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ORIGINAL RESEARCH

Hip joint isokinetic muscle strength profiles of elite middle distance runners: a pilot study

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Abstract

The running performance and strength is important for many runners. This study aimed to examine hip joint isokinetic strength profiles of elite middle-distance runners. Nine elite middle-distance runners volunteered to participate in this study. Hip joint isokinetic muscle strength was measured using by an isokinetic dynameters. Participants performed isokinetic tests on dominant and non-dominant legs at a speed of 60°-s-1 for 10 repetitions. Isokinetic tests were conducted to flexion/extension, abduction/adduction and internal/external rotation movements of hip at concentric/concentric mode. There was no significant difference between dominant and non-dominant legs in peak torque and relative peak torque values. When the hip flexors were evaluated bilaterally, it was determined that the non-dominant side produced higher torque than the dominant side. However, in all other movements, the dominant side had higher torque values than the non-dominant side. As a result; on evaluated all joint movements bilaterally, hip flexor/extensor and adductor muscles were in normal values. However, hip abductor and internal/external rotator muscles values were in a risky range.

Keywords: Athlete, athletic, imbalance, running.

Introduction

Middle distance running has a challenging structure when considered physically and physiologically. Considering especially in terms of energy systems, the active use of both aerobic and anaerobic energy metabolisms is shown as one of the most important reasons for this (Duffield et al., 2005; Stellingwerff et al., 2019). In addition to these challenging physiological conditions, middle-distance runners demonstrate performance with technical-tactical, physical and anthropometric parameters (Maćkała and Stodółka, 2014; Maynar et al., 2019). When evaluated physically and physiologically, it is very important for middle-distance runners to provide anaerobic endurance, strength, continuity in strength, speed and continuity in speed, correct technique and tactic for performance (Brisswalter et al., 2011).

Considering the running biomechanics, it is seen that all joints can affect the technique at different levels. However, it is seen that especially the lower extremity joints affect the running performance during a run. Therefore, evaluation of lower extremity strength is very important. The isokinetic profiles of the knee joint have been studied extensively in different sports where the lower extremity is used effectively. However, since it is considered in terms of running biomechanics, it is seen that the hip joint is as effective as the knee joint. The hip joint is a multiple-joint. There are eight osteokinematics of the hip joint: flexion-extension, abduction-adduction, internal rotation-external rotation, horizontal adduction-horizontal abduction (Sever et al., 2021). Since running generally takes place in the sagittal plane and on the mediolateral axis, the most prominent of these are hip flexion to move the body forward and extension to provide thrust. During running, flexion phases in swing phases and extension phases in

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propulsion phases are active (Dicharry, 2010). On the other hand, since ankle movements are limited in the frontal plane, hip joint movements are used much more actively during running (Nicola and Jewison, 2012; Sever et al., 2021). Although the pelvis tends to remain stable during the support phases, the hip joint is adducted. Simultaneously with this movement, the contralateral hip joint is abducted. When the flight phase starts during running, the kinematics starts to reverse and accordingly, the ipsilateral limb tends to abduction (Van Oeveren et al., 2021). Later, when the contralateral side enters the support phase, adduction reaches its highest level and then goes into abduction before first contact. In addition, it is stated that the hip joint at the first contact of the foot and the femur tend to internal rotation during the run (Sever et al., 2021). During absorptive running, the pelvis rotates externally and the femur internally rotates. External rotation of the pelvis and internal rotation of the hip reach their maximum in the mid-support phase. In the pushing phase of the support phase, the pelvis is rotated inward again and the hip joint is externally rotated (Snyder et al., 2009). When evaluated in general, the hip joint contributes to performance by working in a complex way during running (Munteanu and Barton, 2011).

In the literature, there are studies on the comparison and examination of different characteristics in runner groups. Brisswalter et al. (2011) investigated effects of Ramadan intermittent fasting on middle-distance running performance. Dellagrana et al. (2015) investigated that physiological, anthropometric, strength, and muscle power characteristics correlates with running performance in young runners. Chen et al. (2022) examined that relationship between isokinetic lower-limb joint strength in recreational runners. Rannama et al. (2013) researched lower extremity isokinetic muscle performance middle-distance runners. In this study, the knee, hip and ankle joints were examined. Another a study investigated high-intensity running and plantar-flexor fatigability and plantar-pressure distribution in adolescent runners (Fourchet et al., 2015). Sugisaki et al. (2011) evaluated that the relationship between 30-m sprint running time and muscle cross-sectional areas of the psoas major and lower limb muscles in male college short and middle distance runners. Studies on the isokinetic strength of middle-distance runners in the literature are generally on the knee joint. Studies on isokinetic strength of hip joint muscles are limited and focused on a single movement. At the same time, multiple movement evaluations are important in order to better understand the relationship between running performance, running mechanics and strength.

