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Reliability And Validity Of A Clinically Calculated Muscle Power Test: A Quasi-Isometric Approach Correlated With Functional Sit-To-Stand Test

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ABSTRACT

Background: Accurate assessment of muscle power is essential for understanding the functional activity in clinical populations. Functional tests, like Single leg Sit-To-Stand test 5 repetition, offer a clinical estimation of lower-limb muscle power, but it is not applicable to all clinical conditions. Quasi-isometric test presents a quiet, simple, and low-cost alternative that may be possible for people with limited mobility.
Objective: The objective of the present study was to evaluate the test-retest reliability of a clinically calculated quasi-isometric muscle power test and to examine the concurrent validity by analysing the correlation between quasi-isometric muscle power and functional muscle power from the SLST5rept test using the Alcazar et al. (2018) equation.
Method: A quasi-experimental design was used. Lower-limb muscle power was measured in two methods. Quasi-isometric muscle power was determined, with the right and left sides tested, via two trials, using a clinical set, and power values were derived from force and lever arm measurements. Functional muscle power was derived from the SLST5rept test of the Alcazar formula, which takes into account body mass, gravitational acceleration, body height, and task completion time. Descriptive statistics were performed on all variables. The reliability of the test for quasi-isometric muscle power was determined by the comparison of repeated tests, whereas the concurrent validity was evaluated by the Pearson's correlation coefficient between the two power measures, namely quasi-isometric vs. SLST5rept, based muscle power.
Results: The quasi-isometric muscle power test displayed an excellent test-retest reliability (ICC=0.99), as the differences between repeated trials and sides were minimal. In contrast, correlation analysis revealed a weak and insignificant relationship between quasi-isometric muscle power and functional muscle power from the SLST5rept ($r = 0.08$), indicating a very poor concurrent validity between two measurement methods.
Conclusion: The study concludes that the clinically calculated quasi-isometric muscle power test is a highly reliable assessment method, but showed poor concurrent validity when compared to functional sit-to-stand method. This can be interpreted as quasi-isometric, and functional sit-to-stand muscle power tests are not interchangeable. The use of both methods together improves the clinical evaluation of lower-limb muscle function and functional performance.

Keywords: Muscle power, Quasi-isometric tests, functional sit-to-stand test.

INTRODUCTION

The meniscus of the knee is a small, crescent-shaped fibrocartilaginous structure which supports the knee joint in stability, shock absorption, load distribution, biomechanics, lubrication, and proprioception (1). Injury to this meniscus disrupts all these functions. There are two types of menisci in the knee, i.e., medial and lateral. Both are essential for the healthy knee performance (2). Meniscal injuries are a very common orthopaedic condition, which mostly occurs in active populations. It also happens to active players in sports like basketball, soccer, and football etc. Also, it can be occurred in the occupational setting where the workers have to do jobs with kneeling and squatting (3). Studies shows that, there is an incidence of 61 cases per 100,000 persons observed with meniscal injuries (4).

While considering the importance of the menisci for the normal knee function, its treatment procedures have also evolved. The treatment of these injuries involves the options from conservative management to the surgical procedures, such as the meniscectomy and meniscal repair (5). Research shows that meniscal injuries are best managed surgically by meniscal repair rather than partial meniscectomy, as the former yields better clinical outcomes and has been shown to delay the progression of degenerative osteoarthritis, together with preserving long-term integrity and function of the knee joint across all age groups (6). Although, the post-operative rehabilitation remains a critical component in the functional recovery of the meniscal injuries, which involves the period of non-weight bearing (NWB) or restricted weight bearing for 4 weeks to 8 weeks to protect the healing of the tissue (7).

Despite the requirements of having NWB for biological healing, this period of immobilization results in skeletal muscle atrophy or muscle mass, especially in the quadriceps and hamstrings (8, 9). This non-weight-bearing period creates a significant barrier for clinicians to perform the conventional assessments. An assessment of lower-limb muscles that encompasses muscle strength and muscle power is an important aspect of rehabilitation (10). Muscle strength refers to the greatest amount of force a muscle or muscle group can generate at a given velocity (11). Muscle power, on the other hand, is defined as the rate of doing work and, in essence, is the product of force and velocity (12).

