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● *Original Contribution*

ANTERIOR TRANSLATION AND MORPHOLOGIC CHANGES OF THE ULNAR NERVE AT THE ELBOW IN ADOLESCENT BASEBALL PLAYERS

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Abstract—The effect of repetitive throwing on the ulnar nerve is not clear. There are no published imaging studies regarding this issue in adolescent baseball players. The purpose of this cross-sectional ultrasonographic study was to use 5- to 10-MHz frequency ultrasonography to define the anterior translation and flattening of the ulnar nerve in different elbow positions. We divided 39 adolescent baseball players into two groups, 19 pitchers and 20 fielders, according to the amount of throwing. Twenty-four non-athlete junior high school students were also included as controls. We ultrasonographically examined each participant's ulnar nerve in the cubital tunnel with the elbow extended and at 45°, 90° and 120° of flexion. Anterior translation and flattening of the ulnar nerve occurred in all groups. Pitchers had larger-scale anterior translation than did controls. In pitchers, the ulnar nerve exhibited more anterior movement on the dominant side than on the non-dominant side. The anterior subluxation of the ulnar nerve occurred in players without ulnar nerve palsy and was not correlated with elbow pain. In addition to the known musculoskeletal adaptations of pitchers' elbows, ultrasonography revealed new changes in the ulnar nerve, anterior translation and subluxation, after repetitive throwing. These changes might also be physiologic adaptations of throwing elbows. (E-mail: jming@mail.ncku.edu.tw) Crown Copyright © 2014 Published by Elsevier Inc. on behalf of World Federation for Ultrasound in Medicine & Biology.

Key Words: **Baseball, Adaptation, Ulnar nerve, Ultrasonography, Elbow, Adolescent.**

INTRODUCTION

Sports injuries of the elbow related to throwing are quite common in both adult and adolescent athletes (Andrews 1985; Conway et al. 1992; Iwase and Ikata 1985; Keefe and Lintner 2004). A significant portion of these injuries have been attributed to pitching biomechanics, which generates a large amount of valgus torque. High-speed videography has been used to analyze the biomechanics, as described in detail (Sabick et al. 2004; Werner et al. 1993), in both adult and adolescent baseball players. In throwing, valgus torque peaks in the late cocking phase, while the shoulder is nearly maximally externally rotated. This causes distraction of the medial elbow structures and compression of the lateral elbow joint. The repetitive force may injure the anatomic structures surrounding the elbow.

The ulnar nerve runs posterior at the distal third of the humerus, passes through the arcade of Struthers and then distally crosses the elbow in the cubital tunnel, which is posterior to the medial epicondyle. This area is the base of the upper arm rotation and elbow flexion-extension bearing a large traction force (Fleisig et al. 1999). Therefore, the ulnar nerve is susceptible to throwing injuries. Cubital tunnel syndrome was thought to correlate with the amount of throwing in one game or in a limited period, although this issue is still controversial. Repeated traction, friction and anterior translation of the nerve are assumed to irritate the ulnar nerve (Byl et al. 2002; Toby and Hanesworth 1998).

The literature dealing with excursion and strain of the ulnar nerve while throwing is limited. Longitudinal

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movement and strain have been described in cadaveric studies (Aoki et al. 2005; Wright et al. 2001). Anterior subluxation of the ulnar nerve onto the medial epicondyle is often diagnosed using palpation (Calfee et al. 2010; Childress 1975) and also dynamically detected *via* ultrasonic examination during elbow movements (Okamoto et al. 2000a, 2000b). Flattening of the ulnar nerve during traction can be seen in magnetic resonance (MR) images (Patel et al. 1998). There is, however, no imaging study that focuses on changes of the ulnar nerve in baseball players, especially adolescent players. In addition, whether these changes are adaptions after repetitive throwing or pathologic conditions remains unclear. Thus, an accessible image modality is needed to better understand the association between throwing mechanics and its effect on the ulnar nerve.

Ultrasonography is able to image the peripheral nerves (Beekman and Visser 2004). This non-invasive, radiation-free and real-time imaging technique makes it possible to observe the ulnar nerve in multiple directions (Beekman and Visser 2004; Okamoto et al. 2000a, 2000b). We used ultrasonography to examine the morphologic changes of the ulnar nerve from elbow extension to flexion in adolescent baseball players and non-athlete controls. The hypothesis was that these groups would exhibit different morphologic characteristics and different reactions to elbow flexion. The relationship between frequency of throwing and these ultrasonographic changes was also determined.

METHODS

Participants

We recruited all members of the baseball team of a junior high school. The school focused on the development of junior league baseball and was famous for its large baseball training camp, which currently hosted 39 players. These players were divided into two groups on the basis of how much they were required to throw a baseball, that is, their team positions. The pitcher group included 19 players who had focused on pitching for more than 3 y. Pitching training was conducted 5 d per week. These players were asked to throw more than 120 to 150 pitches a day according to their personal training projects. The fielder group consisted of 20 players who had received basic baseball skill training, but without intensive pitching. Their throwing counts were less than 100. Fielders practiced 1 h less than pitchers per training day. The fielders' throwing intensity was generally less than that of pitchers in training. Twenty-four non-athlete junior high school students of similar ages were also included as a control group for comparison. All participants were interviewed and asked to complete questionnaires to collect basic demographic data. History taking and physical examination focused on ulnar nerve palsy and presentation of elbow pain or discomfort. The personal training records of all players were reviewed to confirm no previous injury. The dominant hand was the hand the player used to throw the ball. The two enrollment criteria were no obvious deformity of and no history of trauma to the arms, especially the elbows. All patients gave informed consent to participate in the study. The study protocol was approved by the Human Experiment and Ethics Committee of National Cheng Kung University Medical Center, Tainan, Taiwan.

Ultrasonographic measurements and experimental procedures

One orthopedic surgeon (T. W. Tai) assessed the range of motion of the wrists, elbows and shoulders of all participants. Then, both elbows of all participants were ultrasonographically examined by another orthopedic surgeon (I. M. Jou) with more than 10 y of experience in musculoskeletal ultrasonography. The surgeons were blinded to the grouping of the participants. Examinations were conducted with a high-resolution ultrasonograph with a 5- to 10-MHz linear-array transducer (SonoSite Inc., Bothell, WA, USA). The participant was seated facing the examiner. The shoulder of the examined arm was placed in 60° of flexion and externally rotated to 90°. The wrist was held in a neutral position by an assistant, and the ulnar nerve was ultrasonographically examined with the elbow extended and at 45°, 90° and 120° of flexion.

The ulnar nerve was first examined in parallel on longitudinal images and identified using the palpable bony landmarks of the cubital tunnel of the extended elbow (Fig. 1a, b). The morphology and dynamics of the nerve were then assessed on transverse images strictly perpendicular to the axis of the nerve at the cubital tunnel of the medial epicondyle (Fig. 1c, d). These measured locations were clearly defined and marked by the surgeon (T.W. Tai). The long-axis diameter and cross-sectional area of the ulnar nerve were measured at the different flexion angles of the elbow. Distances between the ulnar nerve and the tip of the medial epicondyle were marked on transverse images, measured in the various positions of the elbow and calculated using a direct trace and ellipse tool provided by the device. Distance values were positive when the ulnar nerve was located in the cubital tunnel and negative when the ulnar nerve was anteriorly translated onto the medial epicondyle. In addition, two-point discrimination was used to evaluate the slowly adapting fiber group and the receptors of the Merkel disk. The surgeon (T. W. Tai) used the Disk-Criminator (North Coast Medical, CA, USA) in constant contact with the skin of the hand innervated by the ulnar nerve to determine the patient's least distance