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Analysis of the Relation between Female SOFTBALL PLAYERS Field Test and Anaerobic Exercise Ability and Isokinetic Muscle Function

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Abstract

This study analyzed the relation between field test(field skills: bat speed, throw distance, base running) and anaerobic exercise ability and isokinetic muscle function related to the performance improvement in 22 female softball players in "D" metropolitan city. The data processing was conducted using SPSS 25.0 to produce the average and standard deviation of all measured items, and the correlation between field skills and anaerobic exercise ability and isokinetic muscle function was measured with the Pearson's correlation analysis. An analysis of the correlation between field tests and isokinetic muscle function showed a significant correlation in the left extensor and bat speed(p<.05) and in weight ratio left extensor and left extensor and throw distance(p<.01). The base running ability showed a significant inverse correlation between the right flexor and 1st base(p<.01), 2nd base(p<.01), and home(p<.05) and between the right flexor/extensor ratio and 1st base(p<.05) and 2nd base(p<.05). For anaerobic exercise ability and isokinetic muscle function, there was a significant correlation between right extensor and peak power(p<.05), average power(p<.05), and total energy(p<.05). Based on the results of this study, it is believed that the bat speed and throw distance of female softball players are related to the left extensor and the base running ability is related to the right flexor and right flexor/extensor ratio.

[Keywords] ***Softball, Bat Speed, Throw Distance, Anaerobic Exercise Ability, Isokinetic Muscle Function***

1. Introduction

Softball is similar to baseball, but throwing underhand rather than overhand is a feature different from baseball[1]. In softball, a pitcher throws a ball, a hitter hits the ball, and defenders catch and throw it. The official ball in softball must be rubber or leather, weighing 177.19-198.45g, lighter and larger than baseball, with a diameter of 9.6-9.8cm, and a bat length less than 86.36cm and 5.72cm or less in diameter of the thickest part with the material of metal, bamboo, plastic, graphite, magnesium, carbon, magnesium, glass-fiber, or a composite of those, but recently mainly aluminum[2]. Softball games have a similar mechanism of bat swing and ball throwing movements. In muscular contraction, it is characterized by the movement of core muscles centered on the torso and hip muscles rotating on the axis and stretching the muscles[3]. The offense requires the ability to judge the pitched ball and accurately hit it with the bat[4], and defenders need the ability to catch and throw the ball accurately[5]. Softball, like baseball, requires four skills: throwing, catching, batting, and base running[4]. Depending on how much these skills are used in the game, they will directly affect the team's victory. Methods for measuring these field skills(throw, bat speed, base running) have been widely practiced in other sports[6][7]. The defense has different physical factors depending on the position[4][6][7]. For players in all positions, throwing the ball is important, and these

movements have the characteristics of the motion in which the muscles contract and then stretch with the rotation of each segment, similar to the hitting[3]. For players in all positions, including pitchers, fast and accurate throw movement is important, and power and myofunction are important factors in this regard[4]. Draw action is the most basic ability of softball, and depending on the strength of the throwing action, there may be a risk of injury, and the beginning of the movement is in the order of each segment of the lower body, the truncus, and the upper limbs[8][9][10][11]. The coordination of the muscles used in the throwing motion produces delicate movements, and the strength of the ball and the posture of the throwing action are determined as the sum of the momentary power and myofunctions of each segment[12]. In particular, since the thrust is obtained from the ground, the mechanism of the upper limbs through the pelvis and the truncus appears at the angular speed of the shoulder, the angular muscle power at the lower body becomes the source of force of the throwing motion and is important to prevent injury[3].

The bat speed is the most important along with accuracy in softball, with a combination of instantaneous power and myofunction of each segment. The hitting is a complex mechanism, and the fast bat speed means that the nerve system response and the mobilization of the motor units are efficient. Most of the force generated by the swing is generated first from the legs, then transferred to the upper body and activated the torso muscles in the entire swing[3][13][14]. Therefore, activating the lower limb muscles increases the power to the upper body and the torso, therefore the faster bat speed[15]. The relevance of the bat speed to anaerobic exercise skills in the hitting with this mechanism is not clearly known, and studies related to constant isokinetic muscle function have been reported a lot, but research on the relevance of field tests is insufficient. The base running time is an important element in the offensive aspect of softball, and there is a lot of training in strengthening lower limb muscle strength[1]. Base running in the left-hand direction of the ground requires lower limbs and the whole body endurance, especially depending on the foot supported[16]. Anaerobic exercise skills and isokinetic muscle function are affecting the power of lower limb muscles[17], but research related to base running is insufficient. By analyzing the correlation between extensor and flexor muscles in the physiologic factors of anaerobic exercise skills related to these field abilities and the lower isokinetic muscle function, improving the associated fitness factors will have a positive effect on the performance of softball players. Therefore, the purpose of this study is to analyze the relation between field test and anaerobic exercise ability and isokinetic muscle function and to provide the results of this study as basic data for future scientific and systematic training of softball players.

