Asian J Sports Med. 2015 March; 6(1): e25330. DOI: 10.5812/asjsm.25330

Published online 2015 March 20. **Research Article**

Relationship Between Grip, Pinch Strengths and Anthropometric Variables, Types of Pitch Throwing Among Japanese High School Baseball Pitchers

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Received: November 19, 2014; **Revised:** January 2, 2015; **Accepted:** January 6, 2015

Background: Grip and pinch strength are crucially important attributes and standard parameters related to the functional integrity of the hand. It seems significant to investigate normative data for grip and pinch strength of baseball players to evaluate their performance and condition. Nevertheless, few reports have explained the association between grip and pinch strength and anthropometric variables and types of pitch throwing for baseball pitchers.

Objectives: The aim of this study was to measure and evaluate clinical normative data for grip and tip, key, palmar pinch strength and to assess the relationship between these data and anthropometric variables and types of pitch throwing among Japanese high-school baseball pitchers.

Materials and Methods: One hundred-thirty three healthy high school baseball pitchers were examined and had completed a self-administered questionnaire including items related to age, hand dominance, throwing ratio of type of pitch. A digital dynamometer was used to measure grip strength and a pinch gauge to measure tip, key and palmer pinch in both dominant and nondominant side. Body composition was measured by the multi frequency segmental body composition analyzer.

Results: Grip strength and tip and palmer pinch strength in dominant side were statistically greater than them in nondominant side ($P < 0.05$). There were significant associations between grip strength and height ($r = 0.33$, $P < 0.001$), body mass ($r = 0.50$, $P < 0.001$), BMI ($r = 0.37$, $P < 0.001$), muscle mass of upper extremity ($r = 0.56$, $P < 0.001$), fat free mass ($r = 0.57$, $P < 0.001$), fat mass ($r = 0.22$, $P < 0.05$) in dominant side. A stepwise multiple regression analysis revealed that fat free mass and tip, palmer, key pinch strength were predictors of grip strength in dominant side. No statistical significant correlations were found between the throwing ratio of types of pitches thrown and grip strength and tip, key, palmar pinch strength.

Conclusions: Our result provides normative values and evidences for grip and pinch strengths in high school baseball pitchers.

Keywords: Grip; Pinch Strength; School

1. Background

Grip and pinch strength are crucially important attributes and standard parameters related to the functional integrity of the hand. It is necessary to produce enough grip and pinch strength to manage activity of daily life. The measurement of grip and pinch strength is simple and inexpensive method to assess forearm and hand function. Many reports of the literature describe evaluations of normative grip strength and pinch strength to detect the deficits and impairment of the upper limb and therapeutic management and to establish evaluation data for setting treatment outcomes (1-3). Furthermore, hand grip strength has been reported as a predictor of disability such as osteoarthritis of the hand, rheumatoid arthritis (4, 5). Assessing grip strength is useful to evaluate the status of people in various fields. Several studies have been reported that handgrip was significant predictor of distal radius bone mineral density in pre and postmenopausal women (6, 7). Moreover, some studies have reported that grip strength was significant measurement to reveal the association between sarcopenia and osteoporosis, falls and fractures in postmenopausal women (8, 9). A few reports have described normative hand grip strength in baseball players. Nakata et al. reported that grip strength is a significant predictor of pitched ball kinetic energy among young baseball players (10). Harada et al. reported a weak but not significant relation between elbow injury and grip strength (25 kg or more) in young baseball players (9–12 years) (11). It seems important to investigate normative data for grip strength of baseball players to evaluate their performance and condition. Nevertheless, few

