Pakistan Journal of Rehabilitation

OPEN ACCESS

ORIGINAL ARTICLE **Volume 12(Issue 1), 2023 | Page No.134-140**

ASSESSMENT OF LOWER LIMB MUSCLE STRENGTH IN ATHLETES BY USING HAND-HELD DYNAMOMETER: A RELIABILITY STUDY

Musab-Bin-Amir[1], Muhammad Waqar Afzal[2], Saadia Perwaiz[3*], Samuel Rafaqat[4]

[1]Clinical Demonstrator, Ghurki Trust Teaching Hospital, Lahore, Pakistan

[2]Incharge Physiotherapy Clinic/Assistant Professor, The University Of Lahore Teaching Hospital, Lahore, Pakistan

[3*]Akhtar Saeed College of Rehabilitation Sciences, AMDC Lahore, Pakistan

[4]Senior Physiotherapist, Ghurki Trust Teaching Hospital, Lahore, Pakistan

ABSTRACT

Background and Aims: Muscle strength is the key area to measure the functional status of an individual. Different tools and techniques has been used to detect strength differences and deficits. Hand- held dynamometer is one of the most affordable and handy tools used for this purpose. This study was designed to determine intra-rater reliability of hand- held dynamometer to measure muscle strength in different muscle groups of lower extremity of young athletes. It will further explore the reliability of hand-held dynamometer.

Methodology: In this cross- sectional study young players of squash and badminton in the age group of 18-26 years were selected. The participants were recruited by non-probability convenience sampling technique. The strength of major muscle groups of lower limb was measured by a single male tester twice with gap through isometric make test of dynamometer. The intra-class correlation coefficient was then calculated for two readings of each muscle group by using SPSS version 21.

Results: The intra- class correlation coefficient showed good to excellent reliability. The hip abductors, hip adductors, hip extensors of left side, knee flexors and knee extensors showed excellent reliability. Whereas, hip flexors, ankle plantar- flexors and dorsi-flexors of both sides showed excellent reliability at 95 % confidence interval.

Conclusion: The isometric make test of dynamometer is a reliable tool for the objectification of strength of lower limb in young players participating in squash and badminton.

Keywords: *Muscle strength, Lower extremity, Reliability, Isokinetic dynamometer, Efficacy, Isometric contraction*

Introduction

Muscle strength plays a pivotal role in the field of rehabilitation sciences and competitive sports to determine the efficiency and performance of an individual. This key factor has been explored by various tools used to measure muscle strength ranging from manual muscle testing and hand-held dynamometer to isokinetic dynamometers[1,3]. Dynamometry is common technique that is used to measure muscle strength. Isokinetic dynamometer is a gold standard which gives complete force analysis but its availability and cost efficacy has been an issue[4]. Owing to cost efficacy various muscle groups are explored by hand- held dynamometer and it has been validated as reliable instrument to detect strength differences[5].

*Akhtar Saeed College of Rehabilitation Sciences, AMDC Lahore, Pakistan

Email: s_perwaiz@yahoo.com

Citation: Amir MB, Afzal MW, Perwaiz S, Rafaqat S. ASSESSMENT OF LOWER LIMB MUSCLE STRENGTH IN ATHLETES BY USING HAND-HELD DYNAMOMETER: A RELIABILITY STUDY. Pakistan Journal of Rehabilitation. 2023 Jan 4;12(1):134–140. https://doi.org/ 10.36283/pjr.zu.12.1/018

Received: Tues, Jan 18, 2022 **Accepted:** Tues, Nov 22, 2022 **Published:** Tues, Jan 03, 2023

