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Comparison of the Isokinetic Strength of Knee Muscles Between Normally Sighted and Visually Impaired Girls

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ABSTRACT

Aims The proportion of strength in knee flexor and extensor muscles is an important factor in balance and fall prevention. This study aimed to compare the isokinetic strength of knee muscles in healthy sighted girls and those with visual impairment.

Instrument & Methods This descriptive study was carried out on sighted and visually impaired female students in June 2023 in Tehran, Iran. The samples were selected by convenience sampling (n=52; 22 visually impaired and blind, 30 sighted). Maximum torque (normalized to body weight), average power, and the ratio of agonist to antagonist muscles in knee flexion and extension at three angular velocities (60, 120, 180 degrees per second) were evaluated and compared between the two groups using an isokinetic dynamometer. Data was analysed by an independent t-test.

Findings The maximum isokinetic torque of knee extensor muscles in sighted individuals at angular velocities of 60, 120, and 180 degrees per second in both the dominant and non-dominant legs was significantly better than their visually impaired counterparts. However, visually impaired individuals had significantly greater maximum torque in knee flexion at a speed of 60 degrees per second in both legs ($p<0.05$). No significant differences were observed at other speeds. Additionally, a significant difference was found in the mean power in the dominant and non-dominant legs at three angular velocities (60, 120, and 180 degrees per second) in favor of sighted individuals.

Conclusion Visually impaired individuals had significantly higher values for maximum torque and power compared to individuals with visual impairments. Therefore, intervention programs to address this deficiency should commence early in the growth period of visually impaired individuals.

Keywords Muscle Strength; Visual Impairment; Hamstring Muscles; Quadriceps Muscle

CITATION LINKS

[1] Expert's choice: 2018's most exciting research in the field of ... [2] Compensatory analysis and strategies for balance in individuals ... [3] Kinetic movement analysis in adults with ... [4] The relationship between aerobic capacity and physical activity in ... [5] The effect of visual impairment on the strength of children's ... [6] The importance of muscular strength in ... [7] The relationships between knee extensors/flexors strength and balance control ... [8] Youth resistance training: past practices, new perspectives ... [9] Reliability of isokinetic knee strength measurements in children: A systematic ... [10] Effect of ankle range of motion (ROM) and lower-extremity muscle strength on static balance control ability in young ... [11] Therapeutic exercise for knee osteoarthritis: considering factors ... [12] Morphological and isokinetic strength differences: bilateral and ipsilateral variation by ... [13] Bilateral difference in hamstrings to quadriceps ratio in ... [14] Is hamstrings-to-quadriceps torque ratio useful for predicting anterior cruciate ligament and hamstring injuries? ... [15] The influence of quadriceps and hamstring ... [16] Comparative assessment of knee extensor and flexor muscle strength measured using a ... [17] A comparison of isokinetic muscle strength and power in visually ... [18] Reliability of isokinetic strength assessments of knee and hip using the Biodex System 4 dynamometer and associations with functional ... [19] Static balance control and lower limb strength ... [20] The Pilates method improves the relationship agonist-antagonist flexor and extensor knee in ... [21] Isokinetic strength test of muscle strength and motor function in ... [22] The influence of isokinetic peak torque and muscular power on the functional performance of active and inactive community-dwelling ... [23] Aging, muscle activity, and balance control: physiologic changes ... [24] Environmental components of mobility disability in ... [25] Determination of the isokinetic muscle strength profile of knee flexors and extensors in visually ... [26] Associations among knee muscle strength, structural damage, and pain and mobility in individuals with osteoarthritis ... [27] Muscle Strength and Flexibility without and with Visual ... [28] The effect of loss of visual input on muscle power in resistance trained and untrained young ... [29] Hamstring-to-quadriceps torque ratios of professional male soccer ... [30] Assessment of muscle strength in para-athletes: A systematic ... [31] The importance of lower-extremity muscle strength for lower-limb functional capacity in ...

Introduction

Muscle strength is an important factor in daily activities such as walking and jumping. Individuals with lower muscle strength have lower power and ability in performances and training, competitions, or sports activities [1]. Muscle strength, weakness, and shortening of muscles affect body alignment, and muscle imbalance disrupts body alignment, subsequently creating the potential for abnormal pressure on body tissues and joints. Developing strength to overcome the effects of gravity to maintain posture and create motor responses for movement is essential. An individual's motor system must be capable of generating sufficient force to maintain posture, control body sway, achieve balance, and prevent falling. Research has shown that individuals with visual impairments have more difficulty maintaining and controlling their body stability, and due to this issue, their strategy shifts from the ankle to the hip, using larger thigh muscles to create stability and maintain balance [2].

