Do within-session changes in pain intensity and range of motion predict between-session changes in patients with low back pain?

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Physiotherapists commonly use post-treatment changes in a patient's pain intensity and range of motion to guide treatment selection and predict possible longer-term outcomes. This study tested the validity of this practice by evaluating the predictive value of within-session changes in pain intensity and range of motion in 53 patients with low back pain. Pain intensity and range of motion measurements of spinal flexion, extension, lateral flexion, and straight-leg-raise were taken by the patient's therapist before and after one treatment session, and were repeated by a blinded therapist at the beginning of the patient's subsequent treatment session. Regression analysis revealed that the strength of association between within-session and between-session changes ranged from r = 0.35 to r = 0.80 for range of motion measurements, and from r = 0.24 to r = 0.47 for pain intensity. Odds ratios for pain and range of motion ranged from 3.5 (95% CI 0.9 to 14.6) to 37.0 (95% CI 4.1 to 330), indicating greater odds of improving between-session if improvement was obtained within-session. These results provide preliminary support for the practice of using within-session changes in pain intensity and range of motion to guide treatment selection when treating impairments in patients with low back pain. **[Hahne AJ, Keating JL and Wilson SC (2004): Do within-session changes in pain intensity and range of motion predict between-session changes in patients with low back pain? *Australian Journal of Physiotherapy* 50: 17–23]**

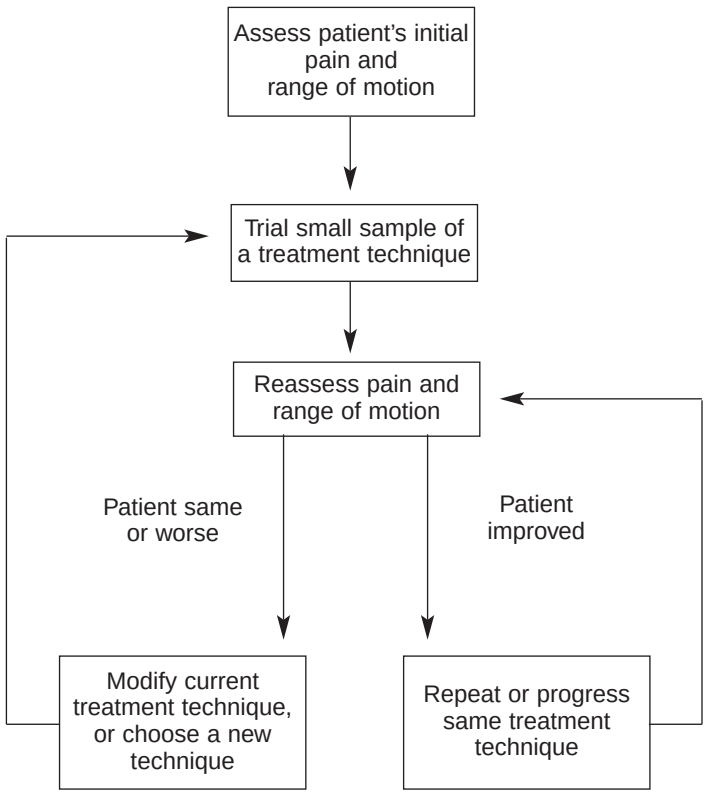
Key words: Low Back Pain; Patient Selection; Physiotherapy; Predictive Value of Tests; Range of Motion

Introduction

A challenge facing clinicians is the selection of treatment for patients with low back pain. Patient management models based on pathology are not always helpful in treatment selection as it is estimated that a specific diagnosis can be made for only 15% of patients with low back pain (Cherkin 1998, Waddell 1998). Compounding this uncertainty is the lack of scientific evidence to support particular treatment approaches for patients with low back pain (Foster 1998, Skargren and Oberg 1998). This complicates treatment selection, as it compels therapists to predict the likely benefit of a particular treatment approach for each individual patient (Waddell 1987).

