Comparison of fixed and non-fixed methods of hand-held dynamometry

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Abstract

Introduction: Hand-held dynamometry (HHD) is a technique used for evaluating muscle strength. The reproducibility and reliability of this instrument have been little reported. Method: Healthy individuals aged >18 years were recruited. Isometric strength was tested for ten upper limb muscle groups. The fixed method was performed using a system with suction cups connected to the dynamometer through an inelastic belt. However, during the non-fixed method, the examiner supported the device with the hand. The reproducibility and reliability were calculated using the intraclass correlation coefficient (ICC). Result: A total of 25 right-handed volunteers participated. The reliability ICC values (0.89-0.99) of the non-fixed method were higher than those of the fixed method (0.43-0.85). The reproducibility of the non-fixed method was also superior to that of the fixed method. Discussion: The comparison between the HHD methods suggested the non-fixed method has greater reproducibility and reliability.

INTRODUCTION:

Hand-held dynamometry (HHD) is a technique for evaluating muscle strength, conducted through a sustained maximum isometric contraction. These dynamometers are small and less in weight for easy handling and applicability[1-5]. Such characteristics make the use of this instrument viable in the most diverse environments and populations[6,7]. However, there is still little research investigating the psychometric properties of the evaluation method adapted for this instrument in measuring upper limb muscle strength[8-12].

The aim of this research was to compare the reproducibility and reliability results of muscle strength evaluation with a hand-held dynamometer using the fixed and non-fixed method.

METHOD:

The reliability and reproducibility of two HHD methods for evaluating upper limb muscle strength was assessed and compared using a prospective, cross-sectional study.

Participants:

Healthy individuals were recruited by direct call, text message or social network. Participants (male or female) older than 18 years and who signed the informed consent form were included in this study. Exclusion criteria included acute bone, muscle or joint diseases, reduced functional range of motion (ROM)[13], presenting severe heart disease or neuromuscular diseases, or cognitive limitations that reduced the understanding of motor commands during the evaluation.

Randomization:

The order of the examiner and evaluation method was randomized for all patients with the use of a draw, which was carried out using a brown envelope.

Instruments:

Muscle strength was evaluated using a previously calibrated digital isometric dynamometer, (model 01165, Lafayette Instrument Company, Sagamore, USA). A goniometer (ISP, Sao Paulo, BR) was used to properly mark the articular position of the segments for each movement evaluated[14]. All patients had the proximal segment (torso, arm, or forearm) stabilized with the use of an inelastic belt, in order to nullify the effect of synergistic muscle chains.

Procedures:

The examiners were trained according to the evaluation protocol prior to testing. The protocol tests the isometric contraction for ten dominant upper limb muscle groups (shoulder flexors and extensors, shoulder internal rotators and external rotators, shoulder adductors and abductors, elbow flexors and extensors, wrist flexors and extensors). Prior to the measurement, the volunteers were instructed and trained how to perform each of the movements, and a muscle warm-up was also performed for each movement.

The fixed method used a system of suction cups adhered to rigid surfaces that were connected to the dynamometer through a Mulligan inelastic belt[15,16]. During the non-fixed method, the examiner supported the device with one hand, in a direction contrary to the movement, stabilizing the segment proximal to the moving joint under assessment[14,17-20].

For both evaluation methods, the isometric contraction was sustained for 3 seconds. Each movement was repeated thrice; the largest of the three values was used. The dynamometer was placed in the distal region of the forearm, 5 cm from the radial styloid process[21]. A muscle recovery time of 90 seconds between tests was ensured for all measurements[14]. If there was visible compensation of synergistic muscles in any of the movements, the volunteer would be instructed on the correct movement, and the measurement would be repeated. The positions adopted for the measurements were based on previous studies (Table 1)[14, 17-21].

A minimum resting time of 30 minutes was given between the evaluation of each examiner[22].

Variables of interest:

The concept of reliability is related to the capacity of the instrument and the evaluation method to generate similar results, even when used by different examiners. Thus, reliability was obtained by comparing the highest peak torque of the evaluations for two independent examiners (or inter-examiner reliability). On the other hand, the reproducibility of the evaluation method (or intra-examiner reliability) was obtained by analyzing the similarity between the HHD test and retest by the same examiner.

Statistical method:

The data were tabulated and analyzed using SPSS (version 21.0, Statistical Package for the Social Sciences, Chicago, USA). The qualitative variables were expressed in absolute and relative frequency, while the quantitative variables were expressed as mean, median, standard deviation (SD) and 95% confidence interval (95% CI). Analysis of variance (ANOVA) was used to evaluate the different the peak torque means obtained from the two methods. The level of significance level was set at $p<0.05$.

Prior to recruitment, a sample size calculation based on the results of a previous study[21] determined 25 participants were sufficient to detect a 10% variation between measurements and a 3% SD with 80% power with α at 0.05. As this was a cross-sectional study sample loss was not expected.

Reproducibility and reliability of the tests were calculated using the intraclass correlation coefficient (ICC) and categorized using the classifications proposed by Weir (2005)[23]: "almost perfect" for values from 1.0 to 0.81, "very good" from 0.80 to 0.61, "good" from 0.60 to 0.41, "fair" from 0.40 to 0.21, and "low" from 0.20 to 0.00. A Bland-Altman plot was used for the visualization of the agreement between the quantitative measurements obtained in the tests.

