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The Effect of the Isokinetic Muscle Function of the Shoulder Joint of Amateur Club Baseball Pitchers in Their 20s on the Speed of a PITCHED BASEBALL

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Abstract

Purpose: This study analyzed the effect of the isokinetic muscle function of the shoulder joint on the speed of a pitched baseball with 21 amateur club baseball players in their 20s in the D city area as subjects.

Method: The subjects played the sport for between two years and seven years, have no pain or disease in their upper and lower limbs over the past year, and are divided into three groups: S1 for the maximum ball speed of 110 km/h or faster, S2 for 100 km/h or faster to slower than 110km/h, and S3 for slower than 100km/h in their pitched ball speed. The data for this study were processed using SPSS 18.0, calculating mean and standard deviations. One-way ANOVA was conducted to compare the differences between each item between the groups, and the Tukey method was used for follow-up analyses between the groups. In addition, multi linear regression was used to determine the effect of the isokinetic muscle function of the shoulder joint on the speed of a pitched baseball by angular velocity. The statistical significance level was set to $p < .05$.

Results: The faster the pitching speed, the higher the statistical significance of the isokinetic muscle function of the shoulder joint (at an angular velocity of 60 degrees, 180 degrees, and 240 degrees). Among the isokinetic muscle function factors, it was shown that the extensor of the shoulder joint had a high explanatory power. Peak torque of right shoulder joint at 180 degrees angular velocity had 44.9%, and work per repetition at 240 degrees had 54.2% had 54.2% explanatory power. To sum up the above results, the better the muscle function the group has, the faster the speed of a pitched baseball, and especially extensor showed higher statistical significance than flexor.

Conclusion: It was also shown that the isokinetic muscle function of the shoulder joint showed a stronger effect on the ball speed in extensor than in flexor of the right shoulder joint.

[Keywords] Baseball Players, Shoulder Joint, Isokinetic Muscle Function, Speed of a Pitched, Muscle Function Test

1. Introduction

Various physical movements involved in playing baseball not only develop each aspect of the physical ability, such as endurance, quick response, agility, and flexibility, but also help develop quick and accurate judgment and determination[1]. Since baseball has characteristics such as teamwork, sacrifice, determination, endurance, and fighting spirit as hitters and runners between offense and defense, it also helps to cultivate mental and social skills as well as physical skills[2].

The pitching thrown by a pitcher is the most important factor in the game of baseball, and about 80% of the winning or losing depends on the pitcher's ability[3]. Therefore, pitchers are the most popular position among baseball players because a team with strong pitchers can lead an absolutely advantageous game[4]. Some enthusiastic amateur club baseball players want to

improve their speed and become an outstanding pitcher by visiting experts to take lessons and get trained. One of the purposes of training for a pitcher is to improve control and ball speed and to keep the speed of a fastball steady throughout the game without losing control[5]. One of the most important factors for a pitcher's success is the ball speed[6], and the top speed is one of the success factors as a baseball pitcher[7]. In baseball, a pitcher is a position that has a static and dynamic aspect at the same time, requires muscle strength and power from the entire body, and also requires balance, agility, equilibrium, and coordination that must be harmonized[8][9][10]. In baseball, hitting or pitching is not done with arms alone, but starts with legs and hip. Legs and hip are the "power zone" and provide more than 50% of the force generated for hitting and pitching[11]. In addition, the speed of a pitched baseball by an overarm pitcher is influenced by the pitchers' steps and hip rotation[12]. The acquisition of correct balance and pitching skills through proper training is an important factor in improving the ball speed, but that alone limits the improvement of the ball speed and control. It essentially requires muscle function[13]. The ball speed of a pitcher is correlated with anaerobic power, and anaerobic training is the main factor for the increase in the ball speed[14]. For baseball players as well as athletes in most sports, anaerobic power is the factor that best predicts success[15][16][17], and for baseball players, especially the power of the shoulder joint is absolutely necessary[18][19].

amateur club baseball pitchers absolutely lack the strength and muscle endurance to maintain the ball speed and accuracy throughout the game, and the longer they pitch, the more they lose form and balance. This can be seen as a result of the difference in the amount of training and practice, as unlike elite athletes, there is absolutely no time for amateur players to invest in training and practice[2]. Many of the prior studies were conducted on professional or varsity baseball players, especially on elite players with more than five years of experience. In addition, these studies were on elite baseball players' anaerobic power and the effect of muscular strength on the ball speed, or simply whether or not muscle strength is related to the ball speed, and research on the relationship between isokinetic muscle strength and the ball speed have been insufficient. Therefore, the purpose of this study is to analyze the effect of the isokinetic muscle function of the shoulder joint on the speed of a pitched baseball as amateur club baseball players as subjects and to provide the basic data for the training approaches for them.

