

A reliability study of isometric shoulder internal and external rotation strength in young badminton players using a hand-held dynamometry

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Abstract:

Accurate measurement of internal rotation and external rotation (IR/ER) muscle strength is crucial for badminton players, coaches, and support staff to ensure appropriate training prescription and reduce the risk of injuries. Previous studies have highlighted the significance of measurement position and stabilisation in achieving reliable outcomes. This study aimed to assess the reliability of Hand-Held Dynamometry (HHD) in measuring shoulder IR/ER strength among young club badminton players using the Microfet 2™ dynamometer. Thirty young badminton players aged 17.4±1.8 years, with a body mass of 56.08±5.7 kg, participated in the study. Isometric strength tests (ISTs) for shoulder IR/ER were conducted using the Microfet 2™ dynamometer. To determine the reliability, the same strength tests were repeated two days apart for each participant. The results demonstrated high reliability for both IR (ICC = 0.92-0.91) and ER (ICC = 0.99-0.96) in both dominant and non-dominant shoulders. Additionally, the percentage of Smallest Real Difference (SRD) remained consistently below 20% for IR and below 12% for ER in both shoulders. The ER/IR ratio also showed good reliability (ICC = 0.83 and 0.82) for both dominant and non-dominant shoulders. The findings of this study indicate that HHD using the Microfet 2™ is a reliable tool for measuring shoulder IR/ER strength in young badminton players. The high reliability and low SRD percentages suggest that the device can yield consistent results, which is essential for accurate training prescription and injury prevention. The use of the Microfet 2™ dynamometer in measuring shoulder IR/ER strength among young badminton players is supported by the high reliability demonstrated in this study. Coaches, players, and support staff can confidently utilize this tool to optimize training programs and minimize the risk of injuries in this population.

Key Words: - handheld dynamometer, muscle asymmetry, shoulder movement, reliability

Introduction

Shoulder strength and stability play a pivotal role in the performance and injury prevention of overhead athletes, with badminton players being no exception. The internal and external rotator (IR/ER) muscles are particularly crucial for badminton players as they are responsible for maintaining the stability and mobility of the glenohumeral joint during various strokes and movements (Ramsi et al., 2004; Wang & Cochrane, 2001). The unique nature of badminton, where players predominantly use their dominant hand to hold the racket, gives rise to an inherent postural imbalance with lateral trunk flexion during overhead actions (Kimura et al., 2010). This imbalanced posture, coupled with repetitive overhead movements, places significant stress on the shoulder joint, particularly on the rotator cuff muscles, and may lead to the development of shoulder-related complaints and injuries in badminton players (Arora et al., 2015).

Several studies have shed light on the relationship between shoulder rotator strength imbalances and the risk of injuries among badminton players. Research by Ng and Lam (2002) showed that the eccentric antagonist and concentric agonist strength ratio in the shoulder is statistically significant in shoulder complaints among badminton players. Moreover, the continuous repetition of motions from cocking to follow-through phases during badminton play inevitably stresses the epiphyseal plate, making it essential to maintain a balanced and stable shoulder joint (Ng & Lam, 2002). A study by Batalha et al. (2015) highlighted that prolonged badminton training could lead to disproportionate increases in shoulder internal rotation strength relative to its antagonist, resulting in an agonist-antagonist muscle imbalance. This imbalance in rotator cuff strength between the dominant and non-dominant arms of badminton players was further corroborated by Arora et al. (2015). Such disparities in rotator strength have the potential to impact shoulder stability, performance, and injury susceptibility, warranting careful attention and monitoring by athletes and coaches (Couppé et al., 2014).

