



ANGLE-SPECIFIC VARIATIONS IN MAXIMUM VOLUNTARY ISOMETRIC CONTRACTION OF HIP FLEXOR MUSCLES: A COMPARATIVE ANALYSIS AMONG VARIOUS ANGLES OF HIP JOINT

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ABSTRACT

The present study aimed to examine angle-specific variations in maximum voluntary isometric contraction of hip flexor muscles among athletes. Ten male swimmers (age: 18–25 years) from LNIPE, Gwalior, were selected as participants. Isometric strength variables, including average torque, peak torque, and peak torque slope, were assessed at 30°, 60°, and 90° of hip flexion using a HUMAC NORM isokinetic dynamometer. The results revealed that all strength variables were highest at 30°, followed by 60° and 90°, indicating a progressive decline with increasing joint angle. Statistical analysis showed significant differences among all angle comparisons ($p < .05$), with large effect sizes. The findings suggest that torque production and rate of force development are strongly influenced by joint angle. The higher force at lower angles may be attributed to the optimal muscle force–length relationship and favorable moment arm conditions. Additionally, neuromuscular activation appears more efficient at smaller joint angles. These results are consistent with previous research on angle-specific strength variations. The study highlights the importance of joint-angle specificity in strength assessment and training. Incorporating isometric exercises at optimal angles may enhance athletic performance. Furthermore, Hatha yoga practices may contribute to improved hip flexor strength and neuromuscular control. It is concluded that isometric strength of hip flexors significantly varies with joint angle, with maximum values observed at lower angles.

KEYWORDS : Isometric Strength, Peak Torque, Average Torque, Average Torque Slope, Angle.

INTRODUCTION

Yoga is a comprehensive discipline that promotes the integration of body, mind, and consciousness (Saraswati, 2006). Among its various forms, Hatha yoga has gained global prominence due to its practical application through asana, pranayama, mudra, bandha, shatkarma, and meditation, which collectively enhance physical, mental and physiological functioning.

Asanas, a key component of Hatha yoga, are practiced in progressive stages (beginner, intermediate, and advanced) and can be categorized into dynamic and static forms. Dynamic practices improve flexibility, circulation, and neuromuscular activation, while static practices enhance muscular endurance, internal organ function, and mental stability.

Muscle strength, particularly isometric strength, is a critical determinant of physical performance and is commonly assessed through maximum voluntary contraction (MVC) and peak torque (Anderson et al., 2007). Isometric torque varies with joint angle due to the muscle force–length relationship (Sale et al., 1982). Measurement using isokinetic dynamometry provides reliable evaluation of muscle function (Neumann, 2010; Marchetti, 2016).

Hip flexor muscles, including iliacus, psoas major, rectus femoris, and sartorius, play a vital role in locomotion and athletic performance. While previous studies have focused on knee musculature (Herda et al., 2008; Behm et al., 1998), limited research exists on hip flexor isometric strength at different angle.

The present study aims to investigate the comparison of isometric strength of hip flexor muscles at different angle of athletes.

Methodology
Participants

Ten (10) male swimmers (age: 18–25 years; mean \pm SD: 20 \pm 1.4 years) were purposively selected from B.P.Ed swimming match practice students of LNIPE, Gwalior. All participants provided informed consent prior to participation. The dependent variable isometric strength variables i.e peak torque, average torque, Peak torque slope of hip flexor muscles measured at 30° and 60° and 90° joint angles.

Instrumentation

Isometric strength was assessed using a HUMAC NORM isokinetic dynamometer in the Exercise Physiology Laboratory, LNIPE, Gwalior. The device was calibrated prior to testing to ensure measurement reliability.

Testing Procedure

Participants were familiarized with the protocol and rested for 10 minutes before testing. In a supine position, the dynamometer axis was aligned with the hip joint (greater trochanter). The tested leg was

secured, and range of motion was set at 0°, 30°, and 60° and 90°. Subjects performed maximal voluntary isometric contractions of hip flexion at 30°, 60° and 90°, holding each contraction for 5 seconds across three trials, with a 5-minute rest between sets.

Data Collection:

Measurements were recorded at 30°, 60° and 90° of isometric contraction with said protocol for each student repeatedly.

Reliability

All measurements were conducted under standardized conditions. Participants performed three trials, and mean values were recorded. Instrument reliability was ensured through routine calibration and prior validated use in

RESULTS

Table 1. Descriptive Statistics (Mean \pm SD) of Isometric Variables at Different Angles

	30° (n=10)	60° (n=10)	90° (n=10)
average torque	76.00 \pm 3.59	52.00 \pm 3.39	37.00 \pm 1.33
Peak torque	84.00 \pm 3.92	68.00 \pm 2.95	47.00 \pm 1.13
Peak torque slope	111.95 \pm 4.24	97.65 \pm 2.82	79.69 \pm 1.12

Table 1. presents the descriptive statistics (Mean \pm SD) of selected isometric strength variables measured at three different joint angles 30°, 60°, and 90° for a sample size of 10 participants at each angle. The mean average torque is at 30° (76.00 \pm 3.59), at 60° (52.00 \pm 3.39), at 90° (37.00 \pm 1.33). This indicates a progressive decline in torque production as the joint angle increases. Mean and SD of peak torque is (84.00 \pm 3.92), (68.00 \pm 2.95), and (47.00 \pm 1.13) at 30°, 60° and 90° respectively. This suggests that maximal force generation capacity is greater at smaller joint angles. The peak torque slope also shows a decreasing trend: 111.95 \pm 4.24 at 30°, 97.65 \pm 2.82 at 60°, and 79.69 \pm 1.12 at 90°. This reflects a reduction in the rate of torque development as the angle increases.