2. Research Method

2.1. Research subjects

The subjects of this study were 22 athletes from women's softball teams in "D" metropolitan city, and field test, anaerobic exercise ability, and isokinetic muscle function were measured. Participants in this study were given a clear explanation of the purpose and content of the experiment in advance, and all studies were carried out after obtaining consent from those who expressed their willingness to participate. The general characteristics of the study subjects are as shown in <Table 1>.

Table 1. The general characteristics of the study subjects.

N	Age	Height(cm)	Weight(kg)	BMI(kg/m^2)
22	24.10 ±5.07	162.95 ±5.64	63.14 ±7.97	23.43 ±3.45

Note: Values are mean±SD.

2.2. Measurement items and method

2.2.1. Field ability

Bat speed: After 10 minutes of warm-up, the bat speed was measured five times at bat. Using the Bushell Velocity Speed Gun(USA), speed was set to be measured at the hitting point, and out of the five swings, average speed(km/h) of three swings was recorded, excluding the highest and lowest value.

Throw distance: The throw distance was measured as the maximum distance that players threw softball from the home plate. A reference line was made at the home plate location for measurement, and an additional 2m line was set rearward to enable two-step run-up. Distance measurements were made by standing on the home plate and using Bushnell pro XE(USA) and marking the spot where the ball fell with a flag. The maximum distance(m) out of five throws was recorded.

Base running: In order to evaluate players' base running speed after hitting, the starting signal was given with a batting position at bat, and the time to return to home through first, second, and third base was measured with a stopwatch. Arrival was based on stepping on the plate at each point, measured twice each, recording the fastest time in seconds.

2.2.2. Anaerobic exercise ability

Anaerobic exercise ability was measured with a Wingate test. It was measured for 30 seconds using a bicycle ergometer(Monark 818E, Sweden). Taking into account the characteristics of this measurement, prior training was conducted on the measurement procedures to reduce the decrease of will and power output in the second half of the test. As a result of the Wingate test, the values for peak power, average power, total energy, and peak drop were calculated.

2.2.3. Isokinetic muscle function

Using an isokinetic muscle measurement system(CSMI, USA), isokinetic muscle function was measured on the knee joints according to the manual. It was measured at angular speed of 60°/sec to verify the muscle strength of the knee joints. After performing three preliminary exercises, the extensor and flexor of the knee joints were performed three times at the angular speed of 60°/sec. Measurements were used to calculate peak torque, average power, total work, left and right ratio(%), and flexor and extensor ratio.

2.3. Data processing

The data processing of this study produced the mean and standard deviation of all measured items using the SPSS 25.0 statistical program. Correlation analysis of Pearson between measurement items was conducted to determine the correlation between field ability and anaerobic exercise ability and isokinetic muscle function, and the statistical significance level was set to $p<.05$.

3. Results

3.1. Results of analysis of the correlation between field ability and anaerobic exercise ability

The results of the analysis of the correlation between field capability(bat speed, throw distance, and base running) and anaerobic exercise ability showed no statistical significance in all measurement items as shown in <Table 2>.

Table 2. Results of analysis of the correlation between field ability and anaerobic exercise ability.

Item	Bat speed (km/h)	Throw distance (m)	Base running(seconds)			
			1st base	2nd base	3rd base	Home
Peak power(W)	0.240	-0.167	-0.067	0.027	0.051	-0.073
Peak power(W/kg)	0.130	-0.249	-0.067	-0.043	-0.020	-0.112
Average power(W)	0.329	-0.043	-0.069	0.069	0.029	-0.050
Total energy(J)	0.325	-0.064	-0.092	0.060	0.028	-0.050
Peak drop(%)	-0.130	-0.002	0.273	0.131	0.126	0.101

3.2. Results of analysis of the correlation between field ability and isokinetic muscle function

Table 3. Results of analysis of the correlation between field ability and isokinetic muscle function(60°/sec).