reports have explained the association between grip and pinch strength for baseball pitchers. Kibler et al. reported that individual body segments, or links, are coordinated in their movements by muscle activity and body positions to generate, summate, and transfer force through these segments to the terminal link. This sequencing is usually termed the kinetic chain (12). The throwing motion consists of 6 phases (windup, early cocking, late cocking, acceleration, deceleration, and follow-through). These phases are linked and resulted in effective generation and transfer of energy from the body into the arm and the hand and ball (13). Gripping and pinching a ball seems to be apparently the goal of the kinetic chain use for the throwing motion. Investigation of normative data related to grip and pinch strength in baseball pitchers is important. Pitchers have thrown pitches of various types from youth. Earlier studies have reported a relation between types of pitches thrown and risk of throwing injury in baseball pitchers (14, 15). However, no report has described a study related to the association between grip and pinch strength and types of pitches thrown by high-school baseball pitchers. Pitchers throw various types of pitches (fast ball, slider ball, curveball, changeup ball, other) to strike a batter out and to keep most hitters off. They use intrinsic muscles of the hand and extrinsic muscles of the forearm to grip a baseball. As an illustration, fastball was the most commonly used pitch. In the grip procedure of fastball, the index and middle finger tips are placed directly on the perpendicular seam of the baseball. The thumb is directly beneath the baseball and is allowed to rest on the smooth leather. Palmar pinch strength is apparently important to hold a ball when throwing a fastball (16). We hypothesized that frequency of throwing types of pitches in pitchers influenced their grip strength and tip, palmar, key pinch strength.

2. Objectives

This study evaluated the association between clinical normative data for grip, pinch strength and anthropometric variables and assessed the relation between grip and three pinch strength and types of pitch thrown by high-school baseball pitchers.

3. Materials and Methods

3.1. Participants

This study examined 133 high-school baseball pitchers aged 15-17 years old. Exclusion criteria were any history of hand injuries and previous hand surgery. The participants and their parents agreed by informed consent form. This study was approved by the Institutional Review Board.

3.2. Measurement

Each participant had completed a self-administered questionnaire including items related to age, hand dominance, years of playing, throwing ratio of type of pitch. We investigated the throwing ratios of five types of pitches thrown (fastball, sliderball, curveball, changeup ball, other). A digital dynamometer (Takei Scientific Instruments Co., Tokyo, Japan) was used to measure the grip strength. A pinch gauge (MG-4320NC pinch gauge; B & L) was used to measure tip, key and palmar pinch on both dominant and non-dominant sides. Grip testing was performed using a standardized position recommended by the American Society of Hand Therapists. Subjects were seated with the shoulder in adduction and neutral rotation, elbow flexed at 90°, forearm in neutral position, and wrist between 0°and 30°of extension and 0°and 15°of ulnar deviation. Pinch testing was performed with the shoulder, elbow, forearm, and wrist in neutral position. We conducted three kinds of pinch tests: a tip pinch is the thumb tip to the index fingertip; a key pinch is the thumb pad to the lateral aspect of middle phalanx of index finger; a palmar pinch is the thumb pad to pads of the index and middle fingers. For each grip and pinch test, three measurements were performed between dominant and non-dominant side. All tests were measured by a single orthopaedic surgeon. Height was measured using a digital height meter (A&D Corp., Tokyo, Japan). The body composition was measured using a multi-frequency segmental body composition analyzer (MC780U; Tanita Corp., Tokyo, Japan). Body mass, body mass index, total muscle mass, fat mass, fat free mass, muscle mass of upper and lower muscle were measured.

3.3. Statistical Analyses

Differences between dominant and non-dominant grip strength, tip, key and palmar pinch were compared using a paired sample t-test. The relation between grip strength and tip, key, palmar pinch strength of dominant and non-dominant sides and anthropometric variables (height, body mass, body mass index, each upper muscle mass, total muscle mass, fat mass, fat free mass) were analyzed using Spearman's rank correlation coefficient. Multiple regression analysis was used to evaluate factors that might affect grip strength such as height, body mass, BMI, tip pinch, key pinch, palmar pinch strength, total muscle mass, fat mass, fat free mass, and muscle mass of the upper extremity of dominant side. Spearman's rank correlation coefficient was performed to elucidate the relation between the throwing ratio of types of pitch and grip, tip pinch, key pinch, and palmar pinch strength of the dominant side. Statistical analyses were conducted with software (SPSS 19.0 for Windows; SPSS Inc.). A P value of < 0.05 was regarded as statistically significant.

