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Research Article

The effect of sensorimotor retraining intervention in the management of persistent pain due to cervical radiculopathy

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Abstract:

Background. Recent evidence suggests that Sensorimotor Retraining (SMR) offers positive outcomes for patients suffering with Nonspecific Low Back Pain (Wand 2010). The objective behind this study is to evaluate the effects of SMR in patients with persistent Cervical Radiculopathy (PCR).

Design. Multiple baseline single –subject A1-B-A2 research design

Method. A case series of five subjects complaining of unilateral PCR participated in graded SMR program and were evaluated using validated outcome measures, weekly during an eight week period of this study.

Results. The DrG goniometer app (ROM) and the tuning fork showed high Intraclass correlation coefficients (ICC's) for flexion (0.800), abduction (0.714) and timed vibration test (TVT) (0.891). Patients reported significant short-term reductions in pain intensity and disability. Wilcoxon rank test's post-intervention score was statistically significant. For the S-LANNS z=-2.060, p=0.039, NPRS: Z=-2.041, p=0.041, with median pain score rating dropped from 6.00 to 3.00. T-test results for PSFS showed: t (4) = -5.138, p<0.007, while the NDI t-test was: t (4) =4.550, p<0.010. However, there was a limited mean average improvement of 7^0 to 9^0 in flexion and abduction ROM's, in spite of statistical significance. Post-hoc power analysis yielded statistically significant values (PSFS-0.96, NPRS-0.99, NDI-0.91, and S-LANSS-0.99)

Conclusion. SMR retraining offers short-term pain reduction and improvement in the disability of patients suffering from PCR pathology. However these preliminary results should be weighed with caution as it was carried out in a private practice setting and the longer term effects still need to be evaluated in a more-robust research design study.

Keywords: Sensorimotor retraining, persistent cervical radiculopathy

Introduction

There are significant functional limitations and disabilities in people suffering from Cervical Radiculopathy (CR). They seek clinical assistance owing to the varying intensities of pain in the regions around their arms and slightly less so around their necks (Cleland, Whitman, Fritz and Palmer, 2005). CR has an annual incidence of 83 cases per 100,000 people, with a peak annual incidence of 2.1 cases per 1000 and mostly occurs in the fourth and fifth decades of life. It recurs in 32 percent of the patient population and the patterns of their symptoms vary considerably depending on the nerve roots involved, which generate sensory and motor impairment of the dorsal and/or the ventral nerve root compartments. Literature recommends multimodal interventions, which include mechanical cervical traction, manipulation and therapeutic exercises, which may be effective in altering patient symptoms for a period of 14 to 16 weeks. (Wainner & Gill, 2000; Carette & Fehlings, 2005) A recent systemic review by Thoomes et al. (2013), mentioned that there was no specific interventions for CR, involving surgical or conservative management in the form of oral medications (Non-steroidal anti-inflammatory drugs and muscle relaxants). It was found that manual therapy, spinal manipulation, bed rest, cervical collar or traction were superior or consistently more effective for CR treatments. Also, they highlighted the research conducted by the Neck Pain Task Force (NPTF), which concluded that the lack of evidence made it difficult to determine the efficacy of non-invasive treatments for CR. This absence of evidence of efficacy of treatments, rate of recurrence leading to persistent symptoms suggests health professionals need to seek alternative approaches.

Boudreau, Farina and Falla (2010) pointed out that intrinsic neuro-physiological components such as, changes in neuronal properties, altered the neuronal representational patterns and motor control deficits seem to be affiliated with chronic pain disorders. They suggested that rehabilitation efforts, which focused on the maximisation of the extent of cortical neuroplastic change, had the greatest potential for success. Wand, O'Connell, Pietro and Bulsara (2011) found that pain intensity and disability were reduced when subjects suffering from Chronic Non Specific Low Back Pain (CNSLBP) participated in a combined Sensorimotor Retraining (SMR) programme. Recently, Daffada, Walsh, McCabe, and Palmer (2015) highlighted a similar concept in their systematic review about the combined SMR approach, which could create short-term improvements to alter pain and disability in patients suffering from CNSLBP. However, so far it has not been possible to establish their long-term efficacy. To the best of our knowledge, there is no publication at present that has investigated the effects of SMR on CR patients. There is a need to investigate other evidence-based approaches to manage persistent CR patients. A few publications, however, have documented the evidence for the use of the SMR approach in conditions involving chronic pain. This study bases itself on those findings and aims to investigate the effects of an eight-week long course of SMR on participants suffering from persistent CR through the use of Single Subject Research Design (SSRD) in a case series.

