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Original Research—CME

Ultrasonographic Median Nerve Changes After Repeated Wheelchair Transfers in Persons With Paraplegia: Relationship With Subject Characteristics and Transfer Skills

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Abstract

Background: Wheelchair users with spinal cord injuries are susceptible to peripheral neuropathies from overuse, yet no studies have established a relationship between median neuropathy and wheelchair transfers. A more thorough understanding of how transfers and technique contribute to pathologic conditions may guide interventions that curtail its development.
Objective: To evaluate the effects of repeated transfers on ultrasound markers for carpal tunnel syndrome (CTS) in people with spinal cord injuries and to relate changes to subject characteristics and transfer skills.
Design: Cross-sectional, repeated measures.
Setting: Research laboratory and national wheelchair sporting events.
Participants: A convenience sample of 30 wheelchair users with nonprogressive paraplegia were recruited via research registries and at the 2013 National Veterans Wheelchair Games and 2014 Paralyzed Veterans of America Buckeye Games. Participants were older than 18 years and could complete transfers independently within 30 seconds without use of their leg muscles.
Methods: Demographic questionnaires and physical examinations for CTS were completed. Quantitative ultrasound techniques were used to measure changes in the median nerve after a repeated-transfers protocol. The Transfer Assessment Instrument (TAI) was completed to quantify transfer ability.
Main Outcome Measurements: Median nerve cross-sectional area at the level of the pisiform (PCSA) and swelling ratio (SR), transfer quality, and skills via the TAI.
Results: PCSA increased after repeated transfers ($P < .025$). Participants who used safe hand positions had a lower baseline SR ($\beta = -0.728$; $P < .01$). Participants with a higher body weight had a lower baseline SR provided they performed higher quality transfers. Participants who scooted to the front of the seat prior to transferring (TAI item 7; $\beta = 0.144$; $P < .05$) and who weighed more ($\beta = 0.142$; $P < .05$) exhibited greater increases in PCSA in response to transfers.
Conclusions: An acute increase was observed in median nerve CSA at the pisiform after repeated wheelchair transfers. Changes were greater in persons with higher body weight and in persons who did not perform certain transfer skills correctly (according to the TAI). It is possible that these factors contribute to chronic injury and possibly CTS.

Introduction

Carpal tunnel syndrome (CTS) is the most frequently diagnosed compressive mononeuropathy [1]. It is caused by compression of the median nerve as it passes through the carpal tunnel beneath the flexor retinaculum [1]. CTS is characterized by numbness, paresthesia, pain, and nocturnal symptoms in the distribution of the median nerve in the hand [1]. Symptoms can be caused by increases in carpal tunnel pressure—induced by extreme wrist angles and thickening of the sheaths around tendons within the tunnel—or by disruptions in the ability of the nerve to glide normally during joint range of motion. Inflammation also plays a role, affecting carpal tunnel flexor tendons and nerve gliding [2]. Thus certain populations exposed to forceful and repetitive hand motions have a higher risk for the development of CTS [2]. Performing force-generating tasks while wrists are in nonergonomic positions has been linked to development of median

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mononeuropathies [3]. Because wheelchair activities such as transfers require the generation of large upper limb forces, they have been implicated in the development of CTS in people with a spinal cord injury (SCI) [3].

Between 236,000-327,000 persons in the United States live with an SCI [4]. People with an SCI rely on their upper extremities for mobility and participation in daily activities. A diagnosis of CTS in a wheelchair user can increase functional impairment, with a potential detriment to quality of life [5]. CTS prevalence in persons with an SCI is between 40% and 66% [3,6-8]—higher than in both general and working populations [9,10]—and increases with time after injury [3,6-8]. As life expectancies for people with an SCI continue to increase [4], it is important to reduce risk factors for developing CTS.

Diagnosing CTS involves a careful history, physical examination, and nerve conduction tests, and it often includes electromyography [11]. Ultrasonography as a diagnostic tool in CTS is becoming more widely used because of its low cost, noninvasiveness, short examination time, and portability [12]. Ultrasound allows for the visualization of carpal tunnel anatomy, as well as real-time assessment of dynamic changes within the carpal tunnel. Recent studies have observed measurable changes in median nerve characteristics after stressful activities [13-15]. In 2 of these studies, changes were greater in persons with CTS [13,15].

In this study, we aimed to identify the effects of independent transfers on ultrasonographic markers of CTS in people with paraplegia. In addition, we sought to develop a better understanding of how subject characteristics and transfer techniques affect the median nerve during transfers. It was hypothesized that (1) repeated transfers would cause acute changes in quantitative ultrasound (QUS) markers for CTS and (2) baseline QUS and changes in QUS would relate to subject characteristics (eg, duration of wheelchair use and body weight) and transfer skills/quality measured by the Transfer Assessment Instrument (TAI).

Methods

Participants

Wheelchair users with an SCI were recruited in response to flyers and research registries, as well as at the 2013 and 2014 National Veterans Wheelchair Games and at the 2014 Paralyzed Veterans of America Buckeye Games. Subjects provided written informed consent prior to enrollment. Ethical approval was obtained through the Institutional Review Board prior to data collection. Subjects were included in the study if they were older than 18 years, had nonprogressive paraplegia for at least 1 year prior to the start of the study, used a manual wheelchair for more than 40 hours per week, and were able to transfer to and from their chair within 30 seconds with or without assistive equipment. Individuals were excluded from this study if they self-reported having arm pain that prevented transfers, having use of their leg muscles during transfers, or having a recent history of cardiopulmonary problems or pressure sores that could be exacerbated by repeated transfers.

An a priori power analysis was performed to determine sample size using pre- and postactivity cross-sectional area (CSA) reported by Altinok et al [13]. The effect sizes in that study were large; however, based on the authors' previous experience and differences in methodology, a power analysis was performed using a medium effect size.

Baseline Questionnaires and Examinations

Subject demographics such as age, gender, race/ethnicity, and duration of wheelchair use were collected with a general demographics questionnaire. Body weight was collected using a wheelchair scale (Befour, Inc, Saukville, WI), and determined by subtracting wheelchair weight from combined subject and wheelchair weights. The Brigham and Women's Carpal Tunnel Questionnaire (CTQ) [16] was then completed. The CTQ is divided into 2 subscales that assess severity of CTS symptoms and functional consequences. Subscales are graded and averaged, with final scores resting between 1 and 5. Higher scores represent a greater severity of symptoms or functional impairment from CTS.

A physical examination of the wrist was performed by a physiatrist to test for the presence of CTS symptoms. The examiner was blinded to demographic and pain/symptom questionnaire information. This examination utilized a set of clinically guided manual tests to evaluate the degree of CTS symptoms: thenar muscle atrophy, thumb abduction weakness, impaired sensation to pinprick between the second and fifth digits along the median nerve distribution, Tinel sign, and Phalen test [17]. Each test was graded either 0 (symptom absent), 1 (equivocal), or 2 (symptom present). Higher scores represent greater clinically graded median neuropathy. The distribution of findings across the sample was highly skewed, and thus participants were dichotomized into those with absence (score of 0) or presence (score of 1 or greater) of physical examination findings.

QUS Examination

A previously designed QUS protocol [18] was used to measure ultrasonographic changes in the median nerve in response to repeated transfers. A single evaluator imaged the median nerve at the levels of the pisiform and distal radius (Figure 1A, B). This evaluator was blinded to clinical findings and transfer quality. This standardized measurement technique has high

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