

Comparative Analysis of Isometric Mid-Thigh Pull and Hand-Held Dynamometer for Gross Muscle Strength Peak Force Output of Selected Recreationally Active Individuals

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Abstract

Background

Muscular strength assessment provides an objective measure of physical performance and supports clinical decision-making in physiotherapy, rehabilitation, and sports science. The Isometric Mid-Thigh Pull (IMTP) and Hand-Held Dynamometer (HHD) are increasingly used to quantify maximal muscle force output.

Objective

This study compared peak muscle force output obtained using IMTP and HHD and determined the relationship between measurements obtained from the two instruments among recreationally active young adults.

Methods

A cross-sectional quasi-experimental design was employed. One hundred recreationally active individuals aged 18–30 years were purposively recruited and randomly allocated into two groups based on the assessment instrument used: IMTP or HHD. Peak muscle force output was assessed under standardized testing conditions. Data were analyzed using descriptive and inferential statistics, with significance set at $p < 0.05$.

Results

Participants had a mean age of 23.82 ± 3.72 years. Mean force output was 232.7 ± 74.39 N for IMTP and 233.3 ± 74.42 N for HHD. A statistically significant difference was observed between the measurements ($t = -3.20$, $p = 0.002$, $d = -0.32$). A very strong, positive, and statistically significant correlation was also observed between IMTP and HHD measurements ($r = 0.99$, $p < 0.001$; Fisher's $z = 4.4$).

Conclusion

IMTP and HHD produced comparable peak force measurements, although a statistically significant difference existed between the two methods. The very strong positive correlation indicates a close relationship between their measurements, suggesting that both instruments can provide useful quantitative measures of peak muscle force under standardized testing conditions.

INTRODUCTION

Muscle strength is an important component of physical fitness and functional performance and is routinely assessed in physiotherapy, sports science, rehabilitation, and exercise settings (1). Objective quantification of muscle force provides useful information for establishing baseline performance, identifying strength deficits, monitoring changes following exercise or rehabilitation, and evaluating functional capacity (2). Although manual muscle testing remains widely used because of its simplicity, its ordinal nature may limit its ability to detect small changes in force output. Instrumented methods, including dynamometry, therefore provide more quantitative measures of maximal voluntary force production (3, 4).

The isometric mid-thigh pull (IMTP) is a commonly used whole-body isometric strength assessment in which an individual exerts maximal force against an immovable resistance from a standardized or self-selected mid-thigh position (5). The test allows the measurement of variables derived from the force-time curve, particularly peak force, which has been identified as one of the most reliable measures of maximal strength during IMTP testing (6, 7). A systematic review involving 16 studies reported good-to-excellent test-retest reliability for IMTP peak force, with intraclass correlation coefficients ranging from 0.73 to 0.99 and a median ICC of 0.96 (7). These findings support the use of IMTP as a reliable method for assessing absolute and relative maximal force in sports and research settings (8).

The IMTP has also demonstrated reliability across different physically active populations. Research involving young athletes has reported high within- and between-session reliability for absolute and relative peak force, while studies in non-elite athletes have similarly demonstrated high reliability of IMTP peak force (9, 10). Importantly, peak force appears to be more consistently reliable than some other force-time variables, such as rate of force development and time to peak force (6, 11). Consequently, peak force is particularly relevant when the objective is to quantify maximal gross muscle force output rather than rapid force-production characteristics.

Hand-held dynamometry (HHD) provides another objective method for quantifying maximal voluntary isometric muscle force. HHD devices are portable, relatively inexpensive, easy to operate, and applicable to a range of individual muscle groups (4, 12)(Start, Huber). Evidence from systematic reviews indicates that HHD demonstrates acceptable-to-excellent reliability and validity for muscle strength assessment, including lower-limb strength testing in healthy adults (4, 13)(Huber,Espino) Compared with larger laboratory-based dynamometers, HHD may therefore provide a more accessible option for clinicians and researchers who require quantitative strength measurements but have limited access to sophisticated laboratory equipment (3).

Despite these advantages, HHD and IMTP assess strength under different testing conditions. HHD generally measures the force produced by a specific muscle group or joint movement, whereas IMTP involves simultaneous contribution from several lower-limb and trunk muscle groups during a closed-chain isometric pulling task (3, 9). HHD measurements may also be influenced by examiner strength, stabilization, device placement, joint position, and testing protocol (13). Standardisation of participant positioning, examiner technique, familiarization, and stabilization is therefore important when using HHD

to obtain reproducible measurements. Recent evidence further emphasizes that evaluator proficiency and protocol standardization can influence HHD measurements(14).