Methods

Subject selection.

Five patients with persistent unilateral neck and arm pain, exhibiting functional disability due to CR were recruited from a private physiotherapy clinic. The demographic data of patient's symptoms, duration and distribution is shown in Table 1. The subjects were included if they fulfilled definite painful CR category II (Radhakrishnan, Litchy, O'Fallon and Kurland, 1994; Tampin, Briffa, Hall, Lee and Slater, 2012) as elaborated here: (1) sensory changes in dermatomal distribution; (2) weakness, atrophy or fasciculation in a myotomal distribution and (3) unilateral diminished deep tendon reflexes. The exclusion criteria specified symptoms which were exhibited due to acute trauma, tumours, neurological conditions (stroke), Complex Regional Pain Syndrome (CRPS) and Phantom Limb Pain (PLP). All the subjects did sign an informed consent form and this study was approved by the Ethics Committee of the University of Hertfordshire (cHSK/PG/UH/00377).

Table1. Clinical and demographical data of patients with persistent cervical radiculopathy

Patient	Age	Gender	Duration of Symptoms Months/Years	Pain referred to				Paraesthesia to	
				Thumb	Arm	Shoulder	Neck	Shoulder & Arm	Thumb
1	73	F	>10 Years	+	+	+	+	+	-
2	55	F	>2 Years	+	+	+	+	+	+
3	68	M	>1 year	-	+	+	+	+	+
4	49	F	6 Months	-	+	+	+	+	-
5	51	F	>1 year	-	-	+	+	+	-

Pain and Paraesthesia data indicates the level of compression (C4/C5/C6 nerve root). The Plus (+) and minus (-) indicates whether the pain or paraesthesia is present or absent.

Study design.

A multiple baseline A1-B-A2 design across five subjects was used where baseline observations were made across all subjects and the intervention was introduced at different stages (Graham, Karmarkar & Ottenbacher, 2012). At the baseline phase, self-reported base line measures and quantitative measures were collected, followed by graded SMR and a Home Exercise Program (HEP), which lasted up to eight weeks. Both, the assessment and treatment interventions were offered by the same physiotherapist. The interventions were introduced to the study's participants in a staggered fashion and in accordance with the given criteria. The short-term effects of the interventions were assessed at every stage. In the last week, the final treatment was withdrawn and a consolidated HEP based on the SMR training was offered to them.

Outcome measures.

Validated and reliable outcome measures, which quantified pain and functional impairments, the Neck Disability Index (NDI), Patient Specific Functional Scale (PSFS) and the Numerical Pain Rating Scale (NPRS) were used (Cleland, Fritz, Whitman and Palmer, 2006). In addition, the S-LANSS (Self- report Leeds Assessment of Neuropathic Signs and Symptoms) questionnaire was used to identify neuropathic pain (Bennett, Smith, Torrance and Potter, 2005). Two objective measures, which included the Active Range of Movement (AROM) and the Timed Vibration Testing (TVT) were chosen to identify the effects of the SMR approach. The TVT was chosen since vibration sensibility test was deemed as a useful clinical test to observe the patient's neural status, as altered vibration sense indicates impaired oxygen delivery to A-beta fibres (Leak, 2008). Unilateral arm movement has always had a strong influence on the biomechanics of the spine. Recent research findings have suggested altered activity of the axioscapular muscles during unilateral arm movements in patients. It has been maintained that this may reduce neuromuscular performance and add to the biomechanical load on the cervical and thoracic spine (Helgadottir, Kristjansson, Einarsson, Karduna, and Jonsson, 2011). Based on these findings, objective assessments did include AROM in flexion and the abduction of the affected shoulder using the iPhone (Apple Inc., Cupertino, CA)-based application (app), DrGoniometer (DrG; C.D.M. srl, Milano, Italy). The Timed Vibration Testing (TVT) used a non-calibrated 128-Hz tuning fork (TF) to assess the vibration sense of the affected peripheral nerve, which was measured over the dorsum of the second metacarpal (MC-2). DrG's reliability was tested by measuring the elbow range of movement (Ferriero et al. 2011), while TVT was tested for its reliability in asymptomatic subjects (Botez, Liu, Logigian and Herrmann, 2009). The AROM, TVT and the NPRS were assessed during every follow-up visit while the NDI, PSFS and S-LANSS were taken at baseline and in the eighth week -- immediately after treatment.

