Change in impairments in the first two treatments predicts outcome in impairments, but not in activity limitations, in subacute neck pain: an observational study

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Question: Does change in impairments within and between the first two manual therapy treatments predict change in activity limitations by the end of treatment in patients with subacute neck symptoms? Design: Longitudinal, observational study. Participants: 29 people with neck pain for more than two weeks who subsequently received ≥ three treatments. Outcome measures: Impairments measured were active neck ROM in six directions (total ROM), most limited direction of ROM (limited ROM), pain intensity, and pain location. Activity limitations were measured using the Neck Disability Index and the Patient Specific Functional Scale. Patients' perceptions of change were measured using the Global Perceived Effect Scale. Impairments and patients' perceptions were measured before and after the first two treatments and before the final treatment whereas activity limitations were measured only before the first and last treatments. Results: All measures improved by the end of treatment. Between-treatment change in limited ROM predicted change in limited ROM ($r_s^2 = 0.53$ and 0.57) and total ROM ($r_s^2 = 0.26$) by the end of treatment. Within- and between-treatment change in pain location predicted change in pain location ($r_s^2 = 0.24, 0.27, 0.27$) 0.28, and 0.57) by the end of treatment. No significant relationships were found between change in any impairments in the first two treatments and change in activity limitations by the end of treatment. Conclusions: Change in impairments predicts change in the same impairment by the end of treatment, but not in other impairments or activity limitations. It is recommended that the reassessments used to guide and refine treatment be individualised and related to the specific goals for that patient. [Tuttle N, Laakso L, Barrett R (2006) Change in impairments in the first two treatments predicts outcome in impairments, but not in activity limitations, in subacute neck pain: an observational study. Australian Journal of Physiotherapy 52: 281-2851

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Introduction

Musculoskeletal symptoms affecting the neck are second in frequency only to those affecting the lower back (Bogduk et al 2003). Altered cervical intervertebral mobility combined with a patient's neurophysiological responses are thought to result in impairments such as pain and/or reduced active neck movement (Banks 1998). These impairments interact with psychosocial factors and result in activity limitations (Edwards et al 2006).

Manual therapy is a common treatment for symptoms of the cervical spine targeting altered intervertebral mobility (Banks 1998). Based on a hypothetico-deductive reasoning model, reassessments of impairments after treatment are typically used to monitor the effectiveness of manual therapy and guide treatment selection and application (Edwards et al 2006). The therapist's reasoning process relies on an unproven assumption that immediate withintreatment improvement in impairments is predictive of progress towards a reduction in limitation of activities. Although immediate changes in impairments have been found to occur following manual therapy treatment (Cassidy et al 1992, Goodsell et al 2000, Tuttle 2005), and manual therapy can be effective in improving activity limitations (Costello and Jull 2002), it does not necessarily follow that within-treatment changes in impairments are predictors of that improvement. Within-treatment changes in ROM and pain have been found to predict between-treatment changes in the same parameters for both the lumbar (Hahne et al 2004) and cervical spines (Tuttle 2005). The possibility that within-treatment changes in impairments may be predictors of activity limitations could therefore be demonstrated either directly or by establishing a link between between-treatment changes and activity limitations.

To our knowledge, no studies have assessed whether, for patients with cervical spine pain receiving manual therapy, within- or between-treatment changes in impairments predict changes in activity limitations. Therefore the aim of this study was to determine if change in impairments in the first two manual therapy treatments predicted change by the end of treatment in patients with subacute neck symptoms. Changes occurring in the first two treatments were considered in this study because anecdotal evidence suggests that many clinicians advise their patients that if treatment is going to be successful, some improvement would be expected to occur within the first two treatments. Outcome at the end of treatment was considered to be the clearest indicator of the effect of manual therapy. It was considered that the intention of manual therapy is predominantly to improve symptoms by the end of treatment, as distinct from other interventions such as exercises, education, and modification of activities that may emphasise longer-term outcomes such as prevention of symptom recurrence. We hypothesised that within- and between-treatment change in impairments in the first two treatments would predict end of treatment outcomes and that changes in combinations of impairments would be better predictors of change by the end of treatment than individual impairments.

