The relative effectiveness of supervised exercise with and without spinal manipulation, and home exercise in terms of fear-avoidance beliefs in chronic neck pain patients.

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Dedication

This work is dedicated to my family for their everlasting love and support,

especially those who keep me sane and grounded in reality,

Mr. Matthew Vihstadt, Honey, Hunter, and Hacksaw.

It is good to be home. ☺

Abstract

Neck pain and related disability place considerable burden on individuals and societies around the globe. Chronic neck pain is considered to be multifactorial in both mechanism and experience, including biological, psychological, and social factors. Little is known regarding the relationship of fear-avoidance beliefs, a specific psychological factor, to chronic neck pain. The primary objective here is to address the relative effectiveness of supervised exercise with and without spinal manipulation, versus home exercise in terms of fear-avoidance beliefs in chronic neck pain patients over time.

This was a randomized, mixed-methods, comparative effectiveness trial conducted at an outpatient university-affiliated research clinic in the Minneapolis/St. Paul metropolitan area. Adults aged 18-65 with chronic, mechanical, non-specific neck pain rated at least 3 on 0-10 scale were included. Qualifying participants were individually randomized to receive one of three 12-week interventions: a) supervised rehabilitative exercise (SRE), b) SRE and spinal manipulative therapy (SMT), or c) home exercise with advice (HEA). The randomization scheme had a 1:1:1 allocation ratio using randomly permuted block sizes; treatment assignment was concealed in sequentially numbered, opaque, sealed envelopes. The self-report Fear-Avoidance Beliefs Questionnaire (FABQ) modified for neck was administered at baseline (week 0) and 4, 12, 26, and 52 weeks post-randomization. The two subscores, work (W) and physical activity (PA), were converted to a 0-100 point scale to facilitate comparison. The outcomes were analyzed with a linear mixed-effects model for repeated measures over time with baseline values treated as outcome.

A total of 270 subjects were randomized into the trial. Loss-to-follow up rates at week 12 ranged from 5.6% to 7.7% for FABQ-PA and 8.0% to 10.9% for FABQ-W; these increased through week 52 to 16.7% to 18.7% for FABQ-PA and 21.3% to 29.7% for FABQ-W. At baseline, participants reported neck pain of nine to ten years in duration that was moderate in severity; they reported mild disability. Scores for FABQ-PA were 45.8 to 48.5 and FABQ-W scores were 22.0 to 25.4 on a 0-100 scale. For FABQ-W at 12 weeks, there was a statistically significant between-group difference (baseline to week 12) in favor of the SRE + SMT group when compared to the SRE group (5.30 points; 95% CI, 0.99 to 9.62; p=0.016); this difference lost significance at weeks 26 and 52. For FABQ-PA at 12 weeks, there were no statistically significant group differences (baseline to week 12); differences remained small and not statistically significant through week 52.

Except for marginal improvements in fear-avoidance beliefs about work in favor of SRE+SMT in the short term (12 weeks), no other statistically significant between-group differences were observed for work and physical activity fear avoidance beliefs. These results should be interpreted cautiously due to limitations of the Fear-Avoidance Beliefs Questionnaire and the Fear-Avoidance Model of Exaggerated Pain Perception. Future research can address shortcomings of the FAM model and the FABQ instrument.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Epidemiology of Neck Pain

The International Association for the Study of Pain (IASP) defines cervical spinal pain as pain perceived in the posterior region of the neck between the superior nuchal line and the tip of the first thoracic spinous process.[1] Neck pain lasting three months or longer constitutes a chronic condition.[1] While much information is available for rare causes of neck pain (e.g. cancer, meningitis), little is known about common causes.[2] In this frequent scenario where the specific cause cannot be identified, the IASP recommends a working diagnosis of "cervical spinal pain of unknown origin."[1] Other groups suggest different terminology such as "idiopathic neck pain"[3] or "nonspecific neck pain."[4,5] This thesis focuses on chronic cervical spinal pain of unknown origin, hereinafter referred to as chronic neck pain (CNP).

Neck pain is a common worldwide experience in the general adult population. Six-month prevalence rates average 28.8%[6], while most 12-month prevalence rates range from 30% to 50%.[7] Prevalence is higher in women and those who are middle-aged.[7] Neck pain can become chronic in nature and frequently results in disability. Of those who report neck pain, approximately 50% will report chronic complaints such as recurrent or persistent pain years later.[8,9] The estimated 12-month prevalence of neck pain coupled with disability (including inability to engage fully in both work and social activities) varies from 1.7% to 11.5%.[7,10]

Neck pain and related disability have considerable impacts on the individual, the healthcare system, and society. Some individuals express negative perceptions regarding

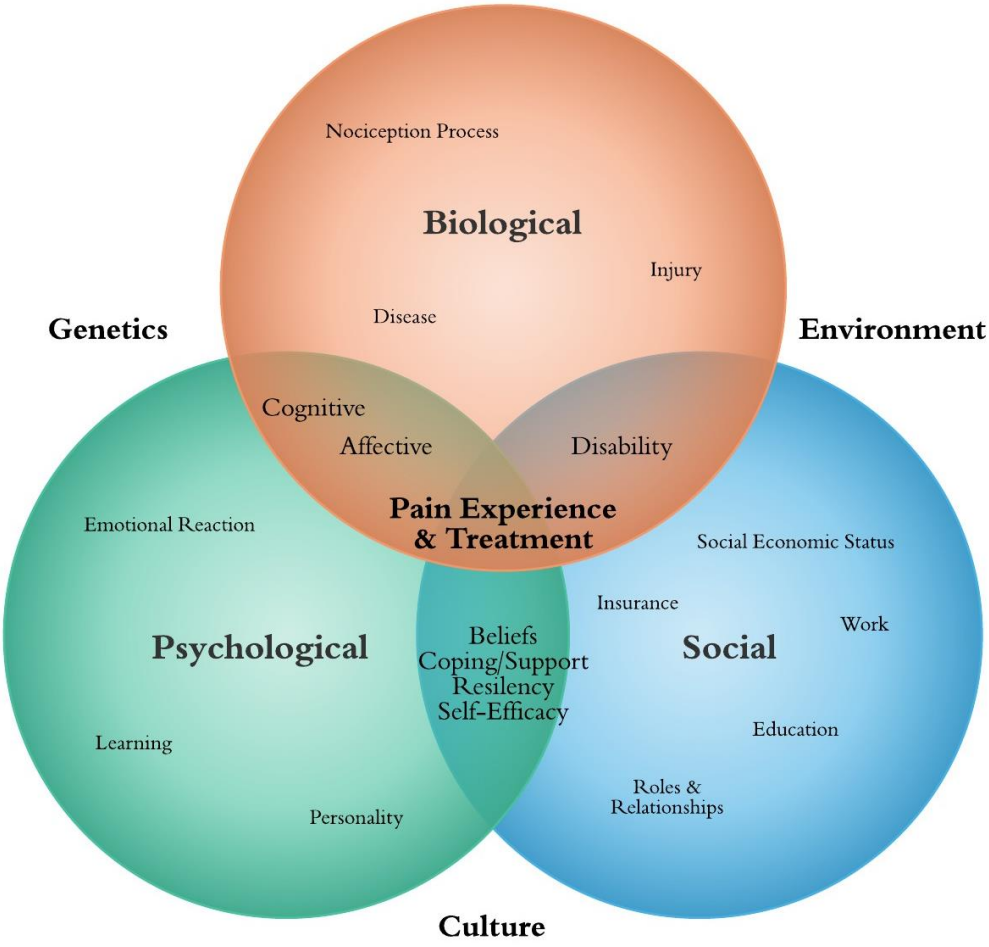
overall health, wellbeing, and ability to function both physically and socially.[11] This is further evidenced by results from the Global Burden of Disease 2010 Study: neck pain was ranked fourth in terms of disability and 21st for overall burden out of 291 conditions.[12] From 1997 to 2005 US national expenditures for individuals with back and/or neck problems was estimated to be $85.9 billion.[13]

Musculoskeletal disorders, including neck pain, are widely accepted to be multifactorial in both mechanism and experience, including biological, psychological, and social factors (see Figure 1).[14] While there is little known about the biological pathology of neck pain itself, potential mechanisms are currently being investigated (e.g. physical degenerative changes of the spine or epigenetic modulation).[15,16,17]

There are clinical signs associated with neck pain that are amenable to treatment such as decreased muscle strength, endurance, and mobility.[15] Evidence is available on the development of chronic and persistent pain. Recent research suggests that chronic pain sufferers may have lower levels of endorphins, an opioid neuropeptide, in their spinal fluid compared to healthy controls.[16] Abnormal central pain processing may also help explain the development of persistent spine-related pain.[17]

One potentially modifiable risk factor for neck pain is psychological health[7]; additionally, psychological health is a strong prognostic factor for neck pain.[18] Evidence suggests that psychosocial characteristics are more predictive of chronic pain and disability in neck pain suffers than clinical or biological/mechanical findings.[11,19,20] Passive coping, which includes fear-avoidance, is associated with increased risk for more disabling neck pain.[19] Specific factors associated with a better prognosis include social support, coping that involves self-assurance, and being more optimistic.[21,22]

Figure 1: The biopsychosocial model of chronic pain



Fear-Avoidance Model of Exaggerated Pain Perception

Despite this growing body of knowledge on chronic neck pain, little is known regarding the relationship of fear-avoidance beliefs, a specific psychological factor, to chronic neck pain (a majority of fear-avoidance research occurs in chronic low back pain populations.[23]). The fear-avoidance model of exaggerated pain perception (FAM) was developed by Lethem et al.[24] and later modified Vlaeyen et al.[25] It proposed how some chronic pain sufferers could develop a psychogenic component to their pain.