Phase A1 (pre-intervention), phase B (intervention) and phase A2 (post-intervention). During the first week (A1 phase), self-reported baseline measures and objective measurements of AROM and the TVT were collected for all subjects. The SMR program and the need for compliance was explained to them. The formal treatment started after the initial evaluation. SMR included five stages, which were graded in relation to the cortical engagement and the participants' abilities. Each stage was planned to last for a week depending on their performance accuracy. The SMR was practised formally for every stage in the clinic and lasted 45 minutes. In order to improve their compliance, the home exercise diary sheet was included with the recommendation

that the subjects had to spend at least 10 minutes undergoing SMR twice a day and record these home training sessions in their

sheets. All subjects were unable to complete stage 5 (part2) MR as they had difficulty in achieving full ROM. The following table summarizes the SMR program (Table 2)

Table 2. SMR program for Cervical Radiculopathy (a)

	Sensory Discrimination Retraining (SDR)	Motor Retraining (MR)	Criteria
Stages	Sensory Discrimination Retraining (SDR)	Motor Retraining (MR)	Criteria
Stage 1	Tactile Stimulus Localisation	Laterality Recognition	SDR-80%accuracy MR-80%Improvement In Speed and Accuracy
	Site of stimulus- to be determined	Recognise software(b) training in clinic under Physiotherapist supervision	
	Start with 10 blocks of 7 numbered dots on the neck and arm. Progress according to ability	Progress laterality recognition training by improving speed, accuracy and difficulty.	
Stage 2	Stimulus Type and Localisation	Imagined Neck and Arm Movements	SDR-80%accuracy MR- Nil criteria
	Determine site of stimulus and size of probe 5 blocks of 12 numbered dots.	Visualise the neck and arm in various positions using recognise online website.	
	Progress by increasing points marked in the neck and arm	Participant will perform the movement in addition to observation and imagination.	
Stage 3	Graphesthesia Training- Phase A	Deep Neck Flexor and Extensor muscle Recruitment	SDR-80%accuracy MR- 10 reps of 1set, Holding -10 seconds in unsupported position
	Start with letter recognition	Slow and Controlled activation Deep neck flexors in supine position	
	Progress by size and orientation	Progress activation in supported followed by unsupported position	
	Further Progression by speed of drawing the letter	Slow and controlled activation of deep lower cervical extensors in supported position followed by unsupported position	
Stage 4	Graphesthesia Training- Phase B	Axioscapular Muscle Recruitment. Feedback and Control- Initial to Mid-Range Movement	SDR-80%accuracy MR- 10 reps of 1set Hold -10 seconds in unsupported position
	3-letter word recognition- Random order	Part 1: Lower and middle trapezius, Serratus anterior muscle local recruitment and dissociation exercises	
	Progress by size and orientation	Part 2: Lower and middle trapezius, Serratus anterior active control initial to mid-range movement using Visual, auditory and Kinaesthetic feedback©	
	Further progression by speed of drawing and overlapping letters		
Stage 5	Graphesthesia Training- Phase c	Cervical and Axioscapular muscle control with feedback maximised - Full Range movement	SDR-80%accuracy MR- 10 reps of 1set, Hold -10 seconds in unsupported position
	Simple sums to be calculated Progress by size, orientation, speed of drawing and overlapping numbers	Part1: Mirror Visual feedback (MVF), Intersegmental spine palpation (d) and perform range of neck and arm movements with visual, tactile, auditory and Kinaesthetic feedback.	
		Part 2: Progress to achieve full range of movement in open kinetic chain with control.	

a. Each stage progressed when criteria was achieved

b. Neuro orthopaedic institute, 19, North St, Adelaide city West, South Australia 5000, Australia

c. Feedback tools (Visual- Mirror, Tactile-Palpation, Auditory- Cueing and Verbal correction, Kinaesthetic-Adhesive tape- Comerford & Mottram,2012)

d. Performed by the subject.

When the subjects achieved the criteria they were able to progress to the subsequent stages. At the end of the eighth week, an individualised home exercise program was assigned to the subjects and the final evaluation and self-reported outcome measures were completed.

