An evaluation of Superthumb and the Kneeshaw device as manual therapy tools

Christopher G Maher¹, Jane Latimer¹ and Ian Starkey²

¹The University of Sydney  ²Westmead Hospital, Sydney

This research evaluated two hand-held tools (Superthumb and Kneeshaw device) that have been developed in order to reduce hand pain associated with the performance of manual therapy. Two studies were conducted: one evaluated the ability to perceive elastic stiffness with the devices and the other evaluated physiotherapist and patient comfort when the devices were used to apply a mobilisation to the lumbar spine. In the first study we found that the two tools and the pisiform grip provided equivalent ability to detect small differences in elastic stiffness, however the tools introduced a bias so that the stiffness stimuli felt stiffer than when assessed with the pisiform grip. In the second study we found that the two tools were substantially less comfortable than the pisiform grip, for both patient and therapist, when a therapist applied a Grade III mobilisation to the lumbar spine. The results suggest that neither tool, in its current form, is suitable for clinical practice. [Maher CG, Latimer J and Starkey I (2002): An evaluation of Superthumb and the Kneeshaw device as manual therapy tools. Australian Journal of Physiotherapy 48: 25-30]

Key words: Equipment Design; Hand; Manipulation, Orthopedic

Introduction

Physiotherapists who work in primary care and outpatient departments may spend a great deal of their day performing manipulative therapy. Physiotherapy workforce surveys report that manual therapy is a common treatment for spinal pain (Battie et al 1994, van der Valk 1995) and that spinal pain is the most common condition managed by physiotherapists (Battie et al 1994). In the past, manual therapy was regarded with some scepticism, however recent systematic reviews (eg van Tulder et al 1997) and evidence-based clinical practice guidelines (eg Waddel et al 1996) provide support for the use of this treatment. This emerging evidence base in support of manipulative therapy makes it likely that manipulative treatment will remain a common physiotherapy treatment option.

While manipulative treatment may be beneficial for patients, there is some concern within the profession that it may be harmful to the operator and lead to wrist/hand/thumb pain. Interestingly, despite anecdotal evidence that many physiotherapists suffer wrist/hand/thumb pain that they attribute to performance of manual therapy, there is a paucity of published research on this topic. Currently there are only three published studies that have examined this issue: Bork et al 1996, Cromie et al 2000 and Holder et al 1999. The USA surveys (Bork et al 1996; Holder et al 1999) both report that approximately one third of physiotherapists reported musculoskeletal symptoms in the wrist/hand and that wrist/hand pain was the second most common problem, surpassed only by low back pain. The Australian study (Cromie et al 2000) sampled Victorian physiotherapists; surveys were sent to one quarter of registered physiotherapists, with 68% responding. The reported prevalence of wrist/hand/thumb pain was quite similar to that reported in the USA studies; the 12 month prevalence of thumb symptoms was 33.6% and for wrist/hand 21.8%.

Two studies provide evidence to suggest that physiotherapists who use manual therapy are more likely to report wrist/hand/thumb pain. Bork et al (1996) noted that therapists who routinely performed manual therapy were 3.5 times more likely to report musculoskeletal symptoms in the wrists and hands than those who did not. Cromie reported a larger effect: physiotherapists who performed manual therapy were 7.7 times more likely to report musculoskeletal symptoms in the wrists and hands than those who did not. Cromie reported a larger effect: physiotherapists who performed manual therapy were 7.7 times more likely to report thumb symptoms and 4.0 times more likely to report wrist symptoms. Unfortunately, both studies used a cross-sectional design so they do not provide strong evidence to suggest that manual therapy is a risk factor for the development of wrist/hand/thumb pain. However, because all three studies report such a high prevalence of work-related hand pain we would argue that there is an urgent need to conduct prospective studies to evaluate this issue.

