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Correlation between Isokinetic Parameters of Knee Joint and Lower Extremity Function

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무릎관절의 등속성 변수와 하지 기능의 상관관계

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Abstract The flexors and extensors of the knee joint are essential for maintaining body stability. The purpose of this study was to investigate the correlation between the isokinetic parameters of the knee flexor and extensor muscles and the function of the lower extremity muscles. Twenty-two healthy adults participated in this study. The time to peak torque (TTP), acceleration time (AT), and peak torque (PT) of the knee flexor and extensor muscles were measured. A 20m sprint, Sargent jump, one leg hop test, and side shuffle were measured to evaluate lower extremity function. The correlation between each variable was analyzed using Pearson correlation coefficient. PT of the knee flexor showed a significant correlation with single leg hops and 6M hops in a single leg. PT of knee extensors was found to be significantly correlated with Sargent jumps and triple hops. Based on the results of this study, we suggest that the strength of the knee flexor and extensor muscles has the potential to be used to predict lower extremity function.

Key Words : Knee flexor, Knee extensor, Lower extremity function, Isokinetic dynamometer

요 약 무릎관절의 굽힘근과 폄근은 신체의 안정성을 유지하는 데 필수적이다. 본 연구는 무릎 굽힘근 및 폄근의 등속성 파라미터와 하지 근육 기능의 상관관계를 조사하고자 하였다. 22명의 건강한 성인이 본 연구에 참여하였습니다. 무릎 굽힘근 및 폄근의 time to peak torque (TTP), acceleration time (AT), peak torque (PT)가 측정되었습니다. 하지 기능 평가를 위해 20m sprint, Sargent jump, one leg hop test, and side shuffle이 측정되었습니다. 각 변수들 간의 상관관계가 Pearson correlation coefficient을 사용하여 분석되었습니다. knee flexor의 PT는 single leg hops and 6M hops in a single leg와 유의한 상관관계를 나타내었다. knee extensors의 PT는 Sargent jumps and triple hops와 유의한 상관관계가 갖는 것으로 발견되었다. 본 연구 결과를 기반으로 무릎 굽힘근 및 폄근의 근력이 하지 기능을 예측하는 데 사용될 수 있는 가능성이 있음을 시사한다.

주제어 : 발목관절, 발등굽힘근, 발바닥굽힘근, 하지 기능, 등속성 동력계

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1. Introduction

The main role of the knee joint complex is to allow exercise to transmit, absorb, and redistribute the force generated during exercise, as well as stability to adapt to various terrains and minimum energy requirements of the muscles [1]. The flexors and extensors of the knee joint affect the increase of lower body muscle mass and strength. And the proportional development of these two muscle groups is essential for maintaining joint stability [2]. One of the exercise methods affecting joint stability is the eccentric and concentric contractions of isotonic contractions in the muscle contraction type. Their training program has a unique effect on skeletal muscles. For example, eccentric training decreases, and concentric training increases the sensitivity of skeletal muscles to delayed pain caused by muscle loss and torque-joint angle relationship changes [3]. Knee load can be studied in several ways [4].

Among the methods of measuring the flexors and extensions of the knee joint, the isokinetic test is a particularly important tool for evaluating dynamic muscle performance [5]. The evaluation of force production is an important helpful factor, and isokinetic testing determines when in the clinic it should be allowed to return to full physical activity [6]. Among them, the maximum torque parameter is an important parameter in the constant property test [7]. Parameters such as acceleration time and time to maximum torque are established in the literature as muscle recruitment parameters that provide valuable information about the neuromuscular readiness to generate maximum contraction [8], and the ability to quickly produce torque. Is an important skill in most exercises, and can better demonstrate functional performance than evaluating only the maximum torque [6]. In addition, the time to reach the maximum torque is a good indicator of the muscle's ability to rapidly generate torque to the point of the highest torque development during isokinetic contraction [9].

