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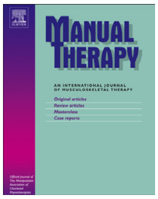

Original article

Effect of prior experience and task stability on the intrinsic muscle activity of the thumb

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ABSTRACT

Manual techniques involving the use of the thumb are commonly employed by physical therapists for treating patients with vertebral disorders. The demands on the intrinsic muscles of the thumb in these manual tasks are very different from those of the pinch tasks. The aim of this study was to investigate the influence of clinical experience and different mobilization techniques on the electromyographic activity (EMG) of thumb intrinsic muscles. Fifteen participants without exposure to manual techniques (the Novice Group) and fifteen physical therapists with at least 3 years of orthopaedic experience (the Experienced Group) participated. Each participant exerted thumb tip forces with 3 different posterioanterior (PA) glide techniques including unsupported, with digital support and with thumb interphalangeal joint supported by the index finger. The exerted force was increased from 25% to 100% maximum force at 25% increments on a 6 component load cell. The thumb tip force and EMG activity of four intrinsic muscles (flexor pollicis brevis, adductor pollicis, abductor pollicis brevis, first dorsal interosseus) were recorded with surface electrodes. Both experience and technique influenced intrinsic muscle activity of the thumb. While participants of both groups generated the same magnitude of force, experienced participants generated less intrinsic muscle activity while performing PA glide through practice. However, novice participants increased activity of the intrinsic muscles in accordance with the stability status of the technique. PA glide with thumb interphalangeal joint supported by the index finger was a more stable technique as evidenced by smallest relative errors of thumb tip force.

1. Introduction

The thumb plays a crucial role in manual manipulative tasks. Disorders involving the thumb are among major job-related afflictions in several health professionals, such as physical therapists (Cromie et al., 2000; West and Gardner, 2001; Wajon and Ada, 2003; McMahon et al., 2006), occupational therapists (Caragianis, 2002), and massage practitioners (Jang et al., 2006). Posterioanterior (PA) glide mobilization techniques are commonly used by physical therapists to treat patients with vertebral hypomobility disorders (Maitland et al., 2001). These techniques involve oscillatory or sustained thumb tip pressure imposed partially by the body weight through the stabilized multi-articular kinetic chain consisting of the thumb and the rest of the upper extremity (Maitland et al., 2001). A close relationship between the use of manual mobilization techniques and the prevalence of thumb pain in physical therapists has been reported (Cromie et al., 2000; West and Gardner, 2001; Wajon and Ada, 2003; McMahon et al., 2006). These studies suggested that specific mobilization techniques, increased repetitions, and working long hours were all risk factors for thumb disorders.

While performing PA glides, the clinician aligns his/her thumb in various positions ranging from flexion to hyperextension at the interphalangeal (IP) and metacarpophalangeal (MCP) joints. Therapists with pain at MCP had difficulty in controlling its hyperextension (Wajon and Ada, 2003) and were more likely to develop osteoarthritis of the carpometacarpal (CMC) joint (Moulton et al., 2001). To alleviate thumb pain symptoms, therapists usually employ alternative techniques (Cromie et al., 2000; Wajon and Ada, 2003) or opt to apply mobilization forces at a lower level (Snodgrass et al., 2010) to reduce stress on the symptomatic joint.

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To perform mobilization techniques with the thumb, a therapist needs a stable thumb kinetic chain for exerting force at its distal end. The stability of this multi-articular kinetic chain is provided by active as well as passive components. The passive components comprise joint surface configurations, capsules and ligaments of the IP, MCP, and CMC joints while the active components include extrinsic and intrinsic muscles of the thumb (Imaeda et al., 1992; Neumann and Bielefeld, 2003; Leversedge, 2008; Edmunds, 2011). Any weakness, paralysis, fatigue or incoordination of the active component(s) or insufficient support from the passive component(s) may lead to instability of the kinetic chain (Brand and Hollister, 1993; Johanson et al., 2001; Neumann and Bielefeld, 2003) and result in pain, joint hypermobility and accelerated articular cartilage degeneration (Eaton and Littler, 1969; Bettinger et al., 1999; Zancolli, 2001; Wajon and Ada, 2003).

