Muscular Characteristics of the Dominant Upper Arm in Japanese Little League Baseball Pitchers

Yuichi Hirano

Department of Sports Sciences, College of Arts and Sciences, University of Tokyo

Abstract

The purpose of this study was to investigate the characteristics of the triceps muscle in the dominant arm in little league baseball pitchers in comparison with that of professional baseball pitchers in Japan. The cross-sectional area and the maximum isometric strength of the triceps muscle and the pitched ball speed were measured on fifteen little leaguers and five professional ones. Results were as follows :

1) The cross-sectional area of the triceps muscle in the little leaguers increased with the increment of the body weight.
2) There was no significant difference between the little leaguers and professional ones in the percentage of the cross-sectional area of the triceps muscle to that of the whole upper arm muscle.
3) No significant difference in the maximum isometric strength per unit cross-sectional area of the triceps muscle was observed between the little leaguers and the professional ones.
4) There was no significant correlation between the pitched ball speed and the maximum isometric strength of the triceps muscle.
5) The pitched ball speed per maximum isometric strength of the triceps muscle for the little leaguers was significantly greater than that of the professional ones.

Key Words: baseball, little league, triceps muscle, ball speed.

Introduction

Various reports with regard to the incidence of the throwing injury have been published[1,2,19]. And it has been said that excessive pitching places abnormal stress on the shoulder and/or the elbow and gradually leads to the throwing injury. Especially, clinical and roentgenographic studies on the little league baseball pitchers[5,7,9,10] revealed that young and growing pitchers tend to suffer this injury. Therefore, with a preventive purpose against the throwing injury, it must have some meaning to investigate physiological nature of pitching motion in youngsters.

The pitching motion consists of three phases such as cocking, acceleration and follow-through. The acceleration phase is considered to be the most important in deciding the speed of the ball, because the ball gets its speed owing to the drastic elbow extension[14,16,17]. EMG analyses of the functions of the muscles on the shoulder and the upper arm in pitching[11,12] have also indicated that the ball speed was dependent upon the magnitude of contraction of the triceps muscle.

In order to clarify the characteristics of the throwing arm of young pitchers, it was intended to investigate the characteristics of the dominant triceps muscle in Japanese little league baseball pitchers in comparison with that of Japanese professional ones.

Procedure

Subjects: Fifteen little league and five professional baseball pitchers in Japan served as the subjects for this study. Preliminary descriptive data for each group are presented in Table 1. All pitchers (right handed) were active as competitive baseball players and had no symptom of exercise-induced pain. After receiving a detailed explanation of the intent of the study, they submitted their informed consents for participation.

Muscle Cross-sectional Area: The length of the right upper arm of each subject, from the acromion to the olecranon, was measured and the 60% distal point from the acromion was marked on the skin. Each subject immersed his right arm perpendicularly in a water tank to get the cross-sectional image of his upper arm, which was obtained by use of the ultrasonic apparatus (ALOKA, Echo-vision, SSD-120) connected with the circular compound scanner. The 5 MHz frequency of ultrasonic wave was selected to get a clear image of each muscle bundle and the image was photographed by a 35 mm camera. The cross-sectional area of each muscle bundle was obtained from this photograph by using a planimeter. In this study, the precentage of the cross-sectional area of the triceps muscle to that of the whole muscle on the upper arm was calculated.

Maximum Isometric Strength: The maximum isometric strength of the triceps muscle in the right arm was measured by means of strain gauge force transducer. Each subject seated on a chair and put his upper arm on a specially designed horizontal rest set above the right edge of the seat, and the forearm was pronated at 60° flexion in the elbow joint (full extension = 0°). Additional stabilization was achieved with a seat belt.

Pitched Ball Speed: Each subject was asked to pitch the official baseball (141.7-148.8 g) with his best effort from the stretch position. His pitching motion was filmed by a 16 mm cinecamera (Photosonics 16-1 P, 200 frames/sec), which was located perpendicular to the line from pitcher's mound to home plate. The film was analyzed with the aid of a film motion analyzer (SPORTIAS model-200, Nac). Pitched ball speed was obtained by dividing the horizontal displacement(m) of the pitched ball for 5 msec after ball release by the equivalent time(sec).

Statistics: Data were presented as ranges (lowest-highest) for the little leaguers and means± SDs for the professional ones, respectively. When the examinations were made on the relationships between given two measurements for little leaguers, the fiirst order of partial correlation by age was used. Means and standard deviations were used to determine the differences between two groups. A p value less than 0.05 was accepted as significant.