A method of selecting and modifying treatment on a case-by-case basis, that does not require confident diagnosis of the underlying pathology, has been promoted by Maitland (1986, 1991). Maitland advocated administering a treatment technique and immediately reassessing the patient's symptoms and signs to evaluate the treatment's potential effectiveness. Treatment modifications can then be made on the basis of reassessment findings until a method is found that positively improves symptoms such as pain, or signs such as range of motion or ability to perform an activity. Maitland suggested that if a patient's signs or symptoms worsen immediately following a technique, the technique should be altered or discarded. If a patient improves following a technique, it could be repeated (see Figure 1). Although Maitland described these principles with reference to peripheral (Maitland 1991) and vertebral (Maitland 1986) joints, their application to low back pain is particularly

Figure 1. The role of within-session reassessment in physiotherapy treatment selection.



useful given the difficulties in tailoring treatment for individuals with this condition.

In addition to Maitland, several other well-known authors and clinicians have recommended within-session reassessment to evaluate the effect of treatment and guide ongoing treatment selection. Such recommendations are evident in the writings of Cyriax (Cyriax and Russel 1977), Kaltenborn (1980), Mennell (1960), Mulligan (1992), Butler (1991) and McKenzie (1981).

Given these recommendations from highly influential authors and clinicians, we considered it likely that the practice of utilising within-session response to treatment to guide treatment selection was widespread. Refshauge and Gass (1995) acknowledged that the work of these individuals, particularly of Maitland, has had a large influence on manual therapy education, and consequently on clinical practice. To explore this possibility we surveyed Australian educators of physiotherapy students. In Australia there were six postgraduate courses in musculoskeletal/manipulative physiotherapy in the year of survey. A survey was sent via electronic mail to the co-ordinator of each course. All six respondents indicated that students were taught that changes in a patient's pain and/or range of motion immediately following the application of a treatment technique may demonstrate the potential usefulness of that technique for the patient.

Evaluating therapy based on the immediate change it produces in measurable impairments or activities is not restricted to those administering the therapy. There is clear evidence that *patients* also assess the benefit of treatment based on its immediate effect. A survey conducted by Grimmer et al (1999) asked 121 patients with low back pain presenting to 24 physiotherapy practices in South Australia about the outcomes they expected by the end of the first treatment session. The most common expectation was symptom relief, cited by 74% of patients who had attended physiotherapy previously and 46% of new attendees. Several new attendees (23%) expected to be completely cured within the first treatment session. Such expectations challenge therapists to achieve large improvements within the first treatment session. In addition, 61 (91%) of the physiotherapists surveyed in the same study shared their patients' views, with these therapists expecting to provide patients with symptom relief within the first treatment session.

Assumptions underlying the use of within-session changes to guide treatment selection and judge the immediate effectiveness of techniques have not been described in the published literature. However, one likely assumption underlying the principle would be that within-session responses to treatment are thought to offer some indication of the potential longer term response to that treatment. There would be little point in methodically reassessing a patient's signs and symptoms to achieve the largest within-session improvement possible, if all or part of this improvement was not maintained. Given that the use of these reassessment principles is strongly advocated, the validity of the assumption that within-session changes endure beyond the duration of the treatment session warrants examination. The aim of this study was, therefore, to determine the utility of within-session changes in pain intensity and range of motion for predicting between-session changes in patients with low back pain.

Method

Overview Research procedures were approved by the Faculty of Health Sciences Human Ethics Committee, La Trobe University. Eighteen physiotherapists from six private practice clinics in Melbourne, Australia, collected data on patients presenting with low back pain between 5 January and 20 June 2000. Therapists were 10 males and 8 females with a mean of 16 years (SD 8.4, range 6–32) of clinical experience. Nine therapists had completed or were studying for postgraduate qualifications in manipulative physiotherapy. Range of motion measurements and pain intensity scores were obtained before and after a treatment session by the treating therapist, and repeated by a blinded assessor prior to treatment on a second occasion. Data were then examined to determine if changes obtained within-session were present when the patient returned for follow up treatment.

Table 1. Subject characteristics (n = 53).