| Table 1. | Mean (SD) o | of score and mean | (SD) of change | score for all outcomes. |
|----------|-------------|-------------------|----------------|-------------------------|
|----------|-------------|-------------------|----------------|-------------------------|

| Outcome | Score | | | | Change score | | | | | |
|--------------------------|----------------|---------------|---------------|---------------|----------------|-----------------------------|----------------------------------|----------------------------------|-----------------------------|-----------------------------|
| | Pre 1 | Post 1 | Pre 2 | Post 2 | Pre Final | Post 1 minus Pre 1 | Pre 2 minus Pre 1 | Post 2 minus Pre 2 | Post 2 minus Pre 1 | Pre Final minus Pre 1 |
| Total ROM (deg) | 259.5 (49) | 281.9 (52) | 284.1 (52) | 294.6 (54) | 292.5 (51) | 22.4 (19.6) p < 0.001 | 24.5 (33.2) p = 0.001 | 10.6 (16.1) p = 0.002 | 35.1 (15.7) p = 0.001 | 33.0 (36.4) p < 0.001 |
| Limited ROM (deg) | 38.1 (17) | 46.7 (19) | 50.3 (13) | 51.5 (14) | 52.4 (17) | 8.5 (10.3) p < 0.001 | 12.5 (12.5) p < 0.001 | 0.9 (3.8) p = 0.24 | 13.4 (13.8) p < 0.001 | 14.2 (16.4) p < 0.001 |
| Pain intensity (0 to 10) | 4.9 (2.1) | 3.3 (1.8) | 3.5 (2.5) | 3.6 (2.6) | 2.0 (2.4) | 1.6 (1.7) p < 0.001 | 1.3 (2.0) p = 0.002 | -0.1 (1.7) p = 0.11 | 1.3 (2.0) p = 0.001 | 2.9 (2.5) p < 0.001 |
| Pain location (0 to 6) | 3.0 (0.9) | 2.3 (1.1) | 2.7 (1.1) | 2.3 (1.1) | 2.2 (1.2) | 0.3 (1.5) p = 0.33 | 0.1 (1.0) p = 0.46 | 0.4 (0.9) p = 0.04 | 0.5 (1.3) p = 0.05 | 1.1 (1.6) p < 0.001 |
| NDI (%) | 28.1 (13.2) | | | | 16.6 (10.4) | | | | | 11.4 (14.3) p < 0.001 |
| PSFS (0 to 10) | 5.3 (1.4) | | | | 7.2 (1.9) | | | | | 2.0 (2.4) p < 0.001 |
| GPES (-5 to +5) | | | | | | 1.8 (2.0) p < 0.001 | 1.6 (1.5) <i>p</i> < 0.001 | 2.1 (1.9) <i>p</i> < 0.001 | | 2.7 (1.5) p < 0.001 |

Note that the level of significance is p < 0.01. NDI = Neck Disability Index, PSFS = Patient Specific Functional Scale, GPES = Global Perceived Effect Scale

Method

Design Measurements were taken on five occasions: prior to and following Treatment 1 (Pre 1 and Post 1), prior to and following Treatment 2 (Pre 2 and Post 2), and prior to the final treatment (Pre Final). End of treatment was deemed to occur when: the patient or therapist considered that treatment was no longer required or that other types of treatment were indicated; greater than two weeks had passed between treatments; or a total of six treatments had been provided. Treatment consisted primarily of manual therapy as defined by Korthals-de Bos et al (2003) and was unaffected by participation in the study. Research procedures were approved by the Ethics Review Committee, James Cook University. A more detailed description of the method used in this study can be found in Tuttle (2005).

Participants Participants were recruited from patients who presented to a private physiotherapy clinic. The inclusion criterion was neck pain of greater than two weeks' duration accompanied by reduced neck mobility. Exclusion criteria were a current third party claim, a history of trauma, physical treatment within the past two weeks, or presence of any inflammatory or other medical condition likely to impact on symptoms or treatment. A total of 29 patients who fulfilled the selection criteria and subsequently received three or more treatments were included in the study; they comprised 21 females and 8 males, aged 55 yr (SD 17, range 28–83). They received 3.4 treatments (range 3–6), 6.1 days apart (range 2–14) within 15 days (range 7–27).

Outcome measures Impairments measured included ROM and pain. ROM was measured using a head-mounted 3axis orientation sensor^(a). The seated patient was asked to perform three movements in each direction of right and left rotation, right and left lateral flexion, flexion and extension. The maximum value for each movement was recorded electronically without the therapist being aware of the value. The six active neck ROMs were summed to give a total ROM. The most limited direction of movement (limited ROM) was defined as the less mobile direction around the axis in which the difference between the two directions was greatest. Pain intensity was measured on an 11-point (0 to 10) visual analogue scale such that a higher number corresponded to a greater intensity of pain. Pain location was measured according to Werneke et al (1999) on a sevenpoint (0 to 6) scale such that a higher number corresponded to a more distal location.