Previous studies have not shown a difference in isometric strength between individuals with visual impairments and those without. However, a significant difference in isokinetic muscle strength has been reported [3]. For individuals with a healthy nervous system, adaptation during movement is controlled through sensory input and output. This helps individuals respond to environmental disturbances and manage the body's acceleration or deceleration. However, for those with sensory-motor abnormalities, problems arise, and in individuals with visual impairments, motor disorders increase and endurance decreases. Individuals with visual impairments exhibit higher energy consumption during their activities, which is associated with inefficient movement patterns [4]. Wyatt *et al.* [5] stated that visually impaired children have weaker hip muscles and weaker static strength in the knee extensors compared to their healthy peers.

The term "muscle strength" describes the measurement of an individual's ability to exert maximum muscular force in both static and dynamic forms. Another definition of strength is the ability to apply force to an external object and resistance. Many studies have identified bilateral strength imbalance between the two sides of the body as a cause of injury [6], and different levels of muscle strength can significantly affect balance control [7]. Adolescents with lower muscle strength have less confidence in their ability to perform motor skills and face limitations in participatory activities, games, and sports [1]. Therefore, caregivers should consider muscle strength as a prerequisite for overall health [8].

In many functional activities, the knee extensor and flexor muscles play a crucial role in stabilizing the knee joint [9]. The strength of the leg muscles, range of motion, joint stability, and proprioception of these muscles are associated with stability. To maintain proper posture, a certain level of muscle strength is required, and the muscles of the lower limb (ankle and knee) must be properly active to maintain stability and prevent falls [10]. Among these, strengthening the quadriceps and hamstrings is essential in maintaining and increasing the strength, stability, and mobility of the knee joint, enabling better flexion and extension movements of this joint [11]. Therefore, strength and power are valuable components for various assessments such as mobility and orientation.

Research shows that individuals with visual impairments perform approximately 30% weaker in terms of power and strength, which is exacerbated by inactivity. Inactivity leads to muscle strength loss and energy wastage. Various components of physical fitness, including cardiovascular endurance, muscle strength, endurance, flexibility, body composition, a high muscle-to-fat ratio, body cell mass, and increased mobility, are influential factors for muscles. A sedentary lifestyle affects the growth and physical performance of individuals. Additionally, the consistent use of a dominant limb and the habitual preference for one limb during activities, as well as a tendency to favor one side during rotation or longitudinal axis rotation, creates asymmetry in the body. This includes lateral differences between limbs, the pelvis, trunk, and upper and lower body parts [12].

Another important issue regarding knee muscles is the ratio of agonist to antagonist muscles. The performance of these muscles is crucial when they act in opposition to each other; during knee movement, the quadriceps and hamstrings contract to maintain knee joint stability [13]. Some studies report this ratio to be between 50% and 60% at 60 degrees per second, and approximately 70% to 80% at an angular velocity of 180 degrees per second. However, in some studies, this ratio is about 10% to 15% higher or lower. For example, Serkan *et al.* [14] and Yılmaz & Erdemir [15] report the hamstring-to-quadriceps ratio to be around 0.79 at 60 degrees per second.

Given the limited studies comparing the dynamic and isokinetic strength of muscles around the knee joint as an important indicator in maintaining balance and mobility between sighted girls and those with visual impairments, this study aimed to compare the isokinetic strength of the knee muscles in sighted girls and girls with visual impairments.

Instrument and Methods

Study design

This descriptive cross sectional study was conducted in Tehran at 2023.

Study population and sample

The statistical population consisted of non-athlete female students. Out of the population, 52 individuals were selected (22 visually impaired and blind, 30 sighted). This study was conducted in June 2023 in the laboratory of the Faculty of Sport Sciences and Health at Shahid Beheshti University. Sampling was performed using the convenience sampling method. The sample size was calculated using G*Power G*power 3.1, considering an effect size of 0.80, α=0.05, test power of 0.80, and an allocation ratio of 1.33. Based on this, the required number of participants was calculated to be 24 for the healthy group and 18 for the visually impaired group (n=42). To account for a potential 20% dropout rate, 52 participants were included in the study.