Data Management and Analysis

Objective measures (AROM- Flexion and Abduction, TVT), which had more data points were analysed using visual analysis and inferential statistics. In visual analysis, the values obtained from the intervention (Phase B) and post-intervention (Phase A2) stages were compared to the pre-intervention values using two-standard deviations -- above and below the pre-intervention mean (A1-interval) (Graham et al.2012; Roy, Moffet, Hébert & Lirette, 2008). Two consecutive ranges of movements measuring beyond the A1 interval were necessary to interpret the significant outcomes in the corresponding B and A2 phases. The self-reported questionnaire (S-LANSS, NPRS, PSFS and NDI) values were analysed by Wilcoxon signed rank tests and the paired sample t-tests were analysed according to their normality values using SPSS version 22(Statistical Package for the Social Sciences, SPSS Inc.2009, Chicago,II) and the P value of <.05 was defined as the statistical significance.

Results

There was a significant difference in the level of pain, vibration sense and level of disability in most of the participants, but the difference in the impairment (especially AROM) was at a minimum level. The results thus obtained were found to be compatible with the results from the systematic review as derived by Daffada et al. (2015) that the combined SMR approach could produce short-term improvements in both, pain and disabilities suffered by Chronic Low Back Pain participants.

Table 3 provides an outlook for the raw data derived from S-LANSS and NPRS, which were analysed using non-parametric test (Wilcoxon rank test). These data illustrated that an 8-week SMR programme for patients with persistent CR symptoms elicited a statistically significant change (z=-2.060, p=0.039 for S-LANNS, NPRS: Z=-2.041, p=0.041) with the median pain score rating dropping from 6.00 to 3.00.

Table 3. Summary of changes for S-LANSS and NPRS

Wilcoxon Signed Rank Test				
Outcome Measures	**Z-Value**	**P-Value**	**Mean Difference 95% CI**	
			Pre Treatment	**Post Treatment**
S-LANSS	-2.060	0.039	17.40 (14.83 - 19.97)	7.20 (5.16 - 9.24)
NPRS	-2.041	0.041	5.80 (5.24 - 6.35)	2.60 (1.91 - 3.28)

Even though P-value of ROM and TVT are statistically significant, there is a mean increase of only 7 to 9 degree increase in flexion and abduction (Table 4).

Table 4.Summary of changes for ROM and TVT

Paired Samples t-Test				
Outcome Measures	**t-Value**	**P-Value**	**Mean Difference 95% CI**	
			Pre Treatment	**Post Treatment**
Flexion	-2.86	0.046	161.92 (153.28 - 170.55)	168.00 (159.72 - 176.27)
Abduction	-9.338	0.001	163.30 (158.07 - 168.52)	172.00 (166.62 - 177.37)
TVT	-3.148	0.035	14.99 (13.25 - 16.73)	19.31 (16.23 - 22.38)