The FAM posits that there is a response continuum for pain coping with two extremes, confrontation or avoidance. Confrontation of pain, an adaptive response, results in a reduction or resolution fear over time. Individuals willing to confront pain may perceive pain as temporary, or are more motivated to participate in work and activities of daily living.[24] These individuals are willing to challenge their condition, in part, to assess their pain experience in light of the specific challenge.

Avoidance of pain, a maladaptive response, results in maintenance and/or exacerbation of fear, which may result in a phobic or psychogenic state. Some individuals who fear pain may experience thoughts regarding their pain leading to avoidance behaviors such as decreased physical activity and altered movement patterns in efforts to prevent pain; some may have extreme catastrophic thoughts (e.g. "if I jump off a chair I might end up paralyzed.[24]) Such inactivity may lead to muscle atrophy and limited range of motion and may start a negative feedback cycle (see Figure 2).[24,25]

In acute pain, avoidance of activity may be appropriate to facilitate healing.[26,27] However, in those with chronic pain, when the pain is no longer an indication of injury or danger, avoidance behaviors are a counter-productive strategy which may result in functional disability.[28,29] Not only do these exaggerated negative beliefs reinforce inactivity but they prevent participation in important health-promoting behaviours.[30]

Figure 2: The negative feedback cycle of fear-avoidance behaviors [24,25]

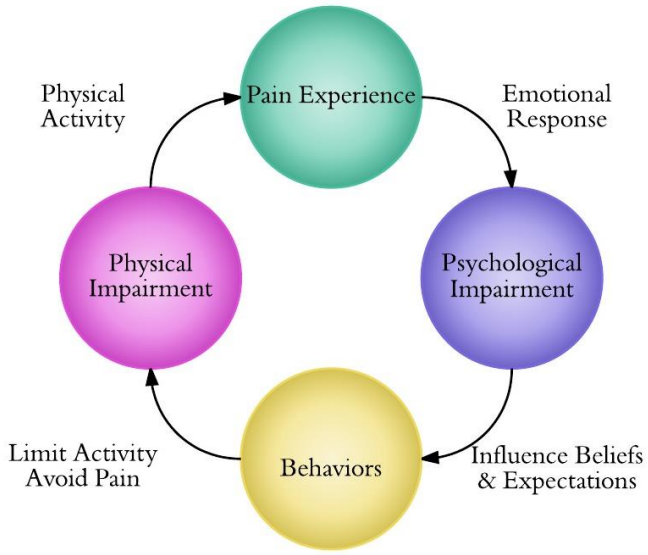


Figure Caption: Fear-avoidance beliefs can trigger a negative feedback cycle of disuse which may result in deteriorating functional disability.

Common treatments (e.g. medications or manual therapy) may improve pain in those with fear-avoidance beliefs in the short term, but they likely have limited value in the long term without supplementary pyschosocial components.[27] Advocated strategies for reducing fear-avoidance beliefs and increasing physical activity includes education, advice and messaging about the importance of staying active despite having pain and that chronic pain does not signify damage.[32,33] Further, additional instruction and recommendations on self-management approaches (e.g. those things that one can do to care for themself) are recommended.[32,33] A combination of psychological and/or behavioral interventions (e.g. acceptance and commitment therapy) and supervised exposure therapy may help reduce fear of pain or movement and increase physical activity. [26,27,32,33] Activities/techniques should be partially individualized in terms of types

of exercise (selecting exercises the patient would enjoy or participate in) and intensity (takes into account the patient's current functional abilities) in hopes of increasing self-efficacy and compliance.[27]

Conservative Interventions

There are many conservative interventions for neck pain sufferers which provide modest treatment effects.[34] Two studies have been done investigating the effect of patient education specifically on fear-avoidance beliefs. For neck pain, generally, recent systematic reviews have reported on the effectiveness of patient education, exercise, and manual therapy (see Appendix 1).

Education

The World Health Organization (WHO) defines education "as helping patients acquire or maintain the competencies they need to manage as well as possible their lives with a chronic disease."[35] Common goals for patient education including having learning objectives and content that target modifiable prognostic factors: 1) to establish a **knowledge** base of their condition and self-management strategies[36,37], 2) to establish appropriate **beliefs and expectations** regarding their pain condition[38], 3) to enable more effective self-management through **skill** development [36,37], 4) to make **informed decisions** about their healthcare, self-care management.[36]

Two recent systematic reviews have found little evidence for the effectiveness of education when used as a monotherapy in neck pain populations on outcomes such as pain, disability, health-related quality of life, anxiety or depression.[37,39] However, there is

evidence to support education when it is used as an adjunctive intervention for neck pain[38]

Two studies investigating experimental education interventions focusing on fear-avoidance (rather than pain) have mixed results. These studies are similar in regards to their experimental and traditional educational interventions. The experimental interventions were small books that described prevalence of pain (common), its prognosis (typically not serious), and encouraged staying active despite having pain (to facilitate a speedy recovery). Traditional education presented a more conservative approach to activity (e.g. "Lying down is one of the easiest things you can do to help relieve pain"[40]). A moderately sized trial (n=162) focusing on education and advice in *back pain patients* found statistically signficant changes in fear avoidance beliefs and disability in those receiving an experimental education (e.g.The Back Book that suggested remaining active despite having pain[41]) when compare to traditional education (e.g. a "Handy Hints" brochure) even after one year.[42] There was no change in back pain during the course of the study in either group.[42] Another study assessing similar interventions for *neck pain patients receiving worker compensation*; the interventions were experimental education (e.g. The Neck Book[43]), traditional education (e.g. a "Handy Hints" brochure modified for neck pain), or no education.[40] While this study found no differences between groups for fear-avoidance beliefs, neck pain and disability at any of the timepoints, the results should be interpreted with caution due to the very poor follow up rate (34%).[40] **Thus, additional research is required to determine how educational interventions influence fear-avoidance beliefs in neck pain patients.**

Exercise

Exercise interventions are commonly used for neck pain.[44] Theoretical benefits specific to exercises which target the neck and upper back/shoulders include: increased circulation in spine which promotes healing, increased flexibility and mobility, and increased strength and endurance.[44] The most recent Cochrane review found moderate quality evidence supporting the use of therapeutic exercise[44] to decrease pain and increase function, such as endurance and strengthening of the neck and shoulder blade regions.[44] The review stated that no improvement was observed when only stretches were utilized.[44] Limitations of the original trials included in the review were small sample size and a general lack of methodological rigor.[44]

Spinal Manipulation

SMT and mobilization, defined as "the application of manual force to the spinal joints"[45] are other commonly used interventions for neck pain.[46,47] Many of the proposed mechanisms of action for SMT focus on biomechanical factors, including increased muscular relaxation[48], muscle recruitment[49], mobility[50]and analgesic effects in the spine.[48] The most recent Cochrane review found moderate quality evidence for SMT as a monotherapy to provide immediate relief for chronic neck pain.[46] However, the effect of combining SMT and exercise on pain reduction is superior when compared to SMT alone.[51,52] Limitations of the studies included in the review consist of many potential biases in design and heterogeneity in participant and treatments that prevented pooling of results.[46]

Primary Objective

The **primary objective** of this thesis project is to address the relative effectiveness of SRE with and without SMT, versus HEA in terms of fear-avoidance beliefs in chronic neck pain patients over time. This will be accomplished by analyzing secondary data collected through patient self-report questionnaires in a previously conducted randomized trial on chronic neck pain. [53,54]

We hypothesize that the supervised rehabilitative exercise (SRE) intervention will experience greater decreases in fear-avoidance beliefs when compared to home exercise with advice. Our rationale is that the increased dose of neck exercises, coupled with the additional motivation, reassurance, and reinforcement provided by the exercise therapist in a supported environment (i.e. a type of general supervised exposure therapy) will be advantageous in challenging maladaptive pain beliefs.

This thesis is innovative in that it is one of few studies to examine the effect of education, exercise, and spinal manipulation on fear-avoidance beliefs in the general neck pain population.