One potential strategy to prevent hand pain in physiotherapists is for the therapist to use a tool to apply manual treatment. In Australia a tool that has been widely promoted for this purpose is Superthumb (Superthumb P/L 2001a). Superthumb consists of a wooden handpiece with...
interchangeable rubber contact heads (see Figures 1A, 1B). The therapist uses the Superthumb as the point of contact with the patient rather than their thumbs or hand. The promoters claim that Superthumb is “an essential tool to protect your most valuable asset…your hands” and that the device “reduces hand fatigue and pain” and is “comfortable for clinician and patient” (Superthumb P/L 2001a). Additionally the promoters claim that while “initially with Superthumb use there may be some loss of clinician sensitivity,” “with experience, Superthumb use can become highly sensitive” (Superthumb P/L 2001b).

The promoters of Superthumb provide no direct data to support their claims for the tool and a literature search failed to locate any research evaluating the tool. The current project began the process of evaluating the tool by evaluating two important attributes: patient and therapist comfort and clinician sensitivity when using the tool. Because a prototype of an alternate tool, the Kneeshaw device, was provided to us for evaluation at the time we were planning the study, we chose to evaluate both tools in the one project. The Kneeshaw device is illustrated in Figures 1A, 1C.

### Study 1

#### Method

**Subjects** Fifteen subjects participated as raters in the evaluation of the sensitivity provided by the devices. These subjects were a sample of convenience recruited from the student body and teaching staff of the School of Physiotherapy at The University of Sydney. Student participants were only eligible if they had passed both the undergraduate subject where they are taught to perform the posteroanterior (PA) pressure and the clinical education placement where they would have used the technique on patients. The group’s mean (SD) clinical experience using the PA pressure was 6.3 (8.8) years.

**Instrumentation** A mechanical device, previously used in stiffness perception studies, was used to generate stiffness stimuli (Maher and Adams 1996). The device consists of a metal base plate and a metal lever arm that rotates at one end around a stand attached to the base plate. The free end of the lever arm rests on a compression spring which may be located in holes in the base plate. The stiffness of the movement of the free end of the lever can be altered by moving the spring closer to, or further away from, the centre of rotation or by changing the spring.

**Procedure** The study used signal detection theory methods (McNicol 1972) to investigate the influence of the three methods of performing the PA pressure (pisiform grip, Kneeshaw device, Superthumb) on: (i) subjects’ ability to discriminate stiffness stimuli; and (ii) the perceived magnitude of stiffness stimuli. This methodology has been used in prior research on the PA pressure to establish the effect of variables such as vision (Maher and Adams 1996).

![Figure 1. Devices tested: A. Superthumb (left) and Kneeshaw device (right). B: Superthumb in use. C: Kneeshaw device in use.](image)
and number of sampling cycles (Macfadyen et al 1998) on stiffness discrimination. In the current experiment, two stiffnesses were chosen which are typical of the PA stiffness of the human lumbar spine: 13.46N/mm and 14.94N/mm (Latimer et al 1996). The 10% difference in magnitude was selected so that the stimuli would be difficult though not impossible to discriminate. In signal detection theory terminology, the less intense stimulus is labelled the noise and the more intense the signal (McNicol 1972).

Each subject underwent two testing sessions of approximately half an hour each. In total, the subjects judged 180 stiffness stimuli: 30 signals and 30 noise stimuli under each of the three testing conditions. The order of stimulus (signal or noise) and testing condition (pisiform grip, Kneeshaw device and Superthumb) was randomised.

At the first testing session, subjects were instructed in the use of both tools and allowed to practise pressing upon the stiffness generating device with the pisiform grip and both tools. The subjects were acquainted with the stimuli using a standardised protocol which involved: (i) presentation of both signal and noise using each testing condition twice (if still unsure of the difference between stimuli, subjects were allowed one more trial with each testing condition); and (ii) presentation of the signal with each method, then the noise with each method. In the second session, subjects underwent the same standardised acquaintance prior to testing.

Testing trials began immediately following the acquaintance phase and each trial involved one judgment of stiffness. Subjects were instructed to press upon the stiffness device three times and to then rate the stimulus as either a signal or a noise using the following four point scale

1 Certain that the stimulus was the noise (less stiff)
2 Uncertain, but think stimulus was noise
3 Uncertain, but think the stimulus was the signal
4 Certain that the stimulus was the signal (more stiff)

The number of testing cycles was standardised to three because previous research has shown that discriminability of stiffness is affected by the number of sampling movements, with the best discriminability achieved when using three cycles (Macfadyen et al 1998).