4. Results

The general characteristic data are presented in Table 1. Considering the throwing side as dominant, 79.4% of participants were right-handed, 20.6% of them were left handed. Grip strength and tip and palmar pinch strength and muscle mass of upper extremity in the dominant side

were statistically greater than those of the non-dominant side. However, key pinch strength of the non-dominant side was greater than that of the dominant side (Table 2). No significant difference was found between grip strength and tip, key, or palmar pinch of the dominant side in right-handed pitchers or those on the dominant side in left-handed pitchers. Significant associations were found between grip strength and height, body mass, BMI and tip pinch, key, and palmar pinch strength and muscle mass of upper extremity, fat-free mass on the dominant side. A stepwise multiple regression analysis revealed that fat free mass, tip, palmar and key pinch strength were predictors of grip strength on the dominant side (Table 4). No significant correlation was found between the throwing ratio of types of pitches thrown and grip strength and tip, key, palmar pinch strength (Table 5).

Table 1. Characteristics of Study Participants

Variable	Mea ± SD	Minimum	Median	Maximum
Age, y	16.5 ± 0.5	15.0	17.0	17.0
Height, cm	172.8 ± 5.7	155.5	172.5	188.3
Body mass, kg	65.4 ± 7.9	40.1	65.4	90.4
BMI, kg/m^2	21.8 ± 2.2	16.6	21.7	31.0
Years of experience, y	8.4 ± 1.8	2.0	8.0	13.0
Fat-free mass, kg	57.1 ± 5.5	36.2	56.9	73.1
Fat mass, kg	8.2 ± 3.6	2.4	7.7	24.1
Muscle mass of dominant upper extremity, kg	2.9 ± 0.4	1.7	2.8	3.9
Muscle mass of nondominant upper extremity, kg	2.8 ± 0.4	1.7	2.8	3.9
Ratio of type of pitching ball, %				
Fastball	59.9 ± 11.4	30.0	60.0	90.0
Slider ball	16.0 ± 10.1	0.0	20.0	45.0
Curveball	14.4 ± 10.7	0.0	10.0	50.0
Changeup ball	3.8 ± 5.6	0.0	0.0	25.0
Other	5.8 ± 7.7	0.0	0.0	30.0

Table 2. Comparison Between Dominant and Non-Dominant Side in Grip and Pinch Strength [a]

Strength Test	Dominant	Non-Dominant	P Value[b]
Grip, kg	39.4 ± 5.5	38.6 ± 5.8	0.002
Tip pinch, kg	6.5 ± 1.8	6.1 ± 1.3	0.000
Key pinch, kg	8.8 ± 1.5	9.0 ± 1.6	0.016
Palmar pinch, kg	7.6 ± 1.4	7.4 ± 1.3	0.016

[a] Values are shown as mean±standard deviation.
[b] $P < 0.05$.

Table 3. Correlation Between Anthropometry and Grip and Pinch Strength in Dominant Side

	Height	Body masst	BMI	Grip	Tip Pinch	Key Pinch	Palmar Pinch	Upper Extremity Mass	Fat-Free Mass	Fat Mass
Height	1.00									
Body mass	0.48[b]	1.00								
BMI	-0.04	0.81[b]	1.00							
Grip	0.33[b]	0.50[b]	0.37[b]	1.00						
Tip pinch	0.09	0.23[a]	0.20[a]	0.20[a]	1.00					
Key Pinch	0.20[a]	0.24[b]	0.18[a]	0.42[b]	0.41[b]	1.00				
Palmal Pinch	0.06	0.19[a]	0.16	0.32[b]	0.38[b]	0.35[b]	1.00			
Upper extremity mass	0.50[b]	0.77[b]	0.56[b]	0.56[b]	0.17	0.33[b]	0.15	1.00		
Fat-free mass	0.62[b]	0.91[b]	0.63[b]	0.57[b]	0.21[a]	0.32[b]	0.16	0.92[b]	1.00	
Fat mass	0.16	0.77[b]	0.80[b]	0.22[a]	0.19[a]	0.08	0.13	0.28[b]	0.47[b]	1.00

[b] $P < 0.01$.
[a] $P < 0.05$.