Chapter 2: Methods

This thesis addresses secondary aims of a clinical trial reported previously.[53,54] The randomized, mixed-methods, comparative effectiveness trial was conducted at an outpatient university-affiliated research clinic in the Minneapolis/St. Paul, Minnesota metropolitan area. Northwestern Health Sciences University's institutional review board (IRB) approved the parent trial; the University of Minnesota's IRB approved this thesis project (1410E54303).

Recruitment efforts included print advertisements (i.e. newspapers, posters) and mass mailings. Screening for eligibility occurred three times prior to randomization: initial phone interview to screen for broad inclusion and exclusion criteria, and two baseline evaluations scheduled seven to 10 days apart. Demographic and clinical characteristics were collected during the baseline evaluations through self-report questionnaires, clinical history, and physical examination.

To qualify for randomization, participants had to be ages 18-65 years of age with mechanical, nonspecific neck pain (Neck Pain Task Force grades I and II[55,56]; pain without neurologic signs that may interfere with activities of daily living) for a minimum of 12 weeks duration. The neck pain rating had to be 3 or higher (0-10 scale with zero indicating no pain). Participants who experienced any of the following were excluded:

- Previous cervical spine surgery
- Referred neck pain
- Contraindications to study interventions, specifically
    - unmanaged cardiac disease

    - progressive neurological deficits
    - blood clotting disorders
    - inflammatory or destructive tissue changes of the cervical spine
    - pregnant or nursing women
- Co-morbid conditions
    - diffuse idiopathic hyperostosis
    - severe disabling health problem
    - significant infectious disease
    - substance abuse
- Issues related to study compliance
    - ongoing treatment by other healthcare providers for neck pain
    - pending or current litigation

At the end of the second baseline evaluation, qualifying participants were individually randomized to receive one of three 12-week interventions: a) supervised rehabilitative exercise (SRE), b) SRE and spinal manipulative therapy (SMT), or c) home exercise with advice (HEA). The randomization scheme had a 1:1:1 allocation ratio using randomly permuted block sizes; treatment assignment was concealed in sequentially numbered, opaque, sealed envelopes. When participants qualified for randomization, the next envelope was drawn and opened by study staff in the participant's presence. All study staff including those who took part in eligibility determination, enrollment, and randomization were blinded to the randomization scheme and block sizes.

Interventions

The intervention phase was 12 weeks in duration. Exercise therapists provided the HEA and SRE and worked under the supervision of study clinicians; therapists had a bachelor's degree in related field (e.g. exercise physiology). Chiropractors provided the SMT and were licensed in the state of Minnesota. Both exercise therapists and chiropractors had at least 5 years of clinical experience. Treatment sessions were conducted one-on-one between the participant and exercise therapist or chiropractor. Components of the SRE and SRE+SMT interventions were tested previously in CNP populations.[57] All participants were requested to abstain from seeking outside treatment for their neck condition during the 12 weeks. Participants who discontinued treatment attended less than 80% of scheduled visits.

Home Exercise with Advice (HEA)

HEA was defined as education and advice to facilitate self-management of neck pain supplemented with a self-administered exercise program; it was considered a minimal intervention control (see Table 1 for psychosocial components of HEA which are considered particularly important in targeting fear avoidance behaviors). Participants attended two, 60-minute sessions one to two weeks apart with an exercise therapist.

The goal of this intervention was to empower participants to self-manage their neck pain through education and simple exercises. Education was provided to increase knowledge of their condition and establish realistic beliefs and expectations (i.e. that chronic pain does not signify damage and individuals could be active despite having pain). One-on-one training was provided to increase skills for self-management and prevention of future neck pain through a self-administered exercise program. Simple

upper body mobilization exercises without resistance included cervical retraction, extension, flexion, rotation, lateral bending, and scapular retraction. The therapist provided instruction, demonstration, and then observed the participant perform exercises, correcting form as necessary. Participants were instructed to complete 5-10 reps of each exercise, 6-8 times per day. The HEA intervention was partially individualized to participant abilities, tolerance, and daily activities. For example, if a participant experienced neck pain while vacuuming, instructions with demonstrations of posture/body mechanics were provided to help manage pain during that activity. Participants received advice on self-care techniques for pain management. This included suggestions on an easy reader bookstand, back support for seated positions, and applications of heat and/or cold to the neck area.

Supportive materials included the "Treat Your Own Neck" book[58] which encouraged self-management, provided information on basic anatomy and biomechanics of the cervical spine, common (theoretical) causes of neck pain, neck mobilization exercises, when to use the exercises, and special instructions for exacerbations of neck pain, and developing healthy lifestyle habits (e.g. getting adequate sleep and eating well). Laminated cards featuring pictures of self-care exercises and instructions were provided to increase compliance. The materials were reviewed verbally between therapist and participant.

Supervised Rehabilitative Exercise (SRE)

SRE was defined as intense and progressive strengthening of the neck and shoulders muscles performed under the supervision of an exercise therapist (see Table 1

for psychosocial components of SRE). Participants attended 20, 60-minute SRE sessions throughout the 12 weeks.

The goal of the exercise intervention was to increase participants' strength, endurance, flexibility, and neuromuscular control. The therapist supplemented exercise with motivation, reassurance, and reinforcement to encourage movement and diminished perceptions that exercise could result in physical damage. The session started with five minutes of aerobic warm up, and stretching before and after the strengthening exercises (cervical flexion, extension, rotation, push-ups, lateral arm raises, and chest flys). Participants were instructed to complete 15-25 reps of each exercise against weighted resistance (1.25-10 pounds), 2-3 times per session. Progressions for strengthening exercises (i.e. increase in weight) were introduced when the participant could complete the maximum number of sets and repetitions with proper form. The SRE program was partially individualized, in regards to weight and repetitions, according to participant abilities, and tolerance.

Supervised Rehabilitative Exercise + Spinal Manipulative Therapy

This group received a combination of SRE defined above, and spinal manipulative therapy (SMT), which is defined as "application of manual force to spinal joints."[45] Participants attended up to 20, 20-minute SMT sessions with a chiropractor in addition to SRE.

The goal of SMT was to enhance joint mobility of the cervical and upper thoracic spine. SMT included high velocity/low amplitude adjustments, distraction, and/or mobilization techniques. SMT was preceded by up to five minutes of soft tissues work (i.e. light massage, trigger point therapy or transverse friction) as needed to prepare the

participant and facilitate the SMT. Other treatment options included the application of heat or cold, limited verbal advice regarding activity modification, and self-stretches. SMT was partially individualized in terms of the techniques used, spinal levels adjusted, and number of appointments. These were determined by the chiropractor based on palpation or passive motion test findings and the participant's preferences and response to treatment.

Table 1: Psychosocial components of the therapies used in the study

Home Exercise with Advice (HEA)				
Psychosocial Components	**Goals**	**Design**	**Delivery Method**	**Dose**
Social Element • Therapist provided education and training in specific exercises **Psychological Element (Education)** • Basic anatomy and biomechanics of cervical spine; common causes of pain • Posture and body mechanics for daily activities • Advice to stay active **Messaging** • Pain does not signify damage • Stay active, despite pain	To increase self-efficacy; empower participants to self-manage their neck pain (current and future) through education and simple exercise	Education and exercise partially individualized to participant's daily activities, abilities, and tolerance	**Materials:** Book with general information, advice to stay active Laminated cards with pictures and descriptions of exercises **One-on-one:** Instruction, demonstration, and observation by therapists	**Low dose supervision**: Two, 1-hour sessions **High dose self-mobilization exercise**: 5-10 reps of each exercise, 6-8 times per day
Supervised Rehabilitative Exercise (SRE)				
Social Element • Therapist provided supervision and training in specific exercises **Psychological Element (Encouragement)** • Therapist provided **motivation, reassurance, and reinforcement** **Messaging** • Pain does not signify damage • Stay active, despite pain	To increase strength, endurance, flexibility, neuromuscular control; To provide motivation, reassurance and reinforcement that encouraged movement, and diminished perceptions that exercise could do damage	Exercise partially individualized to participant abilities and tolerance in terms of load and repetitions	**One-on-one:** Supervised by therapist with coaching	**High dose supervision**: 20, 1-hour sessions **High dose strengthening exercise:** 3 sets of 15-25 reps with progressive weight (1.25-10 pounds)
Spinal Manipulative Therapy (SMT)				
Social Element • Chiropractor delivered care **Psychological Element** • Chiropractor provided **reassurance** **Messaging** • **Limited advice** regarding activity modification, self-stretches, general range of motion	**To enhance** joint mobility	Partially individualized in terms of advice offered and spinal levels adjusted (determined by the chiropractor)	**One-on-one:** Delivered by licensed chiropractor	**High dose SMT**: Up to 20, 15-minute sessions

Data Collection & Outcome Measures

The Self-report Fear-Avoidance Beliefs Questionnaire (FABQ) was administered at baseline (week 0) and 4, 12, 26, and 52 weeks post-randomization. It was administered at the clinic from baseline through week 12 and through the mail for weeks 26 and 52 (with follow up phone calls as needed). The FABQ and all other participant-reported outcome measurement instruments were completed by the subject without influence from study staff.