It quantifies muscle strength. The manual muscle testing has been most common tool to measure strength of muscle but the subjective approach of grade 4 and 5 has always been issue. This variation in grade 5 of manual muscle testing can also be quantified through the objective approach of dynamometer[6]. It is considered sensitive to detect small strength difference, though variation in the characteristics of instruments along with the issue of tester measuring the strength, has its own draw backs[7,8]. In sports sciences usual practice of strength measurement is affiliated to enhancement of performance and power. Isokinetic dynamometer gives complete force analysis. But due to the expenses and handling issues associated with it, it is not accessible. There is a need to incorporate a handy instrument with objective approach in sports. As an alternate various types of hand-held dynamometers are used to quantify muscle strength. These tools have been explored in various populations taking into account strength assessment of different muscle groups[9,11]. Hand- held Dynamometers measure muscle strength by placing it at right angle to the muscle group being evaluated. The force exerted by the subject is represented in units of weight such as pounds or kilograms. Owing to its objective approach the validity and reliability of dynamometer has always been an area of discussion to establish the extent it can be trusted as an instrument in various practices. Both the techniques of break test and make test has been employed to evaluate strength of different muscle groups in different populations[12,14]. Different reliability studies have showed varied results in different populations, ranging from poor to excellent using make and break test. The populations include healthy as well as impaired ones. Regardless the type of test employed (break or make), reliability, that is sustenance towards reproduction of the results has been an issue in various studies. Make test of dynamometer is considered more reliable by some studies as compared to break test to measure muscle strength[15,17]. In make test the maximal isometric contraction is measured against the force of the examiner, whereas, in break test the resistance is applied by the examiner to overcome the maximum effort of the subject being tested. Both break and make test have been associated with involvement of different mechanisms. The break test is associated more with eccentric contraction rather than greater recruitment resulting in greater force production[18]. This study was focused to explore the intra-rater reliability of isometric make test for strength measurement, using dynamometer as an instrument. The population of interest was professional squash and badminton players. Both these sports are not much explored in the context of reliability by using hydraulic hand held dynamometer. With established reliability of instruments like hand- held dynamometer in these sports, a leverage can be get in milieu of expenses as well as standardized process can also be induced. Further, this will establish the worth of a handier and less expensive instrument in sports to evaluate muscle strength.

Methodology

Participants and study design

This was a cross-sectional study in which thirty-one elite male athletes participated. Athletes were selected from the sports centers of Lahore. The age of the participants was between 18-26 years. The non-probability convenience sampling technique was used to select the participants.

Inclusion and exclusion criteria

The athletes participating in badminton and squash were selected. Based on it the hand used to hold racket was labelled as dominant extremity. Those healthy young male athletes which used to play squash and badminton, with in age group of18-26 years were included in the study. Those players who were having any associated condition, history of recent injury within last 6 months or were at rest, not participating in regular training program during last six months were excluded. The quantitative data was collected by Hydraulic Hand-Held pull push dynamometer, with the consent of the players. Baseline 250 hydraulic push-pull HHD (Baseline Corporation, Irvington, New York) used in this study for measurement of strength has been used as a valid tool in previous studies[19,20]. It gives the reading of measured strength in kilograms and pounds.

Procedure

In this study the intra rater reliability of isometric make test of hand- held dynamometer was measured. For this purpose, the basic procedure of isometric make test was used. Following the respective guidelines for particular muscle group the strength of various muscle groups of lower limb was assessed. In this procedure, as endorsed in earlier studies, the participants were asked to exert maximally, building maximum amount of force within 4-5 seconds according to the action of muscle[21]. The physical therapist held the dynamometer fixed against the effort of the participant. The same procedure was revised to get second reading. The strength was measured in pounds. The readings were taken by a male therapist. The position of the participants and therapist along with placement of dynamometer for various muscle groups of lower limb are explained in table 1, the positions exhibited were the ones that were reliable according to earlier studies.

Muscle Group	Position of Athlete	Placement of Dynamometer	Position of Therapist
Hip flexors	Supine lying with hip flexed at 90	On anterior aspect of testing knee at the distal femur	Test Side
Hip Extensors	Prone lying, hip flexed at 90	At posterior aspect of thigh at distal femur	Standing at the test side
Hip Abductors	Supine lying with hip neutral, knees extended	On lateral aspect of thigh of the testing knee at the distal femur	Standing at test side
Hip Adductors	Prone lying with hip neutral, knees extended	On medial aspect of thigh of the testing knee at the distal femur	Opposite to test side
Knee Flexors	Short sitting, knee and hip joint flexed to 90°	At posterior aspect of tibia, above the ankle joint	At the test side
Knee Extensors	Short sitting, knee and hip joint flexed to 90°.	At anterior aspect of tibia, above the ankle joint	At test side
Ankle Dorsi-Flexors	Supine lying hip and knee extended	At the dorsal surface of foot, on the metatarsal heads	At test side
Ankle Plantar-Flexors	Supine lying hip and knee extended	At the sole of foot, on the metatarsal heads	At test side

Table: 1 Position of therapist, dynamometer and limb of athlete for muscle group tested

Data analysis

SPSS version 21 was used for data analysis to measure reliability of hand- held dynamometer. The descriptive characteristics of the athletes was presented through mean age, weight and BMI. The intra rater reliability was measured through intra- class correlation coefficient of two readings at 95 % confidence interval. The level of significance used was α=0.05.