The practical differences between the two methods are particularly relevant when assessing gross muscle strength peak force output in recreationally active individuals. While IMTP is frequently used in sports performance and strength assessment, HHD is more commonly associated with isolated muscle or joint-specific testing(15). Evidence directly comparing the peak-force output obtained from these two approaches under comparable conditions remains less established than the evidence supporting their individual reliability(15). Furthermore, differences in the muscles recruited, mechanical configuration, stabilization, and measurement technique may influence the magnitude of force recorded by each device(16)s. Therefore, direct comparison is important to determine whether the two methods produce comparable measures of gross isometric force output in recreationally active individuals.

Accordingly, the present study compares peak force output obtained using IMTP and HHD. Establishing the similarities or differences between these assessment approaches may provide useful information for physiotherapists, exercise professionals, and researchers when selecting appropriate tools for quantitative muscle-strength assessment. The findings may also contribute to understanding the practical applicability of portable dynamometry and IMTP for strength assessment among recreationally active individuals.

METHODS

The study purposively recruited one hundred (100) recreationally active individuals from selected public gymnasiums in Ondo State, Nigeria, who were randomized into two groups: Group I (Isometric Mid-Thigh Pull Kit) and Group II (Hand-Held Dynamometer) for the assessment of peak muscular strength in this cross-sectional quasi-experimental design. Ethical approval was obtained from the University of Medical Sciences Research Ethics Committee, and informed consent was obtained from each participant before the commencement of the study. Data were analysed using descriptive and inferential statistical methods, with the level of significance set at $p < 0.05$.

Isometric Mid-Thigh Pull (IMTP) (Figure I)(17) :

Setup: A barbell is set on safety arms at mid-thigh height, often using chains for adjustment, with one athlete standing on a foot plate.

- Joint angle is determined with a goniometer (Knee: range: 125–145 degrees, Hip: 140–150 degrees)
- The above are done during a warm-up session
- Three repetitions are done without switching on the load cell to measure the force of pull as a warm-up at 50% of the max pull, then a 5-minute rest.
- The load cell is switched on for the actual session

Starting Position: The participant assumes a "power position" (like the start of an Olympic lift's second pull): hips and knees are slightly bent, back is upright, feet are flat, and the participant is gripping the bar.

Execution: Remove slack from the bar, then pull as hard as possible against the fixed bar for 3–5 seconds, driving through the feet.

Verbal cues: On command, the athlete is instructed to push his feet into the ground as hard and fast as possible for 3–5 seconds.

Hand-Held Dynamometer (HHD)

Equipment Setup: A calibrated Hydraulic Hand dynamometer (Model number: SH5001, from Grip SAEHAN, South Korea), the elbow flexor of the athlete's dominant hand is tested while seated (knee extension, shoulder abduction).

Participant Positioning: Position the limb at a standardized angle (commonly mid-range of motion). Stabilize the participant to minimize compensatory movements.

Standardised Positioning (according to the American Society of Hand Therapists (ASHT) protocol for grip strength assessment using a dynamometer (18):

- Seated upright, feet flat on the floor.
- Shoulder adducted and neutrally rotated.
- Elbow flexed at 90°, close to the torso.
- Forearm neutral (thumb pointing upward).
- Wrist straight (no flexion or extension).

Testing Protocol: Place the dynamometer against the distal segment of the limb. Instruct the participant to push maximally against the device for 3–5 seconds. Repeat 2–3 trials with rest intervals. For endurance, record sustained contractions or repeated maximal efforts until fatigue. Perform 2–3 trials with adequate rest (2–3 minutes) between attempts.

Data Analysis

Data will be cleaned, organized, and analyzed using the Statistical Package for the Social Sciences (SPSS version 28). Descriptive statistics, including means, standard deviations, confidence intervals, and minimum/maximum values, will be computed for all anthropometric features and strength measurements.

RESULTS

Descriptive Statistics of the Variables

Table I presents the descriptive statistics of the variables. The mean age was 23.8 ± 3.71 years, and the mean forces obtained from the isometric pull (232.7 ± 74.39 N) and the dynamometer (233.3 ± 74.42 N) are reported, respectively.

Comparative Effect of Isometric pull and Dynamometer using Paired Samples T-Test

The paired t-test results for the mean comparison are shown in Table II. It is found that there was a significant comparison of the two measuring instruments for grading of body strength, also demonstrating a low negative effect size) ($t = -3.204$, $p = 0.002$, Cohen's $d = -0.32$).

Relationship between the Isometric Pull and Dynamometer in general body strength measurement

The relationship between isometric pull and dynamometer measurements is presented in Table III. Results indicate a significant association between the forces obtained from the isometric pull and the dynamometer, with a very large effect size observed ($r = 0.99$, $p < .001$, $z = 4.40$).

DISCUSSION

The objective of this study was to compare and correlate the effectiveness of the Isometric Thigh Pull Kit (ISO PULL) and a standard Dynamometer (DYNAM) for measuring peak force output strength of the athletes.