Item	Bat speed (km/h)	Throw distance (m)	Base running(seconds)			
			1st base	2nd base	3rd base	Home
Right extensor(%BW)	0.161	0.208	-0.103	-0.217	-0.212	-0.236
Left extensor(%BW)	0.246	0.551**	-0.125	-0.170	-0.244	-0.201
Right extensor(Nm)	0.229	0.044	-0.101	-0.105	-0.137	-0.143
Left extensor(Nm)	0.490*	0.636**	-0.209	-0.183	-0.318	-0.238
Left/right extensor(deficit)	-0.119	-0.314	-0.223	-0.055	0.086	-0.016
Right flexor(%BW)	-0.122	-0.181	-0.450*	-0.548**	-0.414	-0.429*
Left flexor(%BW)	0.160	0.396	-0.344	-0.304	-0.220	-0.202
Right flexor(Nm)	-0.010	-0.267	-0.376	-0.377	-0.303	-0.313
Left flexor(Nm)	0.269	0.311	-0.364	-0.255	-0.208	-0.170
Left/right flexor(deficit)	0.077	-0.056	-0.099	0.078	0.085	0.070
Flexor/extensor left ratio	-0.087	-0.272	-0.119	-0.066	0.101	0.036
Flexor/extensor right ratio	-0.275	-0.339	-0.439*	-0.468*	-0.371	-0.329

Note: *p<.05, **p<.01.

The results of the analysis of the correlation between field ability(bat speed, throw distance, base running) and isokinetic muscle function are shown in <Table 3>. The bat speed showed a significant correlation with left extensor(r=0.490, p=0.021), and throw distance showed it with weight ratio left extensor(r=551, p=0.008) and left extensor(r=0.636, p=001). For base running, there was a significant correlation with weight ratio right flexor and the first base(r=-0.450, p=0.036), the second base(r=-0.548, p=0.008), and the home(r=-0.429, p=0.047) and right flexor/extensor ratio and the first base(r=-0.439, p=0.041) and the second base(r=-0.468, p=0.028).

3.3. Results of analysis of the correlation between anaerobic exercise ability and isokinetic muscle function

The results of the analysis of the correlation between the anaerobic exercise ability and isokinetic muscle function are shown in <Table 4>. Significant correlation were found between

right extensor and peak power(r=0.452, p=0.035), average power(r=0.473, p=0.026), and total energy(r=0.448, p=0.037).

Table 4. Results of analysis of the correlation between anaerobic exercise ability and isokinetic muscle function.

Item	Peak power (W)	Peak power (W/kg)	Average power(W)	Total energy(J)	Peak drop (%)
Right extensor(%BW)	0.182	0.245	0.154	0.127	0.025
Left extensor(%BW)	-0.268	-0.005	-0.288	-0.299	0.162
Right extensor(Nm)	0.452*	0.192	0.473*	0.448*	0.072
Left extensor(Nm)	.062	.005	.095	.070	.238
Left/right extensor(deficit)	.143	.154	.137	.157	.046
Right flexor(%BW)	.012	.179	-.146	-.151	.149
Left flexor(%BW)	-.349	-.183	-.364	-.357	-.020
Right flexor(Nm)	.325	.191	.226	.216	.172
Left flexor(Nm)	.029	-.137	.049	.045	.043
Left/right flexor(deficit)	-.012	-.115	.049	.059	.018
Flexor/extensor left ratio	.097	-.081	.074	.092	-.140
Flexor/extensor right ratio	-.159	-.002	-.285	-.269	.082

Note: *p<.05.

4. Discussion

Although domestic softball is said to have achieved qualitative and quantitative growth, it is still one of the most unpopular ball sports that is being distributed to the public, focusing on club members rather than elite players. Citing prior research data from Yang Seung-won and Yeo Chul-hoon(2013)[1] due to the difficulty of collecting the latest data, there are currently 20 domestic softball teams, with fewer than 300 players registered[18]. However, no information on the current status of teams, players, and coaches are available on the official website of the Korea Baseball Softball Association(KBSA). According to the results of the domestic and foreign prior research related to softball, domestic research shows the physical strength of pitchers and fielders[1], the correlation between pitcher's isokinetic myofunction by body segment and pitch speed[19], kinetic analysis of batting motion[15], the relation between batting average and physical strength factors[20], the physical strength comparison according to defense position[14], and dynamic analysis for effective hitting of left-handed batters[21]. Foreign studies were also mostly sports medical or dynamic approaches, such as injury-related studies[8][22][23], pitcher's shoulder and elbow joints alignment[9][11][12], the scope of operation of the shoulder and hip joints[10], the effect of pitchers and catchers on performance[24], and cross-analysis of baseball and softball players[25], and only some field-related research was conducted in relation to the field expertise in baseball[6][7][26]. As mentioned above, this study was conducted to find out the correlation of softball players' field skills, anaerobic exercise ability, and isokinetic muscle function, which were deemed to be very insufficient in domestic and foreign prior research.

