Manual Therapy 19 (2014) 608–613

Contents lists available at ScienceDirect

Manual Therapy

journal homepage: www.elsevier.com/math

Original article

The deformation and longitudinal excursion of median nerve during digits movement and wrist extension

Wai Keung Christopher Lai [a, *], Yin Ting Chiu [b], Wing Sze Law [c]

[a] Department of Health Technology and Informatics, The Hong Kong Polytechnic University, Hung Hom, HKSAR, China
[b] Department of Radiology, The Pamela Youde Nethersole Eastern Hospital, Chai wan, HKSAR, China
[c] Department of Radiology, Tuen Mun Hospital, Tuen Mun, HKSAR, China

ARTICLE INFO

Article history:
Received 29 May 2013
Received in revised form
5 June 2014
Accepted 17 June 2014

Keywords:
Median nerve
Excursion
Mobile phone
Doppler ultrasound

ABSTRACT

The use of electronic devices, such as mobile phones and computers, has increased drastically among the young generation, but the potential health effects of carpal tunnel syndrome (CTS) on university students has not been comprehensively examined. Thirty-one university students aged 18 to 25 y with no symptoms of CTS were successfully recruited in this study. By using noninvasive ultrasonography, the morphological characteristics of the median nerve of each volunteer, and the extent of its longitudinal excursion movement under experimental conditions, in which a real operating environment of electronic devices was simulated, were quantified. The results demonstrated that the median nerve at the carpal tunnel inlet was flattened during wrist extension: the flattening ratio increased from 3.40 ± 0.91 at the neutral position to 4.10 ± 1.11 at the angle of 30° and 4.09 ± 1.11 at the angle of 45°. In addition, the median nerve became swollen after the students performed rapid mobile-phone keying for 5 min, indicated by a significant increase in the cross-sectional area from 6.05 ± 0.97 mm^2 to 7.56 ± 1.39 mm^2. Passive longitudinal excursion was observed at the median nerve when the students performed mouse-clicking (2.4 ± 1.0 mm) and mobile-phone keying tasks (1.7 ± 0.6 mm), with the mouse-clicking task generating a greater extent of longitudinal excursion than the mobile-phone keying task did. In conclusion, the findings of the present study verify the potential harm caused by using electronic devices while maintaining an inappropriate wrist posture for a substantial period.

1. Introduction

Carpal tunnel syndrome (CTS) is a progressive painful condition that occurs at the wrist, and is caused by a combination of factors that are associated with increased carpal pressure such as trauma or injury, diabetes, rheumatoid arthritis, acromegaly, hypothyroidism, and pregnancy (Silman et al., 1993). In addition to these factors, repetitive wrist-hand movements, especially involving digit movement combined with extension, ulnar deviation, or external compression at the wrist, increase the risk of CTS (Fagarasanu and Kumar, 2003; Palmer et al., 2007; Thomsen et al., 2008). Ali and Sathiyasekaran (2006) demonstrated that year-long exposure to computer work and the long working hours of computer workers were risk factors for CTS (Ali and Sathiyasekaran, 2006). Therefore, with the growing availability and excessive use of electronic devices such as mobile phones and computers, the effects on health have become a concern because certain patients with CTS are idiopathic and exhibit no definite contributors such as synovitis or other compressive conditions of the wrist (Wright et al., 1996).

In Hong Kong, the increased availability of computers has resulted in extremely high usage. Students are using computers to perform various tasks including word processing, gaming, and searching for information on the Internet (Kent and Facer, 2004). Approximately two-thirds of U.S. high school students aged 16–18 y were reported to use their computer for more than 4 h per d (Sommerich et al., 2007), whereas in Hong Kong, students aged 12–16 y reported an average of 2.5 h per d (Ho and Lee, 2001). Therefore, the finding that students are using electronic devices for substantial periods from an early age is not surprising.

The emerging study of the morphological changes and gliding movement of the median nerve is crucial for the identification of CTS risk markers. When the median nerve is under increased carpal tunnel pressure, it typically becomes swollen and flatten (Klauser et al., 2009). Moreover, previous studies have reported that the median nerve of symptomatic CTS subjects exhibited a large cross-

* Corresponding author. Tel.: +852 3400 8596; fax: +852 2362 4365.
E-mail addresses: chris.lai@polyu.edu.hk, six1106500@yahoo.com.hk (W.K.C. Lai).

http://dx.doi.org/10.1016/j.math.2014.06.005
1356-689X/

sectional area (CSA) (Lopes et al., 2011)and high flattening ratio (FR—the ratio of the transverse diameter over the anteroposterior diameters of the median nerve) (Chan et al., 2011), although such associations were generally confounded by the body mass index (BMI) and wrist circumference measurements (Moghtaderi et al., 2005). In addition, Burgess-Limerick et al. indicated that when the wrist was extended, the carpal tunnel pressure increased because of the constricted space in the carpal tunnel, which exerted increased force onto the median nerve (Burgess-Limerick et al., 1999).

Recently, the application of B-mode ultrasonography was determined to be useful in the measurement of nerve deformation. Although it is a noninvasive and readily available imaging tool used in neuromusculoskeletal imaging, the current use of this tool in the clinical diagnosis of CTS is limited. Ultrasound can be used to evaluate morphological changes and identify certain focal lesions on the median nerve, but it fails taking into the consideration of the capacity of median nerve to glide during wrist-hand movements.