The use of functional testing tests of the lower extremities is recommended as a component to assess the patient's ability to return to full physical activity [10]. By establishing confidence in the lower extremity performance test, individuals can better determine when they can safely return to an unrestricted routine [11], which includes trunk, knee, ankle and foot strength, mobility, balance, and neuromuscular control. It includes several components of the same [12]. Tests such as sprint, sergeant jump, and hop test are commonly used to evaluate the lower extremity function [13].

Short-distance driving requires the ability to generate force at high speed, high relaxation rate, and good elasticity of muscles [14]. Exercise performance, such as jumping and sprinting, is a test that shows maximum muscle contraction over a minimum period of time, and Sergeant Jump is a great item designed to test muscle contraction [15]. Side shuffle performs multiple movements as a method of evaluating lateral stability. In this process, biomechanics and performance are evaluated [16]. Isokinetic knee extensor and flexor strength tests and hop tests are useful tools to compare knee strength and function in both directions when returning to everyday life. [17]. It is important to know whether the maximum torque has a strong relationship with functional performance [18]. In the previous studies, there have been many studies that have analyzed the isokinetic muscle strength measurement of the knee joint and the comparison of lower

function. However, we do not evaluate only the maximum torque, but add parameters such as acceleration time and time to analyze the correlation between isokinetic measurement and lower extremity function in the knee joint.

2. Methods

2.1 Participants and design

This study recruited 22 male students from S University in A city, Chungcheongnam-do. Before participating in the study, all subjects were fully explained about the purpose and method of the study, and subjects who had visited and received medical treatment due to pain in lower extremity function, nervous system disorders, and musculoskeletal system were excluded. Prior to participating in this study, prior consent was obtained from all study subjects, and the subjects made written informed consent to participate in the study. The research was conducted according to the process approved by the Research Ethics Committee of Sunmoon University (approval number: SM-202005-026-1).

2.2 Experimental procedures

The subjects were measured isokinetic parameters and lower extremity function. The isokinetic parameters measure the time to peak torque (TTP), acceleration time (AT), and maximum muscle force (peak torque; PT) to the maximal torque of the extensor and flexor muscles using an isokinetic dynamometer. When the isokinetic parameter was measured, right eccentric and concentric were measured, followed by left eccentric and contric measurements. At this time, the speed was set to 60/s. After three measurements, 20 seconds of rest was performed, and the average of the three measurements was analyzed.

Lower limb function was measured 24 hours after isokinetic parameter measurement. After measuring the 20m running record once, after a 10-minute break, a total of three measurements were made to record the fastest record. When measuring the sargent jump, the subject jumped as high as possible and touched the wall. The record was measured from the floor to the highest mark. When measuring the side shuffle, the number of reciprocations was measured by performing a reciprocating movement of two points, point A and point B, left and right for 1 minute. When measuring a single jump distance in the one leg jump test, the subject performed one step jump relative to the starting line and measured the distance from the starting line to the heel. One leg HOP test- crossover hop the subject folded one leg and jumped forward a total of 3 times from the center line to the left and right. The distance to the third heel was measured. One leg HOP test-When measuring Triple hop for distance, I folded one leg and jumped forward 3 times from the starting line. The distance to the third heel was measured. One leg hop test-When measuring the 6 meter hour hop, I folded one leg and run to the 6M from the starting line. Transit times of up to 6 m were measured.

After measuring the lower extremity, the average value of the isokinetic parameter and the measured value of the lower extremity were correlated using spearman correlation analysis. After that, the results of the correlation analysis were plotted and graphed.

2.3 Measurement

TTP, AT, and PT of the knee joint were measured using CSMI as a device to check the isokinetic contractile force. And as tools to measure the lower extremity function, a

stopwatch, a tape measure, and a hand counter were used.