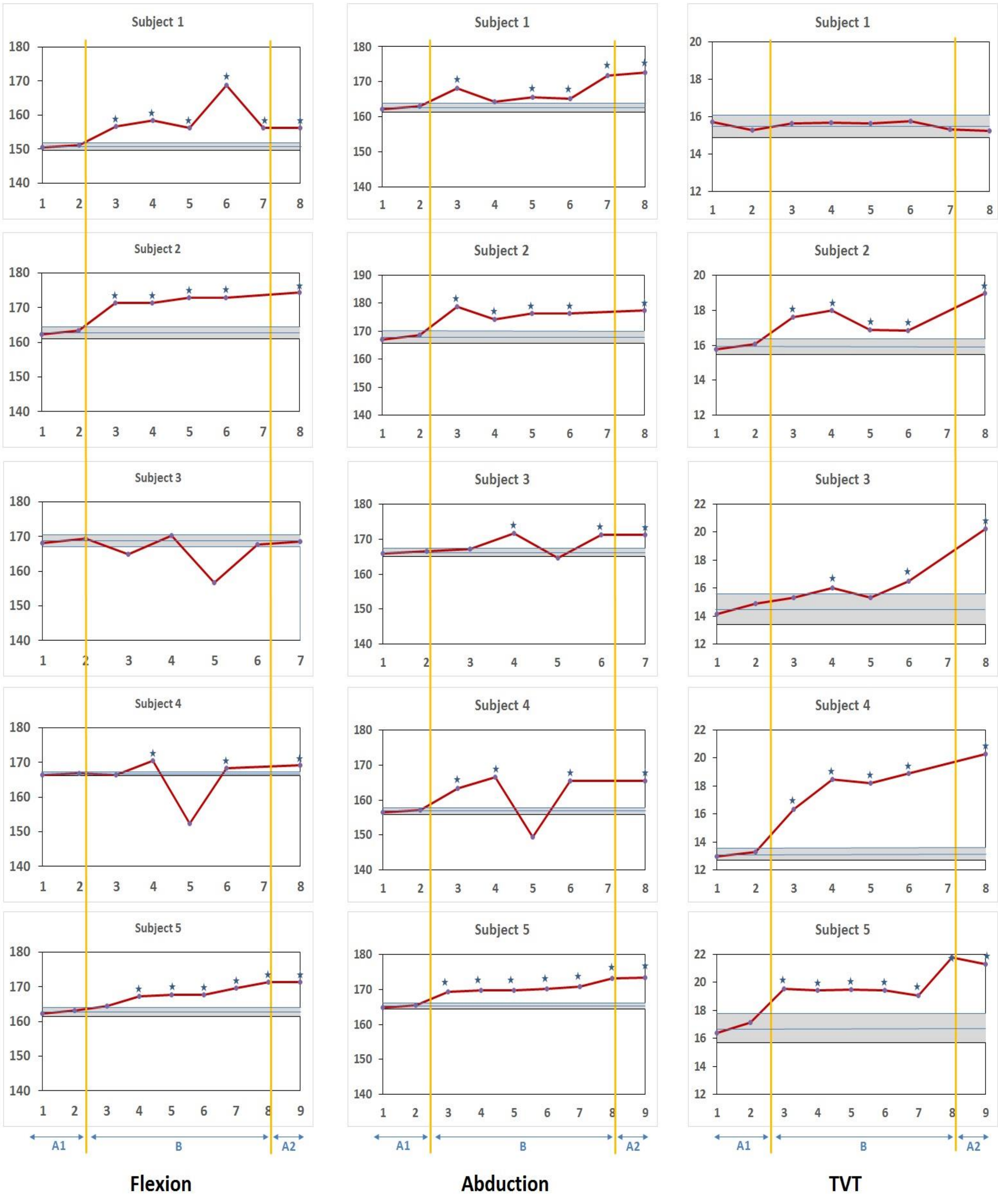

Fig.1. ROM and TVT profile over three phases of the study (pre-intervention phase - [A1], intervention [B] and post-intervention [A2]). The line in the middle of the grey band depicts the mean (n=2) value during the A1 phase, while the line above and below is the two standard deviations of upper and lower limit of the pre-intervention mean.

The * indicates significant changes in the ROM and TVT during the phases B and A2.

Analysing the graphed data (Fig.1), it is clear that subjects in the pre-treatment baseline did not show any trends in TVT and ROM of flexion and abduction. While in the treatment phase the data series showed an upward trend in flexion and abduction range with subject 2 and subject 5, interestingly, subject 1 had a significant upward trend when she participated in the stage 2 and stage 3 of SMR programme and then, her flexion ROM dropped down significantly, thereby perhaps indicating her positive response to the initial phase of the interventions. While subject 3's drop in the flexion and abduction ranges during the treatment phase was related to his two-week holiday where he did not comply with the exercise programme, subject 4 had a similar non-compliance issue due to her unexpected cardiovascular health condition, which affected her overall mobility. Overall, there was an average increase in the mean range of movements in both, flexion and abduction. In relation to the TVT, there was a stable trend observed in subject 1, while 3 subjects (S2, S3, and S4) displayed significant upward trends in the A2 phase. Even though subject 5 improved during the intervention, there was a minimal drop in the TVT value during the A2 phase of the SMR programme.

While Table 5 showed the disability and functional measures (PSFS and NDI) has significantly changed post-intervention and the output of the PSFS t-test showed t (4)= -5.138,p<0.007, and the NDI t-test had values of: t(4)=4.550,p<0.010, which clearly demonstrated the benefits accruing from the SMR intervention.