Variable	n	%
Gender		
Male	22	42
Female	31	58
Pain		
LBP, buttock only	35	66
LBP and leg pain	18	34
LBP and leg pain below knee	11	21
LBP and radicular signs	5	9
Treatment session entered into study		
First	39	74
Second	8	15
Not recorded	6	11

Variable	Mean	SD	Median	Range
Age (y)	43.1	16.5	45	18–82
Duration of current LBP episode (days)	30.3	44.3	10	1–180

Subjects Consecutive subjects presenting for treatment of low back pain were recruited if they were 18 years of age or older, were presenting for their *first* or *second* treatment session for their current episode of low back pain, and had not received any manual therapy for their current episode. Patients were excluded if they presented with pathology where manual therapy was contraindicated (Grieve 1989, Maitland 1986), were pregnant, or had a condition that may have been substantially aggravated by performing the test procedures, as determined using Maitland's irritability criteria (Maitland 1986). Six patients (9%) who had tape applied to the back as part of treatment were also excluded from data analysis, as this can restrict spinal range of motion. An additional six patients (9%) did not return for the follow-up session. The characteristics of the remaining 53 participants involved in data analysis are presented in Table 1. All subjects signed consent forms.

Measurement methods The range of motion measurement procedures were identified through an extensive literature search. A pilot study was then performed where two therapists measured range of motion on 15 asymptomatic physiotherapy students on two occasions, separated by one week. This study aimed to identify ways to quantify the variability in repeated measurements and to improve the accuracy of the measurements. It was our preference to use fast and simple measurement procedures that required minimal equipment in order to simulate likely clinical practice. Modified versions of previously reported finger-to-floor methods of measuring spinal flexion and lateral-flexion were tested in the pilot study and used in the present study (Frost et al 1982, Gauvin et al 1990, Hyytiäinen et al 1991). A previously unreported finger-to-floor method of measuring

Table 2. Random error associated with inter-therapist, inter-session measurements in the pilot study (n = 15).

Measurement	r	SEM	MLDC
Flexion	0.96	2.1 cm	4.8 cm
Extension	0.96	1.5 cm	3.6 cm
Lateral-flexion	0.91	1.8 cm	4.2 cm
Straight-leg-raise	0.88	4.9°	11.3°

r = Pearson product moment correlation coefficient. SEM = Standard error of measurement, calculated using the formula SEM = SD $\sqrt{1-r}$, where SD is the average standard deviation of test scores on the two measurement occasions (Stratford and Goldsmith 1997). MLDC = 90% confidence for minimum level of detectable change, calculated using the formula *MLDC = SD x 1.64*, where SD is the standard deviation of the difference scores between measurements and is estimated by *SD = SEM x* $\sqrt{2}$ (Stratford et al 1996).

Table 3. Treatments administered in Session A.

Treatment technique	% of patients receiving technique
Passive joint mobilisation	81
Education/advice	43
Exercises	43
McKenzie movement therapy	26
Electrotherapeutic modalities	25
Soft tissue massage	17
Mechanical traction	6
Manipulation	4
Muscle stretches	4
Neural stretches	2

extension was developed in the pilot study, and demonstrated acceptable reliability for use in the main study. All finger-to-floor tests involved the subject standing with feet either side of an A4 sheet of paper. The distance between the middle finger and the floor was measured by the therapist using a retractable metal tape measure as the subject moved forwards, laterally, and backwards to the end of available range. A digital inclinometer[(a)] was used to measure straight leg raise. The device was placed over the anterior aspect of the subject's distal tibia, and the therapist passively raised the subject's leg. The straight leg raise measurement was recorded at the first point of onset or increase in back or leg symptoms, in keeping with other studies (Chow et al 1994, Porter and Trailescu 1990). The inter-therapist and inter-session error estimates obtained in the pilot study for these measurements are expressed using the standard error of measurement in Table 2.

During assessment of each movement, patients were asked by the assessor to rate their pain intensity on a verbally administered 0–10 numerical rating scale (NRS) (Paice and Cohen 1997, Turk and Melzack 1992). This scale was used for its speed of administration compared to a visual analogue scale (VAS) (Price et al 1994), given the large number of pain scores to be obtained. Surveys have also shown that more patients and therapists prefer to use a NRS than a VAS (Price et al 1994, Turner et al 1996). In addition, the reliability of the NRS appears to be excellent (r = 0.94 to 0.96) (Bosi Ferraz et al 1990). Pain intensity was not measured for straight leg raise, given that onset or increase in pain was used to determine end of range for this test; so changes in pain scores were not expected.