Fear Avoidance Belief Questionnaire (FABQ)

The FABQ was used to quantify a subject's fear avoidance beliefs about physical activity and work; specifically how a participant's beliefs about activity and work impact their pain.[59] It was originally developed by Waddell, et al., for use in the back pain population[59] but has been modified for use in neck pain participants by replacing the word 'back' with 'neck' (see Appendix 2).[60-62] Items on the FABQ were taken from previous work on pain beliefs and associated behaviors including the Survey of Pain Attitudes [63], Pain and Impairment Relationship Scale Beliefs Questionnaire[64], as well as work by Sandstrom and Esbjornsson[65], and Fordyce[66].

The FABQ is a 16-item questionnaire featuring two subscales, physical activity (PA) and work (W), with responses on a 7-point Likert scale (0=completely disagree, 6 = complete agree). Higher scores suggest more strongly held fear-avoidance beliefs. Only 11 of the 16 items are scored: four (items 2-5) for fear-avoidance beliefs about physical activity (FABQ-PA) for a possible range of scores from 0 to 24, and seven (items

6,7,9,10,11,12,15) for fear-avoidance beliefs about work (FABQ-W) for scores from 0 to 42.[59] Waddell suggested excluding items 1, 8, 13, 14, and 16 from scoring for the following reasons: item 1 demonstrated inconsistent factor loadings and low communality, item 8 was not acceptable for either work or physical activity, and items 13, 14, and 16 were considered redundant.[59]

Cleland, et al., evaluated the psychometric properties of the FABQ in a cohort (n=78) of mechanical neck pain participants (20% acute, 50% subacute, and 30% chronic).[61] Test-retest reliability results for the FABQ-PA indicated moderate to substantial agreement while FABQ-W indicated substantial agreement between administrations. Internal consistency was high for both subscales, with Cronbach's alpha coefficients for FABQ-PA = 0.92 and FABQ-W = 0.97. These internal consistency and test-retest results are similar to other reliability results in low back pain participants.[61] However, the high internal consistency of the FABQ-W may indicate internal redundancy.

Statistical Methods

Data analyses were conducted using Stata 13.1.[67] Longitudinal data were analyzed using a linear mixed model, a type of conditional model that compares the response of an average individual from each intervention group. The goal was to estimate the effect of treatment and time on FABQ subscores.

The outcomes, FABQ-PA and -W, were analyzed with a linear mixed-effects model for repeated measures over time with baseline values treated as outcome. The

model was adjusted for additional baseline covariates identified through bivariate analyses.

Both subscores of the FABQ were converted to a 0-100 point scale to facilitate comparison. Descriptive statistics were calculated for participants' baseline characteristics in each treatment group. Baseline values for participant-rated outcome variables were obtained by averaging the two baseline visits with the exception of the FABQ which was measured only once at baseline. Descriptive plots and histograms were generated to ascertain to the overall trend and identify unusual observations. Second, bivariate analyses were conducted; baseline demographic and clinical variables that have a moderate correlation of 0.5 or greater with the outcomes were included as covariates (i.e. determined to impact outcomes).[68]

The model specified fixed effects for group, time, and group-by-time interaction, a random intercept for subject, and a random slope for time:

$Y_{ij} = \beta_0 + \beta_1(group_{ij}) + \beta_2(time_{ij}) + \beta_3(group_{ij}*time_{ij}) + b_{0i} + b_{1i}(time) + \varepsilon_{ij}$

Where Y_{ij} = FABQ-PA (or W) for individual 'i' measured at time j; where $group_{ij}$, $time_{ij}$, and ε_{ij} are treatment group, measurement time, and error for the individual; where b_{0i} = individual-specific intercept (if $b_{0i} < 0$, then the individual started off with lower FABQ subscore compared to group average); and where b_{1i} = individual-specific slope (if < 0, then the individual's FABQ subscore showed a steeper decrease compared to group average).

An intention-to-treat analysis was used for the physical activity outcome. A modified intention-to-treat analysis was used for the work outcome; those without

baseline data for FABQ-W were not included in the analysis since there was no basis for comparison.

Model assumptions regarding regression residuals were evaluated after fitting. Normality was assessed through QQ plots and histograms. Linearity was assessed by plotting residuals versus predicted values. The alpha level was maintained at 0.05 for all analyses since fear-avoidance beliefs were a secondary outcome in the parent trial.

Crude mean values for FABQ-W and PA are plotted over time. Adjusted means and 95% confidence intervals (CI) in FABQ for between-group differences in change from baseline for all follow up periods are reported. To facilitate interpretation, effect size differences were calculated using between group differences and baseline standard deviations and interpreted as follows: 0.8 = large effect, 0.5 = moderate effect size, and 0.2 = small effect size.[69]

Missing Data Analysis

The quantity and pattern of missing data was determined. Variables that predicted missingness of FABQ physical activity and work subscores were evaluated separately using logistic regression; those with $0.9 \leq OR \geq 1.10$ were included in the imputation model. Ten datasets were imputed using multivariate normal regression as recommended by STATA for an arbitrary missing data pattern.[67] The linear mixed-effects model present above was used for analysis.

Rationale for Change in the Analysis Plan

The initial analysis plan called for treating the baseline values as a covariate rather than an outcome. However, this complicated extraction of results from the missing data analysis. By treating the baseline values as an outcome, the output from the missing data analysis are the estimates of interest. This change is considered acceptable for two main reasons. First, the difference between groups at baseline is relatively small (2.64 points for physical activity and 3.46 points for work on a 0-100 scale). Second, the results from the updated model did not change meaningfully (i.e. there was no difference in the statistically significant findings, the interpretation/discussion, or the conclusions).

Sample Size

The sample size for the parent trial[53] was based on detecting a group difference of 8% in the primary outcome at 12 weeks, participant-rated neck pain.[53,57,70] In a three-arm design at an alpha level of 0.05 with power of 0.80, 77 participants per group were required (SPSS SamplePower 1.0 International Business Machines, Armonk, NY). A 15% dropout or loss to follow up rate was assumed; 90 participants were required per group, for a total of 270 participants.[53]

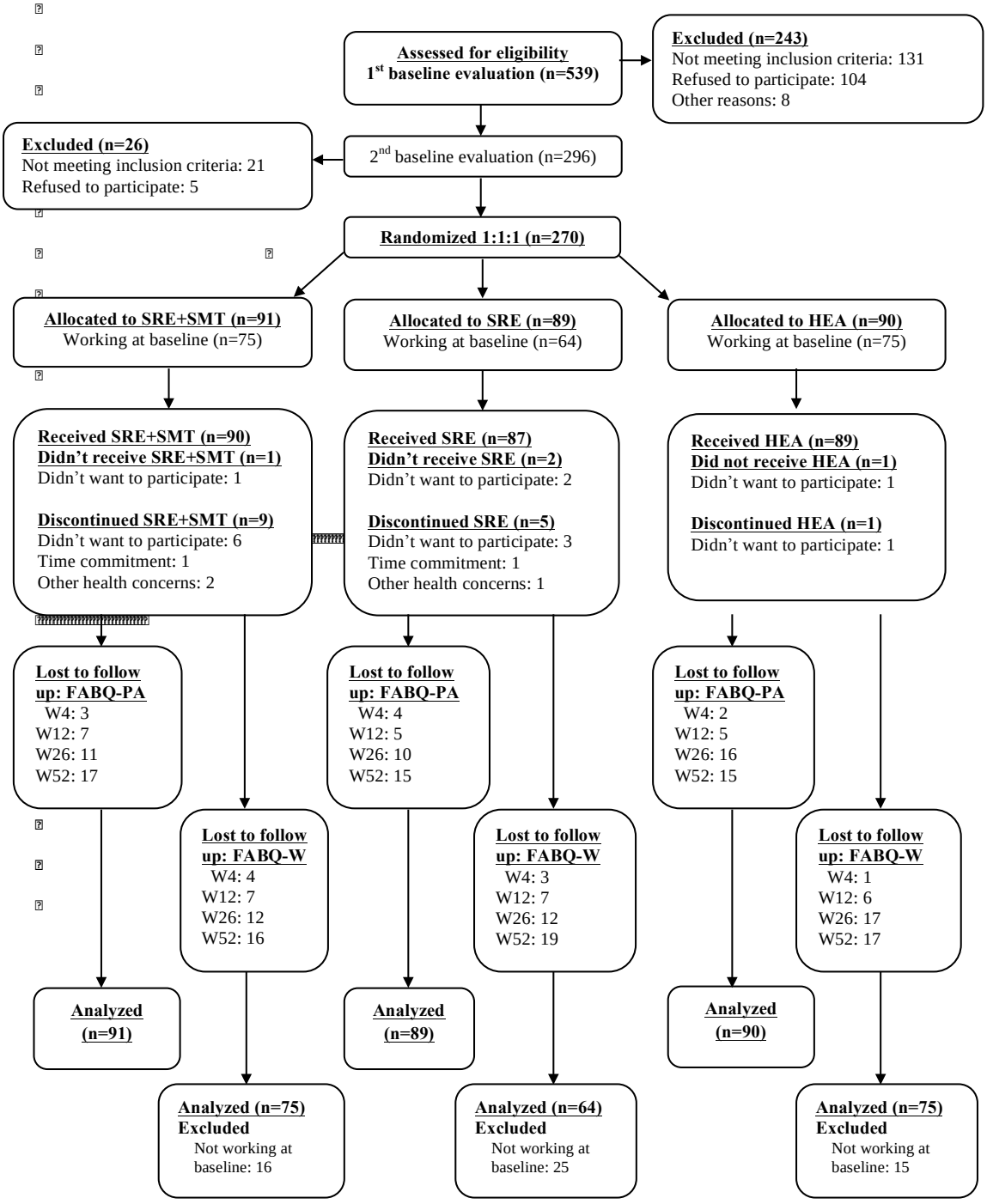
A post-hoc power calculation for FABQ is not worthwhile since it does not help explain the state of the data or facilitate interpretation of the results.[71] The purpose of a power calculation is to describe future possibilities given a specific study design; it is not meant explain data once it has been collected. [71]