To remove extraneous cues to stimulus identity we placed a cloth screen around the stiffness device so that the spring position was not visible. Subjects also wore goggles with an opaque cover that could be flipped down to occlude vision when the spring was being moved and lifted up to allow vision during performance of the PA pressure. Also between each trial, the spring position was moved and replaced regardless of whether the stiffness was changed, so that subjects could not rely upon the previous rating. Finally, no feedback was provided to subjects until they had completed both testing sessions.

Data processing and statistical analysis The ratings for each subject were used to create a 2 x 4 confusion matrix and receiver operating characteristic curves were constructed for each subject and testing condition (ie 45 curves). The area under the curve (AUC) varies from 0 to 1.0 and provides a measure of the subject's ability to discriminate the two stiffness stimuli. An AUC value of 0.5 represents discriminability no better than chance and an AUC value of 1.0 represents perfect discrimination. The
curves and areas were calculated using a macro within Excel.

Each subject’s average rating for each of the three conditions was also calculated. Since there were an equal number of signal and noise stimuli, the average rating should lie halfway between 1 and 4 if there were no bias in ratings. However, it may be that under a given testing condition, the stimuli may feel more or less stiff and this would be reflected in the average rating. For example, in past research we have shown that occlusion of vision makes stiffness stimuli appear stiffer than when vision is allowed, even though the physical value of the stimuli has remained unchanged (Maher and Adams 1996).

The group mean and 95% confidence intervals for both perception measures were calculated for each condition. A one-way repeated measures analysis of variance with planned comparisons (pisiform grip versus Kneeshaw, pisiform versus Superthumb and Superthumb versus Kneeshaw) was conducted on the AUC data. A similar separate ANOVA was performed on the bias measure.

Results

The group mean and 95% confidence intervals for the stiffness discrimination scores (AUC) under each of the three testing conditions is shown in Figure 2A. The ANOVA revealed that the testing methods had similar discriminability (pisiform vs Kneeshaw $F_{1,14} = 0.984$, $p = 0.347$; pisiform vs Superthumb $F_{1,14} = 0.049$, $p < 0.828$; Kneeshaw vs Superthumb $F_{1,14} = 2.744$, $p = 0.120$).

The group mean and 95% confidence intervals for the perceived magnitude of stiffness under each of the three testing conditions is shown in Figure 2B. The stimuli tended to feel stiffest when sampled with the Superthumb and least stiff with the pisiform grip. Each pair-wise comparison was statistically significant (pisiform vs Kneeshaw $F_{1,14} = 9.133$, $p = 0.009$; pisiform vs Superthumb $F_{1,14} = 51.539$, $p < 0.001$; Kneeshaw vs Superthumb $F_{1,14} = 5.136$, $p = 0.040$).

Study 2

Method

Subjects Six physiotherapists participated in the study. The physiotherapists’ mean (SD) duration of clinical experience was 14.7 (10.0) years. Each physiotherapist was required to have experienced thumb and/or hand pain that they attributed to the performance of spinal manual therapy. Four of the six reported having altered their work practices to accommodate their symptoms, three reported having sought treatment and one had been forced to cease practice due to symptoms. Each physiotherapist completed a modified Pain Disability Index (range 0-70) to describe their disability due to their hand problem (Tait et al 1990).

The questionnaire was modified by replacing the words ‘pain’ and ‘chronic pain’ with the words ‘hand problem’ in the first two explanatory paragraphs. The mean (SD) hand disability score was 7.0 (8.2).

Twenty-four asymptomatic physiotherapy students participated as mock patients in the study. Exclusion criteria were: a history of low back pain requiring treatment or work/university absence in past 12 months, history of cancer or arthritis, recent weight loss, current back or leg pain. Each subject was required to be pain-free when overpressure was applied to lumbar flexion and extension active movements. The students’ mean (SD) age was 21.9 years (4.0); height 167.8cm (8.4) and weight 58.9kg (11.1).

