

Research Article

The Validity and Reliability of a Sphygmomanometer in Assessing Isometric Muscle Strength of Shoulder Flexors and Abductors

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Abstract

Background: A sphygmomanometer is a medical instrument which is normally used to measure blood pressure in an individual. This instrument has a potential of being used as a device for measuring isometric strength of muscles in the shoulder and to be used in clinical settings for this purpose.

Objective: To measure the validity and reliability of sphygmomanometer in assessing the isometric strength of shoulder flexor and abductor muscles.

Methods: A study was performed in which isometric strength of shoulder flexors and abductors of 30 university students who were healthy, was measured using a handheld dynamometer (HHD) and a commonly available sphygmomanometer. Isometric strength of right and left sides was measured. The values were analyzed for within day reliability, between days reliability and criterion validity.

Results: The results exhibited that the validity of the sphygmomanometer was excellent for shoulder abduction and flexion isometric strength measures of both right and left sides (Pearson's $r = 0.964-0.979$). The sphygmomanometer showed good within day (ICC = 0.994-0.998) and between days (ICC = 0.993-0.998) intra-rater reliability for shoulder flexion and abduction of both sides. The within day and between days intra-rater reliability calculated for handheld dynamometer was also good. (ICC = 0.996-0.998 and ICC = 0.995-0.998 respectively).

Conclusion: A sphygmomanometer is an easily accessible instrument which is both inexpensive and present in most clinics which allows clinicians to analyze isometric shoulder strength providing objective values for assessment.

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Introduction

Isometric strength testing can prove to play a significant role in the comprehensive examination, assessment and therapy of a patient with a shoulder injury. The assessment of strength stands as a fundamental constituent of physical examination.¹

Assessment of shoulder strength helps to provide an awareness about weakness of certain regions in some athletic populations, contribute towards injury prevention and monitor effectiveness of an intervention program. Upper limb (UL) strength is an appropriate outcome to be measured in rehabilitation, for disabling or weakening conditions such as stroke, in order

to understand its functioning and the process of disability.²

Shoulder pathology is thought to be the most common among complaints regarding health and fitness in both athletes and the overall population. There are often inequalities in the strength of shoulder musculature that can lead to maladaptive variations in the shoulder that can become the main source of pain, which may be due to work or sport-related activity.³

Objective measurements of strength have higher levels of reliability and validity as opposed to subjective assessments, such as manual muscle testing, which give us lower levels. Manual muscle testing (MMT) is a comparatively speedy method of measuring strength not demanding any equipment so it is commonly used, but then again, the subjective results reduce its reliability.⁴

Strength can be measured objectively using a hand-held dynamometer (HHD). Handheld dynamometry offers the clinician, who is working as a health professional in a clinical setup, with objective results for assessment of shoulder strength.⁵ Regardless of the recognized validity and reliability of the HHD, the fact of its inaccessibility and the cost being very expensive is the shortcoming of its use. A possibly practical and feasible option is the sphygmomanometer. A sphygmomanometer, which is low-priced and economical, is a device used for blood pressure measurement. This is a device that has the capability of being utilized for isometric muscle strength measurement.⁶

The hand-held dynamometer is used as a gold standard in this study due to its established validity and reliability in previous studies. One previous study had values of Pearson's correlation for validity from 0.90-0.97 and values of intra-class correlation coefficient for reliability ranging from 0.96-0.99(2).

The utilization of a sphygmomanometer to quantify strength of shoulder musculature has not been thoroughly assessed. There are a few studies in the past that have measured the strength of shoulder musculature using a sphygmomanometer and explored its validity and reliability, and one recent study has revealed good results (Pearson's $r = 0.90-0.97$, ICC = 0.96-0.99) relating to reliability.² Although, preliminary proof from the former researches is

reassuring, every one of these researches involve modification of the sphygmomanometer in an effort to increase accuracy, which means their results don't truly represent the use of a standard sphygmomanometer which is present in clinics. In this study the sphygmomanometer has not been modified so that the results can be applicable to clinical settings.

Moderate to high validity and reliability for the sphygmomanometer has been found for hand and knee muscle strength assessment in previous studies.⁶ The evaluation of the strength of healthy individuals^{6,7} and those with various diseases, disorders or other conditions, such as Parkinson's disease,⁸ stroke^{9,10} and lower limb amputation¹¹ has been performed using the aneroid sphygmomanometer.

To allow for correct understanding and analysis of results, validity and reliability of the device should be established, which is crucial to guarantee that the primary diagnostic values obtained are applicable and follow-up assessment measures are correct to permit for precise analysis and explanation.

