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ORIGINAL RESEARCH

Inter- and intra-examiner reliability of the strength of shoulder rotators in different positions using isometric dynamometry

Confiabilidade inter e intra-avaliador na medida de força dos músculos rotadores do ombro em diferentes posições com a dinamometria isométrica

Confiabilidad inter e intraevaluador en la medida de fuerza de los músculos rotadores del hombro en diferentes posiciones con la dinamometría isométrica

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ABSTRACT | The handheld dynamometer is a portable device of easy use in clinical practice. However, its use requires reliability and reproducibility parameters in shoulder positions with and without stabilization. The objective of this study was to evaluate the inter- and intra-examiner reliability of the shoulder rotator strength measurement at 0° and 90° abduction with inexperienced examiners. Twenty subjects (27.05 ± 8.17 years, 76.6 ± 10.97 kg, 1.74 ± 0.07 m) of both sexes and no previous or current complaints of shoulder and neck pain participated in this study. The evaluation of the internal and external shoulder rotators was performed using a handheld dynamometer (MicroFET 2, Hoogan Health Industries, West Jordan, UT, USA) in two positions: sitting with 0° shoulder abduction and supine and with 90° shoulder abduction. Inter- and intra-examiner reliability and reproducibility were assessed through the intraclass correlation coefficient (ICC) considering a 95% confidence interval ($p<0.05$). There was excellent reproducibility in the intra-examiner analysis and very good levels of reliability measures in the inter-examiner analysis for most variables. The positions of 0° and 90° shoulder abduction showed reliable and reproducible results when using the handheld dynamometer with examiners that had no clinical experience.

Keywords | Muscle Strength Dynamometer; Shoulder; Reproducibility of Results; Muscle Strength.

RESUMO | O dinamômetro manual é um equipamento portátil e de fácil uso na prática clínica. Entretanto, sua utilização necessita de parâmetros de confiabilidade e reprodutibilidade em posições de ombro com e sem estabilização. O objetivo deste estudo foi avaliar a confiabilidade inter e intraexaminador na medida de força dos músculos rotadores do ombro nas posições a 0° e 90° de abdução com avaliadores inexperientes. Vinte sujeitos (27,05±8,17 anos; 76,6±10,97kg; 1,74±0,07m) de ambos os sexos e sem queixas anteriores ou atuais de dor no ombro e cervical participaram do estudo. A avaliação dos rotadores mediais e laterais do ombro foi realizada por meio de um dinamômetro manual digital (MicroFET 2, Hoggan Health Industries, West Jordan, UT, USA) em duas posições: sentado, com 0° de abdução do ombro, e em supino, com 90° de abdução de ombro. A confiabilidade interexaminador e a reprodutibilidade intraexaminador foram avaliadas pelo coeficiente de correlação intraclasse (ICC) considerando o intervalo de confiança de 95% ($p<0,05$). Houve uma excelente reprodutibilidade na análise intra-avaliador e níveis de confiabilidade muito bons para as medidas interavaliador na maioria das variáveis analisadas. As posições de 0° e 90° de abdução do ombro demonstraram resultados confiáveis e reprodutíveis com a utilização do dinamômetro manual digital por avaliadores sem experiência clínica.

Descritores | Dinamômetro de Força Muscular; Ombro; Reprodutibilidade dos Testes; Força Muscular.

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RESUMEN | El dinamómetro manual es un equipamiento portátil y de fácil uso en la práctica clínica. Sin embargo, su uso requiere de parámetros de confiabilidad y reproducibilidad en posiciones del hombro con y sin estabilización. Se objetivó en este estudio evaluar la confiabilidad inter e intraexaminador en la medida de fuerza de los músculos rotadores del hombro en las posiciones 0° y 90° de abducción con evaluadores inexpertos. Veinte personas (27.05±8.17 años; 76.6±10.97kg; 1.74±0.07m) de ambos sexos, sin problemas anteriores o actuales de dolores en el hombro y cervical participaron del estudio. Se evaluaron los rotadores medianos y laterales del hombro a través de un dinamómetro manual digital (MicroFET 2, Hoggan Health Industries, West Jordan, UT, USA) en dos posiciones: sentado, con 0° de abducción del hombro, y en supino, con 90° de abducción de hombro. Se evaluaron la confiabilidad interexaminador y la reproducibilidad intraexaminador por el coeficiente de correlación intraclase (ICC) considerándose el intervalo de confianza del 95% (p<0.05). Hubo una excelente reproducibilidad en el análisis intraevaluador y niveles de confiabilidad muy buenos para las medidas interevaluador en la mayoría de las variables analizadas. Las posiciones de 0° y 90° de abducción del hombro demostraron resultados confiables y reproducibles con la utilización del dinamómetro manual digital por evaluadores sin experiencia clínica.