The study found no statistical significance in all measurement items in field skills and anaerobic exercise abilities. Due to the characteristics of the Wingate test, which assesses anaerobic exercise ability based on field skills and the lower body, it is believed that there will be some difficulties in explaining the clear correlation and further research will be needed.

The analysis of the correlation between field skills and isokinetic muscle function shows a significant correlation between bat speed and left extensor(p<.05) and in throw distance, a

significant correlation was shown in weight ratio left extensor($p<.01$) and left extensor($p<.01$). In base running, there was an inverse correlation in weight ratio right flexor and the first base($p<.05$), second base($p<.01$), and home($p<.05$) and right flexor/extensor ratio and the first($p<.05$) and second base($p<.05$). These results suggest that the left extensor is involved in the throwing and batting movements. In particular, it is believed that the left leg is related to the left extensor as the movement of the left leg supports the foot and becoming the axis. The kinematic analysis of excellent softball players' batting behavior(Baek Jin-ho and Park Jong-cheol(2008)[14]) also supports this study, which shows that the hitting position of an excellent player is significantly related to bat speed and left extensor, as it is said that the center of the body moves closer to the home plate at the point of impact and leads to a swing with the weight towards the pitcher. A significant correlation between base running and right flexor and right flexor/extensor ratio partially supports the results of previous studies by Jung Jae-hoo and Kim Jung-tae(2012)[27] that the movement of running involves stabilizing the lower limbs as well as the truncus. According to a previous study, the extensor and muscle power with flexor of the lower body has a significant impact on sprint ability[28], and performance improves as muscle power increases[28], and sprinting athletes have a better knee joint muscle power than those in other field events[29]. Although there is no direct discussion of the correlation of field tests and lower limbs isokinetic muscle function, it is thought that the relation between right flexor and right flexor/extensor ratio could be partially explained, given the strength and muscle power required for sprinting abilities as well as the characteristics of base running in softball to dash towards home through the first, second, and third bases in the counterclockwise direction. Muscle groups involved in stabilizing posture generally use more flexor than extensor, and for landing after jumping, flexor is used more than extensor.

The analysis of the correlation between anaerobic exercise ability and isokinetic muscle function showed a significant correlation between right extensor and peak power, average power, and total energy($p<.05$). Studies on the correlation between anaerobic exercise ability and isokinetic muscle function were conducted for several sports, including soccer[30][31][32][33][34], rowing[35], and basketball[36]. According to a prior study of male middle school soccer players, anaerobic exercise ability had a significant correlation with right extensor and peak power and average power of left/right extensor and left flexor at 60°/sec angular speed[35]. A prior study on female soccer players showed that in anaerobic exercise ability, peak power and average power had positive correlation with the lower limbs isokinetic muscle function at all the angular speed[32]. According to a prior study of high school rowers, in peak power of anaerobic exercise ability, it reported a significant positive correlation in all measurement items except left and right extensor with an angular speed of 60°/sec and left flexor with angular speed of 180°/sec in average power[35]. A study of high school cyclists showed that the peak power and average power in anaerobic exercise abilities showed significant positive correlation with left and right extensor[37]. As mentioned above, the correlation between anaerobic exercise ability and lower limbs isokinetic muscle function differed depending on the gender, age, physique, fitness, training type, and sport of the subjects. Considering the results of this study, it is believed that the female softball player's peak power, average power, and total energy of anaerobic exercise abilities are related to right extensor of the lower limb isokinetic muscle function.

5. Conclusion

This study analyzed the correlation between field ability, anaerobic exercise ability, and isokinetic muscle function for female softball players. Studies have shown a significant correlation in bat speed and left extensor, throw distance and weight ratio left extensor and left extensor, base running of first base, second base, and home base and weight ratio right flexor, and base running of the first and second bases and right flexor/extensor ratio. Peak

power, average power, and total energy of anaerobic exercise ability showed a significant correlation with right extensor. These findings are expected to provide useful information on the efficient physical training of female softball players in the future.

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7. Contribution

7.1. Authors contribution

	Initial name	Contribution
Lead Author	CWK	-Set of concepts ☑ -Design ☑ -Getting results ☑ -Analysis ☑ -Make a significant contribution to collection ☑ -Final approval of the paper ☑
Corresponding Author*	PJS	-Corresponding ☑ -Play a decisive role in modification ☑
Co-Author	LSJ	-Significant contributions to concepts, designs, practices, analysis and interpretation of data ☑ -Participants in Drafting and Revising Papers ☑ -Someone who can explain all aspects of the paper ☑

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- Exercise Training-induced PPAR-β Increases PGC-1α Protein Stability and Improves Insulin-induced Glucose Uptake in Rodent Muscles, Nutrients, 12(652) (2020).

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