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Effectiveness of Visual Perceptual Learning on Inter-Therapist Reliability of Lumbar Spine Mobilization

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ABSTRACT
Manual therapy is a widely used treatment technique among physical therapists and is effective in the treatment of musculoskeletal disorders. The theory behind the selection of the appropriate grade of mobilization dictates that proper assessment of the stiffness or resistance of a joint must occur in order to assign the therapeutic intensity. Educational models to teach this theory have shown variable success. In numerous studies, the reliability of clinicians' assessment of stiffness and movement assessment is poor. This present study involved a pre-perceptual educational model designed for 22 practicing physical therapists that performed Grade I, II, III and IV mobilizations on two asymptomatic volunteers. Therapists stood on a Kistler force plate™ during mobilization, and mobilization forces were calculated based on the magnitude of reduction of the therapist's ground reaction forces during mobilization. The five maximal force values for each grade and each subject were used for Intraclass correlation (ICC) analysis of inter-therapist reliability. The ICC value was -0.05 for Grade I mobilizations, -0.05 for Grade II mobilizations, -0.04 for Grade III, and -0.03 for Grade IV. The results for a pre-perceptual educational model are similar to past studies and indicate poor inter-therapist reliability in the performance of all grades of manual therapy mobilization.

INTRODUCTION

Passive accessory intervertebral movements (PAIVMs) are widely used in joint mobilization.[1-3] One particular PAIVM, the posterior-anterior (PA) mobilization applied specifically to the spinous process, is a fundamental technique in clinical judgment in determining joint stiffness and corresponding treatment.[1,4-6] Past studies measuring inter-rater reliability of PA mobilization forces without verbal feedback of the subject have reported a high degree of variability.[7-15] These studies found poor inter-therapist reliability regardless of material or human model, or selection of instrumentation.[5,7-9,12-14,16,17] Patients with non-specific low back pain commonly demonstrate increased resistance of the lumbar spine, thus mastering the PA technique is important for clinical judgment and treatment.[17]

One possible explanation for the poor reliability may be the lack of a standardized educational method for PA interpretation and instruction.[18-26] The most common method of education in manual therapy involves a tutor's perception of tissue resistance compared against student judgment.[17,18,27] This form of retrospective method of education is not optimal because evidence suggests that the tutor's perception of resistance may not be accurate.[17,27]

Past authors have found modifications in the traditional educational model of tutor instruction/student replication, effective in improving reliability.[18,24,27-29] In these studies, the authors used either concurrent or retrospective education sequentially, with feedback devices that reported force output. Concurrent feedback has been shown to be effective in reducing inter-rater error.[18,29] Concurrent feedback allows students to make alterations in their mobilization force during the educational bout, thus improving their reliability. However, the only effective feedback mechanisms have involved mechanical devices such as a force plate or strain gauge that provide data that are numerically compared to the desired forces.[24,27] Concurrent feedback based on instructor or student (acting as a patient) recommendation has not proven effective.

The retrospective education method is not effective in reducing inter-clinician variability.[7,19,27] The retrospective use of perceptual learning methods such as force diagrams and reports, and delayed training, may not be optimal educational methods. Additionally, concurrent and retrospective education may not be practical for most educational settings since the method often requires the use of a force plate, unrestricted time, and introduction to pathological patient tissue all of which are expensive commodities.[19,27]

An alternative method for manual therapy education may be the use of a movement diagram. Movement diagrams generally function as prospective learning models, and were first used by Maitland as a teaching aide and means of communication.[25] As Maitland states "The movement diagram is a dynamic map representing the quality and quantity of passive movement perceived by the manipulative physiotherapist during the examination of any passive movement direction.[25] Movement diagrams offer a pre-perceptual visual representation of the spatial and temporal responses necessary to detect passive resistance of the tissue examined. Spatial and temporal learning consists of a pattern of active movements defined in terms of space and time, anticipated through visual information. Visual modeling has been shown to improve motor learning, specifically in situations that involve exposure to stimuli that require new learning.[30-32]

