remained fixed while the other reached a maximum range in three directions (medial, inferolateral and superolateral) named according to the stationary hand. Four attempts were allowed with an interval of 30 seconds between them, the first being for practice, and the average of the last three for analysis. The UQYBT was done in an adapted way using measuring tapes.[22] Men and women performed the test in the same way, and they were instructed to remain with their feet supported in the initial position throughout the test. The repetition was considered invalid when either the stationary hand or feet changed their position during the test or if the reach hand performed weight unloading and not a light touch on the tape.[23] Total excursion (medial + inferolateral + superolateral) and a composite score was calculated taking the total excursion distance and dividing it by three times the upper limb length.[5]

Statistical analysis

The data were analyzed in the Statistical Package for the Social Sciences (SPSS, version 23.0; Chicago, IL, USA). Descriptive statistics was performed with calculation of mean, standard deviation and 95% confidence interval. The Shapiro-Wilk test was used to verify normality of the data. A t test for independent samples was used to compare the anthropometric characteristics, and the performance in the CKCUEST, SMBT, and UQYBT between asymptomatic adults with and without scapular dyskinesis. Effect sizes between groups were calculated for the performance in the tests using the Cohen's d coefficient. An effect size greater than 0.8 was considered large, ~0.5 was moderate, and less than 0.2 was small.[24] Significance level adopted was $p < 0.05$.

Results

The sample consisted of 20 non-athletes asymptomatic adults, 10 with scapular dyskinesis and 10 without scapular dyskinesis. No significant differences were found in terms of age ($p = 0.49$), body mass ($p = 0.78$), height ($p = 0.10$) and body mass index ($p = 0.65$), showing that the groups were homogeneous (Table 1).

Table 1 - Comparison of the anthropometric characteristics between asymptomatic adults without and with scapular dyskinesis

Characteristics	Without (n = 10)	With (n = 10)	Mean difference (IC 95%)	p-value
Age (years)	23.30 (4.05)	25.40 (5.68)	-2.10 (-6.73 – 2.53)	0.49
Body mass (kg)	79.77 (10.13)	81.40 (14.47)	-1.62 (-13.85 – 10.61)	0.78
Height (cm)	178.00 (5.09)	174.44 (3.64)	3.55 (-0.78 – 7.89)	0.10
BMI (kg/m²)	26.70 (3.61)	25.97 (3.42)	0.73 (-2.67 – 4.13)	0.65

Note: BMI = Body mass index. Significance level of $p < 0.05$.

In relation to the CKCUEST, it was not observed a significant difference in the number of touches (p = 0.09), normalized score (p = 0.07) or power (p = 0.19). A small to moderate effect size was found for the scores of the CKCUEST (d = 0.16-0.78). For the SMBT, no significant difference was presented (p = 0.77). A small effect size was found for the distance in the SBMT (d = 0.12). Similar results were presented in the UQYBT; no significant differences were found for the medial (p = 0.62; p = 0.66), inferolateral (p = 0.90; p = 0.35), and superolateral (p = 0.95; p = 0.39) reach in both upper limbs between participants with and without scapular dyskinesis. Also, no significant differences were found for total excursion (p = 0.73; p = 0.94) and composite score (p = 0.40; p = 0.74). A small to moderate effect size was for found for the scores of the UQYBT (d = 0.02-0.43) (Table 2).

Table 2 - Comparison of the performance in the CKCUEST, SMBT, and UQYBT between asymptomatic adults without and with scapular dyskinesis

	Without (n = 10)	**With** (n = 10)	**Mean difference** (IC 95%)	**p-value**	**d**
CKCUEST					
Number of touches	15.90 (1.96)	17.90 (3.03)	-2.00 (-4.40 – 0.40)	0.09	0.78
Normalized score (%)	0.08 (0.01)	0.10 (0.17)	-0.01 (-0.02 – 0.00)	0.07	0.16
Power (%)	56.82 (11.56)	66.28 (17.99)	-9.45 (-24.29 – 5.38)	0.19	0.62
SMBT					
Distance (cm)	480.00 (109.25)	493.80 (107.46)	-13.80 (-115.61 – 88.01)	0.77	0.12
UQYBT – Right					
Medial (cm)	101.44 (7.97)	99.60 (8.03)	1.84 (-5.91 – 9.60)	0.62	0.22
Inferolateral (cm)	62.40 (9.26)	61.80 (11.63)	0.60 (-9.27 – 10.47)	0.90	0.05
Superolateral (cm)	44.78 (9.28)	45.00 (5.67)	-0.22 (-7.91 – 7.46)	0.95	0.02
Total Excursion (cm)	205.87 (17.40)	209.30 (23.26)	-3.42 (-24.44 – 17.59)	0.73	0.16
Composite (%)	72.62 (5.81)	75.26 (7.08)	-2.64 (-9.24 – 3.95)	0.40	0.40
UQYBT – Left					
Medial (cm)	98.30 (8.82)	100.40 (12.16)	-2.10 (-12.08 – 7.88)	0.66	0.19
Inferolateral (cm)	54.89 (17.70)	48.70 (9.87)	6.18 (-7.49 – 19.86)	0.35	0.43
Superolateral (cm)	60.78 (7.77)	58.50 (12.69)	2.27 (-8.06 – 12.61)	0.39	0.21
Total excursion (cm)	206.70 (26.88)	207.60 (27.96)	-0.90 (-26.67 – 24.87)	0.94	0.03
Composite (%)	74.89 (6.41)	73.70 (8.97)	1.18 (-6.44 – 8.81)	0.74	0.15

Note: CKCUEST = Closed Kinetic Upper Extremity Stability Test; SMBT = Seated Medicine Ball Throw; UQYBT= Upper Quarter Y Balance Test. Significance level of $p < 0.05$. Cohen's d: 0.2 = small, 0.5 = moderate, 0.8 = large.