To better manage training and reduce the risk of injuries, accurate and reliable assessments of shoulder rotator strength are essential for badminton players and their support staff (Couppé et al., 2014). Among the various methods available for evaluating shoulder strength, Hand-Held Dynamometry (HHD) has gained prominence due to its ease of use, portability, and objective nature, making it a practical tool for routine assessments (Roman et al., 2022). While other techniques, such as Manual Muscle Testing (MMT) and

isokinetic testing, have been employed to measure shoulder rotator strength (Kolber et al., 2007), the latter presents challenges due to the need for controlled laboratory conditions and higher operational costs, limiting its widespread use in sports settings (Cools et al., 2014; Stark et al., 2011).

Numerous studies have investigated the reliability and reproducibility of HHD in measuring shoulder strength, providing valuable insights into its effectiveness. Rieman et al. (2010) demonstrated that prone position testing resulted in greater ER strength than seated position testing in both genders, while neutral stance exhibited higher IR strength, but only in females. Katoh et al. (2015) found that isometric shoulder joint muscle strength measured using HHD and a stabilizing belt showed high reproducibility in young healthy individuals, emphasizing the importance of proper stabilization during testing. Additionally, McLaine et al. (2016) reported excellent intra-rater reliability in both ER and IR strength tests, regardless of three different body positions (prone, supine, and sitting) at 90° shoulder abduction.

Despite the potential benefits of HHD in measuring shoulder IR/ER strength in badminton players, ensuring its reliability is crucial for accurate training prescription and injury prevention (Batalha et al., 2014; Pontaga, 2018; Byram et al., 2010). Numerous factors, such as mechanical aspects, joint and testing protocols, shoulder posture, and body positioning during assessment, may influence the reliability of HHD testing (Edouard et al., 2011; Radaelli et al., 2010). Therefore, this study aims to investigate the reliability of HHD in assessing shoulder IR/ER strength in a single prone body posture among young badminton players.

By establishing the reliability of HHD testing in this specific body position, this research seeks to contribute valuable evidence to the sports science community, coaches, and medical staff, enhancing the understanding of muscle imbalances and supporting effective strategies for training management and injury prevention in badminton players. Accurate and consistent assessment of shoulder rotator strength is vital for optimizing performance, reducing the likelihood of injuries, and ensuring the long-term health and well-being of badminton athletes.

Badminton, as a sport that demands a combination of strength, agility, and precision, places immense demands on the shoulder joint and its surrounding musculature (Kamalden & Gasibat, 2021). The repetitive nature of badminton strokes, particularly overhead movements such as smashes and clears, requires the shoulder to undergo a wide range of motion at high speeds. Consequently, this exposes the shoulder to potential injury risks and necessitates careful management and training protocols to maintain optimal shoulder health and performance (Couppe et al., 2014; Wang & Cochrane, 2001).

In the context of badminton, the rotator cuff muscles, namely the infraspinatus, supraspinatus, teres minor, and subscapularis, play a critical role in stabilizing the glenohumeral joint and facilitating the complex motions required for overhead shots (Ramsi et al., 2004). These muscles work in unison to provide dynamic stability and control, preventing excessive translation of the humeral head within the glenoid cavity during shoulder movements. Consequently, they aid in optimizing shoulder joint mechanics and reducing the risk of impingement and other shoulder-related pathologies commonly observed in overhead athletes (Wang & Cochrane, 2001).

The unique demands of badminton, where players predominantly use their dominant hand to hold the racket, result in an inherent postural imbalance. This unbalanced posture is further exacerbated during overhead strokes, leading to lateral trunk flexion and increased stress on the dominant shoulder (Kimura et al., 2010). Over time, such repetitive movements, coupled with the powerful forces generated during badminton play, can lead to muscle imbalances and altered shoulder biomechanics, potentially increasing the risk of shoulder injuries (Arora et al., 2015). Therefore, understanding and addressing shoulder rotator strength imbalances in badminton players is critical for injury prevention and long-term athletic success (Kamalden et al., 2021).