The visual information provided in a movement diagram defines objective constructs associated for the appropriate amount of graded mobilization forces.[6,9,24,33-36] An example of a movement diagram is provided in Figure 1. The X-axis (line A-B) is used to indicate the onset of pain or resistance, whichever is depicted first. The Y-axis defines the force associated with the mobilization movement. The first point of pain is identified by P1, the first point of resistance, R1, maximum pain, P2 and maximum resistance, R2. Typically, lines are drawn by the therapist upon evaluation of the detected resistance of the joint. Movement diagrams are essential to the understanding of the relationship that the various grades of movement have to the abnormal joint signs.[15] Each grade of motion should vary from subject to subject depending on the first point of resistance felt within the tissue.[26] The first point of resistance is identified as R1.[6,9,24,33-36] Based on the Maitland model, oscillatory forces for Grades I and II should be below R1, whereas forces applied for Grades III and IV should exceed R1 with some degree of overlap.[15] In the presence of these subjective guidelines it may be reasonable and pertinent to quantify the applied magnitude, amplitude, and frequency of oscillations in order to appropriately select the correct therapeutic force.[9,12,37,38]

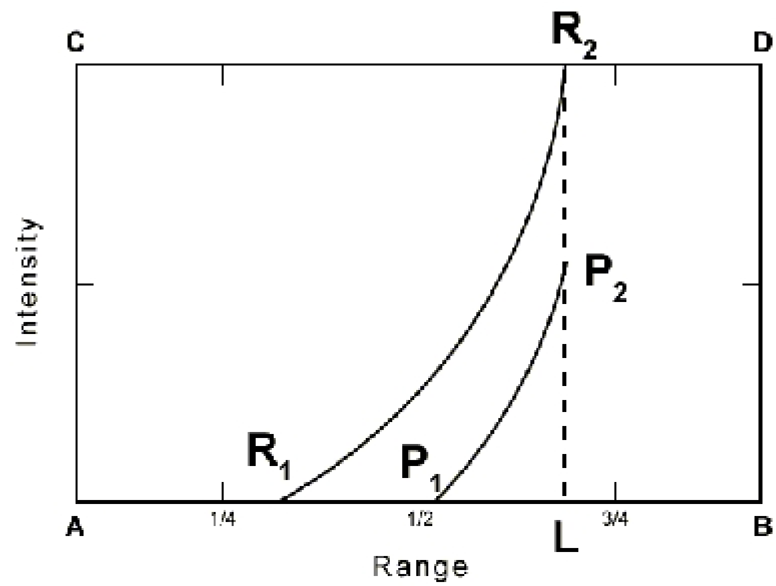

Figure 1 - Example of Movement Diagram

Movement diagrams have been shown to be an effective teaching method for recording the stiffness-force relationship in manual therapy mobilization of the shoulder and ankle.[39-41] At this date there are no studies that measure the effectiveness of a pre-perceptual visual education using movement diagrams on consistency in graded mobilization of the lumbar spine. The purpose of this study is to determine if education using an unfamiliar pre-perceptual visual model (movement diagram) will improve the predictability of a group of manual therapy clinicians. This study has importance because the majority of educational models designed to interpret the amount of resistance of tissue and required force needed to perform a mobilization grade results in inconsistency among students and clincians.[34]

METHODS

Sample

Twenty-two licensed, practicing, physical therapists participated in this study. For this study, the term "subjects" refers to the physical therapists, and "volunteer" refers to the role the patient would play (i.e., recipient of mobilization). Physical therapists were selected through a purposive sample of convenience of practicing clinicians within the West Texas region. The current practice setting of the therapist was not taken into consideration, unless the therapist excluded his/herself because unfamiliarity with mobilization techniques. The order of study participation by the participants was random and based on the order of response through letter of request.

Table 1 summarizes the demographic information of the therapists within the sample. Ages ranged from 27 to 52 years old, with a mean age of 32 years and average of 6.3 years of licensed clinical experience. Clinical background included a variety of post-graduate training; three participants identified themselves as manual therapy instructors for national organizations. Manual therapy utilization ranged from daily use to rarely utilized, with 61% indicating daily use. Sixty-five percent indicated they were educated at a master's level, 31% bachelors, and 4 percent doctoral. The local Institutional Review Board approved this study.

Table 1. Therapist Demographics (N=12)

Age	Mean age 32 (range 26 to 52 years of age)
Sex	17 males and 5 females
Manual Therapy Training/Perspective	43% "Maitland"; 17% "Paris"; 13% "NAIOMT"; 27% None indicated
Terminal Education Level	65% Masters degree; 31% Bachelor's degree, 4% Doctoral degree
Years of Clinical Experience	Mean experience 6.3 years (range 2 months to 23 years)
Frequency of Manual Therapy Utilization	61% daily use; 23% at least 3 times a week; 16% rarely

Three participants were national instructors in Orthopedic Manual Therapy with the designation of "COMT".