RESULTS:

The sample consisted of 25 volunteers (60% female), with a mean (SD) age of 33.1 (13.4) years, body mass of 72.6 (18.3) kg and a height of 1.7 (0.1) m, all of which were right-handed (Table 2). Similar peak torque values were observed between the two methods, whereby the non-fixed method had with slightly greater peak torque values in relation to the fixed method (Table 3). However, no statistical difference was found for these differences between the mean torques for any of the movements evaluated.

The reproducibility of the test and retest for the non-fixed method was categorized as almost perfect for all ten movements evaluated (Table 4). The Bland-Altman plot demonstrated a greater degree of agreement between the test and retest of the non-fixed method than that of the fixed method (Figure 1). The reliability followed a similar behavior, with higher inter-examiner ICC values for the non-fixed method when compared to the fixed method (Table 5). The only exception was the measurement of elbow extension where the fixed method had a higher score (ICC :0.81; 95% CI [0.17-0.96]) in comparison to the non-fixed method (ICC: 0.91 (95% CI [0.54-0.98]) (Figure 2).

DISCUSSION:

This study demonstrated that the evaluation of the upper limb muscle strength with an isometric dynamometer showed almost perfect reliability as well as reproducibility. In the study by Saccol et al.[21], reproducibility of HHD for the internal and external shoulder rotators was evaluated in 20 volunteers placed in supine position using a manual method and in sedestation position using a fixed method, with a rigid device. The ICC values of the non-fixed method determined in this current study, were higher than those determined by Saccol et al.[22].

In a study with 12 volunteers, Awatani et al.[24]measured the reproducibility and reliability of HHD with a non-fixed method for the internal and external shoulder rotators. The intra-examiner ICC value (ICC: 0.94, 95% CI [0.81-0.98]) for the measurement of shoulder internal rotator strength determined by Awatani et al. was lower than the ICC value of 0.96 determined in this current study. On the contrary, the inter-examiner ICC value (0.96 [95% CI: 0.87-0.99]) was higher than the value of 0.93 found in this study.

Dowman et al.[25] evaluated the reproducibility of HHD with a non-fixed method for the measurement of elbow flexor and knee extensor strength in 30 patients with interstitial lung disease. The evaluation protocol for the elbow flexors was similar to that of this study. As a result, the reproducibility ICC values were similar to those of this study, ICC 0.98, 95% CI [0.96-0.99] and ICC of 0.97 [0.93-0.99], respectively. This supports the notion that the reproducibility of HHD for evaluation of elbow strength in diverse populations remains high.

This is the first study to evaluate the reproducibility and reliability for ten different upper limb movements, thus demonstrating the clinical importance of this publication. Study limitations include: the absence of non-dominant limb measurements, which is justified by the extension of the evaluation protocol to the ten main upper limb muscle groups; as well as the absence of measurements such as pronation and supination of the elbow, and radial and ulnar deviation of the wrist.

The reproducibility of the evaluation of the upper limb muscle strength with HHD was very good, as was the reliability. The comparison of the fixed and non-fixed method of HHD assessment demonstrated the superior reproducibility and reliability of the non-fixed method in comparison to the fixed method. Only HHD for elbow extensors and external shoulder rotators showed equivalence between the evaluation methods.

ABBREVIATIONS:

ANOVA: Analysis of Variance

CI: Confidence Interval

HHD: Hand-Held Dynamometry

ICC: Intraclass Correlation Coefficient

ROM: Range of Motion

SD: Standard Deviation

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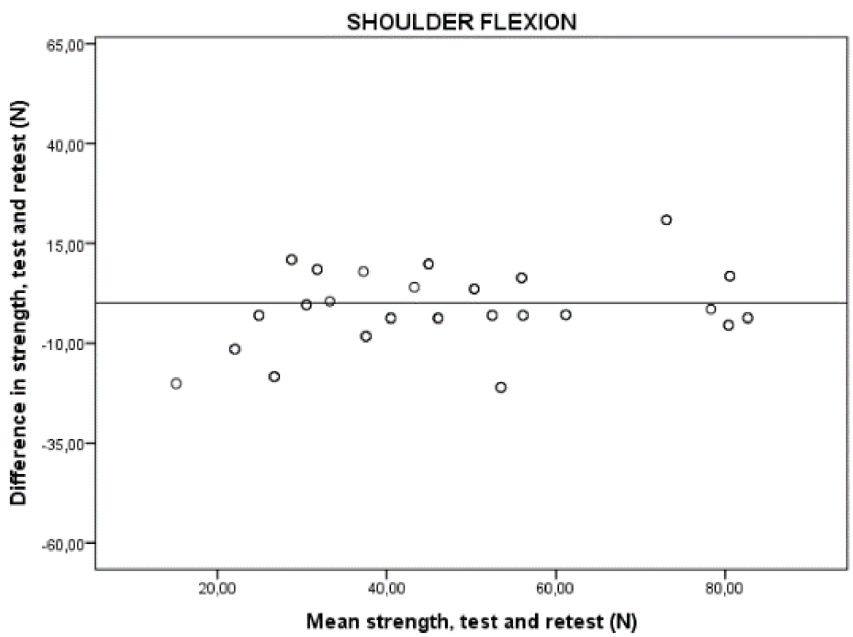