Chapter 3: Results

Study Population

The primary and other secondary results of this study have been reported elsewhere.[14,15] A total of 270 subjects were randomized into the trial; see Figure 3 for details regarding evaluation, enrollment, participation, and attrition. After randomization, a small number of participants refused their group allocation and did not receive treatment: SRE+SMT (n=1); SRE (n=2); and HEA (n=1). During the course of the treatment phase, some participants discontinued treatment: SRE+SMT (n=9); SRE (n=5); and HEA (n=1). All randomized participants were included in the FABQ-physical activity (PA) analysis. However, only participants who reporting working at baseline were included in the FABQ-work (W) analysis: SRE+SMT (n=75); SRE (n=64); and HEA (n=75). Loss-to-follow up rates at week 12 ranged from 5.6% to 7.7% for FABQ-PA and 8.0% to 10.9% for FABQ-W. These rates increased through the final data collection period at week 52: 16.7% to 18.7% for FABQ-PA and 21.3% to 29.7% for FABQ-W.

Figure 3: Participant flow through the study



Baseline sociodemographic and clinical characteristics for participants are detailed in Table 2. The study population is similar to that described previously in CNP literature, primarily middle-aged (mid-forties) and female.[7] Twenty-two percent to 30.8% of participants reported their current neck pain started due to an injury or trauma; duration of neck pain ranged from 8.8 to 10.4 years. Baseline neck pain was moderate in severity, 5.5 to 5.7 out of 11 points; neck-related disability was considered mild (26.1 to 28.6 on a 0-100 scale). Scores for FABQ-PA were approximately mid-range (45.8 to 48.5 on a 0-100 scale); FABQ-W scores were lower (22.0 to 25.4 on a 0-100 scale)

Table 2: Baseline demographic and clinical characteristics by intervention group; mean (SD) unless otherwise noted

Characteristics	SRE+SMT	SRE	HEA
N	91	89	90
Age (years)	44.1 (11.6)	48.7 (9.6)	46.0 (10.4)
Female, %	71.4%	73.0%	72.2%
White, %	90.1%	91.0%	91.1%
Neck Pain (0-10)	5.6 (1.4)	5.7 (1.3)	5.5 (1.4)
Duration (years)	8.8 (9.1)	10.4 (9.6)	8.9 (8.8)
Neck Disability (0-100)	27.8 (9.0)	26.1 (9.8)	28.6 (8.8)
NP due to injury, %	28.6%	30.3%	22.2%
Frequency of NP	3.8 (1.0)	3.9 (0.85)	4.1 (0.89)
FABQ-W (0-100)	23.8 (16.8)	25.4 (20.3)	22.0 (16.2)
FABQ-PA (0-100)	48.5 (23.8)	46.5 (21.9)	45.8 (20.3)
Married/Living, %	62.6%	73.0%	65.6%
Employed, %	82.4%	71.9%	83.3%
College education*, %	56.0%	50.6%	64.4%
Currently smoke, %	15.4%	7.9%	13.3%
SF-36 Physical	45.7 (6.6)	46.6 (6.8)	44.6 (6.9)
SF-36 Mental	51.1 (9.9)	53.7 (9.2)	51.6 (10.6)
NHI Summary	2.5 (3.5)	1.5 (2.1)	2.3 (3.3)
Exercise 2+x/wk, %	51.6%	56.2%	51.1%
Depression (0-100)	16.2 (12.3)	13.2 (9.9)	17.0 (12.3)

*completed post-secondary education (includes 2-year associate's degree or equivalent); NP = neck pain; FABQ = Fear Avoidance Beliefs Questionnaire; W = work; PA = physical activity; SF-36 = Short-Form health survey 36; NHI = National Health Index; SRE+SMT, supervised rehabilitative exercise combined with spinal manipulation therapy; SRE, supervised rehabilitative exercise; HEA, home exercise and advice

None of the baseline demographic and clinical variables had a moderate correlation of 0.5 or greater with the outcomes (i.e. determined to impact outcome)[68]; thus no additional baseline covariates were included in the regression model.

Fear-Avoidance Outcomes

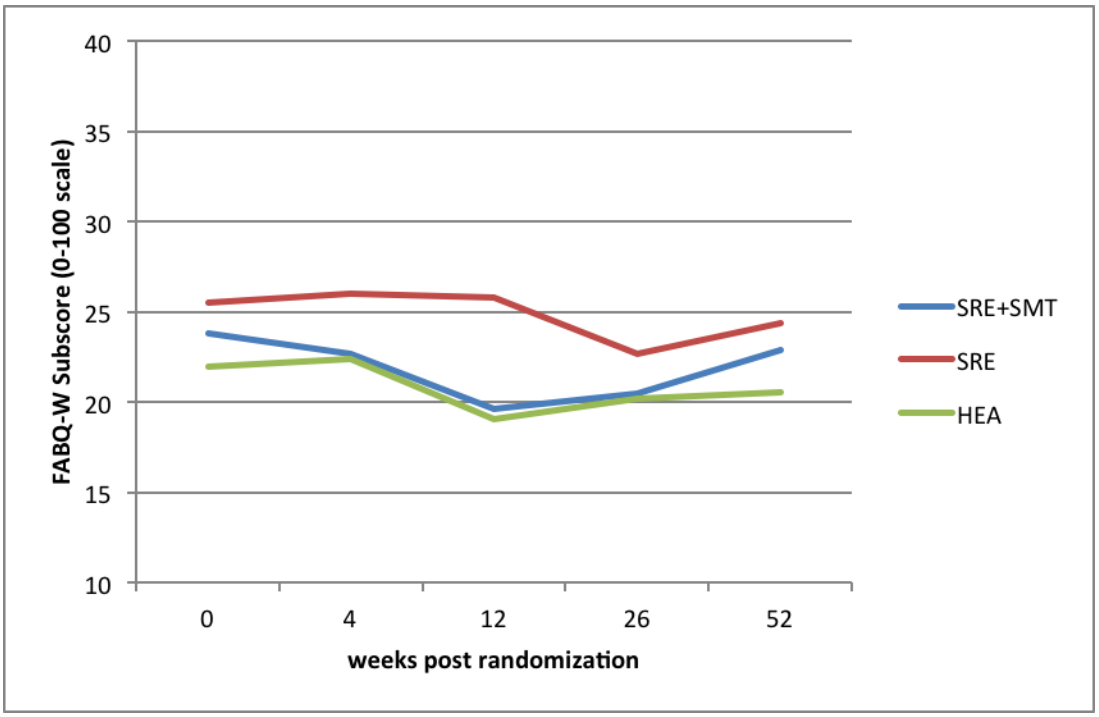
As seen in Figure 4 for fear-avoidance beliefs about work (FABQ-W), SRE+SMT and HEA demonstrated slight improvement compared to SRE by the end of the 12-week treatment phase. By week 52, the differences regressed back to baseline values. For fear-avoidance beliefs about physical activity, the three intervention groups exhibited similar improvements during the 12 weeks of treatment; these differences remained relatively consistent through week 52 (see Figure 5). Table 3 provides crude mean values and standard deviations for patient-rated FABQ-W and FABQ-PA at each time point.