2. Research Method

2.1. Research subjects

This study was conducted on 21 amateur baseball pitchers in their 20s who had no pain or medical history in the upper and lower limbs over the past year and with two to seven years of experience living in D city. Seven players were assigned to each of the three groups, S1, S2, and S3, by measuring their ball speed <Table 1>.

Table 1. The physical characteristics of the research subjects.

Group	Age(yr)	Height(cm)	Weight(kg)	Body fat(%)	BMI(kg/m ²)	Experience(yr)
S1(n=7)	24.57 ±1.99	178.29 ±3.77	80.00 ±19.22	19.98 ±9.12	25.73 ±5.97	4.43 ±1.99
S2(n=7)	23.14 ±1.77	177.86 ±4.56	80.86 ±16.09	20.50 ±4.15	25.93 ±4.36	3.14 ±0.90
S3(n=7)	22.57 ±2.70	176.00 ±4.32	67.00 ±7.28	17.12 ±5.97	21.95 ±3.29	3.57 ±1.81

Note: Values: mean±SD, S1=The fast speed group(110/km/h or faster), S2=The middle speed group(100km/h to 109km/h), S3=The slow speed group(slower than 100km/h).

2.2. Measuring units and items

Table 2. Measuring unit and items.

Description	Item	Measuring units and items
Physique	Physique, body composition	Height, weight, body fat, BMI
Isokinetic muscle function	Shoulder joint	Isokinetic muscle function (left and right extensor and flexor)

2.3. Method of measuring physique and basic physical strength

Heights were measured using a height measuring device(SH-9600A, Sewoo, Korea) with the shoes off, and the weight and body fat rate were measured using the InBody 3.0(Biospace, Korea) with minimal clothing while limiting food and water intake at least two hours prior to measurement and the bottom of feet and palm wiped with tissue wet with electrolyte. BMI was calculated using measured height and weight[20].

2.4. Method of measuring isokinetic muscle function

Isokinetic muscle function was measured at the angular velocity of 60°, 180°, and 240° for the peak torque and work per repetition of extensor and flexor, and the unit was recorded in Nm.

2.5. Statistical processing

The data processing of this study was done using SPSS 18.0. The mean and standard deviation of each item were calculated to analyze the sub-factors of the isokinetic muscle function of the shoulder joint affecting the speed of a pitched baseball, and one-way ANOVA was performed to compare the differences by each item between groups. The Tukey method was used for post-hoc analysis. Multiple linear regression was used to determine the effect of the isokinetic muscle function of the shoulder joint on the ball speed. The statistical significance level was set to $p < .05$.

3. Results

The results of analyzing the isokinetic muscle function of the shoulder joint by the pitching speed groups with amateur club baseball players as subjects are as follows.

3.1. Isokinetic muscle function

3.1.1. Peak torque measured at the angular velocity of 60 degrees

The mean and standard deviation of the peak torque of the isokinetic muscle function of the shoulder joint among the pitchers by each group measured at the angular velocity of 60 degrees are shown in <Table 3>. As shown in <Table 3>, it was significantly higher in S1 group than in S3 group for extensor of left and right should joint($p < .05$).

Table 3. Comparison between the groups for peak torque measured at the angular velocity of 60 degrees.

Group	Shoulder(RE)	F	Shoulder(LE)	F	Shoulder(RF)	F	Shoulder(LF)	F
S1	94.00±9.62		93.00±19.86		73.00±16.40		63.00±17.20	
S2	93.00±15.48	4.086*	87.17±19.75	4.668*	66.50±19.41	2.571	65.00±23.08	1.233
S3	73.33±15.03		64.17±9.39		52.00±10.71		57.50±10.97	

post-hoc S3 < S1 S3 < S1

Note: Values: mean±SD, *p<.05

RE=Right extensor, RF=Right flexor, LE=Left extensor, LF=Left flexor, E=Extensor, F=Flexor

3.1.2. Work per repetition measured at the angular velocity of 60 degrees

The mean and standard deviation of work per repetition of the isokinetic muscle function of the shoulder joint among the pitchers by each group measured at the angular velocity of 60 degrees are shown in <Table 4>. As shown in <Table 4>, it was significantly higher in S1 group than in S3 group for extensor of left and right should joint(p<.05).