Table 4. Predictor Variables of Grip Strength in Dominant Side

Variable	Standard Partial Regression Coefficient	95% CI	P Value
Fat free mass	0.50	0.29-0.6	0.000[b]
Key Pinch	0.41	0.49-1.99	0.001[b]
Palmar Pinch	0.32	0.30-1.68	0.005[b]
Tip pinch	0.14	(-1.64)-(-0.01)	0.046[c]

[b] $P < 0.01$.
[c] $P < 0.05$.

Table 5. Correlation Between Grip and Pinch Strength and the Ratio of Type of Pitch

	Grip	Tip Pinch	Key Pinch	Palmar Pinch
Fast	-0.06	-0.08	0.06	0.05
Slider	0.10	0.06	0.05	0.06
Curve	-0.05	-0.03	-0.07	-0.14
Change up	-0.09	0.12	-0.03	-0.03
Other	0.12	-0.01	0.04	0.05

5. Discussion

Measurements of the hand grip and pinch strength are convenient means to evaluate forearm and hand function. Furthermore, grip strength has been advocated as a predictor of etiological factors of mortality and disability in many patients and elderly people (4-9). Hand grip assessment provides clinical information that reflects many human characteristics. In sports, grip strength is a significant predictor for pitched ball kinetic energy among young baseball players (10). In baseball players, pitchers especially use the intrinsic muscles of the hand to throw balls with various pitches. It is therefore apparently important to assess the grip strength and pinch strength to evaluate sporting performance. Normative grip and pinch strength data hold utility in the management of hand injuries related to baseball and the standard for monitoring grip and pinch strength in baseball pitchers. A few reports have described normative data of grip and pinch strength in youth baseball players, but many reports have examined the general population (1-3, 17-21). We investigated the normative data of grip and pinch strength and the relation between those data and the types of pitches thrown by high-school baseball pitchers. For this study, a digital dynamometer (Takei Ltd.) was used to measure grip strength. The Jamar dynamometer, recommended by the American Society of Hand Therapists, has been used in many studies to analyze the quantity of grip strength. The Takei device has been used in large-scale studies conducted in Europe (18, 22). It was recently reported to have superior criterion-related validity and reliability compared to the Jamar dynamometer for the study of adolescents (23). A B&L pinch gauge was used in this study for the quantitative evaluation of tip, key and palmar pinch strength. Earlier reports have described that this instrument exhibited high reliability and validity in measuring tip, key, and palmar pinch strength (24). Earlier reports have described that the dominant hand is 10% stronger than the non-dominant hand in the general population (25). However, this evidence has only been validated for right-handed subjects. In this study, the grip strength of the dominant side was about 3.9% greater than that of non-dominant side in right-handed pitchers; the grip strength of the dominant side was about 2.0% weaker than that of non-dominant side in left-handed pitchers. This result suggests that pitchers, in contrast to the general population, have no laterality of the grip strength because of the use of bilateral hand for pitching and catching the ball. Crosby et al. studied grip and pinch strength and the difference between dominant and non-dominant hands in healthy volunteers. They reported that key pinch averaged 22%, whereas tip pinch averaged 16% of maximum grip (26). Our data show that key pinch averaged about 22%, whereas tip pinched about 16%, and palmar pinch was about 19% of averaged grip in both sides. Our data show that tip pinch and palmar pinch strength of the dominant side were significantly stronger than those of the non-dominant side and that the key pinch strength of the dominant side was equal to or weaker by the approach of combing scores of right-handed and left-handed pitchers. These results suggest that tip pinch and palmar pinch strength are connected to pitching. However, our sample was small, the small sample size possibly influenced the statistical power to assess grip and pinch strength in high-school baseball pitchers. Additionally, the small number of left-handed dominant pitchers might result in unbalanced distribution of data. Further, we did not use questionnaires that evaluate the laterality of hand before being sure the thrower is a left-handed or right-