Table 3: Crude mean values (SD) for participant-rated fear-avoidance beliefs at each time point

FABQ Subscore	Group	Baseline	W4	W12	W26	W52
Work (0-100)						
	SRE+SMT	23.81 (16.80) n=75	22.61 (16.30) n=72	19.56 (15.45) n=70	20.47 (16.82) n=67	22.88 (17.18) n=63
	SRE	25.45 (20.26) n=64	26.01 (20.59) n=65	25.77 (21.77) n=60	22.62 (22.47) n=58	24.31 (22.98) n=52
	HEA	21.99 (16.19) n=76	22.43 (16.87) n=76	19.04 (15.85) n=71	20.21 (17.94) n=60	20.55 (18.28) n=62
Physical Activity (0-100)						
	SRE+SMT	48.47 (23.80) n=91	42.61 (22.75) n=88	35.42 (21.53) n=84	35.57 (23.71) n=80	34.12 (24.68) n=74
	SRE	46.54 (21.87) n=89	38.68 (24.36) n=85	33.48 (23.37) n=84	33.76 (25.01) n=79	33.11 (27.31) n=74
	HEA	45.83 (20.35) n=90	39.44 (22.13) n=88	35.83 (21.74) n=85	35.29 (21.67) n=74	33.56 (25.07) n=75

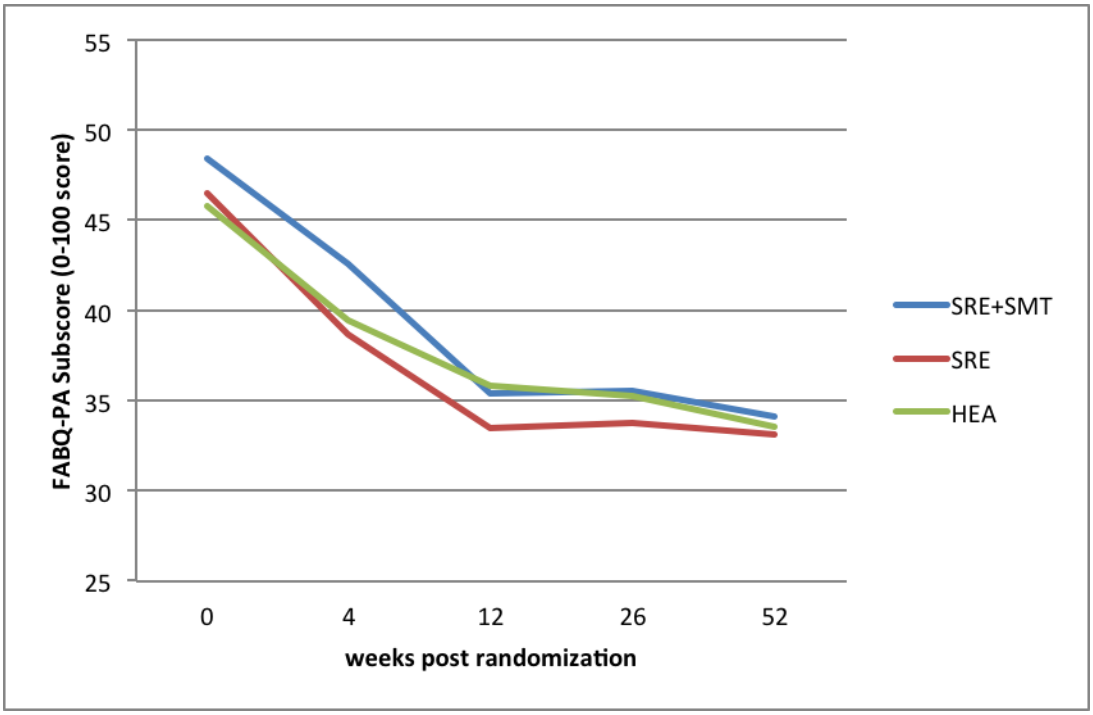
FABQ, Fear-Avoidance Beliefs Questionnaire; W, week; SRE+SMT, supervised rehabilitative exercise combined with spinal manipulation therapy; SRE, supervised rehabilitative exercise; HEA, home exercise and advice; Lower FABQ scores are preferred (suggest fewer fear-avoidance beliefs and/or improvement)

Figure 4: Crude mean values of participant-rated fear-avoidance beliefs about work (FABQ-W) over time.



FABQ, Fear-Avoidance Beliefs Questionnaire; W, work; SRE+SMT, supervised rehabilitative exercise combined with spinal manipulation therapy; SRE, supervised rehabilitative exercise; HEA, home exercise and advice; Lower FABQ scores are preferred (suggest fewer fear-avoidance beliefs and/or improvement); please note the y-axis has been truncated from the 0-100 scale

Figure 5: Crude mean values of participant-rated fear-avoidance beliefs about physical activity (FABQ-PA) over time.



FABQ, Fear-Avoidance Beliefs Questionnaire; PA, physical activity; SRE+SMT, supervised rehabilitative exercise combined with spinal manipulation therapy; SRE, supervised rehabilitative exercise; HEA, home exercise and advice; Lower FABQ scores are preferred (suggest fewer fear-avoidance beliefs and/or improvement); please note the y-axis has been truncated from the 0-100 scale

Interaction Results

For FABQ-W at 12 weeks, there was a statistically significant between-group difference (baseline to week 12) in favor of the SRE + SMT group when compared to the SRE group (5.30 points; 95% CI, 0.99 to 9.62; p=0.016). The remaining between-group differences in change from baseline to week 12 were not statistically significant; the SRE + SMT performed better when compared to HEA (2.12 points; CI, -1.99 to 6.24; p=0.312), SRE had a slight disadvantage compared to HEA (-3.18 points; CI, -1.13 to 7.49; p=0.148).

For FABQ-W at 52 weeks, there were small, not statistically significant between-group differences (baseline to week 52): SRE+SMT had a slight disadvantage compared to SRE (-0.91 points; CI, -7.11 to 5.28; p=0.772) and HEA (-0.47 points; CI, -6.31 to 5.37; p=0.875) while the SRE demonstrated slight improvement when compared to HEA (0.44 points; CI, -5.77 to 6.65; p=0.888).

For FABQ-PA at 12 weeks, there were no statistically significant group differences (baseline to week 12): the SRE+SMT group demonstrated slight improvement compared to the SRE group (1.07 points; 95% CI, -5.44 to 7.58; p=0.746) and HEA group (4.09 points; CI, -2.40 to 10.58; p=0.217), while the SRE group performed slightly better than HEA group (3.01 points; CI, -3.50 to 9.52; p=0.364).

For FABQ-PA at 52 weeks, differences remained small and were not statistically significant (baseline to week 52); the SRE+SMT group performed better than the SRE group (2.05 points; CI, -5.84 to 9.93; p=0.611) and HEA group (2.78 points; CI, -5.08 to 10.64; p=0.488) while the SRE group performed slightly better than the HEA group (0.73 points; CI, -7.51 to 8.61; p=0.56).

See Table 4 for mean between-group differences (baseline to follow up week) and 95% CI in participant-rated fear-avoidance beliefs about work and physical activity at each time point.

Table 4: Mean between-group differences (baseline to follow up week) and 95% CI in participant-rated fear avoidance beliefs about work and physical activity

FABQ subscore	SRE+SMT vs SRE	p	SRE+SMT vs HEA	p	SRE vs HEA	P
Work (0-100)						
W4	1.39 (-2.76 to 5.55)	0.511	1.93 (-2.03 to 5.89)	0.339	0.54 (-3.59 to 4.66)	0.798
W12*	5.30 (0.99 to 9.62)	0.016	2.12 (-1.99 to 6.24)	0.312	-3.18 (-7.49 to 1.13)	0.148
W26	0.80 (-3.98 to 5.59)	0.742	2.19 (-2.42 to 6.81)	0.352	1.39 (-3.45 to 6.23)	0.573
W52	-0.91 (-7.11 to 5.28)	0.772	-0.47 (-6.31 to 5.37)	0.875	0.44 (-5.77 to 6.65)	0.888
Physical Activity (0-100)						
W4	-1.50 (-7.89 to 4.89)	0.645	-0.26 (-6.61 to 6.08)	0.935	1.24 (-5.17 to 7.64)	0.705
W12*	1.07 (-5.44 to 7.58)	0.746	4.09 (-2.40 to 10.58)	0.217	3.01 (-3.50 to 9.52)	0.364
W26	1.11 (-5.75 to 7.97)	0.751	2.55 (-4.37 to 9.47)	0.471	1.44 (-5.51 to 8.39)	0.685
W52	2.05 (-5.84 to 9.93)	0.611	2.78 (-5.08 to 10.64)	0.488	0.73 (-7.51 to 8.61)	0.856

*Denotes the end of the treatment phase; FABQ, Fear-Avoidance Beliefs Questionnaire; W, week; SRE+SMT, supervised rehabilitative exercise combined with spinal manipulation therapy; SRE, supervised rehabilitative exercise; HEA, home exercise and advice

The effect sizes between groups for both FABQ-W and –PA during follow up were small ranging from 0.02 to 0.30; the largest was 0.30 between SRE+SMT and SRE at week 12 for FABQ-W (see Table 5).

