Position of undergraduate students' thumbs during mobilisation is poor: an observational study

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Questions: What is a clinically-representative maximum force for central posteroanterior mobilisations performed using the thumbs on the lower cervical spine? Can students reach this force while maintaining the recommended thumb position of neutral to slight flexion at the interphalangeal and metacarpophalangeal joints? What happens at the interphalangeal and metacarpophalangeal thumb joints of students who are unable to maintain this position? ***Design:*** Observational study. ***Participants:*** Eleven physiotherapy educators (academic and clinical) and 25 physiotherapy students (4th year). ***Outcome measures:*** The clinically-representative maximum force was determined by physiotherapy educators performing posteroanterior mobilisations on a simulated neck for a hypothetical patient. The force used by the educators became the target force. Videos of physiotherapy students performing posteroanterior mobilisations to this force were analysed for (i) the ability to maintain the recommended thumb position while attempting to reach the force, and (ii) the ability to maintain the position during 30 oscillations around the force. ***Results:*** A mean maximum force of 122.86 N (SD 50.16) which equates to 12.52 kg was determined. Only 2 of the 25 students assessed could maintain the required position while applying approximately 12 kg through their thumbs. Of the remaining 23 (92%), 14 (56%) could reach the target force but could not concurrently stabilise their thumbs in the recommended position. The other nine (36%) could not reach the target force and also could not maintain their thumbs in the recommended position. ***Conclusion:*** This study has occupational health and safety implications for physiotherapy students. **[Buckingham G, Das R, Trott P (2007) Position of undergraduate students' thumbs during mobilisation is poor: an observational study. *Australian Journal of Physiotherapy* 53: 55–59]**

Key words: Thumb; Physical Therapy Modalities; Physical Therapy (specialty); Manipulation, Orthopaedic

Introduction

There is a high prevalence of work related musculoskeletal disorders in physiotherapy (Cromie et al 2000, Reglar and James 1999). The work can be repetitive and may use high loading of physiotherapists' joints. In physiotherapists the wrist and hand is rated the second highest anatomical area of injury after low back injuries (Bork et al 1996, Caragianis 2002, Cromie et al 2000, Holder et al 1999). Manual orthopaedic techniques, and in particular posteroanterior mobilisations have been identified as a causative factor in work related musculoskeletal disorders of the thumbs (Cromie et al 2000, Cromie et al 2001, Wajon and Ada 2003, Winzeler and Rosenstein 1996). Incorrect thumb position during these techniques, coupled with high compressive loads, could theoretically lead to pain, or even permanent and debilitating thumb injury.

Posteroanterior mobilisation as described by Maitland (2001) is taught in the undergraduate physiotherapy program at the University of South Australia. It is not known whether students who are taught this technique are able to maintain the recommended position of their thumbs while applying forces required in clinical practice. The high prevalence of work-related musculoskeletal disorders in young therapists (Cromie et al 2000) indicates that there is a requirement to understand why they are developing these problems, and whether they first occur in physiotherapy students. There is also a requirement to increase student and therapist knowledge about recommended workplace environment, posture during the application of manual techniques, and workload limits.

The recommended position of the thumbs for the application of a posteroanterior technique is with the thumbs in opposition and as close to back-to-back as possible, neutral to slight flexion of the metacarpophalangeal and interphalangeal joints and points of contact over the spinous process to be mobilised (Maitland 2001, Manheim 2000). It has been calculated that increased flexion or hyperextension (extension beyond zero degrees) at the metacarpophalangeal or interphalangeal joints can cause increased loading on the joints during weight bearing (Buckingham 2003, Wan 1986). The ability to maintain the recommended position of the thumb when performing posteroanterior mobilisation may depend on both dynamic and static stability of the thumb joints, as well as the magnitude of force that students are required to use in clinical practice. Currently the magnitude of these forces is not known. The research questions for this study were, therefore:

1. What is a clinically-representative maximum force for central posteroanterior mobilisations performed using the thumbs on the lower cervical spine?
2. Can students reach this force while maintaining the recommended thumb position of neutral to slight flexion at the interphalangeal and metacarpophalangeal joints?
3. What happens at the interphalangeal and

metacarpophalangeal thumb joints of students who are unable to maintain this position?

Method

Design: The observational study comprised two parts. In Part 1, physiotherapy educators were asked to perform posteroanterior mobilisations on a simulated neck for a hypothetical patient. The patient was described as a young male with a short stocky build and thickset neck who had a hypomobile C6 that was stiff, not painful or irritable, and had no contraindications to any treatment. The force used by the educators became the target force. In Part 2, physiotherapy students were asked to perform posteroanterior mobilisations to the target force on the simulated neck using the recommended thumb position of neutral to slight flexion at the interphalangeal and metacarpophalangeal joints (Figure 1). Ethical approval was granted by the Divisional Ethics Committee (Health Sciences) of the University of South Australia. Each participant gave informed consent.