Therapists were provided written instructions of the standardized technique to be used during the study and the data collection process, including a movement diagram (Figure 1), a graphical representation of the four grades of mobilization (Figure 2), and the conceptual method in which these methods should be used during testing. Instructions advocated the performance of grades of movement around the detection of R1 (first point of detectable stiffness), as described by Maitland.15 Each point within the movement diagram was described to reference the clinician to the visual parameters associated with force. The subjects had 15 to 20 minutes to familiarize themselves with this pre-perceptual education.

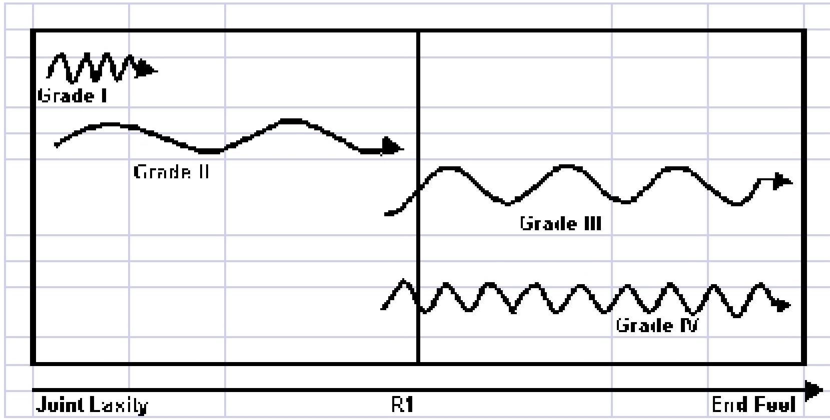

Figure 2. Diagram of Grades of Mobilizations provided to Subjects as a Component of Mobilization Education

Therapists were instructed not to lean against the plinth or move their feet during mobilizations. This minimized structural interference, which could have invalidated the forces measured by the force plate (described below).

Procedure

The experimental design was one-way repeated measures, useful for detecting differences across levels of one repeated factor. A one-way repeated measure designs was selected in place of a pre-test post-test design to stay consistent with current manual therapy inter-rater educational studies. Two asymptomatic volunteers, one male and one female, were used for all test sessions to function as the patient model throughout the study. The asymptomatic volunteers had no history of low back pain that had required consultation by a medical professional. Asymptomatic volunteers were selected versus symptomatic subjects because repeated mobilization does not increase the linear tissue mobility, and will not bias the results of the outcome.[36] The therapists performed three sets of Grades I, II, III, and IV PA mobilizations on the third lumbar spinal segment (L3). L3 was marked on the volunteers prior to the arrival of therapists each day using the method described by Latimer, Lee and Adams.18 The procedure involves palpating with the thumbs medially from the landmark of the superior border of the iliac crests and then palpating the spinous processes of L4-5. Each spinal level is then marked using a permanent market. This procedure has been used frequently in many similar publications and standardizes the reliability by using only one researcher responsible for identification of spinal level for each volunteer. L3 is commonly used by multiple studies since the angle of the vertebra is most perpendicular at this point, and should yield the most predictable results.[18] This process was repeated for each volunteer during each data collection period. The same plinth was used for all trials. The height of the plinth was at the discretion of the therapist.

A Kistler six component force platform system (model 9286AA) was interfaced with the PEAKTM Biomechanical Analysis system to record and analyze ground reaction forces of the therapists during mobilizations. The difference in the magnitude of reduced ground reaction forces before and during mobilizations was taken as the measure of the mobilization forces applied to the volunteer. This process for indirectly measuring the magnitude of mobilization forces applied to human subjects has been validated in a previous study, and has been the procedure of choice for many similar studies.[37] Only vertical forces were collected with the force plate, since horizontal forces play a very small part in the application of PAIVMs.[37]