Instrumentation To standardise the amount of force used with each tool, subjects were positioned on a height-adjustable instrumented plinth. The plinth contains seven load cells and is able to measure the force applied to the plinth in three axes. The plinth has been shown to have high accuracy, with errors less than 2% (Chiradejnant et al 2000).

A computer screen was positioned in front of the physiotherapist and provided immediate visual feedback on the magnitude of vertical force applied. The force was displayed on the screen as a vertical column analogous to a thermometer. The limits of the target forces were portrayed using a number scale and also by changing the colour of the column when the force was outside the desired limits.

Mock patients and physiotherapists rated their comfort, during the performance of the PA pressure, on 100mm visual analogue scales (VAS) anchored with the descriptors ‘very uncomfortable’ (0mm end of scale) and ‘very comfortable’ (100mm end of scale).

Procedure Prior to data collection, physiotherapists underwent a 10min training session during which they were taught how to use each tool to apply a Grade III PA pressure to the L3 spinal level of one of the investigators. For this study, we defined a Grade III PA pressure as an oscillation between 75 and 125 Newtons (see normative data provided by Harms and Bader 1997). The physiotherapists were acquainted with the computer screen force display and practised producing a Grade III mobilisation in the range 75-125 Newtons. The comfort VAS was then explained to both patient and physiotherapist.

The first three physiotherapists performed the PA pressure under the three conditions (ie pisiform grip, Kneeshaw device, Superthumb) on the same panel of 12 patients while the second three physiotherapists used a different panel of 12 patients. Two panels of patients were used to minimise the time commitment required and to minimise the potential for soreness from repeated PA pressure testing. The testing sequence was pre-determined to counterbalance the order of conditions for both patients and physiotherapists. Testing for each physiotherapist was completed at the one session, so that in total, six testing
sessions were required. Each patient attended three testing sessions.

At each testing session, the first mock patient was positioned on the instrumented plinth with his or her lumbar spine exposed. One of the investigators then palpated and marked the L3 spinal level according to the method described by Grieve (1991). The plinth force reading was zeroed and the physiotherapist applied 10 seconds of Grade III PA mobilisation to L3, at the same time observing the computer screen to ensure that the force was within the force limits. The mobilisation was restricted to 10 seconds duration, rather than a typical treatment dose, to minimise the risk of exacerbating the physiotherapist’s hand pain. At the completion of the mobilisation, both therapist and patient completed their comfort VAS and rested for 60 seconds. This process was repeated for the other two conditions. The mock patient then left the room and the therapist then repeated the process for the next 11 patients.

Statistical analysis The group means and 95% confidence intervals for comfort ratings under each condition were calculated for both physiotherapists and patients. A one-way repeated measures analysis of variance with planned comparisons (pisiform grip versus Kneeshaw, pisiform versus Superthumb and Superthumb versus Kneeshaw) was then conducted on both the physiotherapist and patient comfort ratings.

Results

The group means and 95% confidence intervals for the patient ratings of comfort for each condition are shown in Figure 2D. The pisiform grip was rated most comfortable, followed by the Kneeshaw device with Superthumb least comfortable of the methods of performing the PA pressure. Each of the pair-wise comparisons was statistically significant (pisiform vs Kneeshaw $F_{1,23} = 50.396, p < 0.001$; Pisiform vs Superthumb $F_{1,23} = 187.153, p < 0.001$; Kneeshaw vs Superthumb $F_{1,23} = 43.063, p < 0.001$).

The group means and 95% confidence intervals for physiotherapist ratings of comfort are shown in Figure 2C. Similarly to the patients, physiotherapists rated the pisiform grip most comfortable, followed by the Kneeshaw device with Superthumb again the least comfortable of the methods of performing the PA pressure. The ANOVA revealed that while there was no difference in comfort between the pisiform grip and Kneeshaw device ($F_{1,5} = 3.753; p = 0.11$), both of these conditions were more comfortable than Superthumb (Pisiform vs Superthumb $F_{1,5} = 23.098, p < 0.005$; Kneeshaw vs Superthumb $F_{1,5} = 17.616, p = 0.009$).