Considering its contribution to performance during running, the evaluation of hip joint strength becomes important in running-based sports. As a result, it is seen that the articles investigating the force profiles of hip joint movements in different planes of middle-distance runners are limited. In this context, the aim of the study is to examine the hip joint isokinetic muscle strength profiles of elite young middle-distance runners and to compare difference between dominant and non-dominant side.

Methods

Subjects

G*power analysis was performed to determine the number of samples. As a result of G*power analysis, the sample group was determined as 12 subjects. But, three subjects did not complete the study due to illness. Nine elite middle-distance runners (19.88±0.60 years; 57.88±3.72 kg; 177.00±3.20 cm) voluntarily participated in this pilot study. All subjects were selected according to inclusion and exclusion criteria. Inclusion criteria included being a national athlete, being a middle-distance runner, being right-handed and training regularly. Exclusion criteria included having undergone any surgery in the last year and having experienced a sports injury. To be considered a national athlete, a participant must have participated in international competitions at least once. Since the running direction in athletics is counterclockwise, the right-hand dominant athletes were selected. After the subjects to be included in the study were determined, the subjects were informed about the study and the measurements. All tests were conducted according to the principles expressed in the Declaration of Helsinki. Ethics approval was obtained for the study from Atatürk University Ethics Committee.

Experimental Approach to the Problem

Nine athletes were tested under the same conditions. Subjects visited laboratory for measurement three times. When subjects visited laboratory, we informed them about the tests. Because three different movements of the same joint were evaluated, each test was done on different days. On the first day of the measurement, firstly, height and weight measurements were made. After the height and weight measurements, hip flexion/extension measurements were made. On the second day, hip abduction/adduction movements were performed. On the last day, hip internal/external rotation measurements were performed. A warm-up protocol was applied before all isokinetic measurements. All subjects were asked to stop using caffeine and not to train within twenty-four hours before the measurement. At the same time, they were asked not to eat at least three hours before the measurements.

Warm-Up Procedure

A standard general warm-up and a special warm-up for the hip joints and muscles were applied to the subjects before the measurements. At general warm-up, a 10-minute jogging was performed with 20-30% of the maximal oxygen capacity. After the general warm-up, a short stretch covering all joints was performed and the general warm-up was completed. Then, 15 minutes of special dynamic warm-up was performed in order to enable the subjects to work with maximum during the test and to minimize the risk of injury. The special warm-up focuses heavily on lower limbs, intensely the hip joints and muscles.

Instruments

1. Hip strength was assessed by an isokinetic dynamometer (IsoMed 2000, D&R Ferstl, Hemnau, Germany).

2. Height was assessed by using a wall-mounted stadiometer (Seca Stadiometer 282, Seca GmBH & Co Kg, Hamburg, Germany).

3. Weight was assesed by using Tanita TBF-300 (Tanita, Middlesex, UK).

Procedure

All tests were performed at Ataturk University Sport Sciences Application and Research Center. Height measurements were done bare feet on a flat platform in an anatomical position. In body weight measurements, the subjects only wore running shorts. Isokinetic strength evaluation was performed with IsoMed 2000 isokinetic dynamometer. Before starting the tests, the isokinetic dynamometer was calibrated according to company procedures. After the calibration, the isokinetic dynamometer was introduced to the subjects and verbal information was given about the tests to be performed. All subjects completed warm-up procedure expressed above. After the warm-up was completed, the subjects were sequentially placed on the isokinetic machine. All isokinetic evaluations were taken in the supine position. After the subjects were taken to the isokinetic machine and the appropriate position was created for the tests, they were fixed with belts and apparatus from the shoulder and waist region. In addition, subjects were fully prepared for measurement by being fixed on the other leg. After the fixation was completed, the athletes were asked if there was a problem. Afterwards, the dynamometer lever was fixed at the part of the femur close to the knee joint. Gravity calibration was performed for each leg before measurements were started. Prior to the measurement, the subjects completed the isokinetic warm-up by performing 5 repetitions with 50% of the maximal. The purpose of this warm-up was to allow the subjects to feel the test and to provide movement-specific warm-up. Ninety seconds of rest was given after isokinetic warming. After resting, the isokinetic strength test was started. The dominant side was evaluated first, and the non-dominant side after 3 minutes. A rest period of 3 minutes was given between both legs. During the measurements, the researcher encouraged the subjects verbally and the screen of the isokinetic machine was positioned so that the subject could see it. Isokinetic strength performance of hip joints was evaluated at 60°/sec angular speed with maximum contraction ten repetitions. Isokinetic tests were conducted to flexion/extension, abduction/adduction and internal/external rotation movements of hip at concentric/concentric mode.

