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# Manual therapy and neck-specific exercise are equally effective for treating non-specific neck pain but only when exercise adherence is maximised: A randomised controlled trial

Iker Villanueva-Ruiz [a,b,*], Deborah Falla [c], Marc Saez [d], Maialen Araolaza-Arrieta [a], Jon Jatsu Azkue [e], Ane Arbillaga-Etxarri [a], Ana Lersundi [f,h], Ion Lascurain-Aguirrebeña [g,h,i]

[a] Deusto Physical TherapIker, Physical Therapy Department, Faculty of Health Sciences, University of Deusto, Spain
[b] Department of Preventive Medicine and Public Health, Faculty of Medicine and Nursing, University of the Basque Country UPV/EHU, Leioa, Spain
[c] Centre of Precision Rehabilitation for Spinal Pain (CPR Spine), School of Sport, Exercise and Rehabilitation Sciences. College of Life and Environmental Sciences, University of Birmingham, United Kingdom
[d] Research Group on Statistics, Econometrics and Health (GRECS), University of Girona, Girona, Spain. CIBER of Epidemiology and Public Health (CIBERESP), Madrid, Spain
[e] Department of Neurosciences, Faculty of Medicine and Nursing, University of the Basque Country UPV/EHU, Leioa, Spain
[f] Department of Traumatology and Orthopedic Surgery, Osakidetza Servicio Vasco de Salud Hospital Universitario Donostia, Donostia, Spain
[g] Physiotherapy, Department of Physiology, Faculty of Medicine and Nursing, University of the Basque Country UPV/EHU, Leioa, Spain
[h] Biogipuzkoa Health Research Institute, Bioengineering Area, Innovation Group, San Sebastian, Spain
[i] Musculoskeletal Pain Research Group, University of the Basque Country (UPV/EHU), Leioa, Spain

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## ABSTRACT

*Objective:* To assess the effectiveness of manual therapy versus a progressive, tailored neck-specific exercise program with high adherence for treating non-specific chronic neck pain (NSNP) and to examine the relationship between exercise adherence and treatment outcome.

*Design:* Single-blind, parallel, randomized clinical trial with two treatment arms, adhering to CONSORT guidelines.

*Methods:* 65 NSNP participants were randomly allocated to manual therapy or exercise. They received four treatment sessions of either manual therapy or neck-specific exercise, once a week for four weeks. Outcomes measured at baseline, two weeks, four weeks, and 12 weeks post-treatment included pain intensity, disability, patient-perceived improvement, quality of life, kinesiophobia and the craniocervical flexion test (CCFT) performance. In addition to evaluating each individual outcome, patients were categorized into either *responders* or *non-responders* according to pain intensity, disability and patient-perceived improvement. Exercise adherence was recorded.

*Results:* There were no differences between groups in individual outcomes. Treatment outcome in the exercise group was associated with exercise adherence. Patients receiving manual therapy were more likely to be classified as responders than those receiving exercise at all measured time points (odds ratio, 2 weeks: 0.14; 95 % CI: 0.02–0.79; treatment completion: 0.31; 95 % CI: 0.12–0.82; 12 weeks after treatment completion: 0.19; 95 % CI: 0.05–0.65), however these differences were no longer present when only patients whose exercise adherence was ≥95 % were analysed. Exercise was more effective than manual therapy in improving CCFT performance but only if patients with ≥95 % adherence were considered.

*Conclusion:* A four-week intervention of manual therapy was more effective than exercise, however when exercise adherence was ≥95 %, the interventions were equally effective. Manual therapy may only be superior to specific-exercise when high exercise adherence cannot be assured.

* Corresponding author. Faculty of Health Sciences, University of Deusto, Mundaiz Kalea 50, Donostia, San Sebastián, 20012, Spain.
*E-mail address:* iker.villanueva@deusto.es (I. Villanueva-Ruiz).