Discussion

The results of the first study demonstrate that the developers of both tools have managed to produce devices that do not interfere with the therapist’s ability to discriminate elastic stiffness in a laboratory. While both devices produce biases so that stiffness stimuli appear stiffer than when sensed with the human hand alone, this is not really a problem unless therapists swap between different methods of performing the PA pressure. The ability to judge stiffness is an important prerequisite for a manual therapy tool because contemporary practice places great importance on the therapist’s ability to sense subtle changes in stiffness during both assessment and treatment. A tool that impaired this ability would be unsuitable for clinical use.

While both devices were designed to prevent pain, it may be possible to design manual therapy tools that actually improve the therapist’s ability to judge physical parameters such as stiffness. In domains outside of physiotherapy, tools are used to improve humans’ ability to judge physical parameters. For example, craftsmen place a piece of paper between the hand and the surface to be judged for roughness in order to assist detection of surface undulations. Subsequent psychophysical research has confirmed that this strategy indeed does improve a subject’s ability to judge roughness of a surface (Gordon and Cooper 1975). In addition to judging elastic stiffness, manual therapy texts (eg Maitland 1986) have suggested a wide array of characteristics that need to be judged during performance of the PA pressure eg resistance, active recoil, resistance-free range. While these characteristics are often imprecisely described, they would seem to correspond to biomechanical parameters such as force, friction and viscosity. At a minimum, a prototype tool should not impair the operator’s innate ability to sense these parameters and it would be desirable to develop tools that enhance the operator’s ability.

Unfortunately, at this stage the results of the second study, evaluating patient and therapist comfort, suggest that neither tool, in the form we evaluated, is suitable for clinical practice. The Superthumb was clearly less comfortable, for both patients and therapists, than the use of the therapist’s own hands. While we did not measure therapist’s symptoms over the long term, it does not seem plausible that a device that causes marked discomfort with brief periods of use would prevent symptoms in the long term. Even in the unlikely event that this were true the patient comfort data persuades a compelling argument against the use of both devices, particularly the Superthumb which, from the patients’ perspective, was clearly the least comfortable method of delivering a PA pressure.

Whilst our study does not support the use of these tools in their current form, it may be possible to redesign the tools so that comfort is improved. For example, the therapists who participated in the study suggested that the Superthumb could be improved if the rubber contact head was made of softer material and was concave (to avoid the contact head rolling off the point of contact). This suggestion concords with many of the impromptu comments from the patients who stated that the
Superthumb was much too hard. In addition to changing the hardness of the contact head, comfort may be improved by increasing the surface area of the contact head. Nicholson et al (1998) estimated that the contact area for the pisiform pressure was on average 1600mm$^2$, whereas the surface area of the contact on the largest Superthumb contact head is approximately 490mm$^2$ (the contact area of the Kneeshaw device is 706mm$^2$). This means that the contact pressure on the skin is three times greater with the use of Superthumb than with the typical human hand. Because the rubber contact heads on the Superthumb have a snap fitting to the body of the tool, to allow the operator to switch between the three heads of different sizes, provision of a series of redesigned contact heads is feasible.

**Conclusion**

While both tool developers have successfully designed tools that do not interfere with the therapist’s ability to judge stiffness, both tools are significantly less comfortable than the traditional pisiform grip. The results of our study argue against the clinical use of either tool in their current form.

**Acknowledgements** The authors would like to thank Mr David Kneeshaw for the donation of the prototype tool evaluated in this study. The authors have no financial relationship with, and did not receive funding from, the promoters of either tool.

**Authors** Christopher Maher, School of Physiotherapy, The University of Sydney, Sydney, NSW 1825. E-mail: c.maher@cchs.usyd.edu.au (for correspondence). Jane Latimer, School of Physiotherapy, The University of Sydney, Post Office Box 170, Lidcombe, New South Wales 1825. Ian Starkey, Physiotherapy Department, Westmead Hospital, Westmead, NSW 2145.

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