Participants: Physiotherapy educators (academic and clinical) from the University of South Australia, who were involved in teaching posteroanterior mobilisations to undergraduate physiotherapy students, and had postgraduate Masters qualifications in manipulative physiotherapy were invited to participate in Part 1 of the study. Participants were excluded if they had: an upper limb injury within the last six weeks, a known generalised inflammatory or joint condition involving the upper limbs, or a known neurological condition affecting the upper limbs.

Fourth year physiotherapy students from the University of South Australia were invited to participate in Part 2 of the study. They were chosen because they had been exposed to Maitland techniques since the second year of the course. The exclusion criteria were the same as for Part 1.

Outcome measures: In Part 1, a clinically-representative maximum force for central posteroanterior mobilisations was measured using a simulated neck. It consisted of a metal bar with a strain gauge attached to one side, an amplification circuit, power supply, and a laptop computer strapped to an adjustable plinth. The metal bar represented a cervical vertebra with the inherent stiffness of the metal providing resistance. As the metal was bent by educators pressing on it with their thumbs, the change in resistance was calibrated to provide an output that represented the force applied. This output was viewed as a real time display on the laptop. Validity of the equipment was tested by applying loads of up to 20 kg to the metal bar. There was a high linear relationship between the output data and the applied loads ($r = 0.99$) and more than 99% of the variability in load could be predicted by variability in the output. The equipment was also tested for reliability by repeated application of specific loads. The output results were so similar that statistical variance between them could not be calculated with an intra-class correlation coefficient, which indicated near perfect reliability (Buckingham 2003). Having familiarised themselves with the equipment and adjusted the plinth height, educators were given three attempts to 'treat' the hypothetical patient using posteroanterior mobilisations by pushing down on the metal bar. Each attempt was recorded and a marker inserted into the data stream when participants indicated they had reached their preferred maximal treatment force. This force was held for approximately 5 seconds for ease of locating the data during processing. The three attempts were averaged to provide a treatment force for that participant. Results were averaged across participants to produce a clinically-representative maximum force for posteroanterior mobilisations to the lower cervical spine. This was designated the target force for use in Part 2.

Figure 1. Recommended thumb position.

In Part 2, students tried to maintain the recommended thumb position while applying the target force. Having familiarised themselves with the equipment and adjusted the plinth height, students were given three attempts to reach the target force using posteroanterior mobilisations by pushing down on the metal bar. They were asked to view the laptop screen to watch the output in real time. There was an indicator on the screen that changed from 'Press Harder' to 'Target Reached' when sufficient force had been applied. If they were successful in any of the three attempts then they were asked to oscillate around the target force for 30 repetitions to the beat of a metronome at a rate of approximately 2 beats a second, to simulate a treatment. Participants were videotaped to determine thumb position and deviation from the recommended position. The camera was positioned at the head of the table to achieve a lateral view of thumb position and was focused on the thumbs to reduce the likelihood of participants being recognised by the examiners. The video was analysed for (i) the ability to maintain the recommended thumb position while attempting to reach the target force, and (ii) the ability to maintain the position during 30 oscillations around the target force.

Data analysis: Analysis of thumb position was descriptive. All three researchers analysed the video footage together to assess the participant's thumb position during the application of force. They determined whether the thumb position was acceptable and, if not, described the pattern of deviation. If necessary, footage was viewed repeatedly until agreement between researchers was reached. In the majority of cases, deviation of thumbs from the desired position was obvious to all three examiners on the first viewing.

Table 1. Generation of target force including gender and years of experience post Masters degree.

Participant	Gender	Post-Masters experience (years)	Force (N)	Weight (kg)
1	M	7	124.80	12.72
2	M	15	69.72	7.11
3	F	17	166.98	17.02
4	F	4	42.17	4.30
5	F	10	78.32	7.98
6	M	8	129.97	13.25
7	F	18	179.03	18.25
8	M	1	69.72	7.11
9	M	18	180.75	18.42
10	F	11	139.98	14.27
11	F	27	170.02	17.33
Mean		12.4	122.86	12.52
SD		7.5	50.16	5.11

Results

Participants: Eleven physiotherapy educators volunteered for Part 1 of the study. There were no exclusions or withdrawals. Table 1 shows the breakdown of participant, years experience with Masters' qualification, and mean force. Twenty-five physiotherapy students volunteered for Part 2 of the study. 15 were female, 10 were male and none withdrew from the study.

Target force: The mean force produced by the educators was 122.86 N (SD 50.16) which is equal to 12.52 kg (SD 5.11). There was no relationship between years since graduation, gender, and force production.