Palabras clave | Dinamómetro de Fuerza Muscular; Hombro; Reproducibilidad de Resultado; Fuerza Muscular.

INTRODUCTION

The shoulder is a complex joint and the most mobile of the human body, being considered of little stability due to its anatomy, especially in the glenohumeral joint[1]. To ensure joint stability and mobility a constant and synchronic harmony between the static and dynamic structures is needed to maintain its biomechanical norm[2].

Several muscle groups are considered important for the proper functioning of the shoulder joint complex, the rotator cuff muscles are included among these[2]. The rotator cuff is composed by the tendons of the subscapularis, supraspinal, intraspinal and teres minor muscles and has as main function keeping the humerus centralized in the glenoid cavity during the anterior elevation movement, as well as participating effectively in internal rotation (subscapularis), abduction and external rotation (supraspinal) and in horizontal abduction and external rotation (intraspinal and teres minor)[3].

Frailty of the rotator cuff muscles may cause imbalances in internal and external rotation forces, thereby changing the normal glenohumeral joint motion[4]. This is listed as a cause or consequence of shoulder injuries[2,5]. To treat these injuries, it is essential to evaluate the muscle strength of the patients.

There are a few ways to quantify the performance of patients with shoulder injuries, such as muscle testing, isokinetic dynamometry and handheld dynamometry[6]. Although manual muscle tests are used by physical therapists in clinical practice, they do not provide a precise measurement of muscle function[7,8], in addition to failing when trying to differentiate patients with varying degrees of muscle weakness[6]. Isokinetic dynamometry on the other hand is considered the gold standard of shoulder strength tests[5], however, the high cost limits its use in research laboratories in most cases[4]. The digital handheld dynamometer is an alternative for these evaluations. It is a portable device, of small size and easy to use in clinical practice, which provides some reports of evaluation of shoulder and scapula muscles in different populations[9-11].

The reliability of handheld dynamometry for shoulder rotators has been a subject of many studies, showing high or moderate results of intra-examiner reliability[4-7,12-16]. However, studies evaluating the position of 90° abduction of the shoulder are still scarce, a position of greater joint instability and very representative of activities related to throwing sports[7,14,15]. Additionally, the evaluation by professionals with little clinical experience has not been addressed.

Thus, the objective of this study was to assess the inter- and intra-examiner reliability of inexperienced examiners in measuring the shoulder rotator strength at 0° and 90° abduction using isometric dynamometry.

METHODOLOGY

Participated in this study 20 volunteers (27.05±8.17 years; 76.6±10.97kg, 1.74±0.07m) of both sexes (15 men and 5 women) and with no prior complaints of shoulder and/or neck pain. They reached the researchers

after the divulgement of the research. Individuals who complained about shoulder, cervical spine or thoracic pain in the last six months or currently were excluded. After the complete clarification of the goals and procedures of the research the volunteers signed an Informed Consent Form, approved by the Comitê de Ética e Pesquisa (CAAE 27354714.4.0000.5323).

Two researchers with no clinical experience, however previously trained to perform the measurement of force were responsible for the collection of data. The movements (internal or external rotation), test position (sitting or lying) and the limb tested (dominant and non-dominant) followed a random order of measurement. The inter-examiners step occurred on the same day, with an interval of an hour between the collections. The intra-examiner evaluation was performed by the first examiner a week after the first collection, at the same place and time.

In this study we only considered the definition of dominant limb provided by the subject, considering the arm that the individual uses to write.