During the data collection, the therapist stood on the precalibrated Kistler force plate while performing each oscillatory mobilization (Figure 3). The therapist was instructed to begin Grade I mobilization, as assessed by that therapist, on the marked L3 segment. This was done three times, for 30 seconds with a 15-second rest period between each mobilization. The repetition allowed the therapist to incorporate the visual pre-perceptual concepts into physical movements, prior to measuring and served to precondition the spine. The overall “practice” allowed 80 seconds of non-recorded practice to “feel” the tissue and correspond the movement diagram’s conceptual presentation to the outcome of the mobilization. This procedure was repeated for Grade II, Grade III, and Grade IV mobilization, in that order. The Kistler force plate was set to record ground reaction forces during the last 10 seconds of the third mobilization for each of the four grades, thus measuring the force of graded mobilization performed by each clinician. After completing all four grades of mobilizations on the first volunteer, the second volunteer was instructed to lie prone on the plinth in the same manner as the first volunteer. The therapist then repeated the process of performing all four grades of mobilization on the second volunteer. It is important to point out that past authors have shown that repeated forces during multiple trails during a single day and repeated days on asymptomatic subjects will not lead to tissue resistance changes.[36]

Figure 3. Picture of Procedural Mobilization

A model (2,1) Intraclass Correlation Coefficient (ICC) was calculated using SPSS® version 11.0 after the peak-force data were collapsed into grades. This repeated measures ANOVA-based type of correlation measures the relative homogeneity within groups in ratio to the total variation and is used, for example, in assessing inter-rater reliability. An ICC reflects both the degree of correspondence and agreement among ratings.

RESULTS

The forces generated by the raters varied depending by grade and patient. In some cases, forces differed by 14 times between raters using the same grade of mobilization (grade I), with overall forces displaying lows of 10 Newtons for grade I and highs of over 370 Newtons for grade IV. The forces generated in this study are outlined in Table 2.

Table 2. Forces Generated During Grades I through IV

Mobilization Grade	Low Male	High Male	Low Female	High Female
Grade I	10	125	10	142
Grade II	45	154	32	230
Grade III	70	275	60	310
Grade IV	135	430	120	370

Forces represented by Newtons. Low and high scores represent the range of forces for the male and female volunteers.

Table 3 presents the data from Grade I-IV (2,1) ICC mobilizations. The Analysis of Variance was statistically significant for variability in grades I through VI (? = < 0.05). The ICC values for Grade I mobilizations were -0.05, Grade II 0.05, Grade III – 0.04

and Grade IV – 0.03 all of which are very poor. The negative ICC for grades I, III and IV indicate that reliability was worse than would have occurred by chance.

Table 3. Model (2,1) Intraclass Coefficients for Grades I-IV

	Grade I	Grade II	Grade III	Grade IV
Intraclass Coefficient (I.C.C.)	- 0.05	- 0.05	- 0.04	- 0.03
Sum of Squares (SS)	111675	57866	180760	213953
F-Statistic Anova (F)	2.51	5.67	3.85	3.00
Significance Anova (p)	0.01	< 0.001	0.013	0.006
Degrees of Freedom (df)	1,44	1,44	1,44	1,44

Table 3 depicts a Model (2,1) I.C.C. values for Grade I through IV analyzed using SPSS version 11.0. The negative I.C.C. for each grade indicates that reliability was worse than would have occurred by chance.

Figure 4 represents a standard error boxplot using SPSS version 11.0. The error bars represent the range of values within the study, and the boxed regions represent the mean of the participants force for both the male and female patients. Outliers were not presented within the graph and were only present in Grade III and IV.