Statistical Analyses

The Statistical Package for the Social Sciences version 25.0 (IBM Corp, Chicago, IL, USA) was used to analyze the obtained data. Shapiro Wilk tests were used for normality and the skewness and kurtosis values of the data ranged from -2 to +2 (George, 2011). As a result of normality tests, it was determined that the data showed normal distribution ($p>0.05$). Descriptive statistics include mean (M) and SDs. Dominant and non-dominant side differences were analyzed by Independent t-test. The significance level was accepted as $p<0.05$ in all analyzes of the data.

Results

Table 2 shows the peak torque values of the hip joint movements of the subjects. As a result of the statistical evaluations, it was determined that there was no significant difference between the dominant and non-dominant extremities in three movements.

Table 3 shows the relative peak torque values of the hip joint movements of the subjects. As a result of the statistical evaluations, it was determined that there was no significant difference between the dominant and non-dominant extremities in three movements.

Table 4 shows the ipsilateral ratio of the hip joint movements. As a result of the statistical evaluations, there was no significant difference between the dominant and non-dominant extremities in three movements.

Table 5 shows the bilateral ratio of the hip joint movements. When the hip flexors were evaluated bilaterally, it was determined that the non-dominant side produced higher torque than the dominant side. However, in all other movements, the dominant side had higher torque values than the non-dominant side. But there was no significant difference between dominant and non-dominant side, bilaterally.

Table 1
Descriptive characteristics of the participants (n=9).

Variables	Mean ± SD
Age (year)	19.88 ± 0.60
Weight (kg)	57.88 ± 3.72
Height (cm)	177.00 ± 3.20
Fat (%)	6.85 ± 1.90

Table 2
Hip joint isokinetic peak torque values.

	Phase	Side	Min.	Max.	Mean	SD	t	p
Peak Torque (nm)	Flexion	Dominant	293.40	524.80	405.87	73.72	-.166	0.87
		Non-dominant	345.90	482.40	411.06	57.82		
	Extension	Dominant	288.90	446.10	363.92	52.80	-.072	0.94
		Non-dominant	267.10	450.60	366.01	69.40		
	Abduction	Dominant	72.10	114.90	89.85	15.16	.110	0.91
		Non-dominant	63.70	127.50	88.94	19.76		
	Adduction	Dominant	94.60	146.40	113.86	18.91	.303	0.76
		Non-dominant	83.40	154.30	110.74	24.46		
	Internal Rotation	Dominant	18.90	32.80	26.82	5.16	1.222	0.23
		Non-dominant	18.10	32.80	24.01	4.58		
	External Rotation	Dominant	26.80	46.60	34.33	6.32	.343	0.73
		Non-dominant	24.90	40.30	33.32	6.18		

Table 3
Hip joint isokinetic relative peak torque values.

	Phase	Side	Min.	Max.	Mean	SD	t	p
Relative Peak Torque (nm/kg)	*Flexion*	Dominant	5.15	9.21	7.02	1.32	-.164	0.87
		Non-dominant	5.77	8.46	7.12	1.06		
	Extension	Dominant	4.44	7.83	6.32	1.07	-.062	0.95
		Non-dominant	4.11	7.91	6.35	1.29		
	Abduction	Dominant	1.12	2.02	1.56	0.29	.113	0.91
		Non-dominant	1.06	2.24	1.54	0.36		
	Adduction	Dominant	1.51	2.57	1.97	0.37	.284	0.78
		Non-dominant	1.39	2.71	1.92	0.45		
	Internal Rotation	Dominant	0.32	0.58	0.46	0.08	1.249	0.22
		Non-dominant	0.30	0.58	0.41	0.07		
	External Rotation	Dominant	0.45	0.82	0.59	0.11	.422	0.67
		Non-dominant	0.42	0.70	0.57	0.09		

Table 4
Hip joint isokinetic strength ipsilateral ratio of the participants.

