Joining Forces – Combining Cognition-Targeted Motor Control Training with Group or Individual Pain Physiology Education: A Successful Treatment For Chronic Low Back Pain.

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Abstract: Chronic unremittent low back pain (LBP) is characterised by cognitive barriers to treatment. Combining a motor control training approach with individualised education about pain physiology is effective in this group of patients. This randomized comparative trial (i) evaluates an approach to motor control acquisition and training that considers the complexities of the relationship between pain and motor output, and (ii) compares the efficacy and cost of individualized and group pain physiology education. After an "ongoing usual treatment" period, patients participated in a 4-week motor control and pain physiology education program. Patients received four one-hour individualized education sessions (IE) or one 4-hour group lecture (GE). Both groups reduced pain (numerical rating scale) and disability (Roland Morris Disability Questionnaire). IE showed bigger decreases, which were maintained at 12 months (P <0.05 for all). The combined motor control and education approach is effective. Although group education imparts a lesser effect, it may be more cost-efficient.

Key Words: Motor Control, Trunk Muscles, Education, Pain Physiology

Chronic unremitting low back pain (LBP) is common and costly. The majority of health care resources devoted to LBP are consumed by a small proportion of patients, who are disabled by pain and characterized by inappropriate beliefs (e.g. "my spinal cord is in danger of being cut") and catastrophic interpretations of the cause and potential consequence of their problem (e.g. "I will probably end up in a wheel chair"). These factors make successful outcomes elusive (see Gatchel and Turk, 1996 [1] for review). One reason why success is elusive is that often conventional strategies adopt a "bottom-up" approach whereby pain is considered to be the consequence of some tissue pathology or dysfunction. This approach largely ignores cognitive and behavioural aspects as well as current knowledge in pain physiology. "Top-down" approaches target behavioural and lifestyle management: learning to cope with and manage pain but conceding that it will not go away. Not surprisingly, these approaches can be effective in decreasing disability and increasing vocational capacity despite pain [2-4]. However, they too can neglect current knowledge in pain physiology by largely ignoring mechanisms that cause nociception and pain.

Findings from biomechanics and physiology have guided an approach to LBP that emphasises motor control of the trunk muscles (see Richardson et al 1999 [5] for review). Preliminary data from mildly disabled patients suggest this approach leads to reduced pain and disability [6; 7], which is consistent with the underlying theoretical model. However, the efficacy of this approach has not been established in the problematic highly-disabled patient group. Consequently, a recent study evaluated the effectiveness of combining this motor control strategy with intensive education about the physiology of pain [8], which is effective in modifying cognitive barriers to treatment [9]. That study supported the efficacy of this

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combined approach in decreasing pain and disability.

The current study is the logical next step in this line of investigation and attempts to answer two questions. The first question concerns the relationship between pain and motor output. Cognitive issues not only have an effect on behavioural responses to pain but probably also influence motor strategies and skill acquisition and development. Moreover, the impact of cognitive issues on motor output is likely to be greatest when the cognitive issues are most pertinent to the body part involved or the task at hand. For example, back muscle and jaw muscle reactivity to psychological stressors is enhanced in LBP and jaw pain patients, respectively [10] and in back pain patients, back muscle activity is affected by watching a film of an individual performing lifting tasks, but not by watching a nature documentary [11].

The theoretical relevance of cognitive aspects to motor control has recently been supported by experimental data [12; 13], however, this question remains to be answered: Is a motor control approach that targets acquisition and development of trunk muscle control in a cognition-specific manner, combined with pain physiology education, effective in reducing pain and disability in people who are characterised by inappropriate pain cognitions?

The second question concerns group versus individual education as part of this approach: Does group education deliver cost- and resource-effective treatment without compromising outcomes?

Thus the aim of the current study is to answer the two questions posed above with the hypotheses: (i) intervention based on a cognition-specific motor control training approach combined with pain physiology education is effective in reducing pain and disability associated with chronic LBP, and (ii) group physiology education is cheaper than, and equally as effective as individualized physiology education.

Methods

Experimental design

The study was a randomized comparative trial with repeated measures comparison of means. Prior to intervention, data were collected for an "ongoing usual treatment" period. Concealed randomization was performed using computer-generated random numbers. The study was approved by the Institutional Medical Research Ethics committee and all procedures conformed to the Declaration of Helsinki.