Procedure Each subject performed all movements on three occasions over two treatment sessions. At the beginning of the first session (Session A), the treating therapist measured the patient's range of motion of spinal flexion, extension, and left and right lateral-flexion. Patients rated their pain intensity on the verbal NRS following each movement. Range of left and right straight leg raise were also measured. In accordance with typical practice, the therapist administered treatment he or she deemed appropriate for that patient, and repeated the measurements at the conclusion of Session A. At this stage only the independent variables had been obtained (the within-session change in each measurement), so no blinding procedures were required. Measurements from Session A were recorded on a standardised form and sealed in an opaque envelope. Although all movements were recorded, therapists were asked to identify the movement(s) that they would be most likely to reassess for each patient. The number of days between treatment sessions was at the discretion of the treating therapist.

At the beginning of the patient's next treatment (Session B), all measurements were repeated and recorded on a separate form by another therapist from the same clinic. The Session B assessor was blinded to the measurements recorded in Session A. Blinding procedures prevented bias in the Session B measurements that might influence the observed relationship between the independent (within-session change) and dependent (between-session change) variables.

Data analysis Within-session changes were the differences between measurements taken before treatment and after treatment in Session A. Between-session changes were the differences between the first measurement taken during Session A and the measurement taken before treatment during Session B. Data analysis was performed using Microsoft Excel Version 7.0[(b)] and SPSS Version 6.1[(c)].

Within and between session changes in pain intensity and range of motion were analysed using a regression analysis for each movement. The strength of association between within-session and between-session changes was determined using the Pearson product moment correlation coefficient (r). The coefficient of determination (r^2), and the root mean square of the residuals (RMS), were calculated to give an indication of the goodness of fit of the regression line.

Odds ratios, and positive and negative likelihood ratios, were calculated to determine the relative odds of retaining treatment effects in patients who improved within-session compared to patients who remained unchanged or worsened. For pain intensity, patients were defined as 'improved' if their pain intensity scores decreased by one point or more in comparison to their pre-treatment scores in Session A. For range of motion measurements, patients were defined as 'improved' if their range of motion increased beyond the 90% confidence interval for the minimum level of detectable change for unchanged subjects as derived from the pilot study data (Stratford et al 1996) (see Table 2).

Subgroup analyses were performed in which a measurement was included only if the therapist had indicated on the Session A recording form that he or she would be most likely to reassess that movement for that particular patient. Such movements are

Table 4. Mean within-session and between-session changes in ROM achieved in patients.

Movement	Mean within-session change (SD)		Mean between-session change (SD)	
	Range of motion	Pain	Range of motion	Pain
Flexion	3.5 cm (9.6)	1.1 (1.7)	9.2 cm (17.1)	1.6 (2.9)
Extension	0.8 cm (2.9)	1.1 (1.9)	1.9 cm (4.4)	1.7 (2.7)
Lateral-flexion (left)	2.3 cm (7.3)	0.8 (1.9)	3.3 cm (7.9)	1.0 (2.3)
Lateral-flexion (right)	2.5 cm (5.2)	0.6 (1.6)	3.2 cm (6.6)	1.1 (2.2)
SLR (left)	5.3° (10.1)	–	7.1° (12.7)	–
SLR (right)	4.8° (7.3)	–	5.8° (11.8)	–

Positive values indicate increases in range of motion, and decreases (improvement) in pain intensity scores.

Table 5. Regression statistics.

Measurement	All subjects			Asterisked movements		
	n	r^2	RMS	n	r^2	RMS
ROM						
Flexion	51	0.34	14.0	25	0.47	15.3
Extension	52	0.12	4.2	30	0.11*	4.9
Lateral-flexion (left)	53	0.64	4.8	11	0.87	5.6
Lateral-flexion (right)	53	0.35	5.3	8	0.22*	5.0
SLR (left)	52	0.51	9.0	12	0.56	8.3
SLR (right)	53	0.42	9.0	14	0.36	12.0
Pain						
Flexion	51	0.22	2.6	25	0.20	2.8
Extension	48	0.16	2.5	30	0.18	2.5
Lateral-flexion (left)	46	0.09	2.2	11	0.01*	3.3
Lateral-flexion (right)	46	0.06*	2.2	7	0.03*	3.0

*$p > 0.05$, all other analyses $p \leq 0.05$. RMS = root mean square of the residuals around the regression line.
r^2 = coefficient of determination.

termed 'asterisked movements' by Maitland (1986).