Activity limitations were measured using the Patient Specific Functional Scale and the Neck Disability Index. The Patient Specific Functional Scale scores activities on a visual analogue scale from 0 (unable to perform activity) to 10 (able to perform activity at the same level as before). The scores for individual activities were averaged with lower scores indicating greater activity limitations (0 to 10). The Neck Disability Index is a 10-item questionnaire with six responses (0 to 5) for each item. The summed score was converted to a percentage with higher scores indicating greater activity limitations.

Patients' perceptions of overall change were measured using the Global Perceived Effect Scale designed to assess all factors related to patients' symptoms in a single integrated measure and was scored on an 11-point scale where -5 is vastly worse and +5 is completely recovered.

Data analysis The mean and standard deviation was calculated for each variable at each occasion. The relationships of interest involved change over time, so the differences between measurements were used for analysis. Change scores were calculated as change within-treatments (Post 1 minus Pre 1 and Post 2 minus Pre 2), change between-treatments (Pre 2 minus Pre 1 and Post 2 minus Pre 1) and change by the end of treatment (Pre Final minus Pre 1).

The significance of changes was assessed using one-tailed paired-sample t-tests of each variable for each time period. Spearman's rank order correlation coefficient (r_{i}) was used to assess relationships between all changes in variables in the first two treatments and those between the beginning and end of treatment. The coefficient of determination (r_s^2) was reported rather than r_s as r_s^2 represents the proportion of the variance accounted for by the relationship and was thus more useful in indicating the clinical significance of the findings. Because of the large number of comparisons performed (~100), a family wise error corrected p value (p< 0.01) was used to control the false discovery rate (Howell 2002). Multiple regression analysis was used to explore more complex relationships between changes during the first two treatments and activity limitations. Possible predictors of changes in activity limitations with p < 0.10 were entered stepwise into a regression model and were retained if their coefficients were significant at p < 0.05.

Results

All impairments and activity limitations improved by the end of treatment (Table 1). Furthermore, most impairments improved *within* the first treatment or, if not, improved *between* the first and second treatment (Table 1). In addition, patients perceived that they had improved (Table 1).

The coefficients of determination between change in the first two treatments and change by the end of treatment are shown in Table 2. In summary, change in outcome measures in the first two treatment sessions was only ever able to predict change in the same outcome measure by the end of treatment. Between-treatment changes in limited ROM predicted changes in limited ROM ($r_s^2 = 0.53$ and 0.57) and total ROM ($r_s^2 = 0.26$ and 0.26) by the end of treatment. Within- and between-treatment changes in pain location predicted changes in pain location ($r_s^2 = 0.24$, 0.27, 0.28 and 0.57) by the end of treatment. Patients' perception of change within the first treatment predicted their perception of change ($r_s^2 = 0.32$) by the end of treatment.

No change in impairments in the first two treatments predicted change in activity limitations by the end of treatment (Table 2). Furthermore, stepwise addition of within- or betweentreatment change in impairments into multiple regression analyses did not demonstrate any improved ability of combinations of impairments to predict change in activity limitations beyond those found with single impairments.

Discussion

This study set out to determine if change in impairments in the first two treatments predicted change in activity limitations

by the end of treatment for patients with subacute neck pain receiving manual therapy. All impairments and activity limitations improved by the end of treatment. Change in some impairments in the first two treatments predicted change in the same impairment by the end of treatment, but our expectation that change in either individual impairments or combinations of impairments would predict change in activity limitations by the end of treatment did not occur.

Strengths and weaknesses This is the first known study to investigate an assumption underlying clinical reasoning commonly used in manual therapy. The sample size used in this study was sufficient to detect strong relationships, but would not necessarily have been able to detect weak or complex relationships. Repeating the statistical analyses with a significance level of p < 0.05 to detect Type 2 errors did not produce a clinically-significant difference in the results. Although the analysis reported in this paper is limited to correlation and regression analysis, we have previously performed other statistical tests, grouping and analysing the variables in a variety of ways, and no additional clinicallysignificant patterns were detected (Tuttle et al 2005).

The results of this study may not be generalisable to treatment by modalities other than manual therapy. The overt interventions used in this study were limited to predominantly manual therapy, but any therapeutic contact impacts on psychosocial factors and potentially has effects that are difficult to predict. In addition, it has been suggested that the hypothetico-deductive model of clinical reasoning used in this study may not be appropriate when extended beyond the relatively mechanistic constructs of impairment to include factors such as activity limitations where 'knowledge is socially constructed, context dependent and...there are multiple realities rather than a single truth waiting to be discovered' (Edwards et al 2006).