Several studies have investigated the impact of badminton training on shoulder rotator strength and have identified differences in strength between the dominant and non-dominant shoulders of badminton players (Arora et al., 2015). Arora et al. (2015) observed that badminton players exhibited significantly greater IR strength in their dominant shoulders compared to their non-dominant shoulders. This finding highlights the potential for muscle imbalances, as prolonged and asymmetrical training can lead to uneven muscular development between the two shoulders. Similarly, Couppe et al. (2014) reported that badminton players showed distinct differences in rotator strength between their dominant and non-dominant shoulders, with the dominant side being stronger.

Despite the importance of shoulder rotator strength assessment in badminton players, there is limited research specifically addressing the reliability of the assessment methods in a single prone body posture. HHD is emerging as a popular and practical tool for measuring muscle strength, including shoulder IR/ER strength, in various populations (Roman et al., 2022). However, to ensure accurate and consistent measurements, it is crucial to investigate the reliability of HHD in a single prone body position among young badminton players.

The IR/ER muscles play a critical role in maintaining the stability and mobility of the glenohumeral joint in badminton players. However, the repetitive and asymmetric nature of badminton movements, coupled with the dominance of the racket in the dominant hand, may lead to imbalances in shoulder rotator strength. Such imbalances can increase the risk of injuries and compromise athletic performance in badminton players

(Arora et al., 2015; Couppé et al., 2014). Therefore, it becomes essential to assess and monitor shoulder IR/ER strength to identify potential imbalances and develop appropriate training and injury prevention strategies.

This study aims to address the gap in the current literature by investigating the reliability of HHD in assessing shoulder IR/ER strength in a single prone body posture among young badminton players. By doing so, the research will contribute to the body of knowledge related to shoulder strength assessment and provide evidence-based insights for training and injury prevention strategies in the context of badminton. Through this research, stakeholders in the badminton community can gain a deeper understanding of the importance of shoulder strength assessment and its impact on athlete performance and well-being, ultimately leading to enhanced athletic development and reduced injury risk in this sport.

Material & methods

Study design

In this study, the isometric strength of the internal and external shoulder muscles was measured in both dominant and non-dominant shoulders of badminton players using a Microfet 2™ dynamometer. The maximal IR/ER achieved with a complete isometric contraction (5 seconds) were selected as variables for measuring the isometric strength of the internal and external shoulder muscles. The ER/IR ratios were used to assess muscle balance.

Participants

In this study, 30 young badminton players, including 5 female and 25 male players, were recruited from the Voltrex Badminton Academy, which is located at CK Sport Centre Kepong in Kuala Lumpur, Malaysia. The estimated sample size was based on literature, suggesting that a minimum of 19 participants would be required to determine an intraclass correlation coefficient (ICC) score of 0.7 with two raters (Carter & Lubinsky, 2015). The mean age, body weight and height of the participants were 17.4 (1.8) years, 56.08 (5.7) kg and 166.16 (6.6) meters respectively (Table 1). In order to be eligible for participating in this study, participants must not have upper-limb problems, train more than four times a week, and compete in national competitions. Additionally, the participants were instructed to refrain from engaging in any formal upper extremity strength, conditioning, or badminton training for 2 days prior to and during the data collection. Before participating in the study, each participant received a detailed explanation of main objectives and experimental procedures of this study and provided written informed consent. All procedures were approved in writing by the Ethics Committee of the host institution (Proceedings JKEUPM-2022-007), which were in accordance with the 1975 Helsinki Declaration.