Table 4. Comparison between the groups for work per repetition measured at the angular velocity of 60 degrees.

Group	Shoulder(RE)	F	Shoulder(LE)	F	Shoulder(RF)	F	Shoulder(LF)	F
S1	113.17±18.73		112.50±24.87		87.17±23.27		86.17±27.65	
S2	100.60±29.36	5.472*	99.60±37.15	5.764*	75.20±32.35	3.582*	70.00±29.44	2.198
S3	73.33±15.03		64.17±9.39		52.00±10.71		57.50±10.97	
post-hoc	S3 < S1		S3 < S1		S3 < S1			

Note: Values: mean±SD, *p<.05.

3.1.3. Peak torque measured at the angular velocity of 180 degrees

The mean and standard deviation of the peak torque of the isokinetic muscle function of the shoulder joint among the pitchers by each group measured at the angular velocity of 180 degrees are shown in <Table 5>. As shown in <Table 5>, it was significantly higher in S1 group than in S3 group for extensor of left and right should joint(p<.05).

Table 5. Comparison between the groups for peak torque measured at the angular velocity of 180 degrees.

Group	Shoulder(RE)	F	Shoulder(LE)	F	Shoulder(RF)	F	Shoulder(LF)	F
S1	86.80±16.18		82.20±19.83		66.40±16.92		63.00±16.93	
S2	82.50±17.73	4.648*	79.33±18.28	3.996*	57.50±12.69	1.678	61.33±13.38	.534
S3	61.00±11.61	S1>S3	57.50±9.33	S1>S3	52.17±8.66		55.33±8.76	
post-hoc	S3 < S1		S3 < S1					

Note: Values: mean±SD, *p<.05.

3.1.4. Work per repetition measured at the angular velocity of 180 degrees

The mean and standard deviation of work per repetition of the isokinetic muscle function of the shoulder joint among the pitchers by each group measured at the angular velocity of 60 degrees are shown in <Table 6>. As shown in <Table 6>, there were no significant differences in all items.

Table 6. Comparison between the groups for work per repetition measured at the angular velocity of 180 degrees.

Group	Shoulder(RE)	F	Shoulder(LE)	F	Shoulder(RF)	F	Shoulder(LF)	F
S1	97.20±19.55		96.40±27.18		73.40±20.60		69.60±18.09	
S2	99.17±18.57	3.697	94.17±19.84	3.472	65.00±18.60	.728	70.17±16.42	.210
S3	72.00±19.18		67.67±14.35		61.00±11.88		64.83±11.91	

3.1.5. Peak torque measured at the angular velocity of 240 degrees

The mean and standard deviation of the peak torque of the isokinetic muscle function of the shoulder joint among the pitchers by each group measured at the angular velocity of 240 degrees are shown in <Table 7>. As shown in <Table 7>, it was significantly higher in S1 and S2 group than in S3 group for extensor of left and right shoulder joint ($p<.05$) and higher in S1 group than in S3 group for extensor of left shoulder joint ($p<.05$).

Table 7. Comparison between the groups for peak torque measured at the angular velocity of 240 degrees.

Group	Shoulder (RE)	F	Shoulder (LE)	F	Shoulder (RF)	F	Shoulder(LF)	F
S1	90.40±15.69		83.80±18.73		67.80±17.06		63.40±14.47	
S2	88.00±15.52	4.974*	81.00±15.61	4.162*	59.00±12.70	1.440	61.17±11.72	1.149
S3	66.50±11.15		59.33±13.05		55.00±7.27		53.67±7.39	
post-hoc	S3 < S1, S2		S3 < S1					

Note: Values: mean±SD, * $p<.05$.

3.1.6. Work per repetition measured at the angular velocity of 240 degrees

The mean and standard deviation of work per repetition of the isokinetic muscle function of the shoulder joint among the pitchers by each group measured at the angular velocity of 240 degrees are shown in <Table 8>. As shown in <Table 8>, it was significantly higher in S1 group than in S3 group for extensor of right shoulder joint ($p<.05$).

Table 8. Comparison between the groups for work per repetition measured at the angular velocity of 240 degrees.