Subjects

Fifty-five subjects volunteered for the study by responding to a note that advertised the project and was included in the material given to each patient on initial attendance at participating physiotherapy clinics, or by a referring general practitioner (GP). Subjects were included if the primary reason for presentation was a history of LBP of greater than 3 months. Subjects were excluded if they were unable to understand, read, and speak English; had worsening neural signs; had any neurological or orthopaedic condition that would interfere with treatment; or were awaiting surgery. Four subjects were excluded according to these criteria. In order to target the population of interest, volunteers were also excluded if they had a score of less than 9 on the 18-item Roland Morris Disability Questionnaire (RMDQ). Ten subjects were excluded on this criterion. Figure 1 presents the recruitment strategy and experimental plan.

Subjects were allocated to the treatment group (21) and control group (20). The mean ± SD age, height and weight of patients were 41 ± 7 years, 173 ± 13 cm, and 66 ± 7 kg respectively. There were no missing cases, the data sets were normally distributed, and there were no pre-treatment differences between the groups ($P > 0.28$).

Materials and procedures

The cost of treatment was calculated in physical therapist-hours. To evaluate the efficacy of intervention, the following items were used as outcome measures; 18-item Roland Morris Disability Questionnaire (RMDQ) [14] and (0-10) Numerical Rating Scale (NRS) for pain. The first assessment, second assessment (36 ± 4 days later), and third assessment (25 ± 2 days later) were performed by the same investigator, who was otherwise not involved in the study and was blinded to treatment group. A follow-up telephone assessment was conducted 348 ± 13 days after the third assessment. The psychometric integrity of the RMDQ and NRS for pain is maintained when administered via telephone [15].

Random allocation to individual education (IE) or group education (GE) was conducted after the second (pre-treatment) assessment. IE involved four 1-hour education sessions on the physiology of pain and injury, which were conducted in the first two weeks after assessment 2. GE involved a single 4-hour education session with a group of 7 - 10 (according to availability) patients, conducted in the first week after assessment 2. The same material was presented to both groups and has been described elsewhere [9].

As well as the education sessions, both groups received two physiotherapy treatments per week for 4 weeks and participated in a structured and diarised home exercise program. Physiotherapy treatment focussed on specific trunk muscle training based on the protocol described by Richardson and Jull, 1995 [16]. However, notable modifications were incorporated. The primary modification was that patients completed all (GE) or half (IE) of the physiology education sessions *prior* to the initial motor control session. Other modifications were that (i) there was no positional requirement for initial acquisition of voluntary activation of the deep trunk muscles such that each patient was advised to select “that position in which they felt most comfortable”; (ii) after acquisition of voluntary trunk muscle activation, progression of the exercise involved an intermediate step in which patients maintained voluntary activation while *imagining* that they were performing the exercise that was logically the functional progression; (iii) progression was targeted and developed in this manner towards those movements and/or activities during which the patient was fearful of pain or (re)injury, for example, mental rehearsal of forward bending *without pain* in patients for whom forward bending elicited fear of pain and (re)injury; (iv) late-stage and final progression involved exposure and training during cognitively and psychosocially stressful conditions in addition to physically demanding tasks.

Analysis

Using Statistica 5.1 (Statsoft, Tulsa, USA), two 2-way ANCOVAs (group x time), with assessment 1 (pre “ongoing usual treatment”) scores entered simultaneously as covariates and Scheffe post-hoc testing, the change in raw scores for RMDQ and NRS pain were used to identify the differences between groups. A T-test was used to compare actual physical therapist-hours between groups. Although multiple measures elevate the probability of a type I error, a Bonferroni correction would elevate the probability of a type II error and reduce type I error significance to P <0.016, which was considered too conservative. In light of criticism in the literature of Bonferroni and other corrections e.g. Perneger, 1998 [17], significance was set at P = 0.05.

The data were also evaluated according to the occurrence of a clinically significant change. Based on a review of the literature [18-25; 4] change of ≥ 50% and ≥ 30% of initial score for NRS pain and RMDQ, respectively, was categorized as a positive outcome.

Results

Subject details are presented in Table 1, and withdrawal and drop-out data are presented in Figure 1. There were no differences in pre-treatment or initial scores between the groups with the data from withdrawals and drop-outs removed.