Table 5. Summary of changes in outcome measure (PSFS and NDI)

Paired Samples t-Test				
Outcome Measures	**t-Value**	**P-Value**	**Mean Difference 95% CI**	
			Pre Treatment	**Post Treatment**
PSFS	-5.138	0.007	2.91 (1.24-4.58)	6.67 (5.04-8.29)
NDI	4.550	0.010	21.80 (14.23-29.37)	13.00 (8.70-17.30)

Post-hoc power analysis yielded statistically significant values (PSFS-0.96, NPRS-0.99, NDI-0.91, S-LANSS-0.99) indicating lack of Type 1 error. During the study, no participant reported any adverse reactions to the treatment and none used any new interventions during the course of the SMR programme. As their pain intensity was reduced, three subjects (S3, S4, and S5) decided themselves to reduce their medication intake. All the subjects returned their partially filled in exercise diary sheets.

Discussion

This study of a case series of single-case experimental designs attempted to analyse the effects of the SMR programme in patients with persistent CR. This is a novel approach to treatment of such a condition. The results are encouraging and suggest that the SMR programme may be effective in reducing the intensity of the pain and the disability in the short-term. While it also improved the vibration perceptions, there was only a minimal change in the ROM impairment. These results are in agreement with other studies, which have shown that the SMR programme or the components of SMR can reduce the intensity of pain (Wand, O'Connell, Pietro & Bulsara, 2011; Bowering et al.2013, Daffada, Walsh, McCabe & Palmer, 2015; Gutknecht, M., Mannig, A., Waldvogel, A., Wand, B. M. & Luomajoki, 2015).

A significant practical aspect of this study is the improvement identified in CR patients within eight weeks of the SMR program, which involves 45 minutes of formal treatment in clinic and 20 minutes of the Home Exercise Program (HEP) every day. In comparison with the length of the SMR treatment studied by Wand et al. (2011), there seems to be a reduction both, in formal treatment time and HEP duration, which is expected to enhance the training-compliance ability of the patients in clinical settings. However, the Gutknecht et al. (2015) study offers combined motor control and tactile acuity training for 30 minutes and includes home exercise of 10 minutes duration per day with an average of 9 treatments by the physiotherapist also produced a significant outcome.

Also, Ryan et al. (2014) explained the results from Wand et al. (2011) study that, there could be a complementary effect derived from a comprehensive SMR programme, which could have contributed to the patient's improvement. In addition, they pointed out that tactile acuity could be more effective in neuropathic pain, which could be the possible rationale behind the improvement noted in the present study's CR participants who had a significant neuropathic pain component.

The rationale behind the improvements seen via the SMR programme could be associated with its influence in modifying the altered cortical organisation and representation, which were instrumental in maintaining the persistent pain. Moseley and Flor (2012) stressed the importance of correlation between improvements in the discriminative ability, pain and cortical reorganisation. In addition, they highlighted the concept of cortical adaptation and working-body schema (Higher-order body maps) to explain the reasoning behind the positive outcomes from motor retraining. Therefore, they suggested that mirror therapy, GMI and tactile training could modify the cortical body maps and remove the incongruence between the motor commands and sensory feedback. This theory supports our clinical findings and encourages the undertaking of the SMR approach as a possible strategy for treating this persistent pain condition.

Interestingly, Post-hoc analysis conducted using Gpower showed significant power values. Thus, we can argue that our finding have less possibilities of type 1 errors and are not influenced by the small sample size. Patient-reported outcome measures showed marked changes after post-interventions. Young, Cleland, Michener and Brown (2010) pointed out that the NDI and the NPRS showed fair test-retest reliability, whereas the PSFS displayed poor reliability in CR patients. But, all three outcome measures exhibited adequate responsiveness in this patient group, where Minimally Detectable Clinic change (MDC) was 13.4 for NDI, 3.3 for PSFS and 4.1 for NPRS, while the MCID (Minimal Clinically Important Difference) for CR patients was 8.5 for the NDI, 2.2 for the PSFS and NPRS measures. Based on these recommendations, our analyses depicts the MDC in the PSFS for 4 participants, while the NDI and NPRS values show that MDC is noted in one to two participants. But the MCID is noticed in all these outcome measures reported by 4 participants. Also, the S-LANNS shows 74% sensitivity and 89% specificity in diagnostic validity (Bennett et al.2005), but has not been shown to interpret the MDC in CR patients. While Tampin, Briffa, Goucke and Slater (2013) questioned the diagnostic accuracy of S-LANNS and suggests to rely on quantitative clinical assessments. It is imperative then to cautiously interpret the results from the outcome measures of this study.