Table 5: The standardized mean effect between groups

FABQ subscore	SRE+SMT vs. SRE	SRE+SMT vs. HEA	SRE vs. HEA
Work			
W4	0.08	0.11	0.03
W12	0.30	0.12	-0.18
W26	0.05	0.12	0.08
W52	-0.05	-0.03	0.02
Physical Activity			
W4	-0.07	-0.01	0.06
W12	0.05	0.19	0.14
W26	0.05	0.12	0.07
W52	0.09	0.13	0.03

FABQ, Fear-Avoidance Beliefs Questionnaire; W, week; SRE+SMT, supervised rehabilitative exercise combined with spinal manipulation therapy; SRE, supervised rehabilitative exercise; HEA, home exercise and advice

Variability of Random Effects

For work, the dominant source of variability within the linear mixed effects model was due to individual variability of FABQ scores at baseline (σ^2=250.6) rather than within individual variability over time (σ^2=74.1). Variability within the linear mixed effects model for physical activity was due to both individual variability of FABQ scores at baseline (σ^2=268.8) and within individual variability over time (σ^2=232.2).

Missing Data Analysis

Mean between-group difference (baseline to follow up week) and 95% confidence intervals from the missing data analysis tended to be more conservative with some exceptions (see Table 6). For FABQ-Work, a statistically significant between-group difference (baseline to week 12) remained in favor of the SRE + SMT group when compared to the SRE group (4.94 points; 95% CI, 0.26 to 9.62; p=0.039).

Table 6: Mean between-group differences (baseline to follow up week) and 95% CI for participant-rated fear avoidance beliefs about work and physical activity from the missing data analysis

FABQ subscore	SRE+SMT vs SRE	p	SRE+SMT vs HEA	p	SRE vs HEA	P
Work (0-100)						
W4	1.20 (-3.31 to 5.71)	0.601	1.91 (-2.32 to 6.14)	0.376	0.71 (-3.75 to 5.16)	0.756
W12*	4.94 (0.26 to 9.62)	0.039	2.06 (-2.33 to 6.46)	0.358	-2.88 (-7.55 to 1.80)	0.227
W26	0.47 (-4.95 to 5.89)	0.865	1.93 (-2.92 to 6.79)	0.436	1.46 (-4.22 to 7.15)	0.612
W52	-1.91 (-8.33 to 4.51)	0.560	-0.91 (-7.07 to 5.25)	0.772	1.00 (-5.52 to 7.52)	0.764
Physical Activity (0-100)						
W4	-1.31 (-7.85 to 5.21)	0.692	-0.14 (-6.58 to 6.31)	0.976	1.18 (-5.31 to 7.68)	0.721
W12*	0.87 (-5.86 to 7.60)	0.800	4.24 (-2.46 to 10.9)	0.215	3.37 (-3.20 to 9.95)	0.315
W26	1.09 (-6.01 to 8.19)	0.763	2.44 (-4.77 to 9.64)	0.507	1.35 (-5.76 to 8.46)	0.710
W52	1.57 (-6.32 to 9.47)	0.696	1.60 (-6.46 to 9.67)	0.696	0.03 (-7.98 to 8.04)	0.994

*Denotes the end of the treatment phase; FABQ, Fear-Avoidance Beliefs Questionnaire; W, week; SRE+SMT, supervised rehabilitative exercise combined with spinal manipulation therapy; SRE, supervised rehabilitative exercise; HEA, home exercise and advice.

Chapter 4: Discussion

This study found that SRE+SMT resulted in small but statistically significant improvements in fear-avoidance beliefs about **work** compared to SRE, but only at week 12. Otherwise, there were no statistically significant differences between groups at other time points for work or for any time point in regards to physical activity. However, it can be argued that the between group difference (SRE+SMT versus SRE) in change of FABQ from baseline is not important. The magnitude of improvement in SRE+SMT when compared to SRE at week 12 was small (5.3 points on 0-100 scale); this is further evidenced by a small effect size difference (Cohen's d=0.30). Subsequently, this small difference is unlikely to be clinically meaningful.

The group trends observed for FABQ-work differ from the other outcomes reported in the primary manuscript for this trial (e.g. pain, disability, quality of life, medication use, global perceived effect, and satisfaction).[53] In the primary results article the two SRE groups performed similarly and better than the HEA group in terms of pain, global perceived effect, and satisfaction[53]; for FABQ-W the SRE group performed less well when compared to the SRE+SMT group. There are a few possible explanations for these observations. First, SRE participants reported a greater number of side effects (97-99%) in comparison to HEA (33%), especially those that were mild, temporary, and expected such as muscle soreness.[53] The presence of these side effects and lack of additional treatment for the SRE-only group (i.e. SMT) may negatively influence perceptions of their ability to function in a work environment. Another possible

explanation for the different FABQ-W trends observed between the SRE groups may be related to limitations of the FABQ instrument (see FABQ discussion below). It is also possible that this finding is spurious.

Fear-Avoidance Model of Exaggerated Pain Perception (FAM)

The FAM was published 25 years ago; in the spirit of knowledge evolution, it is important to re-evaluate the model in light of current evidence. Today, uncertainty of the relationship between risk factors and model assumptions has thrown into question the theoretical underpinnings of the FAM. Risk factors (e.g. pain catastrophizing, fear, depression) detailed in the model are considered valid although other risk factors not yet identified may also contribute to the model.[72] For example, other positive psychological risk factors (e.g. optimism, resiliency, self-efficacy, and hope) may play a role in fear-avoidance and pain-related disability.[21,22] Further, evidence suggests that the cumulative interactions between the known risk factors may be more informative of treatment than the cyclic, unidirectional relationship that was originally proposed.[72] One questionable assumption of the model is that is shares similarities with phobia disorders[72,73]; currently there is little evidence to support this assumption.[72]

Reviewers of the FAM support the assessment of pain-related fear despite limitations of the fear-avoidance model.[72] A likely reason for this inconsistency is that tools used to assess fear-avoidance beliefs may not be mapped appropriately to the fear-avoidance model.[72,74] For example, the FABQ quantifies a subject's fear-avoidance beliefs about physical activity and work[59], however it fails to evaluate important phobia

components present within the FAM. [72] This distorted conceptualization and understanding of the fear-avoidance model might result in misleading conclusions.

Limitations of the Study

Fear Avoidance Belief Questionnaire (FABQ)

The FABQ remains the strongest instrument available for assessing fear-avoidance beliefs despite some noteworthy limitations.[74] There is no evidence regarding the responsiveness of the FABQ overall or for the physical activity and work components for the English version in back or neck pain populations.[74] The interpretability of FABQ scores is limited; the interpretation is limited to higher scores suggest more strongly held fear-avoidance beliefs,(WADDELL) which makes the FABQ less useful in clinical settings. Some studies have investigated how to identify individuals with elevated fear-avoidance beliefs through utilization of FABQ scores [75,76]; the limited success of these efforts may suggest weak construct validity.[74] Attempts have been made in *low back pain* populations utilizing a median split on the FABQ-PA [42,77] that tested poorly in a larger clinical trial.[75] A cutoff value to identify those with elevated FABQ-W has been determined through receiver operating characteristic curve analysis[78]; this value tested well in a low back pain trial.[75] However, to my knowledge none of these cutoff values have been used to identify elevated fear-avoidance beliefs in neck pain populations. A minimal clinically importance difference, a change score that is meaningful to patients, has not been established for the FABQ.[74,76]

A minimal detectable change (MDC), a value that indicates what changes are indistinguishable from the point estimate, has been proposed in Norwegian and French

versions of the FABQ (10 to 12 points out of 42 for work; 7 to 9 points out of 21 for physical activity).[79-81] MDC values are not established in the English version yet. Assuming the values from Norwegian and French versions are applicable to the English version and are subsequently converted to a 0-100 scale, the range for work is 24 to 29 points and for physical activity, 33 to 43 points. When applying these MCD ranges to this study's findings, the results lie within the MDC range, which would imply follow up score are indistinguishable from baseline scores.

Other Limitations

Psychometric results of the neck-specific FABQ were not available when the study was initially designed in 2000. This means that investigators modified the FABQ for the study influencing its validity and reliability in unknown ways. This concern is mitigated by Cleland's work on the neck-specific FABQ that was published in 2008, which found that the FABQ for neck pain had similar validity and reliability results to the FABQ for back pain.[61]

Another limitation of the study included the amount of missing data that was present which may bias results. By week 52 approximately 17% of data was missing for FABQ-PA and 24% for FABQ-W. Results from the missing data analysis were consistent with results from the initial model. However, the multiple imputation analysis used in this study assumes that data are missing at random. If data were missing not at random, the point and variability estimates may still be biased.