Comparison of both treatments to pre-treatment control period

Figure 2 presents the mean and SD for RMDQ and NRS pain over the course of the study. There was a significant decrease in both measures in both groups during the treatment period, which was maintained at follow-up (P <0.05 for all). Table 2 presents the treatment effect size and number needed to treat to obtain a positive outcome for IE and GE, calculated for the 4-week treatment period and with reference to the 5-week “on-going usual treatment” period, presented in units of the variable of interest (i.e., RMDQ and NRS pain).

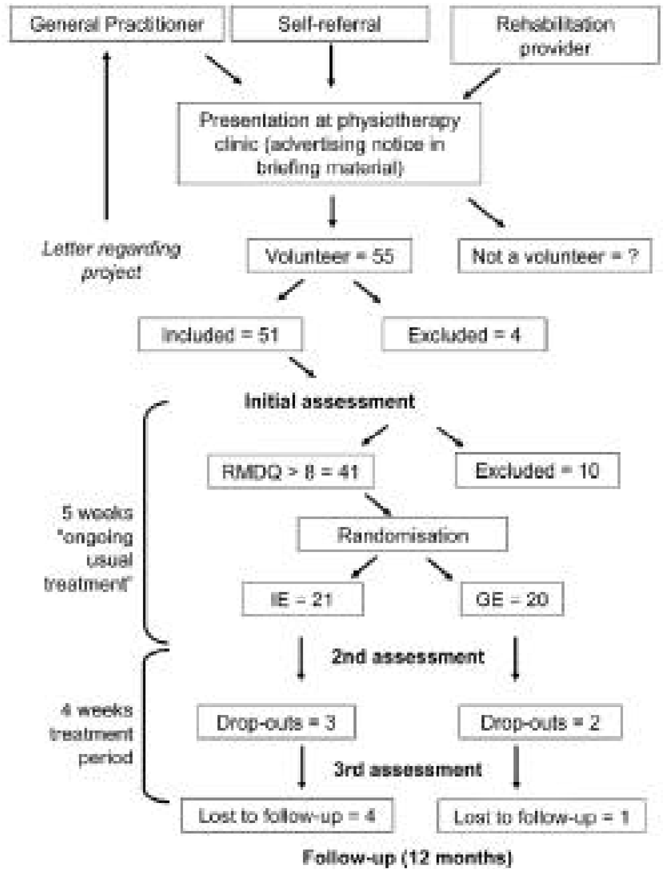

Fig. 1: Experimental plan and assessment schedule, including drop-outs, withdrawals and follow-up. RMDQ denotes Roland Morris Disability Questionnaire, IE denotes individual education and GE denotes group education.

Comparison of IE and GE

Two-way ANCOVAs (group x time, pre-treatment scores as covariates) showed a difference between groups in change in pain ($F(1,34) = 6.4$, $P = 0.016$) and RMDQ ($F(1,34) = 9.8$, $P = 0.004$). Scheffe post-hoc tests showed differences at post-treatment and at follow-up (Figure 2). The mean (95% confidence interval) effect due to IE between pre-treatment and post-treatment was 1.0 (0.3 – 2.0) point on the NRS for pain, and 2.4 (0.8 – 4.2) points on the RMDQ. The number needed to treat (NNT) (95% confidence interval) in order to obtain a positive outcome in IE that would not have been obtained in GE was 7 (3 – 13) and 6 (3 – 11) for NRS pain and RMDQ, respectively.

IE consumed more physical therapist hours than GE (P <0.02).