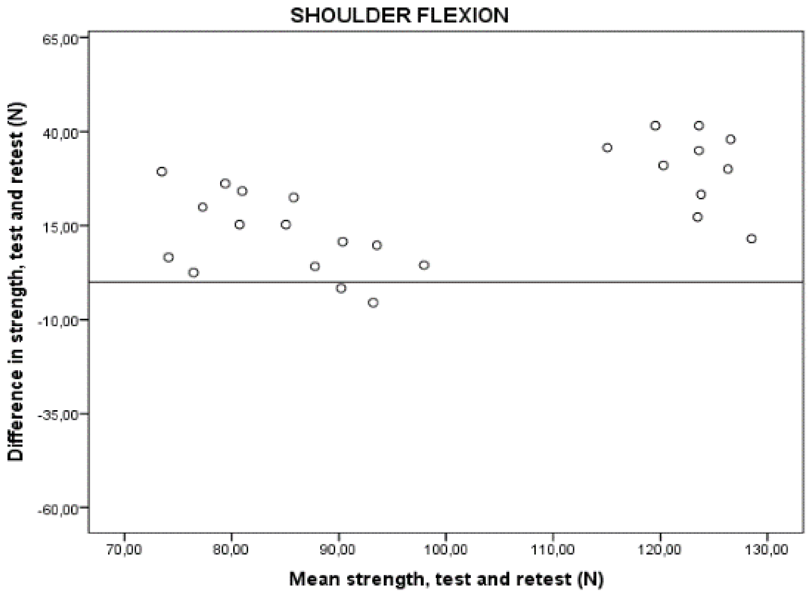
SHOULDER FLEXION
Difference in strength, test and retest (N)
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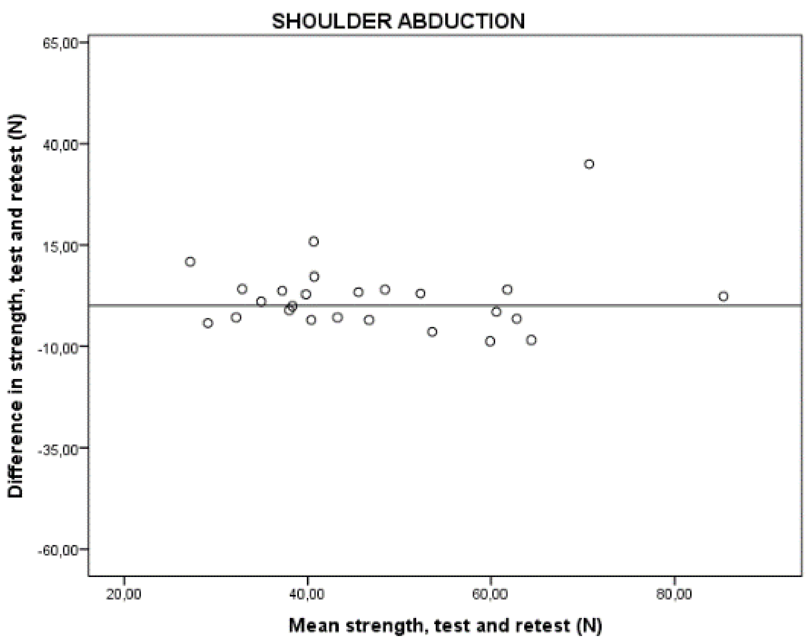
40,00
15,00
-10,00
-35,00
-60,00
70,00
80,00
90,00
100,00
110,00
120,00
130,00
Mean strength, test and retest (N)


SHOULDER ABDUCTION
Difference in strength, test and retest (N)
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-10,00
-35,00
-60,00
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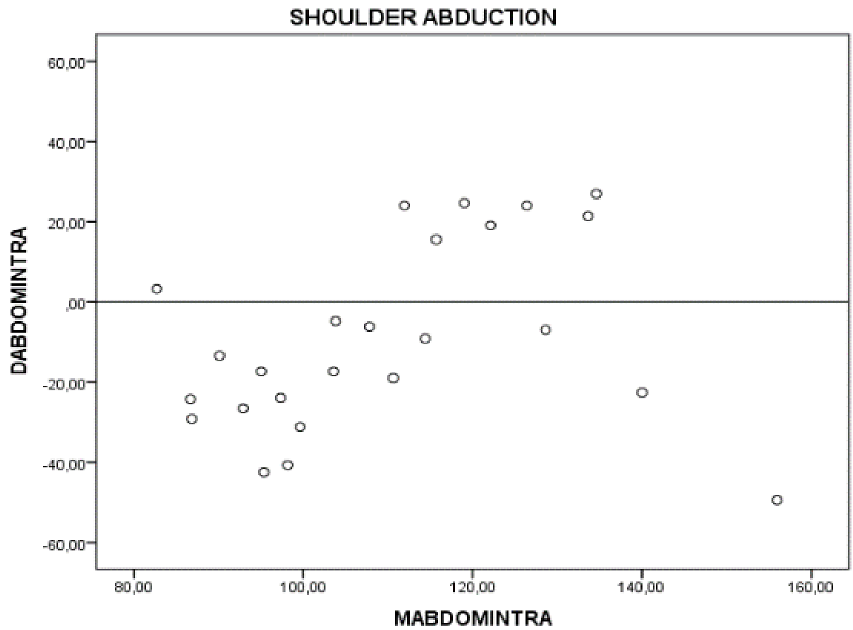
60,00
80,00
Mean strength, test and retest (N)