	Movement	Side	Min.	Max.	Mean	SD	t	p
Ipsilateral Ratio (%)	Flex-Ex	Dominant	61.10	98.50	87.80	11.32	.241	0.81
		Non-dominant	55.60	94.80	86.47	12.07		
	Abd-Add	Dominant	72.98	84.14	78.96	4.32	.241	0.53
		Non-dominant	73.69	87.80	80.33	4.75		
	Ir-Er	Dominant	62.62	96.98	78.64	11.28	1.187	0.25
		Non-dominant	59.06	87.99	72.69	9.96		

Flex-Ex: Flexion-Extension; Abd-Add: Abduction-Adduction; Ir-Er: Internal Rotation-External Rotation.

Table 5
Hip joint isokinetic strength bilateral ratios.

	Movement	Min.	Max.	Mean	SD	t	p
Bilateral Ratio (%)	Flexion	0.89	15.83	8.84	5.93	-.108	0.91
	Extension	0.65	21.39	9.18	7.36		
	Abduction	0.18	24.96	12.73	8.48	1.604	0.12
	Adduction	0.41	13.43	7.53	4.75		
	Internal Rotation	0.00	34.87	13.71	13.23	.132	0.89
	External Rotation	1.00	31.64	12.98	10.03		

Discussion

The purpose of this study was to evaluate isokinetic hip joint strength profiles of elite middle-distance runners by a pilot study. Peak torque (PT) values of hip flexor and extensor muscles were 405.87±73.72 nm, 363.92±52.80 nm for dominant limb and 411.06±57.82 nm, 363.92±69.40 nm for non-dominant limb, PT values for hip abductor and adductor muscles were 89.85±15.16 nm, 113.86±18.91 nm for dominant limb and 88.94±19.76 nm, 110.74±24.46 nm for non-dominant limb, finally PT values of hip internal and external rotator muscles were 26.82±5.16 nm, 34.33±6.32 nm for dominant limb and 24.01±4.58 nm, 33.32±6.18 nm for non-dominant limb, respectively. PT values have no significant difference, bilaterally. But, in conclusion, it was seen that the flexor and extensor muscles had more peak torque than the other muscle groups (abductor/adductor and internal/external rotator). At the same time, it was determined that abductor muscles had lower values than adductor muscles and internal rotation muscles have lower values than external rotation muscles. Running biomechanics can be shown as the main reason for this. In running, the peak extension angle occurs at the end of the toe thrust; the flexion angle occurs in the first-mid swing phase and begins to decrease in the final swing phase. As a result, flexors worked more than extensors. On the other hand, Abductor and internal rotator muscles worked usually stance phase of running on the contrary to adductors and external rotators. Adductor and external rotator muscles worked generally at swing phase of running. These reasons may explain the differences in peak torque between these muscles. Isokinetic strength evaluation is often used to determine muscle imbalance (Payton & Burden, 2017). In the results of the study were examined, it was determined that there was no statistically significant difference between the dominant and non-dominant sides. However, while the values of the dominant side were higher in all joint movements, the values of the non-dominant side were higher in hip flexion movements. Bilateral difference of hip flexor/extensor and adductor muscles were in normal values. However hip abductor and internal/external rotator muscles values were in a risky range. Reason for all bilateral differences in hip flexors can be explained with running direction because athletes run counterclockwise. This may be the reason for the higher peak torque values of the non-dominant limb flexors. In running, hip flexors and extensors play an important role in the forward swing of the body. In addition, the adductor magnus, brevis and longus muscles contribute to the extension when the hip is extended (Sugisaki et al., 2011). This may be the reason why flexor and extensor muscles of runners have higher RPT and PT values compared to other muscle groups. At the same time, this rationale may explain that the adductor muscles were higher than the abductor muscles in our study.