Maintenance of recommended thumb position: Of the 25 students, only two (8%) were able to maintain the recommended position and reach the target force. Both of these students were also able to maintain the thumb position during oscillations. Of the remaining 23 (92%), 14 (56%) could reach the target force but could not concurrently stabilise their thumbs in the recommended position. The other nine (36%) could not reach the target force and also could not maintain their thumbs in the recommended position. During the application of force through the thumb joints, common abnormalities were 'wobbling' of one or both thumbs alternately into flexion and hyperextension at one or both joints, a quick collapse ('flick'), mostly into hyperextension, at one joint, a slow collapse ('sag'), mostly into hyperextension at one joint and in some participants this involved a 'sag' of both thumbs into an 'S' shaped curve (see Fig. 2 on the eAddenda). The metacarpophalangeal joints were just as likely to move into flexion as hyperextension.

Discussion

There have been no data published about the magnitude of force used clinically during posteroanterior mobilisations, necessitating the calculation of a relevant force for this study. Given that the forces used by students will most likely be influenced by their educators, it was decided that as many educators as possible, who teach posteroanterior mobilisations to students, should be included in the study. A hypothetical case involving a very stiff, non irritable lower cervical joint was selected as it was thought to be the area of the spine where clinicians would use the maximum force through their thumbs without reverting to the use of alternative hand positions such as using the pisiform (commonly used during thoracic and lumbar mobilisation techniques).

The wide variation in forces produced in this study suggests that there is great variation in the treatment practices of individual therapists. This has implications for students as they may attempt to replicate the large forces applied by their clinical educator before their thumbs can tolerate that level of force. Another factor that may have contributed to the wide variation is that a metal bar has a different feel to a hypomobile joint in a real patient. Clinically the force applied takes into consideration other factors such as co-morbid conditions and tissue resistance. This may have altered the amount of force that participants may apply naturally in a clinical situation, though whether it would encourage the use of more or less force than found in this study is uncertain. While the requirement to hold the force for 5 seconds is atypical of pure posteroanterior mobilisations, it is accepted practice to use sustained pressure over a hypomobile joint. Therefore it was not thought that this requirement would alter the treatment force in any significant way. The wide variation in results also indicates that students may be asked to apply quite different forces, ranging from 42.17 N (~ 4.3 kg) to 180.75 N (~ 18.4 kg), to treat the same condition depending on their clinical educator. Finally, it was not determined whether the clinical educators maintained the recommended position with their thumbs as the aim of this part of the research was to determine the forces that a student might be attempting to replicate. Further research could be conducted to address the question of thumb position of experienced clinicians during posteroanterior mobilisations.

There are sound biomechanical reasons for the metacarpophalangeal and interphalangeal joints of the thumb to be maintained in a stable position during posteroanterior mobilisations. Of the 25 participants, only two were able to complete all testing while maintaining the recommended thumb position. Of the remaining participants, 14 could reach the target force using an altered position or with

some degree of instability visible, and nine could not apply sufficient force to reach the target. Many of those who started with the correct position quickly deviated during the application of force.

The view of the participants' thumbs was not always purely lateral due to the positions participants adopted to perform the posteroanterior technique. Despite this, all three examiners found it relatively easy to detect deviations and agree when participants deviated from the recommended thumb position. The general direction of deviation (flexion or hyperextension) was described rather than determining exact angles, which discounted the need for a pure lateral view of the thumbs.

Given that the target force was the mean of the forces applied by the educators rather than the maximum, it is conceivable that throughout their training some students may be encouraged to attempt the application of even higher forces through their thumbs than those required in this study. As the target force was considered a clinically-relevant force, the expectation was that students should be able to demonstrate sufficient thumb stability to complete the task in order to be regarded as practising posteroanterior mobilisation techniques safely. Furthermore, it was felt that the workload requirement was lenient, because if they were successful in reaching the target force, they were asked to oscillate for only thirty seconds, which is brief in relation to usual treatment times. Even with this reduced work load most participants still could not achieve the required outcome. It was also thought that the different feel of the equipment as compared with a human neck was unlikely to affect participants' ability to hold the required position as the target force they were trying to reach was related to the feedback on the screen rather than the amount of resistance they were feeling. Thumb stability was therefore the most pertinent factor.

The stability of participants' thumbs may be compromised by inherent structural instability, by an acquired capsular or ligamentous laxity due to poor technique, or by a lack of dynamic stability provided by the muscles acting on a particular joint. From this relatively small sample, 23 (92%) could not maintain thumb position during the application of force. If occupational factors were already affecting the thumb stability of 4th year students, then it is not surprising that Cromie et al (2000) found that young graduate physiotherapists reported thumb problems. Whether it is increased laxity due to the use of thumbs for massage and mobilisations, or just poor technique, students could potentially be at risk of long term injury due to an inability to maintain the recommended position of their thumbs during posteroanterior techniques.