SHOULDER ABDUCTION
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40,00
20,00
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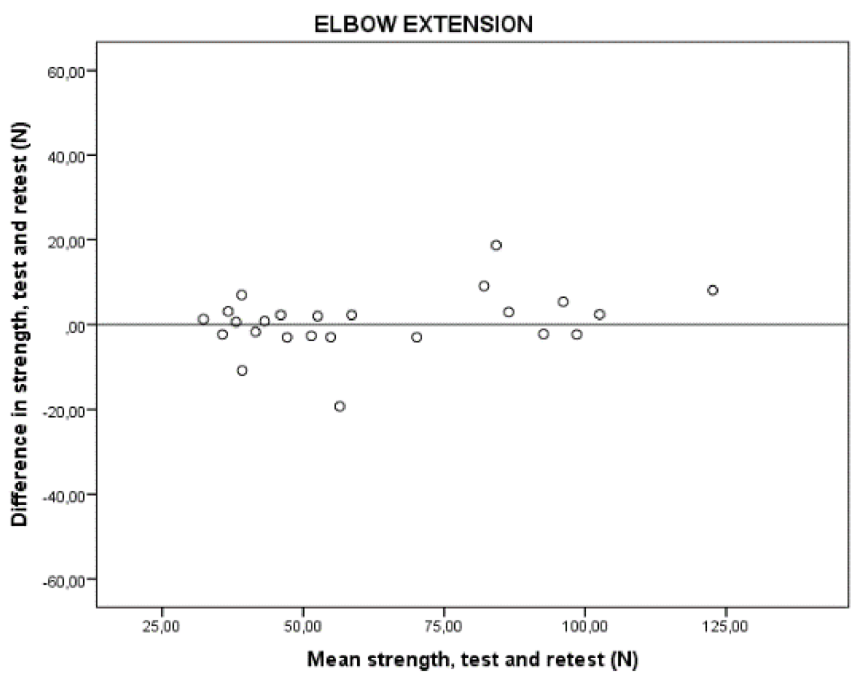
-40,00
-60,00
DABDOMINTRA
80,00
100,00
120,00
140,00
160,00
MABDOMINTRA


ELBOW EXTENSION
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40,00
20,00
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-20,00
-40,00
-60,00
Difference in strength, test and retest (N)
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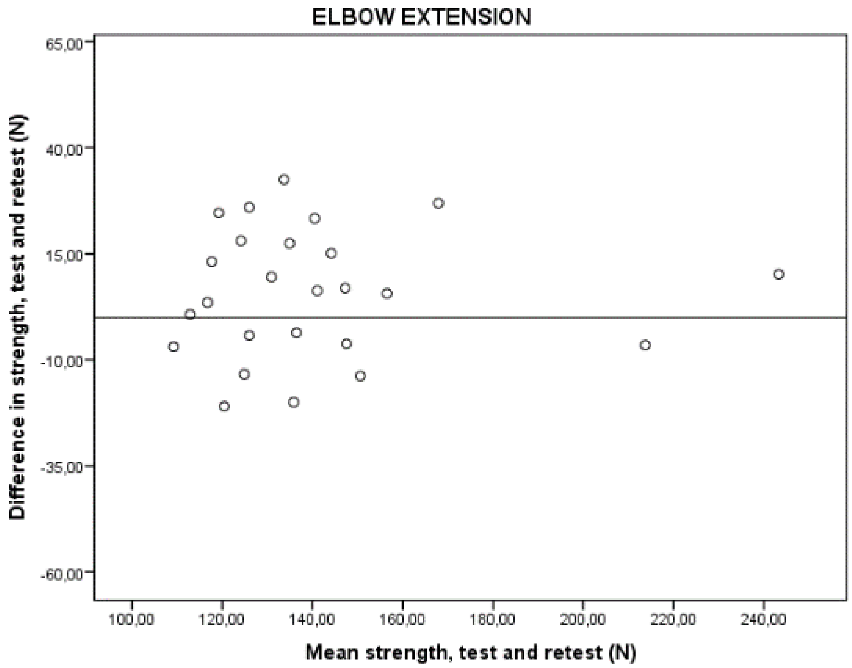
50,00
75,00
100,00
125,00
Mean strength, test and retest (N)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-10,00
-35,00
-60,00
Difference in strength, test and retest (N)
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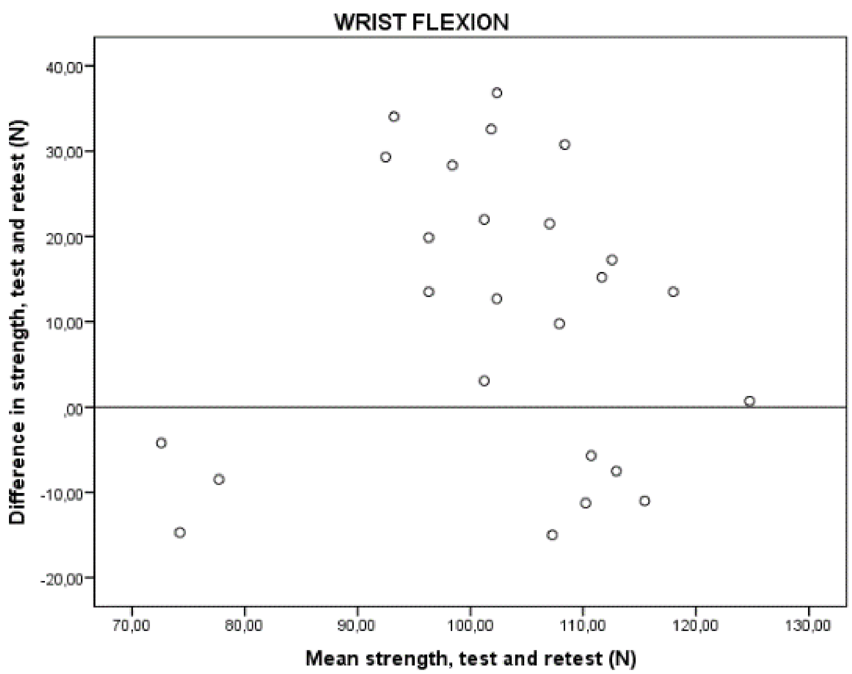
140,00
160,00
180,00
200,00
220,00
240,00
Mean strength, test and retest (N)