Hence, the aims of the study were to explore the reliability and validity of a standard monetarily accessible sphygmomanometer, in the evaluation of isometric strength of the flexor and abductor muscles of the shoulder, contrasted with the reference standard of hand-held dynamometer. This investigation will decide whether a sphygmomanometer can be utilized clinically in future examinations as an easy option in contrast to progressively costly and inaccessible HHD to evaluate isometric muscle strength. Between-day and within-day intra-rater reliability is measured which has not been done before.

Methods

A sample size of 30 individuals were taken. The study setting was The University of Lahore and the sample was taken by convenience sampling. In the sample 19 were females and 11 males. Of the 30 participants, 29 were right-handed whereas 1 was left-handed. Individuals were suitable to partake in the study if they had an age above 18 years and below 25 years and if they were healthy. They were excluded from the study if they had a recent shoulder injury or have any other condition that has affected the shoulder muscles. Moreover, gym users or athletes were excluded as their muscle strength can be expected to

change. Participants provided informed signed consent. The duration of this study was 4 months.

For this study a test-retest design was used. 3 values were obtained. Two were obtained in one day with a one-hour gap between both values for within day reliability. The last measurement was obtained within 5 days of initial testing for between days reliability.¹² Testing of the participants was completed in 5 days to make sure that muscle fatigue had not occurred and to avoid variations in muscle strength, which can have been caused by other factors, to occur.¹³ The muscle group tested, the order of device used and the order of testing for the side of the body for each person was randomized using a simple randomization technique i.e. by coin flipping, and for the repeat testing session the same order was utilized. The second device was used 2 minutes after the first device for each reading. The readings for both devices were checked by the same person.

A commonly accessible aneroid sphygmomanometer (Certeza) was used for the study. It was prepared for testing by folding the cuff into thirds, followed by its pre-inflation to 20 mmHg to use the sphygmomanometer for the assessment procedure.¹⁴ The highest score was recorded to the nearest 5 mmHg, which was displayed on the measurement dial. It records pressure over a range of 0-300 mmHg. A hand held dynamometer (BASELINE push and pull dynamometer) was used as the reference standard, which measures maximum muscle strength in kilograms (kg), which is the unit of force, over a range of 0-45 kg. Both devices were adjusted to zero before testing. Measurements for isometric muscle strength were recorded using the HHD and sphygmomanometer for shoulder abduction and flexion on the right and left

side of every participant. First the procedure was explained to the participants followed by a practice effort with sub-maximal force for each of the shoulder motions tested, preceded the testing session to let the participants become aware of the testing method. Every partaker was requested to comfortably sit in an erect posture in a chair without resting their posterior side on the back of the chair. Next the individuals were given a command to do a maximal isometric contraction of the muscle by performing the movement against resistance for 5-10 seconds, with a resting period of 1 minute in between the contractions of different muscles. Shoulder flexion was measured by asking the participant to elevate their UL in flexion up to 90° with neutral shoulder rotation, extension of elbow, pronation of the forearm and neutral wrist with flexed fingers. Placement of the device was proximal (about 5 cm) to the distal radial joint surface. Shoulder abduction was measured in similar manner as flexion, with the arm in 90° of abduction, extension of elbow, pronation of forearm and neutral wrist with flexed fingers. The device was placed in the same position. All readings were obtained in the same manner.

All the data was analyzed using SPSS Statistics (version 25). Within day (between 1st and 2nd measurement) and between days (between 1st and 3rd measurement) reliability was calculated using intra-class correlation coefficients and validity was analyzed using Pearson's correlation.

Results

All the thirty participants that were recruited in the study completed the study. The majority of participants were female (63.3%). The mean age was 20.60

Table 1: *Within Day Reliability Results*

Measures		Right shoulder		Left shoulder	
		ICC (95% CI)	SEM	ICC (95% CI)	SEM
Sphygmomanometer	Shoulder flexion	0.994 (0.988-0.997)	2.08	0.996 (0.992-0.998)	1.73
	Shoulder abduction	0.998 (0.995-0.999)	1.16	0.995 (0.989-0.997)	1.76
HHD	Shoulder flexion	0.996 (0.992-0.998)	0.19	0.998 (0.995-0.999)	0.14
	Shoulder abduction	0.997 (0.995-0.999)	0.17	0.997 (0.993-0.999)	0.16

Note: HHD = hand-held dynamometer, ICC = intra-class correlation coefficient, SEM = standard error of measurement, CI = confidence interval

Table 2: *Between Days Reliability Results*

Measures		Right shoulder		Left shoulder	
		ICC (95% CI)	SEM	ICC (95% CI)	SEM
Sphygmomanometer	Shoulder flexion	0.997 (0.994-0.999)	1.47	0.997 (0.993-0.998)	1.50
	Shoulder abduction	0.995 (0.990-0.998)	1.83	0.993 (0.985-0.997)	2.09
HHD	Shoulder flexion	0.995 (0.990-0.998)	0.21	0.998 (0.996-0.999)	0.14
	Shoulder abduction	0.998 (0.996-0.999)	0.14	0.998 (0.995-0.999)	0.13