The inclusion criteria were being in the age range between 14-16 years, no have neuromuscular diseases, cardiovascular diseases, knee joint diseases, or surgeries or injuries to the lower leg [16], and ability of visually impaired individuals to perform their daily activities independently and having full mobility [17]. The exclusion criteria were taking medications that could affect muscle strength or neuromuscular function, no comply with the study protocols, including attendance and effort during isokinetic testing sessions. Participants who do not provide informed consent or whose guardians do not provide consent if the participants are minors excluded.

Study instruments

The strength test in this study was conducted using a Biodex isokinetic dynamometer (Biodex Pro 4 model; USA) [18]. The procedure was explained to the participants, and before starting the test, they performed stretching exercises for the knee flexor and extensor muscles to warm up. This was followed by 5 maximal repetitions, a 1-minute rest, and then the main test was conducted. The participants were guided to the machine's seat (with the seat set at a 110-degree angle and the knee at 90 degrees of flexion, the dynamometer's mechanical axis aligned with the knee's lateral epicondyle). The trunk, pelvis, and thigh were stabilized with belts to prevent compensatory movements, and the range of motion was set at the distal end of the dynamometer arm, near the proximal part of the internal ankle (2 cm), and the device was calibrated. The participants made five attempts at angular velocities of 60, 120, and 180 degrees per second [19], exerting maximum effort in knee flexion and extension (starting with the dominant leg and then the non-dominant leg). A 1-minute rest was given between angles and a 2-minute rest between tests for each leg. During the tests, the participants' hands were placed on their chests. According to previous studies, the agonist-to-antagonist muscle ratio at 60 degrees per second is between 50% and 60%, and at 180 degrees per second, it is around 70% to 80% [20]. The results were recorded as peak torque (relative to weight) in the knee flexor and extensor muscles, the average power, and the agonist-to-antagonist muscle ratio at the specified angles. During the attempts, the examiner provided verbal encouragement to improve performance.

Statistical analysis

Data was analysed using an independent t-test through SPSS 27 software.

Findings

There was no significant difference in the indices of height, body mass, and age (Table 1).

Table 1. Comparison of demographic information between the two groups

Parameter	Sighted	Visually impaired	t	p
Age	15.1±0.5	15.5±1.2	-1.47	0.15
Height	1.6±4.0	1.85±0.02	1.92	0.16
Weigth	51.4±8.6	49.7±5.5	2.11	0.40
Body mass	21.25±3.20	21.93±1.91	1.83	0.974

To assess the normality of the data, the Shapiro-Wilk test was used, and for homogeneity, Levene's test was employed. All variables were found to be normally distributed (p>0.05). The results indicated that in the non-dominant leg, at three angular velocities of 60, 120, and 180 degrees per second, the extension performance of the sighted group was better, showing a significant difference between the two groups. However, no significant difference was observed in flexion between the two groups. In evaluating the mean power in the dominant leg at three angular velocities (60, 120, and 180 degrees per second), a significant difference was found, with the sighted group performing better in both extension and flexion (Table 2).

Table 2. Isokinetic strength of dominant knee flexor and extensor muscles

Parameter	Angular velocity	Contraction type	Sighted	Visually impaired	t	p-value	Effect size
Peak torque (Newton-meter)/weight (kilogram)	60 degrees/second	Extension	189.40±39.63	144.5±32.04	4.343	0.001>	1.228
		Flexion	107.9±37.4	136.8±31.85	-2.911	0.005	-0.823
	120 degrees/second	Extension	151.90±27.61	121.8±34.80	3.439	0.001	0.972
		Flexion	165.30±47.17	173.0±46.77	-0.578	0.566	-0.163
	180 degrees/second	Extension	132.0±29.6	112.6±31.25	2.266	0.028	0.641
		Flexion	175.50±47.75	171.9±41.83	0.437	0.664	0.123
Mean power (watts)	60 degrees/second	Extension	64.0±13.6	39.0±13.29	6.543	0.001>	1.850
		Flexion	14.90±8.50	10.7±3.60	2.428	0.020	0.623
	120 degrees/second	Extension	95.20±26.56	68.7±24.74	3.630	0.001>	1.026
		Flexion	46.70±26.96	26.2±12.02	3.648	0.001>	0.939
	180 degrees/second	Extension	112.1±42.8	80.8±35.23	2.790	0.007	0.789
		Flexion	50.30±29.11	23.5±13.46	4.378	0.001>	1.130
Flexor/Extensor	60 degrees/second		0.580±0.190	0.99±0.299	5.963	0.001>	-1.686
	120 degrees/second		1.060±0.333	1.39±0.405	-2.674	0.01	-0.756
	180 degrees/second		1.250±0.277	1.54±0.366	-3.196	0.002	-0.904