In a healthy individual, the muscle power helps in the stabilization of the knee joint to balance during a slip or trip (13). Muscle power accelerates the functional activity more than the muscle strength alone. After the surgery, the loss of muscle power leads to difficulties in coordination and increases the risk of falls once weight bearing is introduced. The traditional gold standard for measuring muscle strength and power is the isokinetic dynamometers which displayed a higher reliability compared to Handheld Dynamometry testing (14). However, isokinetic dynamometers are computerized machines, which are expensive and non-portable (15) and which are unsuitable for non-weight-bearing conditions as it display the complexity of early rehabilitation and high variation in loading status (16).

To fill this gap, the clinicians have begun to use the Quasi-isometric testing method. Quasi-isometric is a variation of isometric testing where the muscles are maintained in a fixed position against the load until a specific time to failure occurs .Quasi-isometric contraction refers to an attempted isometric contraction in which the joint position is maintained with minimal movement, but a small yielding motion may occur due to external load or fatigue (17). In isokinetic testing, the muscle performance is controlled by a constant angular position that is specified over the full motion range and clearly puts dynamic load on the joints (18). Quasi-isometric testing, on the other hand, is done with the joint in a fixed position, requiring holding a muscle force without joint movement (19). This scenario is ideal since minimal excursions will be imposed on the joint, thereby offering reduced shear forces across the knee and mechanical load on the repaired meniscus (19). Hence, quasi-isometric testing is very appropriate in this case for non-weight-bearing patients since high mechanical tension can be developed in the muscle while the joint is adequately protected during early rehabilitation (20).

The studies indicate that, muscle power is much more sensitive and functionally meaningful indicator of recovery than muscle strength (21). The loss of muscle power is present in patients after lower-limb surgery, which leads to significant difficulties with rising from a chair, stair negotiation, and gait initiation (22). Thus, it is necessary for the early identification and monitoring of the muscle power for successful rehabilitation and optimizing functional outcomes.

In the clinical setting, the widely used practical, simple, and low-cost assessment method are the functional performance tests. From which the most common method is the Sit-to-Stand (STS) test, which is an established, low-cost, reliable method for measuring the lower-limb functional performance (23). The functional sit-to-stand requires coordinated movements of the quadriceps, hip extensors, and trunk muscles, and is heavily dependent on lower-limb muscle power rather than strength alone (24). The previous studies have indicated that lower-limb muscle power is positively correlated with functional performance like sit-to-stand in various populations with knee problems and after surgery conditions (25, 26). Although studies stated that, during the early phase of recovery in non-weight-bearing period in meniscal repair, the functional assessment methods like STS are not often performed (27). It is often performed after 12 weeks of recovery to prevent any stress or injury to the healing tissue (28).

Thus, it offers a significant gap in a clinically acceptable, objective, safe, and feasible method of assessment to check the muscle power in the early rehabilitation phase of ACL reconstruction with meniscal repair. A clinically calculated muscle power test using the quasi-isometric approach will be a safe and effective alternative method for assessment while protecting the knee joint. Thus, the present study aims to explore on

the establishment of the psychometric properties like the reliability and validity of the clinically calculated muscle power test using a quasi-isometric approach correlated with the functional sit-to-stand test (SLST5rep). The reliability ensures the consistency and repeatability, while validity determines whether the test accurately measures lower-limb muscle power using the quasi-isometric with the functional sit-to-stand method (SLST5rep).

METHODOLOGY

Research Design:

Quasi-experimental research design:
A quasi-experimental study design was used to determine the test-retest reliability and concurrent validity of a clinically calculated quasi-isometric muscle power test by comparing it with the functional muscle power obtained from single leg sit to stand 5 repetition test (SLST5rep).

Sample Size: Twenty-two healthy participants (5 males, 17 females; age: 20 -28; height (cm), 155-173; weight (kg), 44-91) volunteered for the study. They were recruited through convenience sampling techniques. Based on literature and sample size estimation, the present sample size of 22 participants was perfectly sufficient to measure test-retest reliability and concurrent validity.