2.3.1 Knee muscle strength

The subjects were instructed to sit on a chair to evaluate the extensors and flexors of the knee joint (Fig. 1). Hold the handles on both sides and fix the measuring legs. When measuring the con/ecc of the knee joint extensor and flexors, the angle was measured from 0° to 90°, and the knee joint was positioned at the center of the measuring instrument, and the fixed speed was set at 60/s. After practicing the measurement method, it was measured three times. A break between measurements was given for 20 seconds.

Fig. 1. Knee muscle strength

2.3.2 20m sprint

To measure the 20m sprint, point A was marked on the hard ground and point B was marked 20m ahead. Subjects were instructed to sprint from point A to point B based on the starting signal. The researcher gave the start signal and measured the time from then to the moment of passing through point B. This was carried out once and then three times with a 10-minute break, and the shortest record was measured. In the event of dyspnea, request to stop, and injury of the subjects during the process, they were immediately stopped.

2.3.3 Sargent jump

Subject was instructed to stand by the wall, raise the hand on the wall as far as possible, jump as high as possible to touch the wall. The highest point marked was measured.

2.3.4 Hop test

The hop test consisted of the following four parts (Figure 2); (1) Single leg hop for distance: Exercise tapes were placed on the floor at intervals of 1 m. Subjects were instructed to hold their arms on their sides with one leg bent. Subjects were instructed to run forward as far as possible with their toes touching the zero point. Then, in each test, the horizontal distance to the heel was measured. When one foot was over, the other was performed in the same way. (2) Triple hop for distance: Exercise tapes were placed on the floor at intervals of 1 m. Subjects were instructed to lay their hands on their sides with one leg bent. Subjects were instructed to jump forward three times when a signal was given. Then, in each test, the horizontal distance to the heel was measured. When one foot was over, the other was performed in the same way. (3) Cross over hop for distance: Exercise tapes were marked at intervals of 1 m and placed on the floor. Subjects were instructed to bend one leg and hold the arm to the side. When the subjects signaled, they were instructed to jump forward 3 times by moving the tape from side to side. Then, in each test, the horizontal distance to the heel was measured. When one foot was over, the other was performed in the same way. (4) Single leg 6m hip for time: After designating the starting line, we designated the finish line 6m ahead with exercise tape. Subjects were instructed to stand on one leg and both arms. Subjects were instructed to run 6m as fast as possible on one foot. The researcher stood at

the finish line holding a stopwatch. The timing of the test begins when the subject bounces forward and ends when the subject crosses the finish line. Time was recorded in hundredths of a second. When one foot was over, the other was performed in the same way.

2.3.5 Side shuffle

On the floor, the 3m distance between point A and point B is marked with exercise tape. The test subject was instructed to stand between point A and point B, and when receiving a start signal, he was instructed to reciprocate from point A to point B for 1 minute left and right. After measuring the A and B points, the obtained points were measured. Subjects were instructed to do sufficient stretching prior to the test and were instructed to immediately report any discomfort or pain during the measurement.

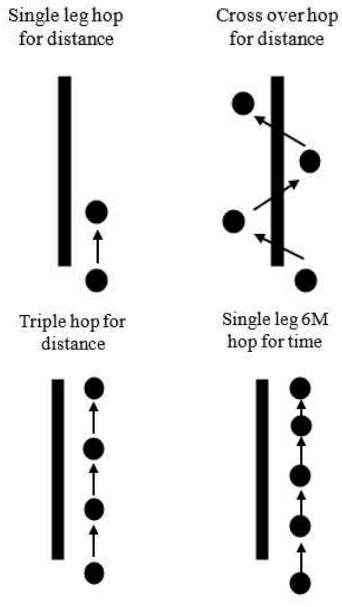

Fig. 2. Hop test

2.4 Statistical analysis

Statistical analysis was used in SPSS 20.0 (version 220, IBM) in this study. Spearman correlation coefficients were used to analyze to find correlations between conformal parameters (TTP, AT, PT) and lower extremity function. The statistical play level was set to α = .05.

3. Results

The results of concentric contraction and lower extremity function of the right knee are as follows in Table 1.