From a biomechanical point of view, the most efficient way of applying a vertical force at a point of contact (end of the thumb) is to remain perpendicular to this point. In this way each joint in the system transmits the same amount of force as the one below to attain a desired force at contact. The recommended position of neutral to slight flexion at the interphalangeal and metacarpophalangeal joints (placing the joints in a mid-position) is a reasonable compromise between function and force generation. Buckingham (2003) and Wan (1986) showed that considerably more force is generated through joints as they move further away from the perpendicular above the point of contact. If the joints continually move into end range flexion or hyperextension then the repetitive stress may damage the joint capsule, causing pain and/or stretch to the ligaments around the joint, resulting in laxity. This in turn requires an increased demand on the dynamic muscle component to retain stability.

In their study of 536 Australian physiotherapists, Cromie et al (2000) showed a high prevalence (91%) of work related musculoskeletal disorders, causing one in six therapists to change their field of practice or to leave the profession. The current study has shown that 23 (92%) of 25 participants had reduced ability to stabilise the interphalangeal and metacarpophalangeal thumb joints. Recent research (Wajon et al in press) indicates that there is an association between thumb position and pain, with either increased flexion or hyperextension at the metacarpophalangeal or interphalangeal joints increasing the likelihood of pain.

The fact that only two of the 25 students could maintain the recommended position strongly suggests that students were not using this position during clinical placements or during practice. The results of this study highlight the need for staff who teach posteroanterior mobilisations to explain the biomechanical effect of different thumb positions and the possible result of poor technique to students and to continually reinforce practice of the recommended position. In addition it may be helpful to teach alternative strategies to students who, despite training, are unable to maintain the recommended position of their thumbs. Such strategies may include the use of splints or other assistive devices. Recent research investigating exercise to improve thumb stability during posteroanterior mobilisations has indicated that this strategy may be effective (Jacobs 2005).

eAddenda: Figure 2, available at www.physiotherapy.asn.au/AJP

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References

Bork BE, Cook TM, Rosecrance JC, Englehardt KA, Thomason MJ, Wauford IJ, Worley RK (1996) Work related musculoskeletal disorders among physical therapists. *Physical Therapy* 76: 827–835.

Buckingham G (2003) Assessing the functional position of undergraduate students' thumbs during mobilisation techniques, Hons thesis, University of South Australia.

Caragianis S (2002) The prevalence of occupational injuries among hand therapists in Australia and New Zealand. *Journal of Hand Therapy* 15: 234–241.

Cromie JE, Robertson VJ, Best MO (2000) Work related musculoskeletal disorders in physical therapists: prevalence, severity, risks, and responses. *Physical Therapy* 80: 336–374.

Cromie JE, Robertson VJ, Best MO (2001) Occupational health and safety in physiotherapy: Guidelines for practice. *Australian Journal of Physiotherapy* 47: 43–51.

Holder NL, Clark HA, DiBlassio JM, Hughes CL, Scherpf JW, Harding L Shepard KF (1999) Cause, prevalence, and response to occupational musculoskeletal injuries reported by physical therapists and physical therapy assistants. *Physical Therapy* 79: 642–652.

Jacobs K (2005) a randomised controlled trial examining the effect of an exercise program on imporoving the ability of physiotherapy students to stabilise their thumbs during posteroanterior mobilisation techniques. Hons thesis, University of South Australia.

Maitland GD, Banks K, English K Hengeveld E (2001) Maitland's Vertebral Manipulation (6th ed.). Oxford: Butterworth-Heinemann.

Manheim C (2001) The Myofascial Release Manual (3rd ed). Thorofare: Slack.

Reglar P, James G (1999) Thumb pain in physiotherapists: a preliminary study. *British Journal of Therapy and Rehabilitation* 6: 505–509.

Wajon A, Ada L (2003) Prevalence of thumb pain in physical therapists practicing spinal manipulative therapy. *Journal of Hand Therapy* 16: 237–244.

Wajon A, Ada L, Refshauge K (in press) Work related thumb pain in physiotherapists is associated with thumb alignment during performance of posteroanterior pressures. *Manual Therapy* ePub ahead of print 12 July 2006.

Wan H (1986) Biomechanical analysis of stresses in the articular structures of the inter-phalangeal and metacarpo-phalangeal joints of the thumb during performance of Maitland postero-anterior vertebral mobilisation techniques. Unpublished Independent Research Project, Lincoln Institute, Melbourne.

Winzeler S Rosenstein BD (1996) Occupational injury and illness of the thumb: causes and solutions. *AAOHN Journal* 44: 487–492.

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