The type of interventions used in this study prevents blinding of participants and exercise therapists/chiropractors to treatment group assignment. To mitigate this

weakness, participants' expectation of outcome for each treatment group was measure at baseline and evaluated for relevance during the analyses.

Strengths of the Study

The analytical methods used in this study are robust. The linear mixed-effects model for repeated measurement takes into account the correlated nature of the data and allows incomplete cases to be included in the analysis. This results in larger sample size and variability estimates that are more precise.

Strengths of this study include its population and pragmatic design, which increase the generalizability of the results. The study sample is similar to that described previously in CNP literature.[7] Both the manipulation and exercise treatments were partially individualized according to participant's abilities, tolerance, and daily activities, which may partly explain the large compliance rates. Consequently, the interventions in this study are more reflective of real world clinical practice.

This study included long-term follow up that provides additional information to patient, clinicians, and policy makers which aides in decision-making. This is especially important for FAB since SOMETHING...see intro Self-reported data were collected free from staff/provider influence.

Comparison with Other Similar Studies

Currently, one study has evaluated the effectiveness of similar combinations of therapies in a chronic neck pain population. Beltran-Alacreau et. al. conducted a small study (n=45) in Spain comparing 4 weeks of SMT to SMT/Education to SMT/Education/Exercise on fear-avoidance beliefs at 4, 12, and 16 weeks post-

randomization.[82] In this study, all 16 items of the Spanish FABQ were used to generate one FABQ score. They found statistically significant differences favoring SMT/Education and SMT/Education/Exercise over SMT alone in FABQ (12 to 18 points improvement on a 0-96 point scale) after treatment was concluded.[82] Using the MCD values presented above, these results lie well within the MDC range implying that follow up scores are indistinguishable from baseline scores despite statistically significant findings.

This small study is likely underpowered. It collected work data on all participants regardless of employment status and used all items to generate one summary score. The results appear to be differences between groups at specific time points, which does not account for differences between groups at baseline. These differences in data collection, scoring, and reporting may help explain the lack of consistency in results between the two studies.

Directions for Future Research

A more comprehensive theoretical framework, which explains the complexity of fear-avoidance beliefs and pain-related disability for the general population, is needed.[72] Recalling the biopsychosocial model of chronic pain, psychosocial characteristics are more predictive of chronic pain and disability in neck pain populations when compared to clinical or biological findings.[11,19,20] Further, the fear-avoidance model of exaggerated pain perception focuses solely on negative aspects of psychological health (e.g. pain catastrophizing, depression). Other positive psychological risk factors (e.g. optimism, resiliency, self-efficacy, and hope) likely play a role in pain-related disability as well.[21,22]

Future research should investigate how positive psychological risk factors might play into the fear-avoidance model of exaggerated pain perception.

In the meantime, the current model of fear-avoidance[25] can be considered a useful framework despite its short-comings[83] as there is no acceptable substitute; those who utilize FAM however need to carefully consider its limitations. The FABQ has the most psychometrically sound instrument for assessing fear-avoidance beliefs.[74] The FABQ used in this study included all items as published by Waddell[59] including the five items were not scored. In future research studies, items that are not scored can be excluded from the questionnaire to decrease patient burden. Importantly, the FABQ does not require participants to complete the work items if they are not currently working. Modifying the language would make the work items applicable to non-paid work-related activities such as housework, yard work, or volunteer work. Future studies on the FABQ can investigate other psychometric properties such as responsiveness, interpretability, construct validity, and minimal clinically important differences in addition to validity and reliability.

To increase physical activity within chronic pain populations, multiple behavior change strategies should be employed.[84] Strategies that are self-regulatory and provide social support have resulted in increased positive health and activity behaviors.[85,86] Future studies could investigate the effectiveness of group exercise in neck pain populations.

Implications of Research Findings

This study of chronic neck pain sufferers compared the relative effectiveness of SRE+SMT, SRE, and HEA on fear-avoidance beliefs about work and physical activity.

Due to the lack of change observed in FABQ between groups, except for marginal improvements in FABQ-W in favor of SRE+SMT at week 12, the clinical relevance of these findings is limited. If the goal is to reduce fear-avoidance beliefs for neck pain, two HEA visits might be preferred to 20 SRE or SRE+SMT visits if one considers patient presentation/preferences, cost of treatment, and the burden and risk to patients.

Conclusions

Except for marginal improvements in fear-avoidance beliefs about work in favor of SRE+SMT in the short term (12 weeks), no other statistically significant between-group differences were observed for work and physical activity fear avoidance beliefs. These results should be interpreted cautiously due to limitations of the Fear-Avoidance Beliefs Questionnaire and the Fear-Avoidance Model of Exaggerated Pain Perception. Future research can address shortcomings of the FAM model and the FABQ instrument.

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Appendix 1. Summary of recent systematic reviews regarding treatments used in the study

Author Yr	Intervention/ Outcomes	Results	Conclusions
EDUCATION ON NECK PAIN			
Gross 2010	Education for neck pain	This Cochrane review included 15 RCTs with 1660 participants • Patient education has similar effects to other treatments on neck pain o No difference was detected when comparing advice to stay active to no treatment, treatments focusing on rest, treatments focusing on exercise, physiotherapy and cognitive behavioral therapy (low quality) o No difference when compared to self-care strategies (e.g. exercise) or no treatment (low quality)	Low quality evidence suggests that patient education has similar effects on neck pain when compared to advice, stress-management, or self-care.
Yu 2014	Structured education for neck pain	Structured education is defined as advice regarding exercises communicated either in written form or written and oral forms together. Structured education has the same or weaker effect on pain compared to other conservative treatments (e.g. massage, supervised exercise, and physical therapy). However, it may provide modest gains when combined with physical therapy.	Structured education results in modest temporary effects on pain; it can be used as an adjunctive therapy.
EXERCISE ON NECK PAIN			
Gross 2015	Exercises on neck pain	This Cochrane review included 27 RCTs with 2485 participants • Strengthening exercises for the upper extremity demonstrate effectiveness for decreasing neck pain and increasing function (moderate quality) • Strengthening exercises used in conjunction with stretching and endurance exercises (moderate quality)	There is moderate quality evidence for the use of exercises focusing on the upper extremities to decrease pain and increase function of the neck.
SMT ON NECK PAIN			
Gross 2010	Manipulation and mobilization on neck pain	This Cochrane review included 27 RCTs with 1522 participants • Cervical manipulation is more effective than a control for reducing pain (low quality**)** • Cervical manipulation and mobilization have similar effects on pain and function (moderate quality) • The combination of cervical and thoracic manipulation provides has the same effect as cervical manipulation only (low quality)	There is low to moderate quality evidence for manipulation and mobilization of the spine to decrease pain and increase function of the neck.

Appendix 2. Fear-Avoidance Beliefs Questionnaire (FABQ) modified for neck[61]

Here are some of the things which other patients have told us about their pain. For each statement, please circle any number from 0 to 6 to say how much physical activities such as bending, lifting, walking or driving affect or would affect *your* neck pain.

		Completely Disagree			**Unsure**			**Completely Agree**
1	My pain was caused by physical activity	0	1	2	3	4	5	6
2	Physical activity makes my pain worse	0	1	2	3	4	5	6
3	Physical activity might harm my neck	0	1	2	3	4	5	6
4	I should not do physical activities which (might) make my pain worse	0	1	2	3	4	5	6
5	I cannot do physical activities which (might) make my pain worse	0	1	2	3	4	5	6

5a Are you currently working?

$_0$ No Please **skip** questions 6-16

$_1$ Yes Please **complete** questions 6-16

The following statements are about how your normal work affects or would affect your neck pain.

		Completely Disagree			**Unsure**			**Completely Agree**
6	My pain was caused by my work or by an accident at work	0	1	2	3	4	5	6
7	My work aggravated my pain	0	1	2	3	4	5	6
8	I have a claim for compensation for my pain	0	1	2	3	4	5	6
9	My work is too heavy for me	0	1	2	3	4	5	6
10	My work makes or would make my pain worse	0	1	2	3	4	5	6
11	My work might harm my neck	0	1	2	3	4	5	6
12	I should not do any normal work with my present pain	0	1	2	3	4	5	6
13	I cannot do my normal work with my present pain	0	1	2	3	4	5	6
14	I cannot do my normal work until my pain is treated	0	1	2	3	4	5	6
15	I do not think that I will be neck to my normal work within 3 months	0	1	2	3	4	5	6
16	I do not think that I will ever be able to go back to that work	0	1	2	3	4	5	6

Scoring:
Scale1: Fear-avoidance beliefs about work— sum items 6, 7, 9, 10, 11, 12, 15 (possible range 0-42)

Scale 2: Fear-avoidance beliefs about physical activity—sum items 2, 3, 4, 5 (possible range 0-24)