Table 1. Subjects' Data

		Age (yrs)	Height (cm)	Weight (kg)
Little League Pitchers	N=15	9-12	130.6-167.1	27.4-62.4 (range)
Pro-Baseball pitchers	N=5	22	182.4	80.4 (mean)

Results

The cross-sectional areas of the whole muscle and the triceps muscle were 11.85–32.46 cm^2 and 6.30–17.16 cm^2 for the little leaguers, and 45.06±4.55 cm^2 and 26.04±4.62 cm^2 for the professional ones, respectively. Fig. 1 shows the relationships between the body weight and the cross-sectional areas of the triceps muscle and the whole muscle. Both cross-sectional areas for the little leaguers increased linearly with the increment of the body weight. Even if the age of the little leaguers was partialized, both relationships were found to be significant ($r_{12,3}$=.738, .714). But, the percentage of the cross-sectional area of the triceps muscle to that of the whole muscle for the little leaguers resulted in a constant value (55.5±3.8% (mean±SD)) in spite of the difference in the body weight. This percent-

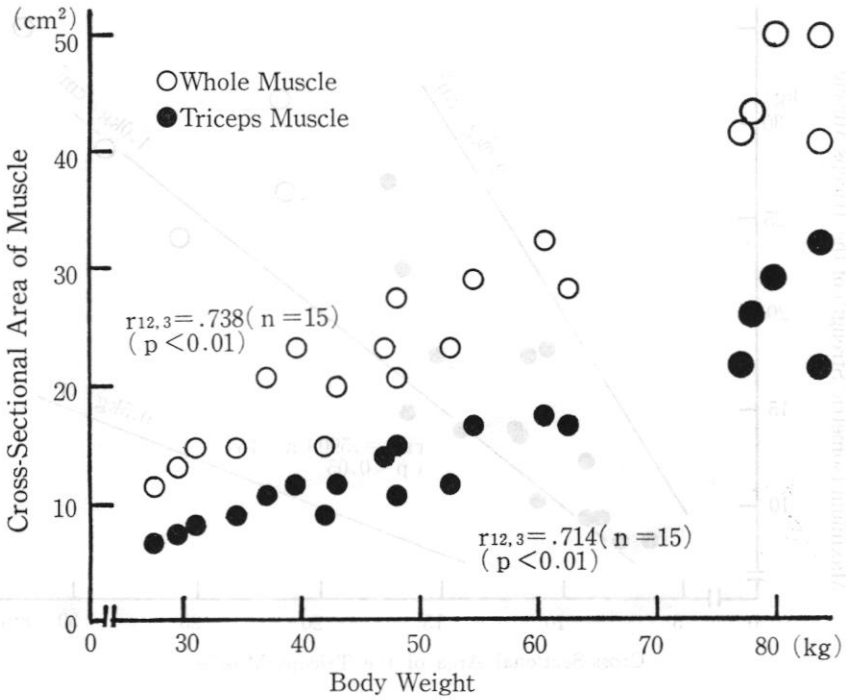

Fig. 1 Relationships between the body weight and the cross-sectional areas of the triceps muscle and the whole muscle (large circles: Pro-Baseball Pitchers)

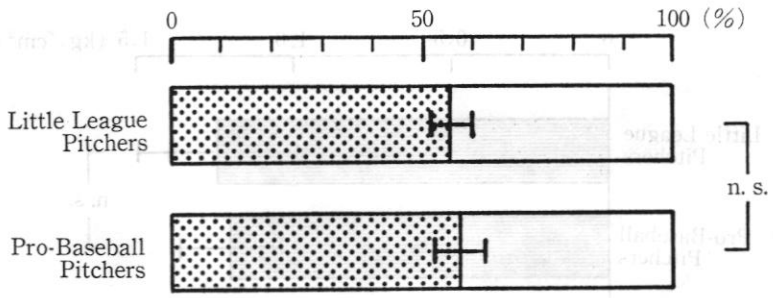

Fig. 2 Percentage of the cross-sectional area of the triceps muscle to that of whole muscle

age was not significantly different when compared with the value of the professional ones (57.5±5.0%) (Fig. 2). This result indicates that the little leaguers have the same relative amount of the triceps muscle as the professional ones.