WRIST FLEXION
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20,00
10,00
,00
-10,00
-20,00
Difference in strength, test and retest (N)
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80,00
90,00
100,00
110,00
120,00
130,00
Mean strength, test and retest (N)

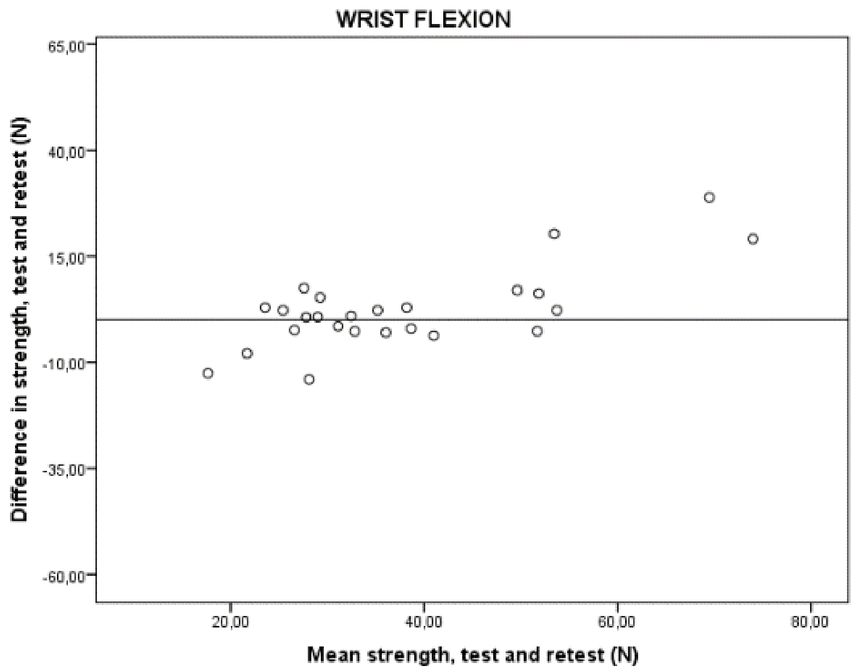
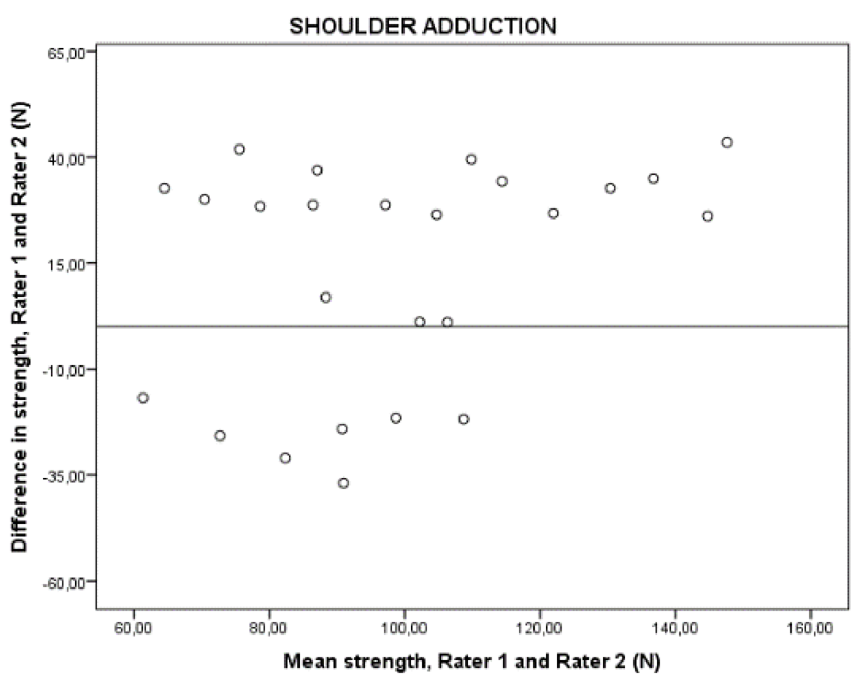
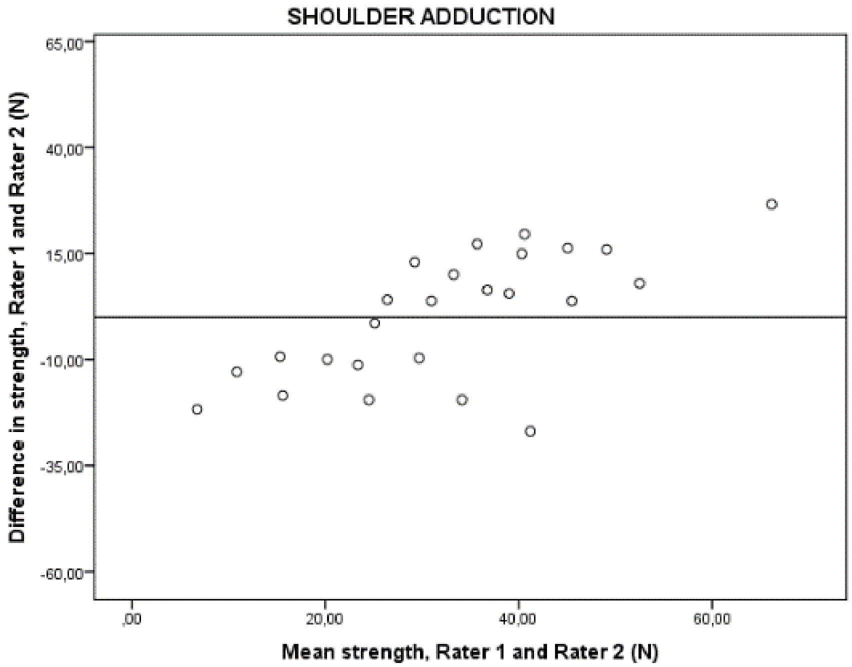