When the literature was examined, it was seen that there was study examining the isokinetic strength profiles of runners at different joint movements and joints. However, there were limited evaluations related to the hip joint isokinetic profiles, while there were studies examining in different sports. In a study on sprinters, Dowson et al. (1998) found that flexor muscles had higher relative peak torque values compared to extensor muscles. The results of the same study stated that the hip flexor and extensor muscles have a strength ratio of 60-70% ipsilaterally. In another study investigating the relationship between sprint time and isokinetic lower extremity strength, it was reported that hip flexors had a higher peak torque average than their extensors (Misjuk et al., 2013). Rannama et al. (2013) reported that hip extensor muscles have higher relative torque values than flexor muscles in middle-distance runners, similar to the results of our study. The reason why the extensor muscles of middle-distance runners reach higher peak torque and relative peak torque values compared to the flexors can be shown with different running techniques, different physiological responses, and the fact that both aerobic and anaerobic mechanisms work very strongly. In these studies, it was reported that there was no significant difference between the strengths of the hip joint muscles bilaterally. Belhaj et al. (2016) stated that there was no significant difference isokinetic strength between adductor and abductor muscles in soccer players, bilaterally. They also determined that there was no significant difference isokinetic strength of internal/external rotator muscles between dominant and non-dominant limb in seated position. Fourchet et al. (2015) stated that high-intensity running can lead to differences in lower extremity biomechanics. These changes in running biomechanics can cause asymmetrical disorders and overuse in lower extremity muscles and joints. Zifchock et al. (2006) in their study on injured and non-injured runners stated that the evaluation of bilateral differences is an important criterion. In the same study, they stated that overuse and exposure to higher loads in the frontal plane during the run may cause injuries. Muscle weakness, impaired muscular coordination, muscle strength imbalances may be the main cause of exposure to overload and asymmetrical disorders. In a study conducted on elite karate athletes by Kotrljanovic et al. (2016), it was stated that there was no significant difference between hip internal and external rotator muscles, both ipsilaterally and bilaterally. Brown et al. (2014) conducted a study on rugby players, it was stated that hip extensors had higher peak torque values than flexors and there was no difference bilaterally. Another study conducted by Sugimoto et al. (2014) found similar results with present study. The agonist and antagonist ratio, called ipsilateral evaluation, in all joint movements was assessed by peak torque (Castro et al., 2020). When the isokinetic strength values between the flexors and extensors of the hip joint were compared bilaterally, there was similar values (Borges et al., 2015; Harrison et al., 2013). Another study that examined internal/external rotation of hip joint stated that there was no difference between dominant and non-dominant limb. Finally, Examined that bilateral comparison of abductor and adductor muscles of hip joint, there was no significant difference (de Marche Baldon et al., 2011; Sugimoto et al., 2014). Silva et al. (2018) examined hip muscle strength balance associated with running economy for endurance runners, and they found that men had 2.92 nm/kg for extensors and 1.52 nm/kg for flexor. This study results were different from our study. This difference can be due to subject group and running-distance. Contreras-Díaz et al. (2023) reported that flexor-extensor and abductor-adductor muscles agonist-antagonist ratios have no significant difference except for left hip abductor/adductor. Lee et al. (2009) stated that the relative torques of hip flexors did not differ bilaterally, similar to the results of our study. This may be because of concentrically work of hip flexors to initiate the swing phase. Noehren et al. (2014) compared to hip Ir/Er and Abd/Add isokinetic strength of healthy men and with iliotibial band syndrome men and their relative torque values were higher present study.

The limitation of this study is that female athletes were not included in the study. The results of this research include male middle distance runners. In addition, the small number of subjects is another limitation of this study.

Conclusion

In summary, the present study demonstrated hip flexor/extensor, abductor/adductor and internal/external rotator muscles' profiles. Hip extensor muscles than flexors were stronger in middle-distance runners. On comparing bilaterally hip flexors, it was also appeared that non-dominant limb have more strength than dominant limb. While hip flexors/extensors and abductors were bilaterally at normal ratio, hip abductors and internal/external rotators were in a risky range. Future studies can be planned with middle distance runners of different age groups. At the same time, studies with different angular velocities and larger sample groups can be designed.

Authors' Contribution

Study Design: HHY; Data Collection: HHY; Statistical Analysis: HHY; Manuscript Preparation: HHY; Funds Collection: HHY.

Ethical Approval

The study was approved by the Atatürk University of Sport Sciences Sub-Ethical Committee (2023/52) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki.

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The authors declare that the study received no funding.

Conflict of Interest

The authors hereby declare that there was no conflict of interest in conducting this research.

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