The maximum isometric strength (8.2-27.0 kg) of the triceps muscle for the little leaguers increased in proportion to the increment of the cross-sectional area of the triceps muscle (Fig. 3). In order to eliminate the factor of growing in the body, age-partialized correlation coefficient was calculated ($r_{12,3}=.590$). The correlationship between the cross-sectional area and the maximum isometric strength of the triceps muscle was found to be significant ($p<0.05$). The professional ones exhibited 29.1±4.3 kg in the maximum isometric strength of the triceps muscle. Although this value was greater than that of the little leaguers, no significant difference was found between the little leaguers (1.24±0.25

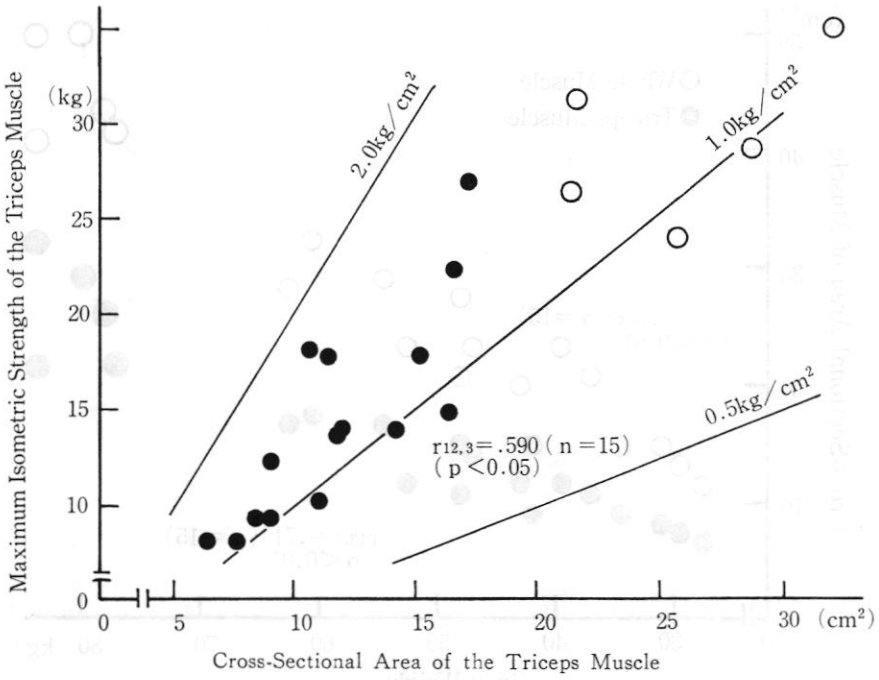

Fig. 3 Relationship between the cross-sectional area and the maximum isometric strength of the triceps muscle. (○ Pro-Baseball Pitchers)

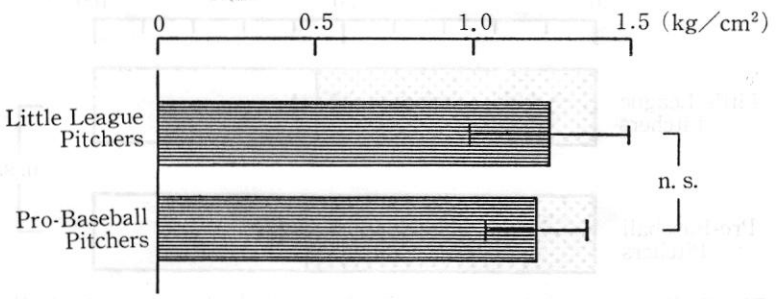

Fig. 4 Maximum isometric strength per unit cross-sectional area of the triceps muscle

kg/cm²) and the professional ones (1.20±0.16 kg/cm²) in the maximum isometric strength per unit cross-sectional muscle area (Fig. 4).

Pitched ball speeds were 20.6–27.1 m/sec for the little leaguers and 31.4±2.3 m/sec for the professional ones. Fig. 5 illustrates the relationship between the maximum isometric strength of the triceps muscle and the pitched ball speed. Estimating from the first order of partial correlation ($r_{12,3}$ = .401; n. s.), it would appear that the pitched ball speed did not solely depend on the maximum isometric strength of the triceps muscle. However, considering that the muscle strength produces the acceleration of body segment and results in the increment in the pitched ball speed, it might suggest that the pitched ball speed per maximum isometric strength of the triceps muscle could be used as an index showing the contribution of the muscle to the pitched ball speed. The value was significantly greater for the little leaguers than for the professional ones (Fig. 6).