Handheld digital dynamometry

The strength of the lateral and medial shoulder rotators was evaluated in decubitus and sitting positions. The dynamometer was positioned over the distal region of the forearm (5 cm from the styloid process of the radius) for the volunteer to exert force on the equipment for five seconds. For every movement of the test three repetitions were collected, with an interval of a minute between them. The measurement unit chosen was kilogram-force (kgf) and this value was corrected by the bodyweight of the subject (kg) to allow for a better comparison among individuals with different body mass.

For evaluation at 0° abduction, the subject was positioned sitting on a fixed chair with hips and knees at 90° flexion. The evaluated limb had towel roll positioned between the trunk and the elbow, neutral rotation of the should, 90° flexion of the elbow and neutral position of the forearm. For this position, the dynamometer was supported on the wall by a cylinder with a magnet level attached to it, thus maintaining the equipment on the adequate position for the test (Figure 1).

For the evaluation of shoulder rotators at 90° abduction, the volunteer was positioned in supine position, bent knees, shoulder abducted to 90° and elbow flexed (Figure 2).

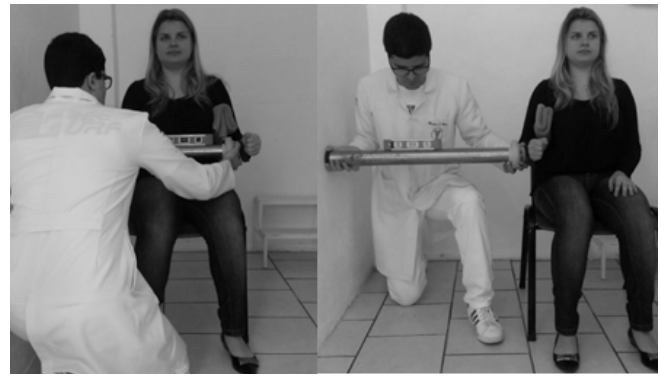

Figure 1. Sitting position to evaluate the strength of medial and lateral rotators of the shoulder

Figure 2. Shoulder positioned at 90° abduction for evaluation of medial and lateral rotators

Statistical analysis

The data obtained were compared regarding their reliability between the measurements performed by different reviewers on the same day and reproducibility in the comparison between the measurements performed by the same examiner on different days. Reproducibility inter-examiner and reliability intra-examiner were evaluated by the intraclass correlation coefficient (ICC) considering the confidence interval of 95% ($p<0.05$).

Using a scale proposed by Weir[17], reliability was considered excellent for values between 1.0 and 0.81, very good from 0.80 to 0.61, good from 0.60 to 0.41, average from 0.40 to 0.21, and poor from 0.20 to 0.00.

RESULTS

Table 1 presents data for the measurements on the movements of lateral rotation and medial rotation of the shoulder.

Table 1. Mean values and standard deviation of the force in kgf of lateral rotation and medial rotation of the shoulder, (D) dominant and non-dominant (ND) in abduction at 0° and 90°, of healthy subjects (n=20). Values measured by examiner 1, examiner 2 and in the re-evaluation by examiner 1

	Examiner 1	Examiner 2	Re-evaluation by examiner 1
D lateral rotation	13.33±3.95	13.26±3.32	12.85±3.54
ND lateral rotation	12.64±3.84	13.21±4.49	11.98±3.36
D medial rotation	16.67±5.42	17.58±5.58	17.69±5.71
ND medial rotation	15.58±4.33	16.43±5.17	16.75±4.75
D lateral rotation 90°	14.81±3.37	15.31±3.88	13.96±3.27
ND lateral rotation 90°	13.95±3.83	14.52±3.85	13.77±3.51
D medial rotation 90°	15.37±3.92	17.45±4.98	14.69±3.90
ND medial rotation 90°	15.34±3.64	17.31±4.90	14.68±4.23

Table 2 on the other hand, presents data concerning the intraclass correlation coefficient (ICC) comparing the intra- and inter-examiner results.

The inter-examiner ICC presented very good and good reliability for all variables, except for the non-dominant medial rotation where the coefficient showed average reliability. The intra-examiner reproducibility, ICC found better results with excellent for all variables, except for the dominant lateral rotation presented, which presented very good reproducibility.