Group	Shoulder (RE)	F	Shoulder (LE)	F	Shoulder (RF)	F	Shoulder (LF)	F
S1	82.20±13.75		83.00±23.37		52.00±26.45		54.20±18.85	
S2	82.83±16.14	3.929*	78.67±15.33	3.389	43.17±19.94	.278	50.33±16.66	.087
S3	62.00±13.13		56.50±16.84		46.83±10.82		51.17±12.30	
post-hoc	S3 < S1							

Note: Values: mean±SD, * $p<.05$

3.2. Effect of flexor and extensor in the shoulder joint muscle strength on the ball speed by angular velocity

Multiple linear regression was conducted to determine the effect of flexor and extensor in the shoulder joint muscle strength on the ball speed by angular velocity. The analysis of the effect of each factor on the ball speed is as follows. <Table 9> <Table 10> show the results of the analysis of the effect of peak torque and work per repetition of the left shoulder joint measured at the angular velocity of 60 degrees on the ball speed, and it was shown that the peak torque and work per repetition of the left shoulder joint measured at the angular velocity of 60 degrees had no significant effect on the ball speed.

Table 9. Effect of the peak torque of the right shoulder joint measured at the angular velocity of 60 degrees on the ball speed.

Independent	Terminal speed		Maximum speed		
	b	SE	β	t	
(Constant)	70.223	11.631		6.037	
Shoulder_RE	.245	.234	.382	1.047	
Shoulder_RF	.189	.220	.313	.858	

R2	.444
F	5.581*

Note: *p<.05.

Table 10. Effect of work per repetition of the right shoulder joint measured at the angular velocity of 60 degrees on the ball speed.

Independent	Terminal speed		Maximum Speed		
	b	SE	β	t	
(Constant)	76.119	8.933		8.522	
Shoulder_RE	.373	.219	.908	1.707	
Shoulder_RF	-.111	.219	-.269	-.505	
R2	.444				
F	5.600*				

<Table 11> shows the results of the analysis of the effect of the peak torque of the right shoulder joint measured at the angular velocity of 180 degrees on the ball speed. It was shown that the intercept($\beta=.554$) of the extensor of the right shoulder joint had a significant effect at the 5% level, and the explanatory power of the regression model that explained the change of the ball speed by the extensor of the right shoulder joint was $R^2=.542$, having the 54.2% explanatory power.

Table 11. Effect of the peak torque of the right shoulder joint measured at the angular velocity of 180 degrees on the ball speed.

Independent	Terminal speed		Maximum Speed		
	b	SE	β	t	
(Constant)	72.416	8.518		8.502	
Shoulder_RE	.470	.218	.829	2.159*	
Shoulder_RF	-.084	.300	-.107	-.278	
R2	.542				
F	8.284*				

Note: *p<.05.

<Table 12> shows the results of the analysis of the effect of work per repetition of the right shoulder joint measured at the angular velocity of 180 degrees on the ball speed. It was shown that the intercept($\beta=.747$) of the extensor of the right shoulder joint had a significant effect at the 5% level, and the explanatory power of the regression model that explained the change of the ball speed by the extensor of the right shoulder joint was $R^2=.449$, having the 44.9% explanatory power.

Table 12. Effect of work per repetition of the right shoulder joint measured at the angular velocity of 180 degrees on the ball speed.

Independent	Terminal speed		Maximum Speed		
	b	SE	β	t	
(Constant)	75.864	8.985		8.443	
Shoulder_RE	.355	.153	.747	2.322*	
Shoulder_RF	-.062	.200	-.101	-.313	

R2	.449
F	5.714*

Note: *p<.05.

<Table 13> shows the results of the analysis of the effect of peak torque of the right shoulder joint measured at the angular velocity of 240 degrees on the ball speed, and the muscle strength of the right shoulder joint was found to have no significant effect on the ball speed.

Table 13. Effect of the peak torque of the right shoulder joint measured at the angular velocity of 240 degrees on the ball speed.

Independent	Terminal speed		Maximum Speed	
	b	SE	β	t
(Constant)	69.453	9.969		6.967
Shoulder_RE	.440	.215	.727	2.049
Shoulder_RF	-.030	.287	-.037	-.104
R2			.485	
F			6.583	

<Table 14> shows the results of the analysis of the effect of work per repetition of the right shoulder joint measured at the angular velocity of 240 degrees on the ball speed. It was shown that the intercept($\beta=.732$) of the extensor of the right shoulder joint had a significant effect at the 5% level, and the explanatory power of the regression model that explained the change of the ball speed by the extensor of the right shoulder joint was R2=.449, having the 44.9% explanatory power.