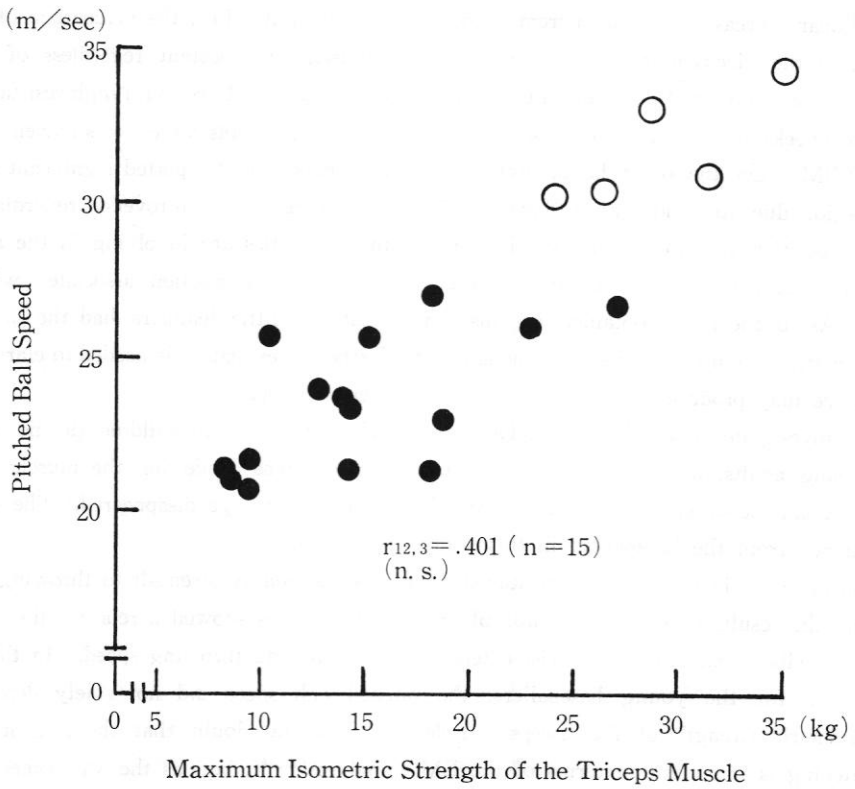

Fig. 5 Relationship between the maximum isometric strength of the triceps muscle and the pitched ball speed (○ Pro-baseball Pitchers)

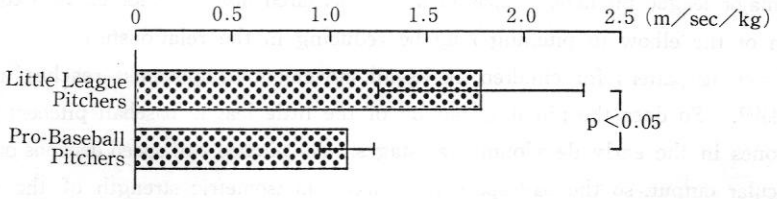

Fig. 6 Pitched ball speed per maximum isometric strength of the triceps muscle.

Discussion

Krogman[13] estimated the maturation age of 55 little league baseball players by means of the X-ray film of the hand and concluded that little league baseball players were, in general, biologically advanced. Using the Crampton public hair index, Hale[6]also reported that 45.5% of little league baseball players were postpubescent and more pitchers and first basemen tened to be maturer than the players at other positions. Considering the age range of subjects in this study, prepubescent pitchers might be included. Therefore, the first order of partial correlation by age was used to estimate the relationships between the given two measured items.

Fig. 1 shows the relationships between the body weight and the cross-sectional areas of the triceps muscle and the whole upper arm muscle. The cross-sectional area of the triceps muscle exhibited a linear increase with the increment of the body weight. But, the percentage of the cross-sectional area of the triceps muscle to that of the whole muscle was constant regardless of the career in baseball (Fig. 2). Gifford[4], having trained prepubescent boys (7-11 yrs) with high resistance cycling (20 min/d, 3 ds/week) for 10 weeks, concluded that the training protocols were not sufficient to induce changes in LBM. On the other hand, Von Dobeln and Eriksson[18] reported significant changes in body composition due to conditioning (boys, 11-13 yrs). There is a controversy regarding exercise and body composition in children and youth, because the difficulties are involving in the attempts to separate the induced effects of exercise from changes in the body composition associated with growth and mature. As to the result obtained in this study that the little leaguers had the same relative amount of the triceps muscle as the professionall ones, further investigation is needed to clarify whether pitching practice may produce the hypertrophy in the triceps muscle.

Davies[3] investigated strength and mechanical properties of muscle in children (9 and 11-year-old boys) and young adults, and reported that, if standardization was made for the muscle (plus bone) cross-sectional area, the difference in muscle strength with respect to age disappeared. The same result was also obtained from the baseballers in this study.