Note: HHD = hand-held dynamometer, ICC = intra-class correlation coefficient, SEM = standard error of measurement, CI = confidence interval

Table 3: *Validity Results*

Measures	Sphygmomanometer (mmHg)	HHD (kg)	Pearson's r
	Mean ± SD	Mean ± SD	
Right shoulder flexion	89.777 ± 26.915	6.844 ± 2.944	0.979
Left shoulder flexion	89.333 ± 27.297	6.916 ± 3.230	0.977
Right shoulder abduction	87.388 ± 25.885	6.666 ± 3.039	0.968
Left shoulder abduction	86.611 ± 24.957	6.7056 ± 2.979	0.964

Note: HHD = hand-held dynamometer, SD = standard deviation

with standard deviation of 1.567. The results reveal that the sphygmomanometer has excellent within day reliability with intra-class correlation coefficients (ICC) between 0.994-0.998 (table 1) and excellent between days reliability with an ICC between 0.993-0.998 (table 2) for shoulder flexion and abduction in both right and left sides. Similarly, the hand held dynamometer also displayed good reliability, for abduction and flexion, the ICC of which ranged from 0.996-0.998 for within day reliability (table 1) and 0.995-0.998 for between days reliability (table 2) in the left and right shoulder. The values of Pearson's correlation show that there is strong positive correlation between HHD and sphygmomanometer. Hence the sphygmomanometer has good validity. The values of Pearson's correlation for shoulder flexion were 0.977 and 0.979 for left and right shoulder, and 0.964 and 0.968 for shoulder abduction in left and right shoulder respectively (table 3).

Discussion

Not many studies have been conducted regarding the reliability and validity of a sphygmomanometer in measuring isometric shoulder muscle strength in healthy individuals. Most of the existing studies measure grip strength. The values of our study indicate that the reliability and validity of the sphygmo-

manometer is satisfactory and suggests that it may be applied in a clinical setting to measure isometric shoulder strength when needed as an alternative to hand held dynamometer. The sphygmomanometer was prepared by folding its cuff into thirds. It was then pre-inflated to 20mmHg.¹⁴ No extra attachment or tool was used.

Strong positive correlation was found between sphygmomanometer and HHD for both shoulder flexion and shoulder abduction (Pearson's r = 0.964- 0.979). This indicates good validity of the instrument. The results found in this study are consistent with the results of previous study that measured isometric shoulder strength (Pearson's r = 0.90-0.97)⁽²⁾. Similar findings in grip strength⁽⁸⁾ and isometric hip strength⁽¹⁵⁾ have also been reported.

The reliability results of our study also support previous findings of studies that the sphygmomanometer has appropriate reliability to assess isometric muscle strength in clinical settings. The excellent within day reliability results (ICC= 0.994-0.998) and between days reliability result (ICC= 0.993-0.998) for shoulder flexion and shoulder abduction indicate this. It is similar to previous findings. One study previously found good reliability scores for abduction and flexion for both right and left shoulders

(ICCs = 0.83-0.97).¹⁶ Another study investigated the reliability of sphygmomanometer in the measurement of shoulder isometric strength and found there was a great intra-rater reliability (ICC = 0.96-0.99).²

The sphygmomanometers in the former studies were modified in some way. The bag method was used in some studies^(11,16). These modifications may make the use of the sphygmomanometer easier but they do not seem as if they are necessary for achieving reliable measurements as seen by the results of this study. In this study, modification of the instruments has been purposely avoided so that the results can be applicable to a clinical setting where a health professional can easily buy and use a widely accessible typical sphygmomanometer.

Interpretation of within day and between days reliability of the hand-held dynamometer for shoulder flexion and shoulder abduction strength correspondingly revealed great results (ICC = 0.996-0.998 and ICC = 0.995-0.998 respectively). These results are similar to the results of a previous recent study calculated for isometric strength of shoulder abduction and flexion using HHD (ICC=0.94-0.98).²

So far, no studies have contradicted to the great results of validity and reliability of a sphygmomanometer. Not many researches have been conducted regarding the validity and reliability of a sphygmomanometer especially in measuring the strength of the shoulder joint. To our knowledge it is the first to be conducted in Pakistan. Limitations of the study include measuring the strength of students of a certain age only and conducting it in one place. Further studies can be conducted using a larger sample with people of numerous ages and diseases. More than one rater can be used to measure the values of strength with both devices to acquire more precise results.

Conclusion

The sphygmomanometer is an inexpensive and readily available tool/instrument that can be utilized to measure isometric strength of shoulder flexion and abduction as proven by this study. The findings show that the sphygmomanometer is both reliable and valid to attain precise objective measures of isometric strength during daily practice in clinical environments.

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