Findings in relation to previous studies Within-treatment (Skytte et al 2005, Werneke and Hart 2001, Werneke et al 1999) and between-treatment (Werneke and Hart 2003) changes in pain location have been found to predict changes in various outcome measures by the end of treatment in patients with low back pain when the treatment is according to the McKenzie method (Walsh 2001). Our findings support pain location being a predictor of pain location by the end of treatment but not being a predictor of other outcome measures. The apparent discrepancy between this study and previous studies may be due to treatment in the current study consisting of manual therapy rather than the McKenzie method.

Within-treatment changes in active ROM and pain intensity have been found to predict between-treatment changes in the same parameters for patients with both low back pain (Hahne et al 2004) and neck pain (Tuttle 2005) receiving manual therapy. Our current analysis extends these findings to the ability of within-treatment change in some impairments to predict change by the end of treatment, but almost exclusively within the same impairment.

The findings of this study support the notion that change in active neck ROM, in particular, change in the most limited ROM, is a better predictor of change by the end of treatment than change in pain intensity. Previous studies have shown that neck ROM in symptomatic patients tends to decrease with repeated measurement (Lee et al 2005), but this did not occur in our repeatability assessments (Tuttle 2005) nor was it apparent in post treatment data. Differences in the method

Table 2. Spearman coefficients of determination (r_s^2) between change in the first two treatments and change by the end of treatment.

| Treatment 1 and 2 | | Pre Final minus Pre 1 | | | | | | | | |
|--|-----------------------|-----------------------|--------------------------------|--------------------------------|------------------------------|------------------------------------|---|--|--|--|
| Impairments and global perceived effect | | | Impa | irments | | Ac limit | tivity ations | Patients' perceptions | | |
| | | Total ROM (deg) | Limited ROM <i>(deg)</i> | Pain intensity (0 to 10) | Pain location (0 to 6) | Neck Disability Index (%) | Patient Specific Functional Scale (0 to 10) | Global Perceived Effect Scale (-5 to +5) | | |
| Total ROM (deg) | Post 1 minus Pre 1 | 0.18 p = 0.01 | 0.07 p = 0.09 | 0.08 p = 0.07 | 0.00 p = 0.42 | 0.01 p = 0.46 | 0.00 p = 0.40 | 0.16 p = 0.02 | | |
| | Pre 2 minus Pre 1 | 0.14 p = 0.03 | 0.18 p = 0.01 | 0.03 p = 0.19 | 0.01 p = 0.32 | 0.00 p = 0.42 | 0.07 p < 0.08 | 0.05 p = 0.12 | | |
| | Post 2 minus Pre 2 | 0.02 p = 0.26 | 0 02 p = 0.24 | 0.09 p = 0.06 | 0.01 p = 0.36 | 0.00 p = 0.46 | 0.06 p = 0.10 | 0.01 p = 0.34 | | |
| | Post 2 minus Pre 1 | 0.11 p = 0.05 | 0.00 p = 0.42 | 0.02 p = 0.25 | 0.01 p = 0.27 | 0.03 p = 0.18 | 0.14 p = 0.02 | 0.06 p = 0.11 | | |
| Limited ROM (deg) | Post 1 minus Pre 1 | 0.11 p = 0.05 | 0.07 p = 0.09 | 0.02 p = 0.27 | 0.02 p = 0.27 | 0.01 p = 0.33 | 0.03 p = 0.21 | 0.12 p = 0.04 | | |
| | Pre 2 minus Pre 1 | 0.26 p < 0.01 | 0.57 p < 0.001 | 0.00 p = 0.50 | 0.15 p = 0.02 | 0.15 p = 0.02 | 0.00 p = 0.44 | 0.00 p = 0.47 | | |
| | Post 2 minus Pre 2 | 0.12 p = 0.03 | 0.13 p = 0.03 | 0.21 p = 0.01 | 0.01 p = 0.36 | 0.00 p = 0.37 | 0.00 p = 0.45 | 0.09 p = 0.07 | | |
| | Post 2 minus Pre 1 | 0.26 p < 0.01 | 0.53 p < 0.001 | 0.05 p = 0.13 | 0.08 p = 0.07 | 0.10 p = 0.05 | 0.00 p = 0.48 | 0.01 p = 0.31 | | |
| Pain intensity (0 to 10) | Post 1 minus Pre 1 | 0.00 p = 0.49 | 0.04 p = 0.17 | 0.00 p = 0.46 | 0.09 p = 0.06 | 0.01 p = 0.34 | 0.00 p = 0.43 | 0.00 p = 0.39 | | |
| | Pre 2 minus Pre 1 | 0.03 p = 0.21 | 0.03 p = 0.18 | 0.10 p = 0.05 | 0.07 p = 0.09 | 0.01 p = 0.33 | 0.00 p = 0.49 | 0.00 p = 0.38 | | |
| | Post 2 minus Pre 2 | 0.02 p = 0.22 | 0.03 p = 0.21 | 0.01 p = 0.34 | 0.00 p = 0.46 | 0.01 p = 0.30 | 0.01 p = 0.37 | 0.03 p = 0.21 | | |
| | Post 2 minus Pre 1 | 0.03 p = 0.21 | 0.03 p = 0.18 | 0.10 p = 0.05 | 0.07 p = 0.09 | 0.01 p = 0.33 | 0.00 p = 0.49 | 0.00 p = 0.38 | | |
| Pain location (0 to 6) | Post 1 minus Pre 1 | 0.00 p = 0.42 | 0.00 p = 0.38 | 0.11 p = 0.04 | 0.27 p < 0.01 | 0.04 p = 0.15 | 0.01 p = 0.31 | 0.00 p = 0.40 | | |
| | Pre 2 minus Pre 1 | 0.02 p = 0.22 | 0.00 p = 0.47 | 0.04 p = 0.16 | 0.24 p < 0.01 | 0.03 p = 0.19 | 0.00 p = 0.47 | 0.04 p = 0.15 | | |
| | Post 2 minus Pre 2 | 0.01 p = 0.33 | 0.00 p = 48 | 0.01 p = 0.28 | 0.28 p < 0.01 | 0.01 p = 0.35 | 0.05 p = 0.13 | 0.00 p = 0.41 | | |
| | Post 2 minus Pre 1 | 0.00 p = 0.42 | 0.00 p = 0.47 | 0.08 p = 0.07 | 0.57 p < 0.001 | 0.02 p = 0.25 | 0.01 p = 0.31 | 0.06 p = 0.12 | | |
| Global Perceived Effect Scale (-5 to +5) | Post 1 minus Pre 1 | 0.03 p = 0.19 | 0.07 p = 0.10 | 0.00 p = 0.49 | 0.00 p = 0.47 | 0.17 p = 0.02 | 0.06 p = 0.10 | 0.32 p < 0.01 | | |
| | Pre 2 minus Pre 1 | 0.01 p = 0.30 | 0.00 p = 0.43 | 0.06 p = 0.11 | 0.01 p = 0.36 | 0.01 p = 0.35 | 0.03 p = 0.18 | 0.17 p = 0.01 | | |
| | Post 2 minus Pre 2 | 0.00 p = 0.50 | 0.02 p = 0.21 | 0.01 p = 0.35 | 0.02 p = 0.26 | 0.03 p = 0.19 | 0.03 p = 0.18 | 0.12 p = 0.04 | | |

