Increased Transverse Carpal Ligament Stiffness in Pianists

Christiane Mhanna, Tamara L. Marquardt, Zong-Ming Li.
Cleveland Clinic, Cleveland, OH, USA.

Disclosures:  C. Mhanna: None. T.L. Marquardt: None. Z. Li: None.

Introduction:
The transverse carpal ligament (TCL) serves as an anchor for the thenar muscles which are vital for thumb strength and mobility. Repetitive biomechanical stimulation of the TCL due to contractions of the thenar muscles may lead to pathomechanical tissue changes such as increased TCL stiffness and thickness [1]. These TCL alternations have been suggested as an etiological factor of median nerve compression and carpal tunnel syndrome [2]. Pianists may be vulnerable to such mal-adaptations of the TCL since piano practicing and performing involves repetitive and forceful use of the thumbs. Recently, the mechanical properties of the TCL for healthy controls have been quantified in vivo using acoustic radiation force impulse (ARFI) imaging [3]. The purpose of this study was to investigate the stiffness of the TCL in pianists who have a history of repetitive hand use. We hypothesized that the muscle-ligament interaction associated with piano playing would lead to a greater tissue stiffness of the TCL.

Methods:
Human Subjects: Twenty healthy, right handed female volunteers participated in this study. Ten of the participants were pianists (20.4 ± 1.6 years) who practice piano 18.6 ± 14.9 (10 to 50) hours per week for 12.8 ± 2.9 (8 to 18) years. The remaining ten participants served as a control group (23.8 ± 3.4 years) and were non-pianists who did not partake in activities involving repetitive hand movements (e.g. typing, texting).

Experimental Protocol: Each participant sat in an upright position next to a testing table. Their right hand and wrist were stabilized in a supine, anatomically neutral position within a thermoplastic splint and submerged in a tank of room temperature water (Figure 1). A positioning arm was used to stabilize a linear array ultrasound transducer for image collection with a Siemens Acuson S2000 ultrasound system equipped with Virtual Touch™ Tissue IQ software. This software permits in vivo quantitative assessment of tissue stiffness by measuring the shear wave velocity (SWV) of tissues using ARFI technology. Four B-mode ultrasound images of the distal level of the carpal tunnel were captured, along with corresponding ARFI grayscale images for the right hand. Then, the protocol was repeated for the left hand of each subject.

Data Analysis: A custom MATLAB script was used to calculate the SWV of the TCL. First, the TCL was manually traced on the B-mode image and the selection was translated to the ARFI image (Figure 2). The SWV was calculated at each pixel within the selection to determine the median SWV of the TCL. Additionally, the thenar muscles’ ulnar point (TUP), the most ulnar insertion point of the thenar muscles on the TCL, was identified. For further analysis, the TCL was divided into radial and ulnar sides, i.e. rTCL and uTCL, respectively. The rTCL was defined as the region from the TUP to the trapezium, while the uTCL was the region from the TUP to the hook of the hamate. For each participant, the SWV values were first averaged within each hand (right and left) and then averaged again across hands to determine participant specific averages of the SWV.
for the TCL, rTCL, and uTCL. A t-test was used to compare the SWV of the TCL for pianists and controls. Furthermore, a two-way ANOVA was performed with factors of group (pianist and control) and TCL side (rTCL and uTCL). An alpha level of 0.05 was used for statistical analyses.

Results:
The SWV of the TCL was greater for the pianist group in comparison to the control group, with SWV values of 5.52 ± 0.46 m/s and 5.01 ± 0.58 m/s, respectively (p < 0.05) (Figure 3). The further analyses revealed that the SWV was affected by factors of group (p < 0.001) and side (p < 0.001). For the pianist group, the SWV of the rTCL (6.09 ± 0.63 m/s) was greater than that of the uTCL (4.84 ± 0.38 m/s) (p < 0.001). However, there was no statistical difference between the SWV of the rTCL (4.52 ± 0.59 m/s) and the uTCL (4.99 ± 0.82 m/s) for the control group (p = 0.109). Across group comparisons showed that the SWV of the rTCL for the pianists was 18.2% greater than that for the controls (p < 0.005), but the SWV of the uTCL was not significantly different between the two groups (p = 0.172).

Discussion:
ARFI imaging permitted in vivo quantification of the SWV of the TCL. The SWV of a tissue has been shown to positively correlate with the tissue’s stiffness, where an increase in SWV signifies an increase in tissue stiffness [4]. This study revealed that pianists have a stiffer TCL than non-pianists, indicated by the higher SWV of the TCL for pianists in comparison to controls. Further analyses revealed that this tissue adaptation was location dependent, occurring only at the radial portion of the TCL. While playing octaves and scales, pianists repetitively abduct the thumb, and this motion has been associated with overuse of the thenar muscles resulting in muscle pain and stiffness [5]. Therefore, the increased stiffness of the TCL on the radial side in pianists may be attributable to the recurrent contractions of the thenar muscles which induce focal biomechanical interactions with the TCL, specifically on the radial aspect where the thenar muscles are anchored.

Significance:
Repetitive use of the hands, including piano playing and other occupational activities, may cause pathomechanical changes to the TCL increasing the vulnerability of developing hand injuries and diseases, including carpal tunnel syndrome.
Figure 1. A schematic of the experimental setup for ultrasound imaging

Figure 2. A representative ultrasound image with the TCL selection outlined on both the B-mode side (A) and ARFI side (B). The hamate (H), trapezium (T), and thenar muscles’ ulnar point (TUP, *) are identified. The vertical line at the TUP represents the division location where the TCL was divided into ulnar and radial portions.
Figure 3. Comparison of SWV for the TCL, ulnar TCL, and radial TCL in pianists versus control. * p < 0.05, *** p < 0.001

ORS 2015 Annual Meeting
Poster No: 1953