Table 1- Characteristics of Sample (N = 30) Mean (Standard Deviation)

Characteristics	Mean (Standard Deviation)
Age	17.4 (1.8)
Weight [kg]	56.08 (5.7)
Height [cm]	166.16 (6.6)
Years of playing badminton	7.23 (1.77)
Training per week	16.33 (3.07)

Procedures

The IR/ER strength of the participants was measured using the Microfet 2™ Digital Handheld Muscle Tester (Hoggan Health, Draper, UT, USA). The test-retest reliability of the shoulder strength measurements was evaluated by conducting the tests on two different occasions, with a two-day gap between each test session. During this period, the participants were advised to refrain from engaging in any strenuous physical activity. The measurements were conducted by an assessor who was trained in the procedures and was supervised by a secondary assessor with over three years of experience in using the HHD equipment to evaluate muscular strength. Before conducting the measurements, the participants were asked to complete a questionnaire that included questions regarding hand dominance and any history of shoulder pain or problems. Under the supervision of the tester, participants performed bilateral ER/IR strength tests using the Microfet 2™ Digital Handheld Muscle Tester. Before starting the tests, the participants warmed up their shoulders for five minutes, including articular mobility exercises in the same directions as the testing. The tests were performed while the participants lay prone with the elbow bent to 90° and extended (Fig 1 and 2). The strength tests were performed in the same order for both sessions.

The humerus was stabilised distally against the stretcher by the tester, and the participants supported it with their opposite arm adjacent to the test table. To measure ER strength, anatomical landmarks were used to locate the HHD on the posterior surface of the forearm. To measure IR strength, the HHD was placed on the anterior surface of the forearm, which was immediately proximal to the ulnar styloid process and was just posterior to the ulnar styloid process (Coinceicao et al., 2018). All tests involved a 5-second isometric maximal contraction with a 10-second rest interval between each 2 repetitions and 60-second rest between each strength test. The tester provided vocal encouragement to inspire the participants throughout the force creation process. The highest recorded from each of the test sessions were included for analysis.



Fig 1- ER Measurement



Fig 2- IR Measurement

Statistical analyses

The reliability of the measurements was evaluated according to established procedures in the literature (Weir, 2005). The Intraclass Correlation Coefficient (ICC) 3.1 with a two-way mixed model and single measures was used to assess the test-retest reliability with 95 percent confidence intervals for the two repetitions (Hopkins, 2000). Absolute reliability was determined by calculating the Standard Error of Measurement (SEM) and the Smallest Real Difference (SRD). SEM was calculated as $SEM = SD \times \sqrt{1 - ICC}$, where SD represents the mean SD of the two repetitions. SWC was calculated as $1.96 \cdot SEM \sqrt{2}$.

To facilitate comparisons with other research, SEM and SWC were converted to percentages. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, version 16.0 for Windows; SPSS Inc., Chicago, IL), and the significance level was set at 0.05. Reliability was classified as excellent (ICC 0.90), good (ICC between 0.80 and 0.89), moderate (ICC between 0.70 and 0.79), and low (ICC 0.70) (Portney & Watkins, 2009).

Results

Table 2 showed that the IR strength measurement for both dominant and non-dominant shoulders demonstrated high reliability with ICC of 0.92 and 0.91 respectively. The percentage of SRD was consistently below 20%, indicating a low level of measurement error. Similarly, the ER measurements for both shoulders also showed high reliability with ICC values of 0.99 and 0.96 respectively.

The percentage of SRD was 7.82% for the dominant shoulder and 11.4% for the non-dominant shoulder. The ER/IR ratio measurements were also found to be reliable for both shoulders, with ICC values of 0.83 for the dominant shoulder and 0.82 for the non-dominant shoulder.

Table 2. Comparison of measurements acquired from two testing sessions (Participants =30)

Action of Shoulder (Newtons)	Max Test Mean (Standard Deviation)	Max Re-test Mean (Standard Deviation)	Intraclass Correlation Coefficients	Standard Error of Measurement	Standard Error of Measurement %	Smallest Real Difference	Smallest Real Difference %
Dominant (IR)	29.2 (7.3)	30.3 (6.3)	0.92	1.86	6.25	5.16	17.32
Non-dominant (IR)	26.7 (5.6)	26.5 (6.1)	0.91	1.68	6.31	4.65	17.50
Dominant (ER)	30.2 (7.3)	30.2 (7.1)	0.99	0.85	2.82	2.36	7.82
Non-dominant (ER)	24.6 (5.0)	24.6 (4.7)	0.96	0.98	3.98	2.72	11.04
Dominant (Ratios %)	105.7 (22.8)	99.9 (15.0)	0.83	7.75	7.54	21.47	20.89
Non-dominant (Ratios %)	93.1 (11.7)	95.2 (17.4)	0.82	6.19	6.58	17.17	18.23