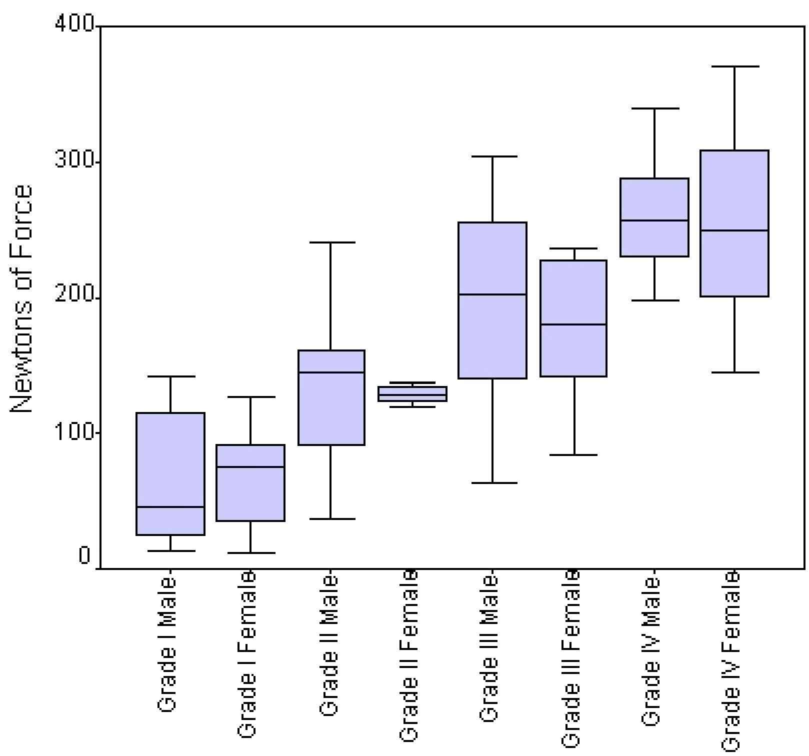

Figure 4. Standard Boxplot for Combined Male and Female Patient Representing Grades I-IV Force Mobilizations in Newtons (N = 23)

DISCUSSION

Past studies have shown that concurrent feedback is effective in improving the reliability among clinicians, but did not measure the capability of a prospective educational technique based on a conceptual learning model. This study endeavored to determine if visual perceptual learning via use of a movement diagram would change responses to sensory stimulation following training of a perceptual task. The results of this study identify that the pre-perceptual use of a movement diagram for spine inter-rater reliability is not effective.

Perceptual pre-training is a pre-practice technique designed to expose the learner to stimuli that will be experienced in the task. Past studies have shown that subjects who receive perceptual pre-training were more accurate in performing motor tasks than those who did not.[42] The majority of these studies utilized single step tasks developed to measure simple skill reaction and repeatability. Functional studies that involve complex motor tasks similar to graded mobilization are lacking and rarely outline methods of type of visual stimulus, intensity and length of time. Recent behavioral studies have investigated motion direction, spatial phase, orientation discrimination and attribute of change, but also limit the required activity to simple motor tasks.[43]

Human motor abilities are not fully understood and involve complex constructs that are difficult to measure.[44] The explanation of variance may be intrinsic to each therapist or some unexplained parameter not associated with pre-perceptual learning.[19] This variability, however, ought to be within clinically acceptable levels, and should fall within the constructs of the visual pre-perceptual model, and these results are not. In some cases forces of one clinician were 14 times greater than the same force of another using the same subjective specifications. In two cases the Grade 1 of one clinician was greater than the Grade IV of two other clinicians. The use of movement diagrams did nothing to regress the interpretation of forces of mobilization toward a common conceptual amount.

The subjects in this study were practicing clinicians. Level of training and experience can provide an internal estimate of grades of motion that would conflict with the movement diagram definition.[39] A consistently practiced motor learning skill such as mobilization will not simply change upon initiation of new evidence.[44] Experience has the effect of changing the learner in a relatively permanent way.[44] This internal examiner bias may allow for differences in interpretation of where each grade should begin, how much force is associated with each motion and the limits of tissue extensibility.[22]

Limitations of study

There are limitations to the study. The subject pool was limited to the immediate area due to the immovable equipment necessary to perform the research. Although the study targeted practicing clinicians, the sample was non-homogenous and included only five females and seventeen males.

Another limitation may be in the inherent nature of the statistical test (ICC) selected. When small Range of Motions are studied such as in the spine the total variability involved is very small.[39] The likelihood of obtaining a high ICC increases when the total variability within a study increases, such as a study using many subjects with different body types or the measurement of extremities. Because measures are influenced by the proportion of total variance that is due to error, ICC calculation for reliability tend to be low.[45]

In this study, the ICC values for all four grades of mobilization were negative, and warrant further investigation. A negative ICC is defined as reliability results that are worse than would have been expected to have occurred by chance. This value typically means some intrinsic variable is altering reliability to the point where values will be distorted. [45] Future studies should focus on understanding why inter-rater values are typically low. Investigation of a combined standardized educational instrument consisting of pre-perceptual and concurrent feedback may assist in improving future results.

CONCLUSION

The results of the study showed that inter-rater reliability results for grades of movement application were very poor. The poor consistency among multiple clinicians indicates that treatment paradigms may be negatively affected. Reasons for this variability may be intrinsic to the therapist and warrant further investigation.

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