AN INVESTIGATION OF THE CONGRUITY IN GEOMETRY OF THE GLENOHUMERAL JOINT ON THE MAXIMUM ACCEPTABLE LOAD DURING PUSHING

Krystyna Gielo-Perczak
Liberty Mutual Research Institute for Safety and Health, Hopkinton, MA U.S.A.
email: Krystyna.Gielo-Perczak@LibertyMutual.com web: www.libertymutual.com/research/

INTRODUCTION

Occupational ergonomics and safety analyses of the human body require a new biomechanical approach that combines the geometric complex nature of the human joints with the requirements of the workplace in order to explain the mechanism of musculoskeletal disorders. Recent analyses of the glenohumeral joint have not focused on the contribution of geometric parameters like the radii of the glenoid fossa of scapula and the humerus, and their functional relationship to strength. However, Saha (1961) pointed out the variance of shoulder anatomy relating to the congruity of the glenoid and humeral head. In the general population we can distinguish the three most common characteristic shoulder joints: 1) Type A, the glenoid with a radius that is larger than that of the humerus, 2) Type B, the glenoid and the humerus with the same radius, 3) Type C, the glenoid with a smaller radius than that of the humerus [1]. The purpose of the current study was to answer to question is the strength used in one-handed pushing related to the congruity of the glenoid and humeral head?

METHODS

The coefficient of congruity(conformity) (R/r) was defined as a ratio of the humerus radius (R) and radius of the glenoid fossa of the scapula (r) curvature. This coefficient for type A was defined as ≤ 0.75, where components were with unequal radii of curvature (glenoid larger) nonconforming articulation; for type B as <0.75; 1.25>, as a conforming articulation where humeral and glenoid components were almost equal and for type C as ≥ 1.25, nonconforming articulation with glenoid radius smaller than the humerus.

Frontal MRI images of the glenohumeral joint of the right arm were obtained from 12 healthy men who had never experienced chronic shoulder pain, stress fracture, or joint injury. Data were recorded by using a 1,5-T Sigma system (GE Medical Systems). The subject lay in an MRI tube in a prone position with his arm in 0° of adduction. The elbow was flexed to 90° with the forearm lying on the chest. The magnetic resonance images were taken at the same arm positions for all subjects.

The same 12 subjects performed a series of simulated pushing tasks in laboratory conditions. A special constrained framework was designed with twelve force sensors. Subjects exerted maximum push force during maximum voluntary contraction (MVC) on a handle in a sidewise direction. The subjects were asked to push on the handle and MVC loads were recorded when the arm was abducted from 5 to 30 degrees in the frontal plane. Over a two-week period, each subject performed two and four repetitions of constraint range upper-limb abduction and abduction at six different randomized angles while standing. For each repetition, participants were instructed to gradually increase their effort to what they felt was an acceptable maximum force. Once the maximum force was reached, subjects sustained MVC on the instrumented handle for three seconds.

Subject	*R/r*	Type
1	1.41	C
2	0.72	A
3	0.70	A
4	0.69	A
5	1.13	B
6	0.77	B
7	0.86	B
8	0.70	A
9	1.39	C
10	0.47	A
11	1.05	B
12	1.38	C
Mean	0.71	

Table 1: The coefficient of congruity (R/r) and type of joint for 12 participants.

RESULTS AND DISCUSSION

The participants' mean age and standard deviation was 40.5 ± 8.7 years, with an average height of 178 ± 7.08 cm and body weight of 81.5 ± 14.9 kg. The coefficient of congruity and related type of joint for the 12 participants are presented in Table 1. The three most common types of shoulder joint congruity among 12 subjects do not correlate with mean forces recorded at the handle during maximum voluntary contraction when arm was abducted from 5 to 30°.

The results from study [2] relating to one-handed pushing showed that the maximum forces exerted were higher than in the current study, but the subjects had free movement and were not constrained. Perhaps the constrained position of participants in the current experiment was a very unique factor which was never before considered during the strength measurements.

CONCLUSIONS

The investigation didn't reveal the influence of the coefficient of congruity on the maximum acceptable load applied to the hand during pushing. However, the study confirmed that the relation of different geometric parameters of glenohumeral joint should be analyzed which have an influence on the strength of the subject.

REFERENCES

1. Gielo-Perczak et al. *Proceedings of HFES 49th*, New Orleans, USA, 233-237, 2004.
2. Mital et al, *A guide to Manual Materials Handling,* 1997.