A further subgroup analysis, planned *a priori,* was performed to evaluate whether episode duration influenced the association between within- and between-session changes. Episode duration has been previously shown to be an overall predictor of outcome (McIntosh et al 2000, Thomas et al 1999) and hence it was feasible that episode duration might be associated with retention of treatment effects.

Results

Descriptive statistics The treatments administered by therapists during Session A are presented in Table 3. Most patients (83%) received a combination of two or more types of treatment. The mean time between Session A and Session B was 4.8 days (SD = 2.6, range = 2–11). The mean pain intensity and range of motion changes are presented in Table 4. These data show that, on average, patients' range of motion for all movements increased within-sessions, and increased further between-sessions, while pain decreased within-sessions and decreased further between-sessions.

Linear regression Results of linear regression analyses are presented in Table 5. The slope of the fitted trendline was positive for all regression plots, indicating that larger within-session improvements were associated with larger between-session improvements. The association between within-session and between-session changes was statistically significant for all movements in the full sample other than right lateral-flexion pain intensity.

To determine the influence of atypical data points on the regression results, some patients were eliminated from the data sets, and the regression lines refitted. High leverage points were defined as X-values (within-session changes) lying more than approximately 3 standard deviations from the mean X-value (Rawlings et al 1998). Eliminating these patients had virtually no effect on the regression results for flexion range of motion and all pain intensity analyses. The range of motion results for extension, lateral flexion (left and right), and straight leg raise (left and right) were influenced by the high leverage points, with smaller r^2 values resulting once these subjects were eliminated. However, clinically important r^2 values still resulted, and most analyses retained statistical significance. The only exception was extension range of motion, which did not remain statistically significant without the one high leverage point identified in these data ($r^2 = 0.05$, $p = 0.12$).

Odds and likelihood ratios Odds and likelihood ratios in Table 6 show that patients who improved within-session were more likely to demonstrate between-session improvements than patients who worsened or remained unchanged within-session. The 95% confidence intervals suggest that results were statistically

Table 6. Odds and likelihood ratio analysis for prediction of between-session changes.

	n	Accuracy (%)	+LR (95% confidence)	-LR (95% confidence)	Odds ratio (95% confidence)
ROM					
Flexion	51	82	9.7 (2.5 to 38.0)	0.3 (0.2 to 0.6)	29.7 (5.5 to 161.1)
Extension	52	79	3.7 (0.9 to 16.0)	0.8 (0.5 to 1.1)	4.8 (0.8 to 28.0)
Lateral-flexion (L)	53	83	9.8 (2.3 to 41.5)	0.5 (0.3 to 0.9)	18.5 (3.2 to 108.3)
Lateral-flexion (R)	53	74	2.6 (0.9 to 7.0)	0.7 (0.5 to 1.1)	3.5 (0.9 to 14.6)
SLR (L)	52	88	19.0 (2.6 to 138.8)	0.5 (0.3 to 0.8)	37.0 (4.1 to 330.8)
SLR (R)	53	81	13.9 (1.78 to 109.1)	0.7 (0.4 to 1.0)	21.1 (2.2 to 203.7)
Pain					
Flexion	51	71	2.5 (1.3 to 5.0)	0.4 (0.2 to 0.8)	5.8 (1.7 to 19.3)
Extension	48	67	2.3 (1.0 to 5.0)	0.5 (0.3 to 0.9)	4.5 (1.3 to 16.0)
Lateral-flexion (L)	46	80	4.4 (1.9 to 10.3)	0.3 (0.1 to 0.7)	15.6 (3.6 to 68.4)
Lateral-flexion (R)	46	74	3.3 (1.4 to 7.7)	0.4 (0.2 to 0.8)	8.0 (2.1 to 30.4)

n = number of patients. Accuracy = percentage of patients who were correctly classified as improved or not improved between-session based on their within-session response. +LR = positive likelihood ratio: indicates how much the odds of improving between-session increase if improvement was made within-session. -LR = negative likelihood ratio: indicates how much the odds of improving between-session decrease if no improvement was made within-session.

Table 7. Subgroup analyses based on duration of episode of LBP for flexion data.