Discussion

The reliability of the Microfet 2TM Digital Handheld Muscle Tester was evaluated in tests which were conducted on the shoulders of badminton players. The results showed that the device was highly reliable. Prior studies tested the reliability of the device on the same day (McLaine et al., 2016), after seven days (Coinceicao et al., 2018; Hopkins, 2000), or after 48 hours (Riemann et al., 2010; Essendrop et al., 2001). In this study, a follow-up test was conducted two days after the initial test. The athletes were instructed to rest during this period, and the researchers contacted their coaches to ensure that no activities took place during the two days of rest.

There is a lack of consensus about the ideal testing position for determining shoulder IR/ER (Hayes et al., 2002; Lynch et al., 2010). Typically, shoulder rotator strength has been assessed in a seated, standing, supine (Cools et al., 2014; Roman et al., 2022; Batalha et al., 2014; Edouard et al., 2011), or prone position (Hopkins, 2000; Cools et al., 2014), with an ICC that is good or excellent (greater than 0.80). At 90° of shoulder abduction and forearm flexion, previous research found excellent ICC (0.93–0.99) in all positions, including the prone position (Cools et al., 2014). According to Papotto et al. (2016) high ICC values in isometric shoulder motions may be linked to SRDs of 6% to 23% when assessing isolated measures (torque). The HHD was also used to test the shoulder rotator strength while in a similar prone position (90° abduction for arm, elbow bent to 90° and 0° rotation), and the stability of the scapula was deemed critical (Ramsi et al., 2004). The strength of ER/IR values measured in this research, which were less than 15%, were similar to those that were found in the past at 90° of shoulder abduction and the prone position (Cools et al., 2014). This study showed that performing ER/IR strength tests in a prone position with 90° of arm abduction and elbow flexion resulted in very reliable results, with good ICC values of 0.83 to 0.82 for the IR/ER ratios and a SEM percentage of around 7%. This finding was contrasted with past procedures which did not utilise external or manual stabilisation techniques (Hayes et al., 2002). Stabilising the scapula is necessary to increase the strength of the muscles in action. Other investigations demonstrated that the ER/IR tests have great reliability when examiners manually stabilise the upper arm, shoulder, scapula, and trunk (Cools et al., 2014).

In a study by McLaine et al. (2016) strength tests in three distinct postures above 90 degrees of shoulder abduction were examined for flexion and extension tests. They found that inter-rater reliability was excellent, with ICC values ranging from 0.87 to 0.99 even without mechanical stabilisation to the upper limb or trunk. These above-average inter-rater reliability results were achieved with tests performed on different days, mimicking a common clinical setting. Interrater reliability was excellent when ER/IR strength tests were performed in all three body postures without external or manual stabilisation. These findings were comparable to previously reported inter-rater ICC values (0.93–0.99) for the ER/IR shoulder strength which was assessed at 90° of abduction (Dollings et al., 2012). This indicated that ER/IR shoulder strength can be reliably measured in both higher and lower ranges when external stabilisation is provided (McLaine et al. 2016).

Several studies have indicated that changes in shoulder strength balance can lead to musculoskeletal dysfunction (Pontaga, 2018). Therefore, it is important to understand the reliability of isokinetic or isometric examination in order to aid in the diagnosis of potential shoulder disorders. The study conducted by Edouard et al. (2011) demonstrated the importance of considering the SEM when evaluating a single measurement or detecting an actual shift between two readings of IR/ER and ER/IR ratios for both dominant and non-dominant shoulders (Edouard et al., 2011). It is also important to note that the testers' strength can affect their ability to stabilise the HHD and impact the measurement's reliability (Stark et al., 2011). However, McLaine et al. (2016) suggested that the HHD consistency, placement of subject, clarity in instructions to participants, and familiarity about tests via warm-up movements might have contributed towards achieving reliable results.