The longitudinal movement of the median nerve is a type of movement that cannot be quantified directly using B-mode ultrasound because of the lack of a distinct marker for tracking. In addition, when the longitudinal movement of the median nerve is perpendicular to the transmission of the ultrasound, tracking the moving echo-reflecting interfaces accurately is difficult. Therefore, directly measuring the longitudinal excursion of the median nerve remains challenging.

Nevertheless, spectral Doppler ultrasonography is a possible method for determining the longitudinal excursion of the median nerve indirectly by using a pixel analysis program (Echigo et al., 2008). Because the extent of longitudinal excursion of the median nerve measured using spectral Doppler ultrasonography was mathematically equal to the total number of calibrated pixels within the area of a spike in the velocity-time integral spectrum, the corresponding longitudinal excursion of the median nerve could, therefore, be calculated indirectly in this study (Fig. 1).

Therefore, the objectives of the present study were to determine the following:

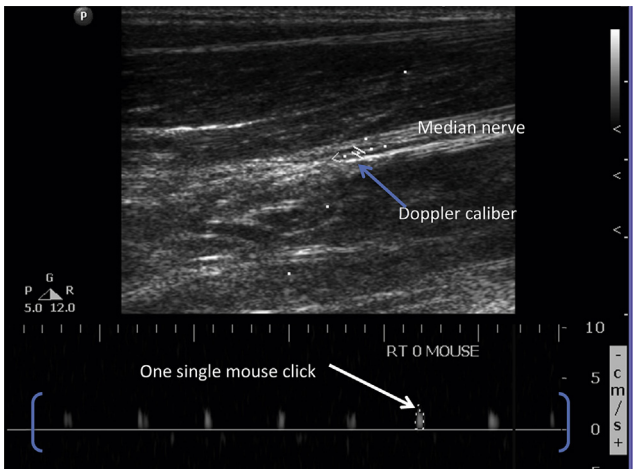

Fig. 1. The Spectral Doppler ultrasound of the right median nerve during mouse clicking task. This figure is a still image of median nerve in longitudinal section captured from the ultrasound examination using B-mode and spectral Doppler mode. In this image, the 2-D B-mode information was projected on the upper portion of the still image. The corresponding Doppler signal caused by the movement of the median nerve was projected at the bottom of the image as a spectrum—Doppler velocity (*y*-axis) over time (*x*-axis). All Doppler signals were detected by placing a calibre (white dotted line) over the median nerve. As shown in this image, 7 consecutive spikes were detected, corresponding to the longitudinal excursion of the median nerve caused by 7 mouse clicks.

1. Whether extension at the wrist (a common posture adopted during the use of mobile phones and a computer mouse) is related to morphological changes (cross-sectional area and flattening ratio) in the median nerve;
2. The effect of a substantial period of intense mobile phone use (performing a rapid keying task for 5 min) on morphological changes in the median nerve; and
3. The extent to which the median nerve demonstrates passive longitudinal excursion during the use of mobile phones and computers.

2. Methods

2.1. Subjects

Thirty-one Chinese volunteers aged 18–25 y were recruited from the Hong Kong Polytechnic University. The inclusion criteria of the present study were (1) Chinese ethnicity, (2) university student, and (3) right handed. The exclusion criteria included (1) subjects with symptoms of CTS including pain, tingling, burning, numbness, or a combination of these symptoms in relation to the palmar aspect of the thumb, index finger, middle finger, or radial half of the ring finger (Katz and Simmons, 2002); (2) subjects with a history of wrist surgery including carpal tunnel injection or fracture within past 10 y; (3) subjects with a history of underlying conditions associated with CTS including diabetes mellitus, rheumatoid arthritis, pregnancy, acromegaly, and hypothyroidism; (4) subjects exhibiting anatomic variations in the median nerve, such as bifurcation, which were identified during the ultrasound experiment (Wong et al., 2002); (5) obese subjects, determined by a BMI > 25 kg/m^2(Moghtaderi et al., 2005); and (6) subjects who engaged in exercise involving their upper arm, such as weight lifting, boxing, racket sports, and cycling, within 1 wk prior to the examination.

2.2. Materials

Ethical approval was obtained from the local research committee and informed consent was obtained from each participant. A Philips ultrasound unit (Model: HD11 XE, Philips Medical Systems, Bothell, WA, USA) with an L12-5 linear array transducer was used in this study. A trained sonographer (MC) performed all ultrasound measurement and another 2 researchers (KL and KC) conducted the image analysis of all the resultant images.

2.3. Procedures

2.3.1. Wrist extension

The CSA and FR of the carpal tunnel inlet in the right wrist were first examined using B-mode ultrasound, which was similar to the technique described in a similar previous study (Toosi et al., 2011), and the measurement was repeated at 4 distinct wrist extension angles (0°, 15°, 30°, and 45°) without the participants performing any specific activity during the process. The values measured at the neutral position (wrist extension angle at 0°) will be used as reference and compared with the values measured from 15°, 30° and 45° respectively. During the examination, the volunteers were asked to sit on a chair with the right side of their shoulder slightly abducted, elbow flexed at 90°, and forearm resting on the table with the wrist fully supinated and the digits fully extended. After the morphological changes in the median nerve were measured at 4 distinct wrist extension angles, the longitudinal excursion of the median nerve was subsequently measured during the mouse-clicking and mobile-phone keying tasks.