Table 14. Effect of work per repetition of the right shoulder joint measured at the angular velocity of 240 degrees on the ball speed.

Independent	Terminal speed		Maximum Speed	
	b	SE	β	t
(Constant)	72.728	9.510		7.647
Shoulder_RE	.455	.145	.732	3.138**
Shoulder_RF	-.077	.131	-.138	-.591
R2			.449	
F			5.703*	

Note: *p<.05.

4. Discussion

This study analyzed the differences in the isokinetic muscle function of the three groups(S1, S2, and S3) assigned by measuring their maximum ball speed. Based on the results of the isokinetic muscle function factors of the shoulder joint by the ball speed presented in this study, we compare and analyze them with preceding studies. A study to establish the relationship between anaerobic power and the pitched ball speed of baseball players reported that anaerobic training could be the main factor of the increase in the ball speed [11], and this study found that in all items, the isokinetic muscle function of the fast-pitching group was higher than that of the slow-pitching group, with the largest statistical difference in the extensor of the left and right shoulder joints. These results are considered to be the characteristics of baseball players with higher isokinetic muscle strength in the extensor rather than flexor. In addition, multiple linear regression analysis of the effects of isokinetic muscle function on the ball speed

showed that the extensor of the right shoulder joint had 44.4% to 54.2% of explanatory power in peak torque measured at 60, 180, and 240 degrees and work per retention at 180 and 240 degrees of the angular velocity. In this study, the isokinetic muscle function of the shoulder joint was shown to affect the ball speed, but conflicting results from preceding studies were also reported. A prior study[13], which analyzed the correlation between the ball speed and the isokinetic muscle function of the shoulder joint of varsity baseball players, and another prior study, which compared and analyzed the ball speed and isokinetic rotational force of professional baseball pitchers, reported no correlation between the ball speed and the isokinetic muscle function[18]. In addition, an analysis of the isokinetic torque of the shoulder joints of professional overarm pitchers reported that there is no link between the ball speed and the peak torque of the shoulder joints[12]. However, this study found that the fast-pitching groups had higher isokinetic muscle function in the shoulder joints compared to the slower-pitching groups and that it affected the ball speed. This is interpreted as a significant difference in the isokinetic muscle function of the shoulder joint, counter arguing the results of preceding studies, as elite baseball pitchers spend a lot of time training, perform daily weight training, and maintain overall muscle function as pitchers, while amateur club baseball pitchers are inferior to elite baseball pitchers in all categories, including overall muscle function and physical condition.

5. Conclusion

This study analyzed the isokinetic muscle function of the shoulder joints of amateur club baseball pitchers by the ball speed and drew the following conclusion:

First, the faster the ball speed, the higher the isokinetic muscle function of the shoulder joints measured at the angular velocity of 60, 180, and 240 degrees, compared to the slower pitching speed groups, and there were statistically significant differences in the extensor muscle strength of left and right shoulder joints.

Second, the peak torque of extensor of the right shoulder joint measured at the angular velocity of 180 degrees had 54.2% of explanatory power, and work per repetition measured at the angular velocity of 240 degrees had 44.9% of explanatory power.

Combining the above results, the better the muscle function, the faster the speed of a pitched ball, and it especially showed a higher statistical significance in extensor than in flexor. It was also shown that the isokinetic muscle function of the shoulder joint had a stronger effect on the ball speed in the extensor of the right shoulder joint than in the flexor.

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6.2. Thesis degree

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7. Appendix

7.1. Authors contribution

	Initial name	Contribution
Lead Author	WKC	<ul style="list-style-type: none"> -Set of concepts <input checked="" type="checkbox"/> -Design <input checked="" type="checkbox"/> -Getting results <input checked="" type="checkbox"/> -Analysis <input checked="" type="checkbox"/> -Make a significant contribution to collection <input checked="" type="checkbox"/> -Final approval of the paper <input checked="" type="checkbox"/> -Corresponding <input checked="" type="checkbox"/> -Play a decisive role in modification <input checked="" type="checkbox"/>
Corresponding Author*	JSP	<ul style="list-style-type: none"> -Significant contributions to concepts, designs, practices, analysis and interpretation of data <input checked="" type="checkbox"/> -Participants in Drafting and Revising Papers <input checked="" type="checkbox"/> -Someone who can explain all aspects of the paper <input checked="" type="checkbox"/>