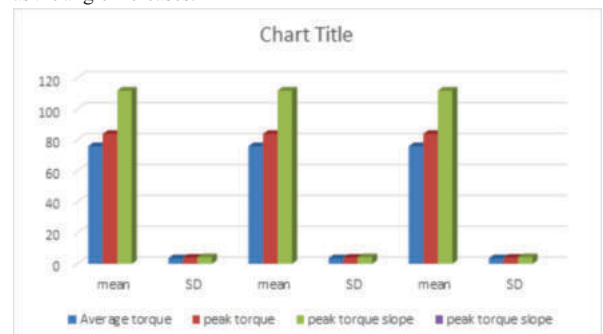


Figure 1. Mean of SD of Isometric Strength Variables at Different Angle of Hip flexor

Table 2. Bonferroni Post-hoc Pairwise Comparisons among Different Angle of Isometric Variables

Variable	Different Angle	P value	Mean difference	F value	Partial eta square
average torque	30-60	<.003	24.00	51.65	.787
	60-90	<.001	15.00	58.99	.768
	30-90	<.000	39.00	49.78	.654
Peak torque	30-60	<.030	16.00	53.44	.657
	60-90	<.002	21.00	57.39	.764
	30-90	<.000	37.00	47.98	.896
Peak torque slope	30-60	<.020	13.65	59.89	.764
	60-90	<.001	17.96	58.76	.675
	30-90	<.004	32.26	52.87	.557

The table 2. presents the pairwise comparisons of isometric variables (average torque, peak torque, and peak torque slope) across three joint angles (30°, 60°, and 90°), along with their p-values, mean differences, F-values, and partial eta squared (effect size).

In average torque Significant differences are observed between all angle comparisons of 30°–60° ($p < .003$), 60°–90° ($p < .001$), and 30°–90° ($p < .000$). large partial eta squared values (.654–.787) suggest strong statistical significance and large effect sizes. In peak torque 30°–60° ($p < .030$), 60°–90° ($p < .002$), and 30°–90° ($p < .000$). The partial eta squared values (.657–.896) indicate moderate to very large effects, with the largest effect seen in the 30°–90° comparison. For Peak Torque Slope at 30°–60° ($p < .020$), 60°–90° ($p < .001$), and 30°–90° ($p < .004$). partial eta squared values (.557–.764) indicate substantial effect sizes, confirming meaningful differences between angles.

The results demonstrate that all three variables differ significantly across joint angles, with values consistently decreasing from 30° to 90°. The low p-values ($< .05$) confirm statistical significance, while the high F-values and large partial eta squared values indicate that joint angle has a strong effect on isometric strength and torque characteristics.

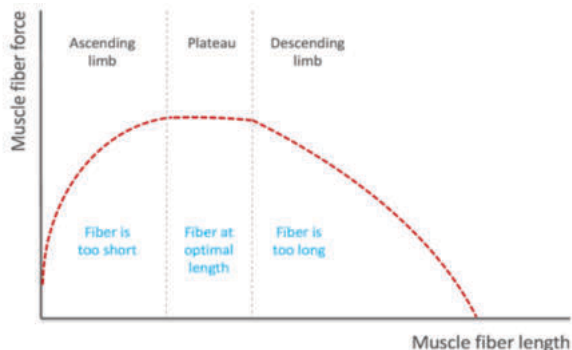


Figure 2. Peak torque in Relation to Muscle Length (F-L) Relationship (Beardsley, C., 2008)

DISCUSSION

Isometric peak torque of hip flexors was found highest in 30° than 60° and 90° angle of hip flexion due to variation of moment arm length with angle (Ito et al., 2000; Maganaris, 2001; Krevolin et al., 2004). The muscle F–L relation, as muscle length depends on joint angle. The active muscle force peaks at an optimal sarcomere length where force decreased to zero at maximum and minimum length (Gordon et al., 1966; Winter, 2005, The Journal of Physiology).

Sarcomere produces maximum force when the sarcomere length is optimum (Beardsley, C., 2008). The other factors included for angle specific peak torque are fibre length, regional muscle size (Blazevich et al. 2006), and neural drive (Altenburg et al. 2009). The present study demonstrated a significant decline in average torque, peak torque, and peak torque slope of hip flexor muscles as the joint angle increased from 30° to 90°. Higher torque values at lower angles indicate that force production is optimal at shorter muscle lengths, which can be explained by the muscle force–length relationship (Sale et al., 1982; Anderson et al., 2007).

The reduction in peak torque slope with increasing angles further suggests that the rate of force development is angle-dependent, with greater neuromuscular efficiency at lower joint positions (Folland et al., 2005; Tsao et al., 2010). The high F-values and large effect sizes

confirm that joint angle has a substantial influence on isometric strength.

These findings highlight the importance of joint-angle specificity in strength training and rehabilitation. Incorporating isometric exercises, including Hatha yoga practices, may enhance hip flexor strength and neuromuscular control, particularly at functionally relevant angles.

CONCLUSION

The present study show that isometric peak torque, average torque, peak torque slope is highest in 30° followed by 60° and 90°. So, it may be concluded that angle specific isometric peak torque of hip flexors varies with different angle of hip joint during hip flexion due to force-muscle length (F-L) relationship, neural drive and regional muscle involvement.

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