早稲田大学審査学位論文
博士（スポーツ科学）
概要書

A kinematic analysis of shoulder and torso during front crawl swimming and its implications to overuse injuries

クロール泳における肩複合体と腰部の 3 次元運動：慢性障害との関連

２０１６年１月

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Chapter 1 Introduction

Overuse injuries are very common complaints among competitive swimmers. More than half the competitive swimmers experience athletic injuries in their career and most of the injuries are classified as overuse injuries. In swimming, overuse injuries frequently occur at shoulders and low back. In general, excessive joint motion has been proposed as a risk factor for overuse injuries in sports as it would generate abnormal stress to the structures within and around the joint. In swimming, torso hyperextension and glenohumeral joint motion beyond the physiologically permissible range of elevation or internal rotation have been postulated as the excessive joint motions responsible for low back pain and shoulder pain, respectively. However, no study has been conducted to determine the three-dimensional movements of low back and glenohumeral joint in swimming and, thereby, no evidence has been provided to evaluate if the excessive joint motion occurs in swimming, when and how the excessive joint motion occurs during stroke cycles and the relationship of excessive joint motions to overuse injuries. This thesis was aimed to determine the three-dimensional movements of torso and glenohumeral joint during front crawl swimming and to evaluate if these joint motions exceed the active range. The findings were expected to provide firm evidence to discuss implications of joint motions to chronic low back pain and shoulder pain in swimming.

Chapter 2 Three-dimensional torso motion in tethered front crawl stroke and its implications to low back pain

A hypothesis that swimmers experience torso hyperextension consistently across the stroke cycles was tested in this study. Nineteen collegiate swimmers underwent two measurements: a measurement of the active range of motion in three dimensions and a measurement of tethered front crawl stroke at their maximal effort. Torso hyperextension was determined as the extension beyond the active range of torso extension for a given amount of torso twist and lateral tilting. It was found that the largest torso extension angle exhibited during the stroke cycles was $9 \pm 11°$ and it was recorded at or around (0.02 ± 0.08s) the instant at which torso attained the largest twist angle. No participant hyperextended the torso consistently across the stroke cycles and the hypothesis was rejected. A reason that swimmers have been presumed to be hyperextending their torso during front crawl swimming may be due to that the complex three-dimensional movement, such as a moderate extension of a twisted torso, has given observers wrong impression of the torso configuration in the oblique view from the pool deck. On the basis of our additional analysis, we postulate a possibility that repeated torso motion beyond a specific section of the active range of motion (e.g. the individual neutral zone), rather than the whole range of motion, may increase the risk of low back pain in front crawl swimming.

The content of this chapter has been accepted for publication in Journal of Applied Biomechanics (2015, PMID: 26398960).

Chapter 3 Three-dimensional glenohumeral motion in tethered front crawl stroke and its implications to shoulder pain

A hypothesis that glenohumeral joint exceeds the physiologically permissible range of elevation

and/or internal rotation during front crawl stroke cycle was tested in this study. Abnormal stress is known to be generated in glenohumeral joint when the humerus was moved beyond the maximal range of elevation and/or the maximum range of humeral internal rotation. The glenohumeral joint motions that satisfied these criteria were detected for 17 collegiate swimmers. The results showed that the average duration over which the glenohumeral joint exhibited excessive motions was limited to 8% of the time spent in one stroke cycle. The excessive elevation at glenohumeral joint was observed in 2 subjects during the stretch phase and the excessive internal rotation was observed in 15 subjects in the outsweep phase, the first half of the insweep phase, and the second half of the recovery phase. Interestingly, visually observable excessive motions at shoulder (e.g., excessive elevation at the stretch phase) were found to occur much less likely than not-so-easily observable excessive motions (e.g., excessive internal rotation in sweep and recovery phases). These observations suggest that the coaches and trainers may not recognize if a given swimmer is at risk of developing shoulder pain. On the basis of the literature in which the structures at risk of abnormal stress are reported in various arm positions, the glenohumeral joint structures at risk of developing abnormal stress during stroke cycles of front crawl swimming may vary across the stroke phases. In the hand entry phase the acromion and the tuberosity of humerus may be subject to bone-to-bone contact stress and the articular surface of rotator cuff and the labrum are subject to compressive stress due to internal impingement; in the stretch phase the supraspinatus ligament may be subject to a contact pressure under the coraco-acromial arch; and in outsweep phase supraspinatus tendon may be subject to a contact pressure under the acromion and also to a compressive stress due to internal impingement.

Part of this chapter was published as a refereed conference proceeding of the 31st International Conference on Biomechanics in Sports (2013).

Chapter 4 General discussion

The findings of each section of the thesis have provided the evidence that the excessive joint motion on glenohumeral joint occurs in resisted front crawl swimming while the excessive joint motion on torso does not. Because of the complex three-dimensional movement of the joint, the general impression of the visually observable excessive motion may misleading the “real” excessive joint motion in swimming and hide the risk of developing chronic injury from coaches and trainer. It suggested that the joint movement during swimming should be determined in details and with considering the movement not in one plane but cross to the three dimensions. The major limitation of the present study was that the swimmers were asked to swim in a tethered condition, rather than the normal “free” swimming condition. Effects of the difference in the measurement condition were evaluated by applying a new methodology that we developed recently and confirmed that the excessive joint motion occurs in glenohumeral joint during multi phases of front crawl swimming but not in low back.