Result

The mean age of the participants in the age group of 18-26 years, was 20.61 years. The BMI was 22.66, which falls within the range of normal.

	N	Min.	Max.	Mean	Std. Dev.
Age (y)	31	18	26	20.61	2.14
Weight Kgs	31	54	77	64.61	5.22
BMI	31	16.7	30.9	22.66	4.03

Table 2: Demographic Variables of Participants

Muscle group	ICC	(95% CI)	
		Lower Bound	Upper bound
Hip Flexors (Right)	0.83	0.65	0.92
Hip flexors Left	0.86	0.71	0.93
Hip Extensors (Right)	0.84	0.68	0.92
Hip Extensors (Left)	0.94	0.88	0.97
Hip Abductors (right)	0.95	0.82	0.98
Hip Abductors (Left)	0.90	0.76	0.95
Hip Adductors (Right)	0.95	0.90	0.98
Hip Adductors (Left)	0.98	0.97	0.99
Knee Flexors (Right)	0.93	0.85	0.96
knee Flexors (Left)	0.97	0.91	0.99
Knee Extensors (Right)	0.96	0.91	0.98
Knee Extensors (Left)	0.91	0.81	0.96
Ankle Dorsi-flexors (Right)	0.85	0.69	0.93
Ankle Dorsi-Flexors (Left)	0.88	0.76	0.94
Ankle Plantar-Flexors (Right)	0.79	0.47	0.91
Ankle Plantar-flexors (Left)	0.83	0.62	0.92

Table 3: The Intra-Rater Reliability of Isometric Make Test in Muscles of Lower Extremity of Young Athletes

Table 3, depicts the intra-rater reliability of isometric make test in various muscle groups of lower limb of young male athletes. The intra-class correlation coefficient between the two readings of strength of different muscle groups of lower limb showed good (0.75-0.90) to excellent reliability (0.90-1.00). Hip flexors, ankle plantar flexors and ankle dorsi- flexors showed good correlation. While other muscle groups including hip extensors of right side, hip abductors and adductors, knee extensors, knee flexors showed excellent ICC. These results emphasize that isometric make test of hand held dynamometer can be used as a reliable tool to measure muscle strength in athletes.

Outcome Measures

The outcome measure of this study was the strength of major muscle groups of lower limb measured by Hand- held dynamometer. Two readings were taken by a single male tester twice with a gap through isometric make test of dynamometer. These readings established the intra rater reliability of hand held dynamometer through intra-class correlation coefficient.

Discussion

This study showed the reliability of isometric make-test of hand held dynamometer to be satisfactory. In various muscle groups of lower extremity it ranged from good to excellent. The findings of previous studies however, have showed varied trends. A diverted approach regarding reliability of dorsi-flexors was observed in a study by Escolar and his fellow researchers. According to him the evidence of inter- rater reliability of dynamometer in the dorsi-flexors of patients with muscular dystrophy was not substantial[22]. However, present study has emphasized the intra-rater reliability of dynamometer to be substantial regarding all muscle groups of lower extremity. Bohannon, earlier studied the reliability of hand- held dynamometer in different populations[23]. In one of his study on neurological conditions ANOVA and Pearson correlation was used to establish reliability by the same observer. The Pearson correlation established good to high correlation, however ANOVA calculated showed significant differences for shoulder and hip abduction. In this study evaluating strength by isometric make test the intra rater reliability of hip abductors was excellent in healthy athletes. The results of this study which was conducted on athletes are quite similar to the study conducted by Arnold et al. on older adults. In his study he analyzed muscle strength of lower extremity in older adults as an indicator to predict fall[24]. This