Figure 01: The Bland Altmann plots provide the agreement between non-fixed HHD (A) and fixed HHD (B).

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Mean strength, Rater 1 and Rater 2 (N)
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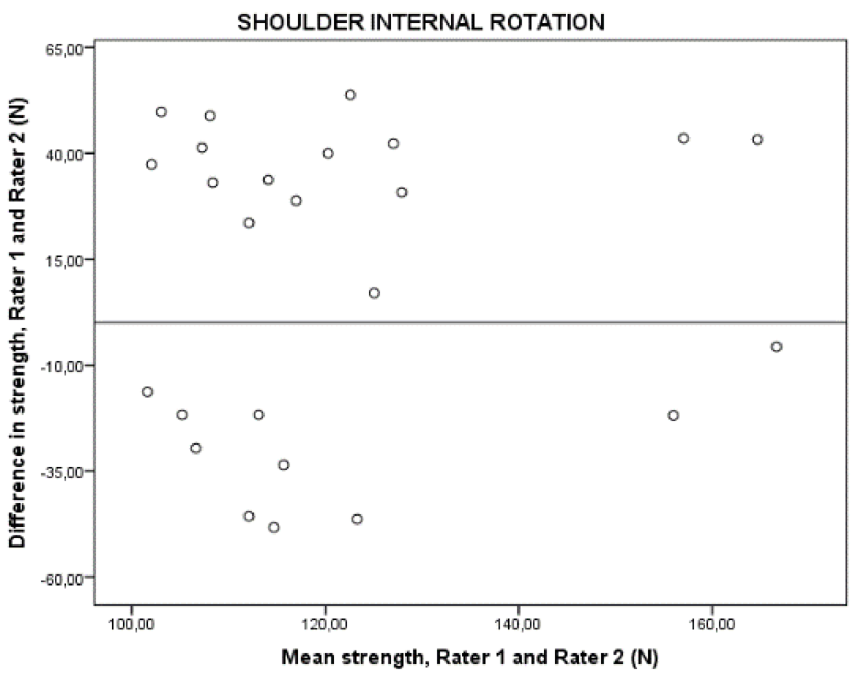
20,00
40,00
60,00