	Flexion ROM		Flexion pain	
	(≤ 1 week)	(> 1 week)	(≥ 1 week)	(> 1 week)
n	23	26	22	27
Ratios				
+LR	5.1 (0.8 to 34.5)	9.0 (2.4 to 34.1)	1.9 (0.7 to 5.1)	2.9 (1.2 to 7.3)
-LR	0.5 (0.3 to 0.9)	0.1 (0.0 to 0.7)	0.6 (0.3 to 1.3)	0.4 (0.1 to 1.0)
Odds ratio	10.7 (1.0 to 109.9)	81.0 (6.4 to 1017.0)	3.2 (0.5 to 19.0)	8.0 (1.4 to 45.8)
Accuracy (%)	70	96	64	74
Regression				
r	0.40	0.89	0.40	0.51
r^2	0.16	0.80	0.16	0.26
RMS	10.7	7.4	3.0	2.4
p	0.06	< 0.001	0.07	0.006

Statistical tests of interaction comparing results in patients with an episode duration of less than or equal to one week compared to more than one week: Regression ROM: $p = 0.001$; Regression pain: $p = 0.65$; Odds ratio ROM: $p = 0.25$; Odds ratio pain: $p = 0.48$.

significant for range of motion of flexion, left lateral-flexion, and straight leg raise (left and right), and for pain intensity on all movements. Confidence intervals for extension range of motion and right lateral-flexion range of motion crossed 1.0, indicating non-significant results. The majority (67–88%) of patients could be correctly classified as between-session improvers or non-improvers based on their within-session response to treatment.

Subgroup analyses Regression results for the subgroup of asterisked movements chosen by the therapist are presented in Table 5. Odds ratios (OR) were also calculated for tests of this subgroup. Although clinically important odds remained evident, the smaller sample sizes resulted in broad confidence intervals that included one. The exception to this was for assessment of flexion range of motion (OR 10.5, 95% CI 1.5 to 72.0) and flexion pain intensity (OR 14.0, 95% CI 1.3 to 150.0).

Results of subgroup analyses based on the duration of the patients' episode of low back pain are presented in Table 7. Regression and odds ratios for those with an episode duration of one week or less were compared with those with an episode duration of more than one week. The only difference between groups was the finding of a significant difference between regressions for flexion range of motion ($p = 0.001$). This indicated that a stronger association existed between within-session and between-session changes in flexion range of motion in patients with an episode duration of more than one week, compared to those with a shorter duration of symptoms.

Discussion

The main objective of this study was to determine the utility of within-session changes in pain intensity and range of motion for

predicting between-session changes in patients with low back pain. This provided a test of the validity of using within-session changes to guide selection of treatments intended to reduce pain or improve impairments in range of motion. The linear regression results suggested that within-session changes in pain intensity and range of motion give an indication of between-session changes, with regression lines sloping positively and reaching statistical significance for all but one analysis (right lateral-flexion pain intensity). The likelihood and odds ratio analysis for both range of motion and pain intensity data further supports the predictive utility of within-session changes. Patients who improved within-session were considerably more likely to demonstrate between-session improvements. These results give preliminary support to the practice of using within-session changes in pain intensity and range of motion as a guide to treatment selection and modification.

The high RMS values obtained in all regression analyses (Table 5) indicate that the fitted regression lines lacked precision in their representation of the actual data points. Thus the regression equations show only a general pattern and would not be an accurate tool for predicting exact between-session changes.

The r^2 values (Table 5) also indicate the predictive accuracy of the regression lines, and aid the interpretation of the clinical significance of the findings (Howell 1992). Within-session range of motion changes accounted for 12–64% of the variance in between-session changes. This is a reasonable result when considering the number of other factors that may potentially influence between-session changes in range of motion. Such factors may include varying rates of natural recovery, changes in activities or medication intake, or aggravation of the problem between treatment sessions. Less variance was explained by the pain intensity associations, suggesting that factors other than within-session changes had a more substantial influence on between-session pain intensity changes.

The overall regression and odds ratio results were similar in magnitude to the subgroup analyses where only asterisked movements were included in each analysis. These were the movements most likely be used by the therapists to monitor the effect of their treatments and to make treatment selection decisions. However, several of these analyses failed to reach statistical significance, due to the smaller sample sizes.