The comparative analysis between the two instruments, evaluated via a paired-samples t-test, demonstrated a statistically significant difference in this study. This finding underscores the sensitivity of paired designs in detecting mean differences within related groups, as the test controls for inter-subject variability by focusing on within-subject changes(19). Paired t-tests are particularly valuable in instrument validation studies, where the goal is to establish whether two measurement tools yield comparable outcomes under similar conditions (20). A statistically significant result suggests that the instruments may not be interchangeable, highlighting potential systematic bias or differences in measurement precision. These outcomes aligned with prior methodological literature, which emphasizes evaluating agreement beyond correlation, as statistical significance alone does not necessarily imply clinical or practical equivalence(20). Therefore, the observed difference provides critical insight into the reliability and validity of the instruments, warranting further investigation into their measurement properties and contextual applicability (21). The slightly higher mean force recorded by the dynamometer may reflect differences in mechanical leverage, the degree of stabilising muscle activation required, or the continuous strain-recording inherent to the device's design(18). Interestingly, Cohen's effect size was small and negative. This low effect size suggests that while the differences are systematic enough to achieve statistical significance, the practical real-world disparity in magnitude

between the physical forces recorded is relatively small. Therefore, the choice between instruments may depend more on clinical utility and field-portable logistics than on large differences in basic data output (22).

A critical finding of this study is the exceptionally strong, significant positive correlation observed between the Isometric Thigh Pull Kit and the Dynamometer. Such a high correlation indicates that both instruments are measuring a similar underlying construct of muscle strength, thereby supporting their concurrent validity (22). Strong correlations between field-based and laboratory-based measures have been reported in prior research, emphasizing the utility of portable devices in clinical and athletic settings (15). However, while correlation demonstrates the strength of association, it does not necessarily imply interchangeability, as systematic differences in measurement scales or sensitivity may still exist(4). The present finding aligns with the methodological literature highlighting the importance of establishing both correlation and agreement when validating strength assessment tools. Thus, the observed positive correlation provides compelling evidence for the reliability of the Isometric Thigh Pull Kit as a practical alternative to the Dynamometer, particularly in contexts where accessibility and ease of use are prioritized(23).

CONCLUSION

This study demonstrates that both the Isometric Mid-Thigh Pull (IMTP) and the Hand-Held Dynamometer (HHD) are effective tools for assessing peak force output in athletes. The two methods showed comparable capacity in measuring gross muscle strength, with IMTP displaying a strong correlation with HHD in evaluating peak force related to muscular power.

DECLARATIONS

Ethical declaration

Ethical approval was obtained from the University of Medical Sciences, Nigeria, Ethical Research Committee (Registration number: UNIMED-HREC/Apv/2026/677), and all procedures involving human participants were carried out in accordance with the ethical principles outlined in the Declaration of Helsinki.

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Clinical trial number

Not applicable

Consent to Publish declaration

Not applicable

Consent to Participate declaration

Ethical approval was obtained from the University of Medical Sciences Research Ethics Committee, and informed consent was obtained from each participant before the commencement of the study

Ethics declaration

Identical to the response provided for the Consent to Participate declaration.

Competing Interest

No competing interests

Data Availability declaration

Not Applicable.

Author Contribution

conceptualisation, data analysis, article write up and Project administration

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Not applicable

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TABLES

Table I: Descriptive Statistics of the Variables

	Age	ISO PULL	DYNAM
Mean (arithmetic)	23.82	232.7	233.3
Std. Deviation	3.716	74.39	74.42
Coefficient of variation	0.1560	0.3197	0.3190
Shapiro-Wilk	0.9456	0.9603	0.9610
P-value of Shapiro-Wilk	< .001	.004	.005

Key: ISO PULL : Isometric thigh Pull Kit

DYNAM: Dynamometer

Table 2: Comparative Effect of Isometric pull and Dynamometer using Paired Samples T-Test

Measure 1	Measure 2	t	df	p	Cohen's d	SE Cohen's d
ISO PULL	- DYNAM	-3.204	99	0.002	-0.3204	0.002520

Key: ISO PULL: Isometric thigh Pull Kit

DYNAM: Dynamometer

Table 3: Relationship between the Isometric Pull and Dynamometer in general body strength measurement

Variable		ISO PULL	DYNAM
1. ISO PULL	Pearson's r	—	
	p-value	—	
	Effect size (Fisher's z)	—	
	SE Effect size	—	
2. DYNAM	Pearson's r	0.9997	—
	p-value	< .001	—
	Effect size (Fisher's z)	4.399	—
	SE Effect size	0.1015	—

Key: ISO PULL: Isometric thigh Pull Kit

DYNAM: Dynamometer

Figures



Figure 1

Isometric mid-thigh pull (IMTP) of one participant



Figure 2

Hand- Held dynamometer used