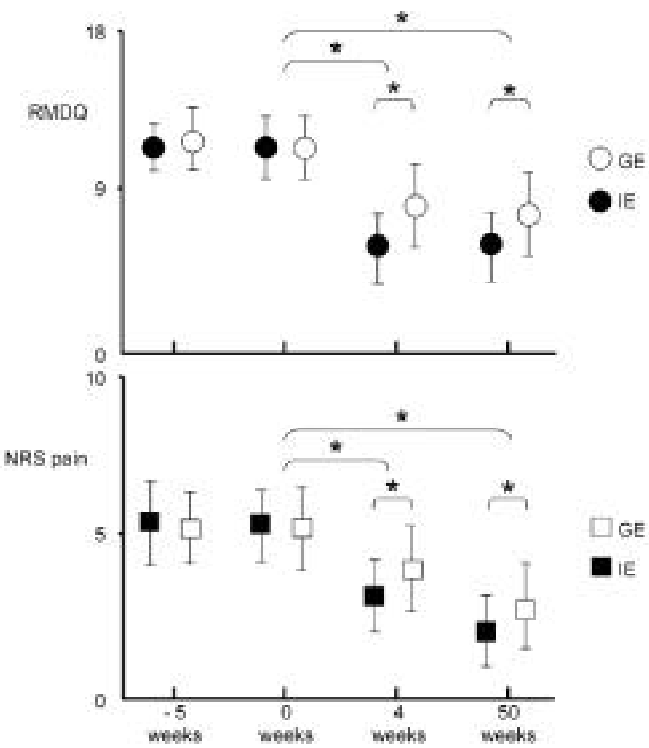

Fig. 2: Mean and SD (error bars) for pain (NRS pain, bottom panel) and disability (RMDQ, top panel) for the individual education (filled shapes) and group education (open shapes) groups before 5 weeks "ongoing usual treatment" period ('-5 weeks') pre-treatment (0 weeks), post treatment (4 weeks) and follow-up (50 weeks). Asterisk denotes significance (P <0.05).

Table 1: Subject details

	Treatment group n = 21	Control group N = 20
RMDQ	12.0 ± 4.1	11.9 ± 4.2
NRS Pain	5.1 ± 1.6	4.8 ± 1.8
Age	40 ± 7 yrs	42 ± 7
Height	175 ± 14 cm	170 ± 12
Weight	65 ± 6 kg	67 ± 6
Duration of LBP (months)	33 ± 11	30 ± 14
Female	67%	60%
Working full-time	29%	24%
Working part-time	33%	35%
Currently receiving compensation	52%	50%
Non-English speaking background	29%	24%

Discussion

The results supported the first hypothesis that intervention based on a cognition-specific motor control training approach combined with pain physiology education is effective in reducing pain and disability associated with chronic LBP. This is evidenced by the treatment effects observed in both groups when compared to the pre-treatment "ongoing usual treatment" period. In contrast, the results did not support the second hypothesis that group physiology education is cheaper than and equally as effective as individualized physiology education. This is evidenced by the difference between groups in the reduction of pain and disability and the treatment effect imparted by individualized education. Thus, although combining motor control training with pain physiology education in a group format is less expensive than one-to-one sessions, it also imparts a smaller effect.

Is a cognition-specific motor control approach combined with pain physiology education, effective in reducing pain and disability in people with chronic LBP?

The current results provide compelling evidence in support of the efficacy of the cognition-specific motor control approach combined with pain physiology education. The results compare favourably with the literature. For example, the chief target of cognitive-behavioural or "top-down" approaches is disability, and the effect size in these programs equates to ~ 3.5 RMDQ points [22], which is less than that observed here (~ 5.5 RMDQ points). Similarly, interventions that target nociceptive tissue ("bottom-up" approaches) have NNTs for pain in the order of 2 – 11 [22], which is similar or worse than that observed here (~ 3.5).

Combined motor control training and pain physiology education is likely to be more effective than pain physiology education alone. In a previous study, while the education modified some attitudes and beliefs about pain, it had little effect on perceived disability or pain [9]. Subsequently, a combined treatment of general motor control training approach and pain physiology education was evaluated [8], and effect sizes of ~ 1.5 and ~ 4 points for NRS pain and RMDQ, respectively, were observed. Those

Table 2: Effect sizes and NNT, and cost of IE and GE

	IE vs control period n = 18	GE vs control period n = 18
Treatment effect RMDQ points (95% CI)	6.1 (4.1-8.0)	5.1 (3.9-6.9)
Treatment effect NRS pain points (95% CI)	3.1 (1.8-4.2)	2.7 (1.6-3.9)
NNT RMDQ (95% CI)	3.5 (1.5-5)	4.0 (2.0-6.2)
NNT NRS pain (95% CI)	3.2 (1.1-5.6)	3.7 (2.2-7.0)
Cost of education in physical therapist-hours per patient	4 hours	0.4-0.75 hours

effects are smaller than the results of the current study, which probably reflects an added benefit of (i) targeting exercise progression toward those activities/movements of which the patient is fearful, and (ii) adding the intermediate step of mental pain-free performance and practice of tasks that were the logical functional progression.