Some preliminary evidence was presented to suggest that within-session changes in pain intensity and range of motion for flexion may be less predictive of between-session responses in patients with an episode duration of less than or equal to one week, compared to more than one week. Although tests for interaction were statistically significant for only the flexion range of motion regression analysis, this finding is a preliminary step towards defining the characteristics of patients whose responses to treatment are unpredictable. Future research might further explore the characteristics of patients who are likely to respond in unpredictable ways, to limit invalid inferences being made from observed change within-session.

A strength of this study was its clinical orientation. This ensured that results would be generalisable to the settings where they will be applied. Data were collected by 18 physiotherapists at six private practices. Hence the findings are generalisable to the wider population of physiotherapists working in private practice.

The importance of the results of this study is limited somewhat by the value of the information provided by measurements of pain intensity and range of motion. Some authors advocate that outcome measures used to monitor patients with low back pain should be multi-dimensional rather than limited to evaluation of impairment alone (Beattie and Maher 1997, Deyo and Centor 1986, Waddell 1998). We agree that monitoring impairment is not a valid substitute for monitoring functional ability in patients with low back pain. Scales for measuring functional ability are, however, not suited to estimating the immediate effects of therapy on a patient's condition. In contrast, the usefulness of impairment measures for planning and monitoring treatment is acknowledged by the Agency for Healthcare Policy and Research (Bigos et al 1994). In addition, therapy that seeks to improve both impairment and function in subjects with low back pain is recommended by the World Health Organisation (WHO 2001).

For further confidence in the findings and generalisability of these results, this study should be repeated. This is particularly important given that some analyses failed to reach statistical significance possibly due to the relatively small sample sizes, particularly in the subgroup analyses. Limitations of the present study that may restrict generalisability of the findings include the high level of experience of the therapists involved, and the participants who were in the early stages of treatment (first or second treatment session).

Measurement reliability was tested on normal subjects in the pilot study. It was assumed that errors would be greater in measurement of patients. Measurement error was not large enough to obscure effects in analyses involving the full sample of patients because most observed relationships attained statistical significance. Measurement error may have obscured effects in subgroup analyses.

The reassessment principles investigated in the current study are also applied to peripheral joints (Maitland 1991). Validation of these practices in selecting treatment for problems affecting peripheral joints could be attempted in future research.

To summarise, this study has shown that within-session changes in pain intensity and range of motion measurements of flexion, extension, lateral-flexion and straight leg raise predict between-session changes for patients receiving physiotherapy treatment for low back pain. These findings provide preliminary justification for the use of within-session changes in range of motion and pain intensity to guide the selection of treatment of impairment.

Footnotes [(a)]Smart-tool Builders Angle Finder, Scientific Instruments, 633 Chapel St, South Yarra, Melbourne 3141. [(b)]Microsoft Corporation, One Microsoft Way, Redmond, WA 98052-6399. [(c)]SPSS Inc, 444N Michigan Ave, Chicago, IL 60611.

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References

Beattie P and Maher C (1997): The role of functional status questionnaires for low back pain. *Australian Journal of Physiotherapy* 43: 29–38.

Bigos S, Bowyer O and Braen G (1994): Acute low back problems in adults: Clinical practice guidelines No. 14. AHCPR Publication No.95-0642. Rockville, MD: Agency for Health Care Policy and Research, Public Health Service, U.S. Department of Health and Human Services.

Bosi Ferraz M, Quaresma MR, Aquino LRL, Atra E, Tugwell P and Goldsmith CH (1990): Reliability of pain scales in the assessment of literate and illiterate patients with rheumatoid arthritis. *Journal of*

Rheumatology 17: 1022–1024.

Butler D (1991): Mobilisation of the Nervous System. Melbourne: Churchill Livingstone.

Cherkin DC (1998): Primary care research on low back pain. *Spine* 23: 1997–2002.

Chow R, Adams R and Herbert R (1994): Straight leg raise test high reliability is not a motor memory artefact. *Australian Journal of Physiotherapy* 40: 107–111.

Cyriax J and Russel G (1977): Textbook of Orthopaedic Medicine: Part 2–Treatment by Manipulation, Massage and Injection. London: Bailliere Tindall.

Deyo RA and Centor RM (1986): Assessing the responsiveness of functional scales to clinical change: An analogy to diagnostic test performance. *Journal of Chronic Disease* 39: 897–906.