Pedegana et al.[15] investigated the relationship of upper extremity strength to throwing speed and concluded that the results of simple and multiple regression analysis showed a relationship between the strength of the elbow extension and wrist extension movement and throwing speed. In this study, it was found that, for the young baseballers, the pitched ball speed did not solely depend on the maximum isometric strength of the triceps muscle. It is of no doubt that the role of the triceps muscle in pitching is important in terms of the EMG analyses[12,16], but, as the well-timed sequential coordination of muscle activation supports the skilled pitching motion, single isometric muscular output may not have so strong a relationship with the pitched ball speed. In addition, Toyoshima et al.[16] reported that, in normal throwing, the angular velocity of the elbow extension was 31.14 rad/sec. For the professional major league pitchers, Pappas et al.[14] measured 4595°/sec for elbow extension. Quick extensing motion of the elbow in pitching may be reducing in the relationship.

Overhand throwing pattern for children, in its all movement components, reaches advanced level by seventh grade[8]. So does the pitching motion of the little league baseball pitchers get to that of the professional ones in the early developmental stages. As pitched ball speed depends on both pitching motion and muscular output, so the ball speed per maximum isometric strength of the triceps muscle for the little leaguers may become greater than that of the professional ones. Therefore, it may be

supposed that the weight of a baseball gives a greater stress on the triceps muscle in the little leaguers. These findings may provide a rationale for the warning derived from clinical and roentgenographic studies on the little league baseball players.

References

(1) Albright, J. A. et al.: Clinical Study of Baseball Pitchers: Correlation of Injury to the Throwing Arm with the Method of Delivery. Am. J. Sports Med., 6: 15-21, 1978.

(2) Atwater, A. E.: Biomechanics of Overarm Throwing Movements and of Throwing Injuries. Exercise and Sport Sciences Reviews, 7: 43-85, 1979.

(3) Davies, C. T. M.: Strength and Mechanical Properties of Muscle in Children and Young Adults. Scand. J. Sports Sci., 7: 11-15, 1985.

(4) Gifford, P.: The Effect of High Resistance and High Repetition Physical Activity on the Body Composition of Prepubescent Boys. Unpublished Ph. D. dissertation, University of Illinois, Urbana-Champaign, IL, 1973.

(5) Gugenheim, J. J. et al.: Little League Survey: the Houston Study. Am. J. Sports Med., 4: 189-200, 1976.

(6) Hale, C. J.: Physiological Maturity of Little League Baseball Players. Res. Quart., 27: 276-284, 1956.

(7) Hale, C. J.: Injuries among 771, 810 Little League Baseball Players. J. Sports Med. and Phys. Fitness, 1: 80-83, 1961.

(8) Halverson, L. E.: Development of the Overarm Throw: Movement and Ball Velocity Changes by Seventh Grade. Res. Quart. for Exer. and Sport, 53: 198-205, 1982.

(9) Hang, Y.: Little League Elbow: A Clinical and Biomechanical Study. Biomechanics VIII-B: 70-85, 1983.

(10) Hansen, N. M.: Epiphyseal Changes in the Proximal Humerus of an Adolescent Baseball Pitcher. Am. J. Sports Med., 10: 380-384, 1982.

(11) Jobe, F. W. et al.: An EMG Analysis of the Shoulder in Throwing and Pitching. A Preliminary Report. Am. J. Sports Med., 11: 3-5, 1983.

(12) Jobe, F. W.: An EMG Analysis of the Shoulder in Pitching. A Second Report. Am. J. Sports Med., 12: 218-220, 1984.

(13) Krogman, W. M.: Maturation Age of 55 Boys in the Little League World Series, 1957. Res. Quart., 30: 54-56, 1959.

(14) Pappas, A. M. et al.: Biomechanics of Baseball Pitching. A Preliminary Report. Am. J. Sports Med., 13: 216-222, 1985.

(15) Pedegana, L. R. et al.: The Relationship of Upper Extremity Strength to Throwing Speed. Am. J. Sports Med., 10: 352-354, 1982.

(16) Toyoshima, S. et al.: Contribution of the Body Parts to Throwing Performance. Biomechanics IV: 169-174, 1974.

(17) Vaughn, R. E.: An Algorithm for Determining Arm Action during Overarm Baseball Pitchers. Biomechanics IX-B: 510-515, 1985.

(18) VonDobeln, W. and B. O. Eriksson: Physical Training, Maximum Oxygen Uptake and Dimensions of the Oxigen Transporting and Metabolizing Organs in Boys 11-13 years of age. Acta Pediatr. Scand., 61: 653-660, 1972.

(19) Wilson, F. D. et al.: Valgus Extension Overload in the Pitching Elbow. Am. J. Sports Med., 11: 83-88, 1983.