While the effect of pain physiology education most logically is imparted via altered attitudes and beliefs about pain and movement, the mechanism of a motor control approach is less obvious. Sufficient data from biomechanical modelling studies [26-28] and *in-vitro* investigations [29] argue strongly that the deep trunk muscles make important contributions to spinal control. The normal control of these muscles is lost in chronic LBP patients [30], which raises the possibility that dysfunction of the deep trunk muscles is etiologic of LBP. Because fear of pain [13] and psychosocial stressors [31] can alter deep trunk muscle control, it is feasible that training these muscles specifically during stressful and fearful tasks improves their performance. It is also possible that improved performance imparts appropriate spinal mechanics, reduction of nociceptive stimulation and decreased pain. This biomechanical rationale is not new [6; 32], but it has yet to be substantiated.

Another possible explanation for the effect is that modifying the meaning of pain via pain physiology education directly alters the intensity of pain (this is both possible and likely at least to some extent (e.g. Smith, Gracely, and Safer, 1998 [33]), and because patients are more willing to resume more normal activities, they perceive themselves to be less disabled. Alternatively, perhaps trunk muscle training of the sort used here imparts cognitive effects in a similar manner to that established for electromyography (EMG) biofeedback training. Although the model that underlies EMG biofeedback training, the so-called "muscle-tension model", has been refuted by extensive experimental data [34-41], evidence for the clinical efficacy of EMG biofeedback training is strong [42-44]. However, the effect is unrelated to muscle tension levels and is dependent on cognitive factors such as perceived control [45-47]. It is possible that this mechanism also applies to the exercise approach used here. A final explanation may lie in the effect of training on somatic awareness of the low back, cortical representations of the area and the so-called "internal body dynamic". Flor et al [48] demonstrated substantial cortical reorganisation associated with chronic LBP and found a strong link between the extent of reorganization and the duration of pain. Perhaps the primary effect of the current treatment was on cortical representation of the back and cortical co-production of pain and motor output. This explanation would be consistent with modern theories regarding the relationship between pain and motor output [49; 50], but at this stage is speculative.

Regardless of the mechanism of effect, a cognition-specific motor control approach that incorporates mental performance of pain-free tasks, combined with pain physiology education, seems to be effective in reducing pain and disability in people with disabling chronic LBP, and this effect is maintained at for at least 12 months.

Does group education deliver cost- and resource-effective treatment without compromising outcomes?

Not surprisingly, group education is substantially cheaper than individual sessions. However, group education is also less effective. In fact, delivery of the material via one-to-one sessions contributed ~ 1 and ~ 2.4 NRS pain and RMDQ points, respectively, and in approximately every seventh patient who gained a positive outcome with individual education and would not have done so with a group approach. However, NNTs provide important information in this regard because they show that for the same investment of physical therapist hours, group programs will deliver a greater number of positive results. Alternatively stated, in order to obtain the same number of positive results, fewer physical therapist hours are needed for group education.

The current work has two main limitations. Most importantly, the experimental design can be criticised in so far as the participants acted as their own controls during the "ongoing usual treatment" period prior to treatment. This design was necessary for ethical issues because the effectiveness of a less specific motor control and education approach had been established [8]. Although the design permitted robust comparison between group and individual education approaches, it also increased the vulnerability of the findings regarding effectiveness, particularly concerning 12-month follow-up (although the treatment effect observed in both groups was of a magnitude that is unlikely to be caused by natural regression to the mean and such a finding would be contrary to the previous study mentioned above). Second, it is likely that the greater impact imparted by individual pain physiology education was due in part to therapist-patient factors such as perceived enthusiasm, knowledge level and attention given [51-53]. Further, it is possible that the difference in effect between groups was due to reduced attention over the course of a 4-hour seminar. In either case however, the main findings are not invalidated because being sure of the mechanism does not legitimize the effect. Nonetheless, future research to investigate the mechanisms involved would be helpful.

Conclusion

A cognition-specific motor control training approach combined with pain physiology education is effective in reducing pain and disability associated with chronic LBP. Pain physiology education in a group format is less expensive than in one-to-one sessions, but it is also less effective for individual patients. However, for the same investment of physical therapist hours, group programs will deliver a greater number of positive results.

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