Discussion

The primary objective of this study was to compare the performance in the CKCUEST, SMBT, and UQYBT tests between asymptomatic adults with and without scapular dyskinesis. It is possible to note that no statistical differences were found in the selected tests between asymptomatic adults with and without scapular dyskinesis. Despite the non-significance, a small effect size was found for SMBT, and a small to moderate effect size was found for CKCUEST and UQYBT.

Our results corroborate with previous studies that compared function, range of motion, muscle strength, and physical performance tests between adults with and without scapular dyskinesis.[20,24,26] Welbeck et al.[25] did not find differences regarding upper extremity function and thoracic rotation range of motion in swimmers. Hannah et al.[26] did not find differences in relation to isometric muscle strength of the upper, middle and lower trapezius, serratus anterior, supraspinatus, and the medial and lateral rotators of the humerus in asymptomatic adults. Similar results were found for

Pires and Camargo,[20] that did not find differences in the lower trapezius, serratus anterior, latissimus dorsi, trunk flexors, hip extensors and abductors in asymptomatic adults. Also, no differences were found regarding the performance in all directions of the UQYBT in our study.

CKCUEST is a closed kinetic chain test performed in the push up position that evaluates functional performance bilaterally and is capable to predict shoulder injuries, while the SMBT is an open kinetic chain test where the participant has to throw a medicine ball forward as far as possible and has the ability to measure muscle power.[2,4,8,9] Both tests are related with muscle strength. The scores of the CKCUEST and SMBT in our study presented a moderate to strong correlation with peak torque of the shoulder external/internal rotators; also, the CKCUEST is related to grip strength, and the SMBT is related to peak torque of the elbow flexors and extensors.[2,3,27] Subjects with scapular dyskinesis did not present deficits in the shoulder external/internal rotators in previous studies,[20,26] what could be an explanation to justify the similar results found in the CKCUEST and SMBT in our study.

UQYBT is a closed kinetic chain test with slow execution, performed in the push up position, that evaluates functional performance unilaterally and measures components related to balance, proprioception, stability, and mobility.[4,23] The study of Westrick et al.[5] showed a small correlation between the UQYBT with lateral trunk endurance; the absence of lateral trunk deficits in subjects with scapular dyskinesis[20] could be a possible explanation to justify the similar results found in this test. Subjects with scapular dyskinesis do not present thoracic mobility deficits.[25] Considering that there is a correlation between the reach in the UQYBT and thoracic mobility, this also could be a possible explanation. However, future studies to verify this relationship must be carried out to confirm this hypothesis.

Physical performance tests and scapular dyskinesis are important components of the upper extremity assessment considering that they are easy, quick to apply, low cost, can be performed in different contexts, and give relevant information regarding scapular positioning, mobility, stability and power in open and closed kinetic chain tasks.[23,28] To our knowledge, this is the first study to compare the performance in the CKCUEST and SMBT tests, and the second study that compared the performance in the UQYBT.[20] Therefore, this study is pioneer in investigating the differences in physical performance tests realized in subjects with scapular dyskinesis.

Based on our results, clinicians should be aware that the scores of upper extremity physical performance tests are not influenced by the presence of scapular dyskinesis alone in asymptomatic adults and this must be considered in the moment of screening. Also, evidence was provided to question the direct influence of scapular dyskinesis in asymptomatic adults, since no difference were found in physical performance tests, and previous studies did not find differences in function, range of motion and strength.[20,25,26] A recent prospective study has demonstrated that a large increase in weekly handball load increases the shoulder injury rate, particularly in the presence of reduced external rotational strength or scapular dyskinesis.[29] In this way, clinicians should note that scapular dyskinesis could act as an interactive indirect factor that, associated with other aspects, may influence the performance in upper extremity PPTs. Scapular dyskinesis may only be important as an interactive factor.

As limitations of this study, we can point out that it was made in a cross-sectional design and that our sample was made by healthy volunteers without shoulder pain or injury. Results cannot be extrapolated to other populations and cause-effect relationships should not be done. Future studies should be performed to identify possible aspects that are related to worse performance in upper extremity PPTs, the association of scapular dyskinesis, mobility, flexibility, stability, strength and fatigue with worse performance in upper extremity PPTs and with shoulder pain/injury, factors that could be altered in subjects with scapular dyskinesis, and if it exists subgroups of patients with scapular dyskinesis that are in high risk of upper extremity injuries.

Conclusion

There are no differences in the performance of the CKCUEST, SMBT, and UQYBT tests between asymptomatic adults with and without scapular dyskinesis. Small to moderate effect size was found for the CKCUEST and UQYBT. These results indicate that scapular dyskinesis alone is a not a factor related to worse scores in upper extremity PTTs.

Authors' contributions

GMPB JRSJ, TVL and JPCM elaborated the study idea. GMPB submitted to the research ethics committee for study. GMPB, JVFS JRSJ initiated the study design, while TVL, JVFS assisted in the design of the methods. GMPB, JVFS and JPCM collected the data. GMPB took the statistical analysis part.

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