As a result, the maximum strength of the right knee concentric flexor was significantly different in the single leg hop and the single leg 6M hop in the one leg hop test (P 〈.05), and the average strength was significant only in the Hop leg 6M. There was (P 〈0.05). The maximum muscle strength of the extensor showed a significant difference in the sargent jump and the triple hop (P 〈0.05), and there was a significant difference in the average strength of the sargent jump (P 〈.05).

As a result, there was no significant difference with lower extremity function in the maximum and average strength of the flexors and extensors of the left concentric contraction (P〉.05) (P〉.05).

The results of the eccentric contraction and lower extremity function of the right knee are as follows in Table 2. As a result, there was no significant difference between the maximum and average strength of the right knee flexor and the lower extremity function (P〉.05), but only the maximum strength of the extensor was significantly different in the 6M hop test. (P 〈.05).

As a result, there was no significant difference between the maximal muscle strength of the left knee flexor and the average strength and lower extremity function (P〉.05), and only the maximum strength of the extensor was significantly different in the crossover hop. (P 〈.05).

Table 1. Correlation between knee concentric strength and lower extremity function

			20S	SJ	SLH	TH	COH	SL6H	SS
PT/BW concentric	RF	r	.310	.565	.652*	.565	.371	-.655*	.095
		p	.383	.089	.041	.089	.291	.040	.795
	LF	r	.439	.372	-.150	-.024	-.335	-.494	-.144
		p	.204	.290	.926	.907	.519	.457	.692
	RE	r	-.091	.636*	.517	.697*	.503	-.152	.565
		p	.803	.048	.126	.025	.138	.675	.089
	LE	r	.213	.171	.012	-.079	-.128	-.268	-.055
		p	.554	.637	.973	.828	.724	.454	.880
AP/BW concentric	RF	r	.467	.297	.474	.321	.297	-.722*	.079
		p	.174	.405	.166	.36	.405	.009	.828
	LF	r	.354	.530	.394	.329	.067	-.866	.058
		p	.316	.115	.259	.353	.854	.001	.828
	RE	r	-.042	.661*	.571	.721	.467	-.201	.444
		p	.907	.039	.084	.019	.174	.578	.199
	LE	r	.158	.219	.396	.213	.103	.-.411	.110
		p	.663	.544	.257	.555	.776	.132	.763

*P<0.05, PT: peak torque, BW: body weght, AP: average power, 20S: 20M sprint, SJ: sargent jump, SLH: single leg hop, TH: triple hop, COH: cross over hop, SL6H: single, SS: side shuffle RF: right flexor, LF: left flexor, RE: right extensor, LE: left flexor

Table 2. Correlation between knee eccentric strength and lower extremity function

			20S	SJ	SLH	TH	COH	SL6H	SS
PT/BW eccentric	RF	r	.091	.383	.335	.359	.140	-.220	-.024
		p	.802	.275	.343	.309	.700	.542	.947
	LF	r	.092	.178	-.271	-.080	-.423	.066	.018
		p	.800	.623	.449	.827	.223	.987	.960
	RE	r	-.158	-.176	-.555	-.298	-.529	.784*	-.369
		p	.663	.626	.096	.403	.116	.007	.795
	LE	r	.273	-.212	-.590	-.491	-.673*	-.212	-.426
		p	.446	.556	.073	.150	.033	.556	.220
AP/BW eccentric	RF	r	.152	.127	.243	.164	.042	-.158	.201
		p	.676	.726	.498	.651	.907	.663	.578
	LF	r	-.103	.359	.058	.170	-.012	-.097	-.034
		p	.776	.309	.874	.638	.973	.789	.927
	RE	r	.036	-.018	-.598	-.316	-.517	.601	-.503
		p	.920	.960	.068	.374	.084	.066	.138
	LE	r	.079	-.139	-.419	-.285	-.612	.188	-.188
		p	.829	.701	.228	.425	.060	.603	.602