Table 2. Values of the intraclass correlation coefficient (ICC) inter- and intra-examiners in lateral and medial rotation of the shoulder (D) dominant and non-dominant (ND) of healthy subjects (n=20)

	ICC Inter-Examiner	ICC Intra-Examiner
D lateral rotation	0.52	0.80
ND lateral rotation	0.71	0.88
D medial rotation	0.61	0.91
ND medial rotation	0.37	0.88
D lateral rotation 90°	0.56	0.85
ND lateral rotation 90°	0.67	0.87
D medial rotation 90°	0.45	0.92
ND medial rotation 90°	0.65	0.91

DISCUSSION

In this study, handheld isometric dynamometry proved to be a reliable tool for inter-examiner evaluation and for reproducible measurements of medial and lateral rotation strength of the shoulder, even when applied by examiner with no clinical experience. Considering the ease of use, portability, cost and size of the equipment, the handheld dynamometer is an instrument that can be safely used by clinicians and reproducible for the accurate evaluation of the strength of the shoulder rotators.

Cools et al.[14] found excellent levels of reliability and reproducibility in measurements of shoulder rotation, on every position tested, decubitus (sitting, prone and supine) and arm (neutral and 90° abduction). Although the prone position was used, the authors report that there was more confidence for the sitting and supine positions.

High reliability was also found in the studies of Andrews et al.[12] and Donatteli et al.[15], but these authors used different test positions from those used in our study. Andrews et al.[12] conducted the test on the 45° abduction position, Donatelli et al.[15] conducted the test in the scapular plane and also at 90° abduction. Moderate reliability indexes are also reported by Beshay et al.[13], Hayes et al.[7], Legging et al.[16] and Riemann et al.[4]. Differences on reliability and reproducibility levels found in studies may be associated to the evaluation positions used.

In our study, we sought to use two positions for the evaluation of shoulder rotator muscles, considering the different profiles of patients in physical therapy clinics. At the start of a rehabilitation program, the pain, the healing of soft tissues or even postoperative restrictions, make the adoption of evaluation in sitting position with the shoulder at 0° abduction more interesting and safe[4]. On the other hand, a throwing sports athlete on the final stage of rehabilitation needs to be evaluated in a position that resembles the functional movement of the glenohumeral joint during sports practice[18]. Despite this importance, especially in the 90° position of shoulder abduction, the need to stabilize the examiner for the

test can induce the same errors if the examiner uses his/her own strength during the test, rather than stabilize the equipment.

The sitting position with a slight abduction by a towel was used considering that the humeral head is compressed on the joint side of the supraspinatus tendon when the arm is in adducted position[19]. Additionally, a previous study[20] reported that by keeping a towel on the lateral rotation movement of the shoulder the use of the adductor muscles of the shoulder on the test execution is avoided, in addition to promoting a low load on the joint capsule.

The difficulty to evaluate the rotator cuff muscles with no contribution from other muscle groups is a limitation of this study, especially in the medial rotation movement in shoulder abduction. Kuechle et al.[21] claim that the medial rotation at 90° abduction uses muscles such as the subscapularis and the pectoralis major. During the abduction tests we noticed a trend of subjects adducting, which did not occur in adduction position due to the better stabilization of the segment.

Considering that the study subjects were not athletes or presented no strength training on the tested muscles, we believe that the reliability in trained subjects may exhibit different values from the ones we found. These differences will probably be more evident in the abduction position at 90°.

We note that the reliability indices were high, even with examiners who had no clinical experience. We know that this is an error factor considered in studies, considering that the practice and the strength of the examiner have direct relation to the resistance applied on the subject during muscle contraction[22,23], as well as in stabilizing the joint[24,25].

Despite not being considered as the "gold standard" for strength testing, the handheld dynamometer is a tool that must have its use encouraged, especially in clinical practice, aiming to replace the manual force test, which is extremely subjective.

CONCLUSION

The proposed study found reliable and reproducible results from the evaluation of strength of shoulder rotators in positions of 0° and 90° abduction with the digital handheld dynamometer performed by examiners with no clinical experience.

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