study revealed the intra-rater reliability for hand held dynamometer to be high with ICC varying between 0.90-0.98. Although older adults have less strength variation as compared to athletes, yet the results of this study are completely in collaboration with the results of our study. This highlights the reliability of dynamometer to measure strength in wide variety of population. In another study, Pfister et al. evaluated the intra-class correlation coefficient, to measure reliability of hand held dynamometer in patients with myopathies[25]. He found the reliability of dynamometer to be in the range of 0.75-0.97 for all muscle groups except for knee extension for which it was 0.61. The variation of results in association with our study indicate a substantial reliability in knee extensors. Recently in a study, kim and his fellows have measured intra-rater reliability of hand- held dynamometer in healthy adults by using an advanced instrument commander tester hand held dynamometer[26]. The intra rater reliability of extensor and flexor compartments of hip, knee and ankle muscles was excellent (0.90 - 1) as revealed by this study. The results of this study complements, the results of present study which was conducted by using hydraulic hand- held dynamometer. This discussion emphasizes that hydraulic hand-held dynamometer to be a suitable instrument which can be used to assess muscle strength in young athletes as a prognostic indicator. To measure impairment some studies indicate it to be inadequately substantial regarding different muscle groups like knee extensors and ankle dorsi-flexors as described earlier. However, in normal population other studies have emphasized it to be substantially reliable.

Strengths

In the field of sports sciences and rehabilitation where sophisticated and expensive instruments are not available, hydraulic dynamometer can be used as substantially reliable tool to measure strength. This can help to standardize the process of sports rehabilitation and training, especially in developing countries where resources are limited.

Limitations and future directions

In future, a study with larger sample size, considering different sports and populations needed to be explored further.

Conclusion

This study conducted on athletes established, isometric make test of hand held dynamometer to be a reliable instrument to measure the muscle strength in young athletes participating in badminton and squash. The reliability varies between good to excellent in various muscle groups of lower extremity. This highlights that hand held dynamometer can be used as a diagnostic and prognostic tool to detect strength differences in young athletes.

AUTHORS' CONTRIBUTION:

The following authors have made substantial contributions to the manuscript as under:
Conception or Design: Saadia Perwaiz, Muhammad Waqar Afzal
Acquisition, Analysis or Interpretation of Data: Samuel Rafaqat
Manuscript Writing & Approval: Musab-Bin-Amir
All authors acknowledge their accountability for all facets of the research, ensuring that any concerns regarding the accuracy or integrity of the work are duly investigated and resolved.

ACKNOWLEDGEMENTS: We would like to offer our special thanks to all the participants and their families for their support in conducting this research study

INFORMED CONSENT: Written Informed Consent was taken from each patient.

CONFLICT OF INTEREST: The author (s) have no conflict of interest regarding any of the activity perform by PJR.

FUNDING STATEMENTS: None declared

ETHICS STATEMENTS: The participants were informed about the benefits of study. Complete procedure was explained to them and then data was collected with their consent. All information regarding participant was kept protected under researcher's supervision.

References

1. Avers D, Brown M. Daniels and Worthingham's Muscle Testing: Techniques of Manual Examination and Performance Testing: Elsevier; 2019.

2. Trajković N, Kozinc Ž, Smajla D, Šarabon N. Interrater and Intrarater Reliability of the EasyForce Dynamometer for Assessment of Maximal Shoulder, Knee and Hip Strength. Diagnostics. 2022;12(2):442.

3. Bohannon R. Manual muscle test scores and dynamometer test scores of knee extension strength. Archives of physical medicine and rehabilitation. 1986;67(6):390-2.

4. Drouin JM, Valovich-mcLeod TC, Shultz SJ, Gansneder BM, Perrin DHJEjoap. Reliability and validity of the Biodex system 3 pro isokinetic dynamometer velocity, torque and position measurements. 2004;91(1):22-9.

5. Romero-Franco N, Fernández-Domínguez JC, Montaño-Munuera JA, Romero-Franco J, Jiménez-Reyes P. Validity and reliability of a low-cost dynamometer to assess maximal isometric strength of upper limb: Low cost dynamometry and isometric strength of upper limb. Journal of Sports Sciences. 2019;37(15):1787-93.

6. Naqvi U. Muscle strength grading. Statpearls [Internet]: StatPearls Publishing; 2021.

7. Sisto SA, Dyson-Hudson T. Dynamometry testing in spinal cord injury. Journal of rehabilitation research and development. 2007;44(1):123.

8. Bohannon RW. Manual muscle testing: does it meet the standards of an adequate screening test? Clinical rehabilitation. 2005;19(6):662-7.

