THE ROLE OF MUSCLE IN GLENOHUMERAL JOINT STABILITY DURING BASEBALL PITCHING

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INTRODUCTION

Joint instability is one of the most common human afflictions. Capsulolabrum, articular surfaces, intracapsular pressure and muscle contractions are the factors in maintaining joint stability. The glenohumeral joint is a common dislocated large joint of the body [1]. Shoulder motion with improper muscular coordination or need of explosive muscle contraction is easy lead to joint dislocation such as baseball pitching. The purpose of this study was to examine how the muscle functions response for joint stability during baseball pitching. We hypothesize that muscle contraction force contributed the most to balance external loading to keep joint stability.

METHODS

A graphic-based musculoskeletal model of the shoulder was utilized for the dynamic analysis [2] (Fig. 1). Ten muscles with fifteen action lines were included in the shoulder model. The pitching motion of a college baseball pitcher was captured using a Qualisys™ motion analysis system (Qualisys AB, Sweden) at a 500Hz sampling rate. Using the inverse dynamic problem solution and Newtonian analysis, the joint resultant forces and moments at shoulder were quantified. The indeterminate problem was solved using an optimization technique by minimizing the sum of the squares of muscle stresses. Additional inequality constraints on muscle stress were considered, thus making the present formulation a "mini-max" problem. Sequential quadratic programming and a steepest decent algorithm were used to search for the muscle contraction force. The magnitude and action line of resultant joint force, joint constraint force (joint contact force and passive element forces) and muscle contraction force was used to identify the contribution to joint stability. For the results presentation, the action line of the muscle, resultant joint force, and joint constraint force were projected to scapular coordinate and expressed as anterior/posterior (z-axis), superior/inferior (y-axis), centripetal/centrifugal (x-axis).

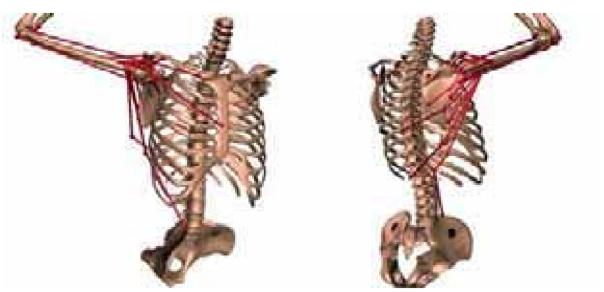

Fig. 1 The graphic_based musculoskeletal model of the shoulder.

RESULTS AND DISCUSSION

Results showed that the resultant joint force has significant loading force until the end of late cocking phase. The maximum resultant joint force in centripetal direction (851N) was occurred in ball releasing, and inferior direction (479N) at the end of late cocking phase. The force in anterior/posterior direction was relative small and found the maximum loading force in follow through phase about 390N. From the muscle forces analysis, the joint constraint forces contributed very little to keep joint stability from the end of late cocking phase to the acceleration phase. During this period, eight of fifteen muscle action lines are mainly in the inferior direction (Table 1). Among these muscles, sternal and clavicle branch of the pectoralis major, infraspinatus, and supraspinatus had significant contraction forces. At this moment, glenohumeral joint could not rely on its geometry to keep joint stability. These muscles forces contribute to both joint motion and stabilization. On the contrary, at the ball release, only four muscle action lines are in the centripetal direction and only latissimus dorsi had significant contraction force. That means that joint contact force could provide enough joint stability.

Table 1. The magnitude and orientation of action line of joint resultant force and muscles at the end of late cocking phase.

	Orientation	Force (N)
Joint resultant force	(0.45, -0.89, 0.09)	479
Pectoralis major (sternal)	(-0.52, -0.84, -0.19)	95
Pectoralis major (clavicle)	(-0.18, -0.98, 0.11)	135
Infraspinatus	(0.46, -0.79, -0.41)	276
Supraspinatus	(0.35 -0.93, 0.06)	82

CONCLUSIONS

This quantitative model improves our understanding of the role of shoulder muscles in glenohumeral joint during the baseball pitching. Muscles not only play the movers but also stabilizers especially when joint had anterior/posterior and superior/posterior external loading. Future study may optimize muscles strengthening to maximize compressive forces to keep joint stability

REFERENCES

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