Limitations and future directions

This study has several limitations that should be considered when interpreting the results. Firstly, there was no control group used in this study. Secondly, the shoulder strength tests were conducted in a single body posture. These limitations may have impacted the reliability of the results. To further explore the reliability of shoulder IR/ER strength testing using HHD, future directions could include conducting the same tests in different body postures and with a control group. Additionally, further research could be conducted to determine which body postures are the most reliable for assessing shoulder strength. Finally, further investigation into the long-term reliability of HHD for measuring shoulder strength would be beneficial.

Theoretical and practical implications

This study provides evidence for the reliability of shoulder IR/ER strength testing using a hand-held dynamometer (HHD). From a theoretical perspective, this provides an assessment method that can be used as a reliable and valid tool for measuring shoulder strength. Practically, this study provides a useful tool for assessing shoulder strength and monitoring changes associated with rehabilitation or training programmes. For example, clinicians could use HHD to track improvements in shoulder strength over time. Additionally, this method may be used to monitor strength gains following specific strengthening exercises or training programmes. Knowing that HHD is a reliable and valid tool for measuring shoulder strength can also provide confidence in the measurements that are obtained.

Conclusion

In conclusion, this study examined the reliability of HHD in assessing shoulder internal and external rotator (IR/ER) strength in a single prone body posture among young badminton players. The results demonstrated high reliability for both IR and ER shoulder isometric torque, with the elbow flexed at 90°, the arm at 90° abduction, and with 0° rotation. Additionally, the IR/ER ratio was also found to be highly reliable. These findings provide robust evidence supporting the use of HHD in a prone body posture as a reliable tool for measuring shoulder rotator strength in young badminton players.

The utility of the Microfet 2™ dynamometer in assessing shoulder strength extends beyond its reliability. With its user-friendly, portable, and objective nature, the Microfet 2™ device can be confidently utilized for various purposes, including assessing muscle strength and monitoring changes associated with rehabilitation or training programs. The availability of such a reliable and convenient tool can significantly benefit badminton players, coaches, and medical staff, enabling them to make informed decisions about training prescription, injury prevention, and rehabilitation strategies.

Moreover, the study adds to the existing body of knowledge related to shoulder strength assessment in the specific context of badminton players. By validating the reliability of HHD in a prone body posture, this research provides essential evidence to support the use of this assessment method in sports settings, particularly in young badminton players. The findings can be integrated into evidence-based training approaches to optimize performance and minimize the risk of injuries.

Practically, the results have implications for the practical application of strength testing in young badminton players. While laboratory-based assessments may offer accurate measurements, they can be challenging to access and costly. The Microfet 2™ dynamometer provides a feasible alternative for conducting reliable shoulder strength tests in the field, reducing the logistical and financial burden associated with laboratory assessments. This practical advantage is especially valuable for coaches, trainers, and medical personnel working with young badminton players, enabling them to assess shoulder strength conveniently and efficiently.

In summary, the present study demonstrates that the Microfet 2™ dynamometer can be confidently utilized for assessing shoulder IR/ER strength in young badminton players. The high reliability observed in a single prone body posture provides a solid foundation for its practical application in sports settings. By incorporating HHD assessments into routine monitoring and training programs, badminton players and their support staff can optimize performance, manage training load, and reduce the risk of shoulder injuries. The theoretical and practical contributions of this research contribute to the broader understanding of shoulder strength assessment in badminton and provide valuable insights for evidence-based approaches to enhance athletic development and well-being in young badminton players.

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