SHOULDER INTERNAL ROTATION
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Mean strength, Rater 1 and Rater 2 (N)
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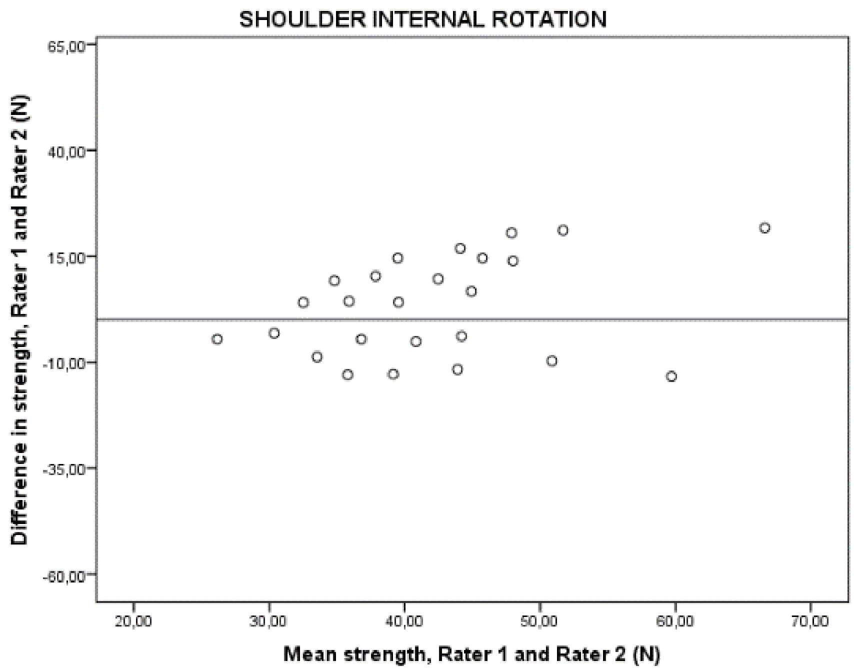
120,00
140,00
160,00


SHOULDER INTERNAL ROTATION
Difference in strength, Rater 1 and Rater 2 (N)
Mean strength, Rater 1 and Rater 2 (N)
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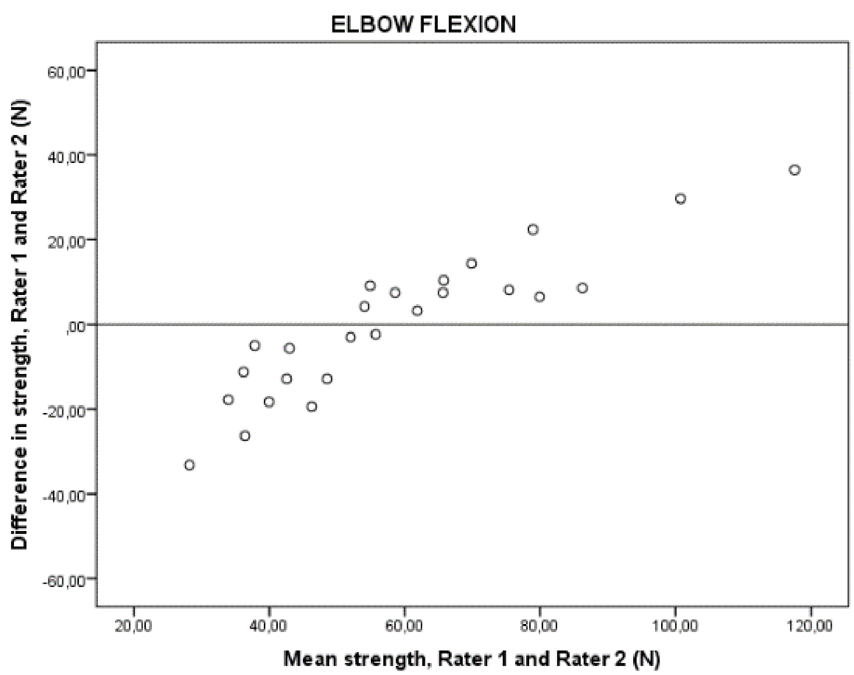
50,00
60,00
70,00


ELBOW FLEXION
Difference in strength, Rater 1 and Rater 2 (N)
Mean strength, Rater 1 and Rater 2 (N)
60,00
40,00
20,00
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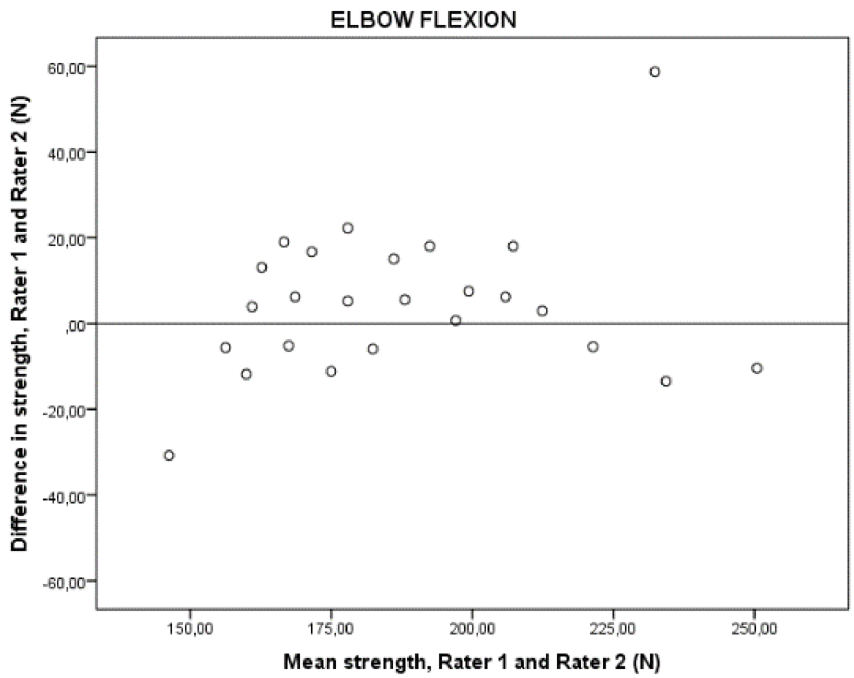
80,00
100,00
120,00