9. Hogrel J-Y, Benveniste O, Bachasson D. Routine monitoring of isometric knee extension strength in patients with muscle impairments using a new portable device: cross-validation against a standard isokinetic dynamometer. Physiological measurement. 2020;41(1):015003.

10. Ganderton C, Kerr B, King M, Lenssen R, Warby S, Munro D, et al. Intra-Rater and Inter-Rater Reliability of Hand-Held Dynamometry for Shoulder Strength Assessment in Circus Arts Students. Medical Problems of Performing Artists. 2021;36(2):88-102.

11. Rock K, Nelson C, Addison O, Marchese V. Assessing the reliability of handheld dynamometry and ultrasonography to measure quadriceps strength and muscle thickness in children, adolescents, and young adults. Physical & Occupational Therapy In Pediatrics. 2021;41(5):540-54.

12. YAZICI G, VAROL F, YAZICI MV, ÇITAKER S. RELIABILITY OF MAKE AND BREAK TESTS IN ASSESSING INTRINSIC FOOT MUSCLE STRENGTH USING A HANDHELD DYNAMOMETER IN HEALTHY YOUNG ADULTS. Türk Fizyoterapi ve Rehabilitasyon Dergisi. 2020;31(3):263-9.

13. Krause DA, Hansen KA, Hastreiter MJ, Kuhn TN, Peichel ML, Hollman JH. A comparison of various cervical muscle strength testing methods using a handheld dynamometer. Sports health. 2019;11(1):59-63.

14. Jeon I-C. Comparisons of test-retest reliability of strength measurement of gluteus medius strength between break and make test in subjects with pelvic drop. The Journal of Korean Physical Therapy. 2019;31(3):147-50.

15. Jeon I-CJTJoKPT. Comparisons of test-retest reliability of strength measurement of gluteus medius strength between break and make test in subjects with pelvic drop. 2019;31(3):147-50.

16. Jeon I-cJJoMS, Technology. Comparison of Test-retest Measurement Reliability of Iliopsoas Strength between Break and Make Test in Subjects with Lumbar Extension Syndrome. 2019;3(2):54-8.

17. YAZICI G, VAROL F, YAZICI MV, ÇITAKER SJTFvRD. RELIABILITY OF MAKE AND BREAK TESTS IN ASSESSING INTRINSIC FOOT MUSCLE STRENGTH USING A HANDHELD DYNAMOMETER IN HEALTHY YOUNG ADULTS. 2020;31(3):263-9.

18. Shah KM, Madara KC, Diehl I, Hyer M, Schur J, McClure PWJCB. Shoulder muscle force and electromyography activity during make versus break tests. 2020;80:105189.

19. Perwaiz S, Afzal MW, Fatima G. Comparison between qualitative and quantitative measurement of strength deficit in shoulder flexors of young females: A cross-sectional study. Journal of the Pakistan Medical Association. 2021;71(11):2559-62.

20. Wong CK, Moskovitz N. New assessment of forearm strength: reliability and validity. The American Journal of Occupational Therapy. 2010;64(5):809-13.

21. Andrews AW, Thomas MW, Bohannon RW. Normative values for isometric muscle force measurements obtained with hand-held dynamometers. Physical therapy. 1996;76(3):248-59.

22. Escolar D, Henricson EK, Mayhew J, Florence J, Leshner R, Patel K, et al. Clinical evaluator reliability for quantitative and manual muscle testing measures of strength in children. Muscle & Nerve: Official Journal of the American Association of Electrodiagnostic Medicine. 2001;24(6):787-93.

23. Bohannon RW. Reference values for extremity muscle strength obtained by hand-held dynamometry from adults aged 20 to 79 years. Archives of physical medicine and rehabilitation. 1997;78(1):26-32.

24. Arnold CM, Warkentin KD, Chilibeck PD, Magnus CRJTJoS, Research C. The reliability and validity of handheld dynamometry for the measurement of lower-extremity muscle strength in older adults. 2010;24(3):815-24.

25. Pfister PB, de Bruin ED, Sterkele I, Maurer B, de Bie RA, Knols RH. Manual muscle testing and hand-held dynamometry in people with inflammatory myopathy: An intra-and interrater reliability and validity study. PloS one. 2018;13(3):e0194531.

26. Kim S-G, Lee Y-SJJopts. The intra-and inter-rater reliabilities of lower extremity muscle strength assessment of healthy adults using a hand held dynamometer. 2015;27(6):1799-801.