*P<0.05, PT: peak torque, BW: body weght, AP: average power, 20S: 20M sprint, SJ: sargent jump, SLH: single leg hop, TH: triple hop, COH: cross over hop, SL6H: single, SS: side shuffle RF: right flexor, LF: left flexor, RE: right extensor, LE: left flexor

4. Discussion

Isokinetic dynamometer and lower extremity function can be used clinically as useful indicators to return to daily life for patients with problems due to weakening of the lower extremity muscles or for patients with ligament problems. Furthermore, it is a useful index that can improve the patient's quality of life as it is used as objective data such as the need for exercise rehabilitation and the results of the rehabilitation exercise process for patients.

In previous studies, there were data that analyzed the relationship between isokinetic

muscle strength and lower function of the knee joint. Our study will be able to add more information to the indicators that the patient's return to life in clinical practice can be achieved by adding parameters that were not measured in previous studies.

The purpose of this study was to investigate the correlation between the torque value and lower extremity function measured by the isokinetic dynamometer of the extensor and flexor of the knee joint. The hypothesis of our study is that the torque value measured by the isokinetic dynamometer of the flexor and extensor of the knee joint is significantly correlated with the lower extremity function.

The experimental results showed that the torque value measured by the isokinetic dynamometer was higher than the average value when the torque value measured by the isokinetic dynamometer was measured by the isokinetic dynamometer compared to the measurement value of the lower extremity function.

Therefore, the isokineticd dynamometer and the lower extremity function were correlated with sing leg hop and sing leg 6M hop in the flexor of the knee joint. This is much more correlated with hop test and average peak torque, according to the findings of English et al (2006) [13]. The hop test was better expressed in the overall range of motion because the distance of movement was calculated by multiplying the force [13]. The naar-Medeni et al (2019) stated that evaluating concentric knee extensor strength at 60° and 90° knee flexion angles during dynamic torque generation can be useful for improving hop test and jump performance because it is a determinant of functional tests. This study also had a significant relationship [19].

The torque value of the knee extensor muscle was higher than the mean value measured by the isokinetic dynamometer in the Sargent jump and triple hop. This study showed that the maximum torque value of the extensor muscle of the knee joint obtained from the analysis performed in the isokinetic dynamometer was higher than that of the Sargent jump performance [20]. The higher the torque value measured by the isokinetic dynamometer of the distal muscle of the knee joint, the better the hop test was found in Barfod et al. (2018) [20]. Harrison et al. (2013) reported a high relationship between isokinetic torque and jump [21]. They said that the extension of the knee joint contributes to several factors in the jump height, and it can be reflected that the knee joint extensor tendons and muscles are very elastic during the jump, and that additional force can be generated through elasticity. It was also reported to be consistent with a biomechanical model of jump, indicating that the knee extensors play an important role in transferring force from the leg to the torso [21]. The extensor muscle of the knee joint was not significantly different in lower extremity function except for the target jump and triple hop when comparing lower extremity function with isokinetic dynamometer. This study was conducted by Sueyoshi et al. (2017) and found that the maximum torque of the knee extremity muscle was not affected by lower extremity function [18]. Anderson et al. (1991) had no functional relationship between the extensor muscle and the flexor torque and sprint, side shuffle and jump in the other postures [19].

The limitation of this study was that it was not targeted at various ages because it was targeted at men in their 20s, and there was a limit to the short period of study. It is thought that measuring sufficient period and various age groups will lead to more accurate results of the study.

5. Conclusion

This study was conducted on 22 healthy adult males, and the correlation between the maximal torque and average strength of the extensor and flexor muscles of the knee joint was analyzed. In conclusion, it was found that the flexors of the knee joint were correlated in the single leg hop and the sing leg 6M hop, and the extensors were correlated in the Sargent jump and triple hop. It is significant in presenting the direction of the isokinetic dynamometer and lower extremity function of the knee joint in clinical trials, and studies comparing the correlation using different parameters should be conducted continuously.

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