Note: significant correlation is ρ < 0.01 for the corresponding $\rm r_s$

of measurement may account for these discrepancies, as our participants were not required to maintain an end of range position while measurements were taken.

Clinical implications The results of this study suggest that although change in impairments in the first two treatments predicts change in the same impairment by the end of treatment, this change is not a good predictor of improvement in activity limitations for patients with subacute neck pain receiving manual therapy. Perhaps most important is the finding of the specificity of predictors for change in the same parameter by the end of treatment.

In order to be useful in guiding the clinician's application and refinement of treatment, a reassessment must be responsive and valid. That is, the reassessments must be able to detect small changes and the changes that are detected must be related to changes in the desired outcomes. Measures of activity limitations are not considered responsive to the small changes necessary for day-to-day reassessment whereas measures of impairments used to assess withinand between-treatment effects are responsive, but their relevance is now questionable.

The importance of this study for the clinician is that no single impairment or combination of impairments accurately predicted improvement in activity limitations. It is recommended that, in order to assist patients and clinicians to achieve specific goals, the reassessments used to guide and refine treatment should be individualised for that patient and related directly to the goals specific to that patient. Reassessment of one impairment or set of impairments is unlikely to be effective for all patients. Rather we suggest that an understanding of the patient's goals can assist the clinician to determine a combination of impairments and activity limitations to be reassessed that balance responsiveness and relevance. Changes in the most limited or most painful direction of active movement may be the most responsive impairment for reassessment, but additional assessments of activity limitations may be necessary to ensure their relevance.

Footnotes ^(a)3DM MicroStrain Inc, 310 Hurricane Lane, Williston, VT, USA

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