Study Setting: The research took place in Medical Trust Hospital & Medical Trust Sports Clinic, Ernakulum, Kerala. It is a clinical and physiotherapy lab environment that was controlled and part of a medical institution. The assessments were done in a specified musculoskeletal assessment area where the equipment included standardized seating, measurement devices, tools, and stopwatches. Data collection happened during one testing session and the context/situation conditions were standardized based on ethical guidelines. Each participant was tested separately by the examiner/physiotherapist for the consistency of test administration and measurement procedures.

Institutional Ethical Committee: Ethical approval was obtained from the Institutional Ethics Committee (IEC) of NIMS University, Jaipur, Rajasthan. The study was conducted in accordance with ethical standards for research involving human participants.

Inclusion Criteria:
1. Healthy adults (male and female), willing to participate voluntarily
2. Age – 20-30 years (physiotherapy students)
3. Able to understand instructions and perform the testing procedures
4. Participants capable of completing:
a. Quasi-isometric muscle power test (right & left side)
b. 5-repetition Sit-to-Stand (SLST5rep) test. (right & left side)

Exclusion Criteria:
1. History of lower-limb injury or acute pain affecting performance
2. Recent fracture or surgery involving hip/knee/ankle
3. Any neurological condition affecting balance or motor performance
4. Known cardiorespiratory condition where repeated sit-to-stand is unsafe
5. Any medical condition restricting safe participation (severe dizziness, instability, etc.)
6. Participants unwilling to provide informed consent

Outcome Measure:

- **Handheld Dynamometer (ActivForce 2):** The handheld dynamometer is a portable and digital instrument for measuring muscle strength in an objective manner. It is used as an alternative to manual muscle testing. It measures the physical force exerted on its load cells. It usually comprises a pad or strap that provides the interface between the body part being tested and the handheld dynamometer. Force applied by the muscle is thus converted into a measurable quantity, defined as muscle strength.

- **Single leg Sit-to-stand Test:** The Single leg 5x Sit-To-Stand test (SLST5rep) is an approach that assesses the functional strength of the lower limbs, transitions, dynamic balance, gait speed, and falls risk in an individual. Scoring for this procedure is based on the time taken for a patient to transfer from a sitting to a standing position and back to sitting in five times. In terms of equipment, a stopwatch is needed together with a standardized height chair that has a straight back (43-47 cm or 17-18 inches tall). Then the instructor asks the patient to, "Cross their arms across the chest," and do the SLST5 repetition as fast as they can. It begins with the examiner saying "Start" and it ends when the patient's buttocks touch the seat of the chair for the last repetition. If the patient cannot do five times, it results in a failure of the test.

Procedure:

The present study was conducted in a controlled physiotherapy rehabilitation environment by ensuring consistency and safety throughout the assessment procedure. Before starting the procedure, the investigator has briefed each and every patient, including the purpose of the test, the steps involved and the safety measures taken. The investigator also demonstrated the procedure to the patient to get familiarised with the testing method and equipment.

1.Quasi-isometric test (QIT)

During the session, the patients were seated comfortably in a quadriceps table with a dividing disc, angle location pin, and calf-adjusted pad to ensure the accurate positioning of the joint. Both hip and knee joints were maintained in a 90° flexion to ensure a stable and reproducible position for the patients. The dividing disc on the side of the table provides a precise measurement and setting of the angle of the knee joint. The angle location pin is used to lock the limb safely and securely in the desired angle to prevent unintentional movement during the contraction. The calf-adjusted pad was placed under the lower leg to support it when using the ActivForce2 Handheld Dynamometer to apply force. The adjustable straps were used to prevent unnecessary movement from the pelvis or thigh to hold them firmly in the table, which will only allow the knee to move during the test. The ActivForce2 Handheld dynamometer was positioned appropriately to assess the movement. During knee extension, the HHD was placed anterior to the calf-adjusted pad, and in knee flexion, it was placed in the posterior position. Here, the HHD was placed in a perpendicular position to the limb to ensure the accurate transmission of force and measurement. The lever arm length is the distance between the knee joint axis and the point of HHD contact. The lever arm distance was standardised based on the patient's measured distance from the midpoint of the patella down to the point where the HHD is placed, which allowed a consistent torque and power calculation in the trials. The placement of HHD is 5cm above the lateral malleolus, so that the position is standardised.