The electromyographic activation patterns of the thumb and/or finger muscles have been studied to address the effects of stable and unstable tasks on the timing and magnitude of the tip force during functional pinch (Johanson et al., 2001) and during fingertip pressing (Keenan and Massey, 2012). Moreover, studies have been conducted to investigate activation patterns of the thumb and/or finger muscles at low isometric forces in precision grip (Maier and Hepp-Reymond, 1995), their relationships with the isometric forces generated (Cooney et al., 1985), and the influence of median nerve block (Kaufman et al., 1999). However, these studies were limited to examining roles of the finger and thumb muscles in functional pinch and grip tasks. During both tasks, the intrinsic muscles are likely to contribute to the pinch force generated. However, during PA glide mobilization the roles of these muscles in generating and directing the thumb tip force may be very different from those during functional pinch and grip tasks.

It has been reported that experience influences muscle activity. Fattapposta et al. (1996) reported that long-term practice resulted in a more efficient pre-programming of skills with better coordinated neuromuscular control and movement patterns. The force production requirements of the muscles involved as well as the mental effort needed for movement execution were, thereby, reduced. Through practice, force produced by the therapists during manual therapy became more accurate and consistent (Scaringe et al., 2002; Enebo and Sherwood, 2005; Chang et al., 2007), and limb stiffness and muscle co-contraction were modulated to enhance the stability of the multi-articular kinetic chain and task performance (Osu et al., 2002; Gribble et al., 2003).

So far, no study has reported the electromyographic responses of thumb muscles while performing PA glide techniques. The purpose of this study was to investigate the influence of experience and different PA glide techniques on the activity of the intrinsic muscles of the thumb.

2. Methods

2.1. Participants

A total of 30 participants took part in this study. The Novice Group included 11 females and 4 males (aged 21.9 ± 2.2 years) with no prior exposure to manual therapy. The Experienced Group included 10 females and 5 males (aged 28.0 ± 2.1 years), each with at least 3 years of clinical experience in orthopaedic physical therapy. Participants with any history of musculoskeletal or neurological disorders, or pain involving the use of thumb in the past year were excluded. None of them reported any pain provoked or dexterity affected while performing daily activities or applying thumb tip pressure such as PA glide techniques.

2.2. Instrumentations

A six-component load cell (MC3A-6-100, Advanced Mechanical Technology Inc., Watertown, MA, USA) was used for measuring forces applied through the thumb at a sampling rate of 50 Hz. The load cell was fixed on top of an L-shaped plate rigidly clamped on to a table (Fig. 1).

The electromyographic activity (EMG) signals of intrinsic thumb muscles were recorded by a wire telemetry system (AMT-8, Bortec Inc., Canada) at a sampling rate of 1000 Hz with pairs of Ag/AgCl surface electrodes (1 cm in diameter). The gain of each channel ranged from 500 to 2k.

2.3. Participant preparation

Before testing each participant read and signed an informed consent form and answered a questionnaire concerning his/her history of pain and disabilities relating to the thumb and hand. The Beighton score of each participant was also recorded (Beighton et al., 1973). The experimental protocol was approved by the Institutional Review Board of the National Cheng Kung University Hospital.

EMG recording sites were shaved when needed and rubbed with alcohol. Electrodes were then placed over bellies of the abductor pollicis brevis (APB), flexor pollicis brevis (FPB), adductor pollicis (ADP) and first dorsal interosseus (1stDI) muscles with an inter-electrode distance of 2 cm. The muscle locations were identified by palpation and by monitoring the EMG activity associated with the specific movement of each individual muscle (Hislop and Montgomery, 2007). The exact placement of electrodes was based on the method proposed by Perotto (1994).

2.4. Experimental procedures

Prior to testing, the maximal EMG signal of each muscle was recorded first during a 5-second maximal voluntary isometric contraction (MVC) with 1-minute rest period between contractions (Hislop and Montgomery, 2007). The participants performed with verbal encouragement to achieve maximal EMG activity. The signal of MVC was determined by averaging the integrated EMG of the 4 seconds for normalization, excluding the first second. The following 3 variations of PA glide techniques were tested in a random order on the 6-component load cell:

1. Unsupported PA glide (T1) was performed with the rest of digits unsupported. (Fig. 1A)
2. PA glide with digital support (T2) was performed with the rest of the digits placed on a supporting base next to the top plate of the load cell. (Fig. 1B)
3. PA glide with index support provided at the palmar aspect of the interphalangeal joint (T3). (Fig. 1C)

The participants were asked to exert a maximum force on the force plate while performing each of the PA glide techniques and the force recorded was set as 100% for each technique. A LABVIEW program (Version 6.1, National Instruments, Austin, Texas, USA) was written to display both the target force (25% to 100% of maximum at 25% increments) and the actual force registered. The participants were then instructed to exert at a force level matching as closely as possible to each of the target force levels displayed on the monitor for a period of five seconds. The EMG signals and the thumb tip forces were recorded simultaneously.

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