Foster NE (1998): Researching low back pain? An overview of the pitfalls. *Physical Therapy Reviews* 3: 9–17.

Frost M, Stuckey S, Smalley LA and Dorman G (1982): Reliability of measuring trunk motions in centimeters. *Physical Therapy* 62: 1431–1437.

Gauvin MG, Riddle DL and Rothstein JM (1990): Reliability of clinical measurements of forward bending using the modified fingertip-to-floor method. *Physical Therapy* 70: 443–447.

Grieve GP (1989): Contra-indications to spinal manipulation and allied treatments. *Physiotherapy* 75: 445–453.

Grimmer K, Sheppard L, Pitt M, Magarey M and Trott P (1999): Differences in stakeholder expectations in the outcome of physiotherapy management of acute low back pain. *International Journal for Quality in Health Care* 11: 155–162.

Howell DC (1992): Statistical methods for psychology. Boston: PWS-Kent.

Hyytiäinen K, Salminen JJ, Suvitie T, Wickström G and Pentti J (1991): Reproducibility of nine tests to measure spinal mobility and trunk muscle strength. *Scandinavian Journal of Rehabilitation Medicine* 23: 3–10.

Kaltenborn FM (1980): Mobilization of the Extremity Joints: Examination and Basic Treatment Techniques. Oslo: Olaf Norlis, p.43.

Maitland G (1986): Vertebral Manipulation. London: Butterworth-Heinemann.

Maitland G (1991): Peripheral Manipulation. London: Butterworth-Heinemann.

McIntosh G, Frank J, Hogg-Johnson S, Bombardier C and Hall H (2000): Prognostic factors for time receiving worker's compensation benefits in a cohort of patients with low back pain. *Spine* 25: 147–157

McKenzie R (1981): The Lumbar Spine: Mechanical Diagnosis and Therapy. Waikanae: Spinal Publications.

Mennell J (1960): Back Pain: Diagnosis and Treatment Using Manipulative Techniques. Boston: Little Brown.

Mulligan BR (1992): Manual Therapy: "NAGS", "SNAGS", "PRPS" etc. Wellington: Plane View Services.

Paice JA and Cohen FL (1997): Validity of a verbally administered numeric rating scale to measure cancer pain intensity. *Cancer Nursing* 20: 88–93.

Porter RW and Trailescu IF (1990): Diurnal changes in straight leg raising. *Spine* 15: 103–106.

Price DD, Bush FM, Long S and Harkins SW (1994): A comparison of pain measurement characteristics of mechanical visual analogue and simple numerical rating scales. *Pain* 56: 217–226.

Rawlings JO, Pantula SG and Dickey DA (1998): Applied Regression Analysis. New York: Springer.

Refshauge K and Gass E (1995) Musculoskeletal Physiotherapy. Oxford: Butterworth-Heinemann, p.3.

Skargren EI and Oberg BE (1998): Predictive factors for 1-year outcome of low-back and neck pain in patients treated in primary care: comparison between the treatment strategies chiropractic and physiotherapy. *Pain* 77: 201–207.

Stratford P and Goldsmith C (1997): Use of the standard error as a reliability index of interest: An applied example using elbow flexor strength data. *Physical Therapy* 77: 745–750.

Stratford PW, Binkley JM, Solomon P, Finch E, Gill C and Moreland J (1996): Defining the minimum level of detectable change for the Roland-Morris Questionnaire. *Physical Therapy* 76: 359–365.

Thomas E, Silman AJ, Croft PR, Papageorgiou AC, Jayson MI and Macfarlane GJ (1999): Predicting who develops chronic low back pain in primary care: a prospective study. *British Medical Journal* 318: 1662–1667.

Turk DC and Melzack R (1992): Handbook of Pain Assessment. New York: Guilford Press.

Turner P, Whitfield A, Brewster S, Halligan M and Kennedy J (1996): The assessment of pain: An audit of physiotherapy practice. *Australian Journal of Physiotherapy* 42: 55–62.

Waddell G (1987): A new clinical model for the treatment of low-back pain. *Spine* 12: 632–644.

Waddell G (1998): The Back Pain Revolution. Edinburgh: Churchill Livingstone.

WHO (2001): International Classification of Functioning Disability and Health. Geneva: World Health Organization.