In the dividing disc of the quadriceps table, the knee joint angles are in a preset position to ensure accuracy. In extension, the movement range was standardised between 90° to 120°, and in flexion, it is 90° to 60°. After positioning the patients, the investigator instructed them to push and pull with their maximum effort and maintain that position for 5 seconds. Here, the ActivForce2 Handheld Dynamometer automatically records the peak forces in Newtons in each contraction. Each patient performs 3 maximal effort trials in both knee extension and flexion. A 30 to 60-second rest is given between each trial to reduce fatigue. The highest peak force value is recorded from the three trials, and this value is selected for further analysis. The recorded values are then used to calculate the torque, work, and power.

The calculation of the muscle power follows;

Torque= Peak force (N) x lever arm distance (m)
Work done (j) = torque x .52 radian (angular velocity)
Power (W) = work done / time (5 sec)

2.SLST5 rept. test (single leg sit to stand in 5 repetitions)

This study consisted of two testing sessions. During the first session, participants completed a five-minute warm-up by walking at a self-paced comfortable speed. Following the warm-up, the examiner demonstrated the Single-Leg 5 Times Sit-to-Stand (SLST5rep) procedure, and each participant performed two practice trials to ensure adequate understanding of the technique.

For each test repetition, participants were instructed to sit on an 18-inch (45.7 cm) chair with the knee flexed to approximately 90°. From this seated position, participants were asked to stand up using only the testing limb,

achieving full knee extension. During the movement, the non-testing limb was not permitted to touch the ground and could be held in any comfortable position, ranging from full knee extension to approximately 90° of knee flexion. After standing, participants were instructed to return to the seated position slowly until the buttocks lightly touched the chair. Participants were required only to touch the chair and immediately initiate the next repetition. Throughout the test, participants maintained their arms crossed over the chest.

Repetitions were considered invalid if the movement was not performed correctly. Incorrect performance was defined as failure to lightly touch the chair with the buttocks, inability to achieve full knee extension during standing, or contact of the non-testing limb with the ground.

The SLST5rep performance was recorded based on the time taken by participants to complete five correct repetitions. Lower limb muscle power was calculated using the equation described by Alcázar et al. (2018). Each participant performed two test trials for each leg, with a one-minute rest interval provided between trials. For statistical analysis, the best score from the two trials was selected for each limb.

The second testing session was conducted 24 hours after the initial assessment. During this session, both the Quasi-Isometric Test (QIT) and the SLST5rep were repeated using the same standardized procedures as followed in the first session.

All testing was conducted in a human performance laboratory. Data collection was performed by two post-graduate physical therapy students who independently recorded results in real time from different locations within the laboratory. Subsequently, another researcher collected the data sheets from both raters and entered the results into Microsoft Excel. The final analysis included assessment of test–retest reliability and concurrent validity.

Figure 1 Handheld Dynamometer Placement

Figure 2 Quadriceps Table

Figure 3 Pre-set 30^0 angle in dividing disc

Figure 4 Quasi-isometric Knee Flexion & Extension

Figure 5 SLST5 rept

Figure 6 Chair height (45.7cm)

Statistical Analysis

Mean and standard deviation were computed as descriptive statistics for all demographics, quasi-isometric, and functional muscle power variables. The test-retest reliability of the quasi-isometric muscle power test was evaluated using the intraclass correlation coefficient (ICC, two-way random, effects model, absolute agreement).

Along with this, Pearson's correlation coefficient was used to evaluate the relationship between quasi-isometric muscle power and functional muscle power measured from a SLST5rep test based on concurrent validity. The correlation level was interpreted as follows: $r < 0.30$ = poor, 0.300.49 = fair, 0.500.69 = moderate, and 0.70 = strong. The significance level was considered at $p < 0.05$.