Table 3. Isokinetic strength of non-dominant knee flexor and extensor

Parameter	Angular velocity	Contraction type	Sighted	Visually impaired	t	p-value	Effect size
Peak torque (Newton-meter)/weight (kilogram)	60 degrees/second	EXtension	184.0±36.08	138.1±41.17	4.231	0.001>	1.196
		Flexion	114.90±37.43	130.4±33.62	-1.524	0.134	-0.431
	120 degrees/second	Extension	154.10±26.12	126.8±24.63	3.8	0.001>	1.074
		Flexion	163.0±38.1	167.5±41.30	-0.400	0.691	-0.113
	180 degrees/second	Extension	131.40±26.01	110.9±32.38	2.503	0.016	0.708
		Flexion	171.90±33.53	172.2±37.63	-0.028	0.978	0.008
Mean power (watts)	60 degrees/second	Extension	62.50±12.78	39.6±16.60	5.573	0.001>	1.576
		Flexion	15.0±7.2	14.6±7.94	0.195	0.846	0.055
	120 degrees/second	Extension	94.60±35.85	70.2±20.89	2.840	0.007	0.803
		Flexion	38.3±20.93	31.4±18.62	1.213	0.231	0.343
	180 degrees/second	Extension	111.40±34.16	81.4±25.19	3.462	0.001>	0.979
		Flexion	49.80±25.77	31.8±16.92	2.846	0.006	0.805
Flexor/Extensor	60 degrees/second		0.630±0.181	1.01±0.378	4.41	0.001>	-1362
	120 degrees/second		1.040±0.219	1.33±0.265	-4.303	0.001>	-1.217
	180 degrees/second		1.290±0.297	1.53±0.365	-2.605	0.012	-0.737

Significant differences were observed in the non-dominant leg in extension at 60, 120, and 180 degrees per second and the sighted group performed better. However, a significant difference was only observed in flexion at 180 degrees per second (Table 3). In evaluating the flexor-to-extensor muscle ratio in both legs, the sighted group showed a better ratio and significant differences were observed at all angles. Significant differences in the flexor-to-extensor muscle ratio were observed in both the dominant and non-dominant legs between the two groups. In the intra-group comparison of the dominant and non-dominant legs in extension at 180 degrees per second, significant differences were observed in peak torque relative to weight in both groups. In the mean power evaluation at three angular velocities, no significant differences were found in the sighted individuals. Significant differences were observed in the visually impaired and blind group flexion at angular velocities of 180 and 60 degrees per second. There were no significant differences in the flexor-to-extensor muscle ratio in both groups.

Discussion

This study aimed to compare the isokinetic strength of the knee muscles between sighted healthy girls and girls with visual impairments. The results showed that the maximum isokinetic torque of the knee extensor muscles in sighted individuals at angular velocities of 60, 120, and 180 degrees per second in both the dominant and non-dominant legs was significantly better than that of their visually impaired counterparts. However, the knee flexor muscles of visually impaired individuals exhibited significantly higher maximum torque in flexion at 60 degrees per second in the dominant leg. No significant differences were observed at other velocities. Additionally, significant differences in mean power at angular velocities of 60, 120, and 180 degrees per second were observed in favor of the sighted individuals for both the dominant and non-dominant legs.