Even though there has been an improvement in disability scores and a reduction in pain intensities, we have to acknowledge that the subjects did not have significant change in their range of movements. Lewis, Wright and Green, A. (2005) pointed out the need to detect a 10 degree change in shoulder flexion and abduction for significant outcome. This prompted us to add manual therapy interventions, after the completion of the SMR programme with ethics permission. This will be reported on in a further study. Boyles, Toy, Mellon, Hayes and Hammer (2011) emphasise that using manual therapy techniques in combination with therapeutic exercise may be effective in improving the AROM and function of CR patients. This is externally valid and consistent with physiotherapy practice.

Study Limitations

The main limitations for a single subject research are the limited generalisability or external validity and threats to the internal validity due to its observer bias and small sample size (Backman, Harris, Chisholm and Monette, 1997). In order to counteract this, post-hoc power analysis was performed and a multiple baseline design was chosen and data was collated independently without interrupting the treatment. There was no long-term follow up with the SMR programme in this study due to the diverse time commitments of the participants and time limitations of the study. Due to the limited resources available, there was a single clinician who performed testing, treatment and data collection duties, which affected the internal validity. To overcome this threat to validity, we performed the intrarater reliability for objective measures. Another threat was the lack of blinding of subjects or the clinician, which was impossible to avoid in this research design. It was also harder to estimate relative effects of the individual treatment interventions as the SMR programme encompassed multi-modal interventions. As Wand et al. (2011) explained, since the SMR programme was in its infancy, testing the comprehensive programme would be a sensible approach, as it could help ascertain whether the treatment paradigm could be useful for patients with persistent pain. This study was able to justify itself using a comprehensive SMR programme for persistent CR patients. It also needs to be acknowledged that the subjects were private patients and that this in itself could contribute significant bias. It is for this reason that it is suggested that SMR is further investigated in another setting and with a different methodology (RCT) to investigate it efficacy further.

In spite of these limitations, the strengths of the study included the presence of a defined dependant and independent variables, which could be replicable in other settings. Also, another strength proved to be the setting, treatment and procedures, which were held unchanged during the research. Data from the outcome measures were analysed using both, the visual and inferential statistics, which enhanced the validity of the outcome.

Recommendations for Future Research

This novel approach to CR patients could be replicated across multiple subjects in different clinical and research settings, which might enhance generalisability of this SMR approach. It is felt that the future study with CR patient groups must include the comprehensive educational component, which may enable participants to understand the potential pain mechanism and improve their quality of training. Some participants in the study reported the difficulties in adhering to the Sensory discrimination retraining (SDR) interventions at home as they lived on their own, so in future, it would be worth considering the inclusion of family members or friends during the formal treatment sessions, which could improve patient-compliance during the training. If participants were unable to bring somebody, it would be worth taking a video of the SDR sessions, so that a family member or a friend could watch the video and help the participant practise the SDR training format. Adding manual therapy techniques after the SMR programme, might be considered adequate to improve impairments like active range of movements. Cervical joint position error was also noted in people with persistent neck pain (Jull, Falla Treleaven, Hodges & Vicenzino, 2006) so, gaze-stability exercises and head repositioning acuity could also be considered for inclusion in the treatment regimen. It may be worth considering the recommendations from Beinert and Taube (2013) on the impact of balance training exercises, which improved the cervical sensorimotor function and decreased the pain intensity in the neck region. If additional interventions were added, it could extend the treatment duration, affecting the cost-effectiveness. But, it is necessary to explore this novel approach to its fullest potential so that we can identify the best way to reduce the persistent pain symptoms.

Conclusion

This research points towards the potential value of application of the SMR programme among persistent CR patients. The participants' outcome measures showed statistically significant results in relation to the decrease in pain intensity and disability. It must be understood that this study was only conducted on a small group of subjects over a short period of time without long-term follow up and in a private setting. Further research is needed in different clinical and research settings to determine the effects across wide groups of subjects before further conclusions may be drawn.

Historically healthcare treatment approaches were primarily focussed on impairment and structural correction. Many chronic pain states have neuronal reorganisation as a common clinical manifestation (Daffada et al., 2015). The neural plasticity element may be worth further exploring to respond to the SMR approach to enhance the prognosis of persistent painful conditions. It has been shown that participants could benefit from an 8-week SMR programme. The findings from the study would be of great practical relevance for CR groups of patients with persistent symptoms of pain and functional impairments.

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Conflict of Interest: None declared.

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