RESULT

Table 1 Test-Retest Reliability of Quasi-Isometric Muscle Power

Variable	Trial 1 Mean ± SD (W)	Trial 2 Mean ± SD (W)	ICC (2,1)	Interpretation
Quasi-isometric muscle power	9.37 ± 1.84	9.39 ± 1.85	0.995	Excellent

Table 2 Concurrent Validity Between Quasi-Isometric and Functional Muscle Power

Variables Compared	Pearson's r	p-value	Interpretation
Quasi-isometric vs SLST5rep	−0.08	0.72	Very poor

DISCUSSION

The present study was designed to examine the test-retest reliability of a clinically calculated quasi-isometric muscle power test and second to ascertain its validity against functional muscle power obtained from the Single Leg Five Times Sit to Stand (SLST5rep) test using the formula given by Alczar et al. (2018). The main outcome of this study is that the quasi-isometric muscle power test has outstanding test-retest reliability however, it has very low correlation with functional single leg Sit-to-Stand derived muscle power in terms of concurrent validity.

Test–Retest Reliability

The quasi-isometric muscle power test revealed excellent reliability as indicated by the very high intraclass correlation coefficient (ICC = 0.995) and the small differences found between repeated trials. Trial 1 and Trial 2 average values were very close to each other, thus demonstrating a high level of measurement stability and a negligible random error resulting from the test procedure. These results imply that the quasi-isometric test is capable of producing very consistent measurements when the test is repeated under the same conditions.

A number of methodological issues might have played a role in the very high reliability shown. A single, trained examiner performed all measurements using a standardized testing position, consistent lever arm measurements, and uniform verbal instructions. Moreover, the same session retesting design eliminated variability in biological factors related to day- to-day neuromuscular changes, thus putting the spotlight on the inherent reliability of the measurement technique. Additionally, sufficient rest periods between the trials helped to further limit any fatigue effects.

From the clinical point of view, the very high reliability attained by this test is highly significant. Reliable measurement instruments are necessary not only for monitoring muscle performance changes from time to time but also for assessing the effectiveness of treatment modalities. The straightforwardness of the quasi-isometric arrangement, along with its high reproducibility, facilitates its potential as a practical, low-cost clinical instrument which may be used for.

Concurrent Validity

On the contrary, the correlation analysis that was done to complement the reliability data showed a very weak and statistically insignificant relationship between quasi-isometric muscle power and functional muscle power derived from the SLST5rep test ($r = 0.08$, $p = 0.72$).

This shows that the two measurement approaches have very poor concurrent validity, and it implies that quasi-isometric and functional power tests assess different aspects of neuromuscular performance.

CONCLUSION

This study concludes that the clinically calculated quasi-isometric muscle power test has excellent test-retest reliability but very poor concurrent validity compared to functional muscle power obtained from the Five Times Single-leg Sit-to-Stand test. The results suggest that quasi-isometric and functional power assessments measure different neuromuscular characteristics and therefore, should not be considered as interchangeable. The quasi-isometric muscle power test can be used independently to assess lower-limb muscle power by quantifying peak force output (and rate of force generation where applicable). However, combining quasi-isometric testing with a functional performance measure such as the 5-repetition single-leg sit-to-stand test provides a more comprehensive clinical evaluation by assessing both muscle power and task-based functional performance.

Recommendations:

1. The clinically calculated quasi-isometric muscle power test may be recommended as a reliable clinical tool, especially in settings where functional tests are difficult to perform.
2. Since the quasi-isometric method showed poor concurrent validity with functional SLST5rep-based power, both methods should be used together for a complete clinical evaluation.

3. Future studies should include larger sample sizes and clinical populations with mobility restrictions to improve generalisability.

Clinical Message - The clinically calculated quasi-isometric muscle power test demonstrates excellent test–retest reliability but shows poor concurrent validity when compared with functional muscle power derived from the SLST5 rep test. Therefore, quasi-isometric and functional single leg sit-to-stand muscle power assessments are not interchangeable, but their combined use improves clinical evaluation of lower limb muscle function and functional performance.

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Conflict of Interest – The authors declare no conflict of interest.

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Ethical Statement – This study was conducted in compliance with the ethical standards of the institutional Ethical Committee and in accordance with the principles of the Declaration of Helsinki.

Consent Statement – Written informed consent was obtained from all participants prior to data collection. Participants were informed about the purpose, procedure, risks, and benefits of the study, and were assured of confidentiality and their right to withdraw at any stage without penalty.

Data availability statement – The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

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