handed. As it happens, in all pitchers who participated in this study, their dominant side accorded with the throwing side. So it seemed not to influence statistical analysis of grip and pinch strength among baseball pitchers. Further large-scale research must be undertaken to assess normative data about grip, pinch strength in high-school baseball pitchers. We inferred an association between grip, pinch strength, and grip procedure of pitches. Therefore, we investigated the throwing ratios of five types of pitches thrown by the study participants: fastball, slider ball, curveball, changeup ball, other. The fastball was the most commonly used pitch by these pitchers and the most important pitch in baseball. In the grip procedure of fastball, the index and middle finger tips are placed directly on the perpendicular seam of the baseball. The thumb is directly beneath the baseball and is allowed to rest on the smooth leather (16). Palmar pinch strength is apparently important to hold a ball when throwing a fastball. The sliderball was the second common pitch. The curveball was the third common pitch among pitchers in this study. The curveball is the exact opposite as a fastball. The fastball spins from the bottom to top, on the other hand, the curve ball spins from top to bottom. The slider ball is a cross between a fastball and a curveball. It's harder than a curveball with less downward action. The slider ball grip procedure resembles that of a curveball. In the grip procedure of slider ball and curveball, the long seam of the baseball is placed between the index and the middle finger, which are close; the thumb is placed on the opposite seam underneath the baseball (16). Palmar pinch strength is apparently crucially important for throwing sliders and curveballs, too. The changeup ball is the least used pitch by these pitchers. Successful changeup pitchers generally pronate their hand outward upon releasing the baseball. This pronation allows the pitchers to apply pressure to the inside half of the baseball, which creates spin and reduces speed. In the changeup grip procedure, the ring, middle, and index are centred on top of the baseball. The thumb and little finger are placed on the smooth leather directly under the baseball (16). Extrinsic muscles of the forearm are apparently used more in the changeup grip compared than with fast, curve, and slider ball grips. However, no significant correlation was found between the throwing ratios of types of pitches thrown and the grip strength and the tip, key, palmar pinch strength. The reason for this result might be that many pitchers had established the composition of pitching with specific examination of the fastball. In this study, we were unable to count actual pitching numbers of types of pitches. Therefore, results related to the ratio of types of baseball pitching might be influenced by recall bias. Additional studies of baseball pitchers should be undertaken to ascertain the relation between the types of baseball pitching and the players' grip and pinch strengths. De Souza et al. demonstrated that grip strengths of dominant side were positively correlated with BMI, height and body mass, and fat free mass in 295 healthy children of both genders aged 6-13 years (27). Jurimae et al. reported that fat free mass, BMI, and height had the great influence on hand grip strength in 64 prepubertal children aged 8-11 years (21). In sports population, Nikolaidis et al. reported that bilateral grip strength were positively associated with body mass, height, BMI, fat mass, fat-free mass in 291 adolescence soccer players aged 12-21 years (28). In our study, grip strength of the dominant side was positively associated with height, body mass, BMI, and tip pinch, key pinch, palmar pinch strength and muscle mass of upper extremity of the dominant side, fat free mass, and fat mass. Furthermore, results of stepwise multiple regression show that tip and palmar and key pinch strength and fat-free mass are predictors of grip strength on the dominant side. Results suggest that in body composition variables, fat-free mass significantly influenced the grip strength among prepubertal and pubertal subjects. Grip strength was strongly connected with pinch strengths. However, Günther et al. found a correlation between forearm circumference, hand width, hand length and grip strength in healthy Caucasian adults (29). We were unable to observe these anthropometric measures in this study. Additional studies must be conducted to confirm the association between grip strength and other anthropometric variables. Normative data were obtained for grip strength and tip, key and palmar pinch strength for high-school baseball pitchers. Tip and key pinch and palmar pinch strength and fat free mass were found to be predictors of grip strength in dominant side. No significant correlation was found between the throwing ratios of types of pitches thrown and the grip strength and tip, key, and palmar pinch strength. We believe these data will be useful for clinical screening and for maintaining the condition of high-school pitchers.

Acknowledgements

For their cooperation and support in this research, the authors thank the high-school baseball players, their parents, coaches, and the staff members of the regional high-school baseball association, as well as medical staff members.

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