ELBOW FLEXION
60,00
40,00
20,00
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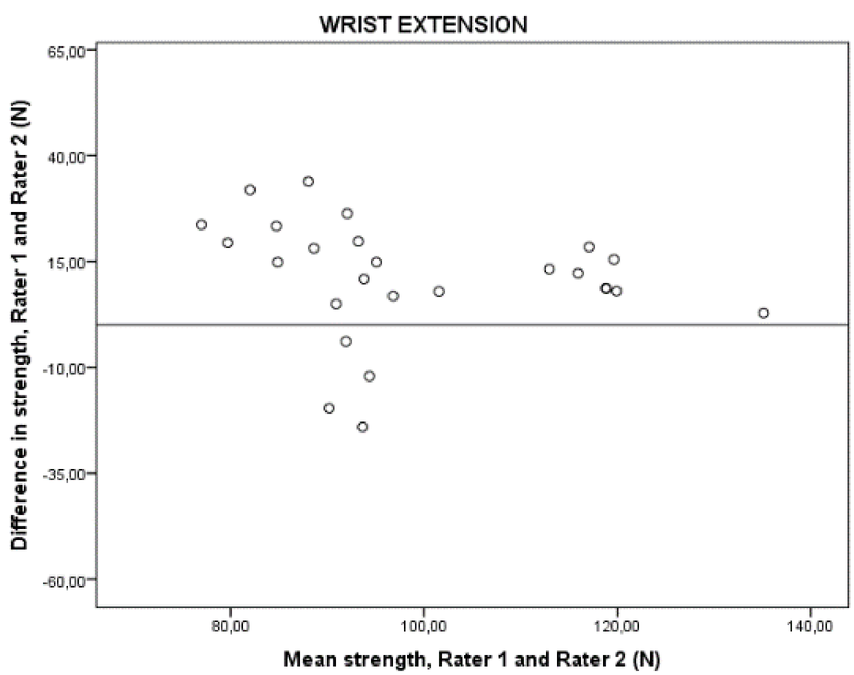
-20,00
-40,00
-60,00
Difference in strength, Rater 1 and Rater 2 (N)
150,00
175,00
200,00
225,00
250,00
Mean strength, Rater 1 and Rater 2 (N)


WRIST EXTENSION
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40,00
15,00
-10,00
-35,00
-60,00
Difference in strength, Rater 1 and Rater 2 (N)
80,00
100,00
120,00
140,00
Mean strength, Rater 1 and Rater 2 (N)

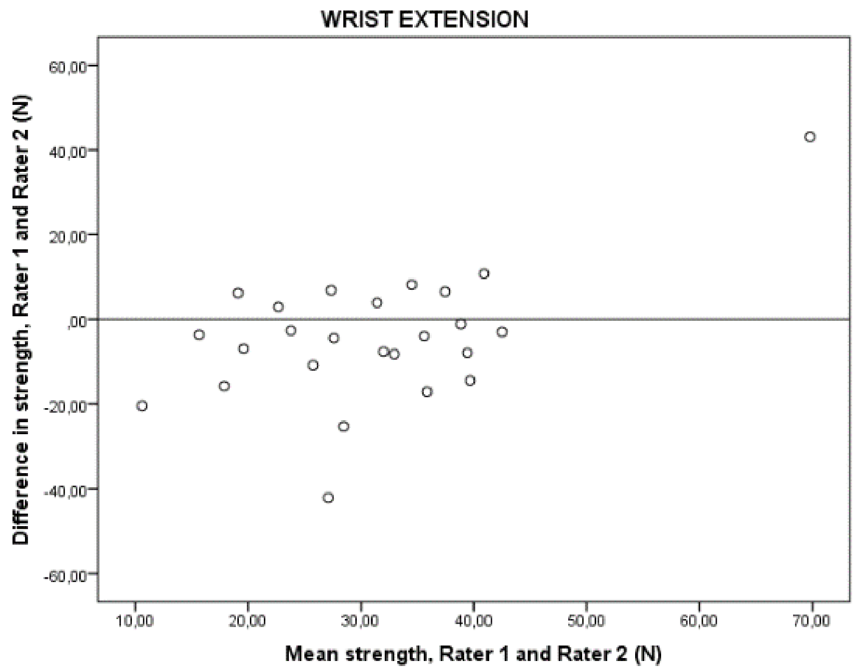

Figure 02: Reliability in The Bland Altmann plots provide the agreement between non-fixed HHD (A) and fixed HHD (B).

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