Diseases such as osteoarthritis (OA) and knee joint degeneration, pelvic tilt, and asymmetry in leg muscle strength can contribute to suboptimal strategies for postural control and body alignment. Normal control and balance require the fine cooperation of afferent inputs and efferent responses of the motor system. The absence of any input factors, such as proprioception, vision, or vestibular input, reduces afferent input and affects balance in efferent output [1]. The relationship between the flexor and extensor muscles of the knee joint is one of the key indicators in assessing the risk of knee injuries, particularly due to imbalance between the hamstring and quadriceps muscles [21]. Research indicates that individuals with muscle weakness or dystrophy experience a higher risk of falling and imbalance compared to healthy individuals [22]. Additionally, weakness in the thigh and knee area leads to reduced balance, which is crucial for maintaining a steady stance against disturbances and preventing sway. Individuals with visual impairments or frontal lobe injuries, cataracts, etc., have a higher risk of falling [22]. Another study showed that increasing the strength of the muscle pairs around the knee and ankle joints, through kinematic adjustments, reduces sway and the risk of falling, thereby improving balance in blind individuals [20]. Furthermore, the relationship between the flexor and extensor muscles of the knee joint is a key indicator in assessing the risk of knee injuries, particularly when there is an imbalance between the hamstrings and quadriceps muscles [23]. Proper physical training can enhance muscular control in the knee flexors and prevent hyperextension of the knee [24]. Among these considerations, visually impaired and blind individuals have less muscle strength around their knee joints compared to sighted and healthy individuals, making them more susceptible to various lower limb injuries [20].

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There has been no study comparing peak torque relative to weight, power, and the ratio of flexor to extensor muscles between non-athletic blind and visually impaired girls and sighted girls. The present study aims to examine these parameters. In this study, the sighted individuals showed higher means in almost all angles in both knee extension and flexion, which highlights how the lack of visual sense leads to reduced muscle strength in visually impaired individuals due to decreased muscle activity, fear of falling, and lack of adequate balance. Furthermore, the ratio of hamstring to quadriceps muscles in healthy individuals was better compared to visually impaired individuals.

Laughton [23] indicates that a reduction in lower limb muscle strength affects the increase in body sway. Similarly, Shumway-cook [24] demonstrate that decreased lower limb muscle strength negatively impacts balance control, and improving balance reduces the risk of falls and helps maintain stability and balance in a standing posture. Giagazoglou *et al.* [19] examine static balance and lower limb strength in visually impaired individuals. They find that the strength in the knee flexor and extensor muscles, as well as balance in all directions (posterior, anterior, and lateral) is significantly lower compared to sighted individuals.

Horvat *et al*. compare the strength and power of the knee flexor and extensor muscles in blind and visually impaired individuals. The results show that visually impaired and blind individuals perform significantly worse in the mentioned variables [17].

Kocahan [25] determines the knee extensor and flexor muscle strength in endurance athletes with visual impairments. The results show that the ratio of maximum torque of the knee flexor to extensor muscles in the non-dominant leg is higher than in the dominant leg (at angular velocities of 60 and 180 degrees per second). However, there is no significant difference between both legs, and this difference is less than 10% [25]. Luk Harkey *et al.* [26] demonstrates that greater muscle strength in the quadriceps and hamstrings improves performance in daily activities and reduces difficulty and pain in individuals with OA. In a study by Karakoc *et al.* [27] the results show a significant difference in leg muscle strength and grip strength between the sighted and visually impaired groups.

In their study, Killebrew *et al.* [28] found a significant difference in comparing the strength of women and men who did not exercise, as well as between sighted and visually impaired individuals who did not exercise. Additionally, men had higher strength compared to women.

In a review article, Baroni *et al.* [29] obtained the ratio of flexor to extensor muscles at angles of 12 to 60 degrees per second ranging from 50 to 71%. However, this ratio is approximately 83% in a study conducted in Brazil at angular velocities of 21 to 30 degrees per second. They report ratios ranging from 51 to 80% at angular velocities of 90 to 180 degrees per second [29]. In a review study by O'Connor *et al.* [30], the evaluation of athletes' strength in the upper and lower limbs is examined in various articles. For example, wheelchair athletes have greater shoulder muscle strength compared to healthy individuals. In another review study by Ramari *et al.*, the strength of the lower limbs and its impact on performance and capacity in individuals with multiple sclerosis (MS) are investigated. These patients have weaker conditions compared to healthy individuals [31].

Strength and limitations

Due to time constraints in conducting the tests, it was not possible to randomly perform the tests at different angles for the participants. Therefore, the tests were conducted in the same order for all participants. This may lead to learning and fatigue effects and could impact the results.

Based on the results, trainers working with individuals with vision impairments should consider the importance of muscle strength and the balance between antagonist and agonist muscle strength.

Conclusion

Visually impaired individuals exhibit significantly higher values for maximum torque and power than those with visual impairments.

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Ethical Permissions: The protocol of this study was registered at the ethical committee of Shahid Beheshti University, with an ethic code of IR.SBU.Rec1402.043.

Conflicts of Interests: The authors reported no conflicts of interest.

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