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## 1. Introduction

Neck pain is a prevalent condition (Safiri et al., 2020), ranks as the sixth leading cause of disability worldwide (GBD 2019 Diseases and Injuries Collaborators, 2020) and the recurrence rate of neck pain is high (Carroll et al., 2008; Childs et al., 2008). In the absence of identifiable pathoanatomical causes, most patients are classified as having nonspecific chronic neck pain (NSNP) (Farrell et al., 2019).

Clinical practice guidelines and systematic reviews advocate the use of manual therapy and specific exercise for the treatment of NSNP (Bier et al., 2018; Blanpied et al., 2017; Côté et al., 2016; Guzman et al., 2009; Kjaer et al., 2017; Monticone et al., 2013; Parikh et al., 2019; Villanueva-Ruiz et al., 2021). However, a recent network meta-analysis comparing the effectiveness of different conservative treatments for NSNP (Castellini et al., 2022) reported low to very low certainty of evidence for the relative effectiveness of different interventions, highlighting the need for further good quality research. Furthermore, the authors concluded that the heterogeneity among current guideline recommendations creates uncertainty for clinicians when deciding the best treatment option and, while multimodal approaches combining both therapies appear promising, it is unclear whether one intervention may be more effective than the other, for it to either be used independently or receive greater weighting in the overall treatment approach. Therefore, conducting a direct comparison between manual therapy and exercise could provide additional critical insights for optimizing treatment strategies for NSNP.

Increased knowledge about the relative effectiveness of manual therapy and specific exercise would help clinicians in their clinical decision-making (Fredin and Lorås, 2017). Furthermore, given the dose-effect relationship of exercise and treatment outcomes in people with neck pain (Mueller et al., 2023; Nikander et al., 2006; Pedersen et al., 2013; Price et al., 2020), it is possible that the true effect of exercise may have been underestimated previously if adherence to treatment was low.

The primary aim of this study was to assess the relative effectiveness of manual therapy and neck specific exercise, for the treatment of NSNP. The secondary aim was to assess the relationship between exercise adherence and treatment outcome.

## 2. Methods

A single-blind, parallel, randomized clinical trial with two treatment arms was conducted (ACTRN12620000711910). There was one deviation from the registered protocol. At the inception of the study, the plan was to enrol 80 participants, however, the COVID-19 pandemic considerably reduced access to patients for research purposes. Nevertheless, data on the first 30 participants of the study (coded, to blind the statistician for the final analysis) were used to obtain context-specific estimates of the effect size and perform a power calculation to determine the final sample size to detect differences in our primary outcome measures. Calculations revealed that in a two-sided test, assuming an alpha risk of 5 %, maximum indeterminacy and with a sample size of 60 patients, the statistical power was 80 %. Patients with NSNP attending a secondary care spinal unit in Donostia (Spain) were invited to participate. The inclusion criteria required participants to be aged 18 years or older, with a primary complaint of neck pain, and a non-traumatic, insidious onset of symptoms. Participants who exhibited radicular pain, signs of central hyperexcitability—such as widespread, non-anatomical or nonspecific pain distribution or stimulus-independent spontaneous pain—were excluded. Additionally, individuals with a history of whiplash injury, those who had undergone or were awaiting neck surgery, and those with inflammatory diseases or other spinal conditions were excluded from the study (Lascurain-Aguirrebeña et al., 2018a,b).

### 2.1. Randomization

Participants were allocated randomly to one of two treatment groups: manual therapy or neck specific exercise. A computer-generated random sequence was used for allocation, the treating physical therapist opened a sealed envelope and provided the intervention according to the allocation. The same physical therapist with 15 years of clinical experience and postgraduate training in neuromusculoskeletal physiotherapy administered all interventions.

### 2.2. Interventions

#### 2.2.1. Manual therapy

Patients in this group underwent four (once a week) 30-min sessions of manual therapy involving both myofascial and articular techniques. Treatment commenced with a suboccipital inhibition manual technique (Guo et al., 2023; Zabala-Mata et al., 2024) and cervical longitudinal intermittent traction (Binder, 2008). Subsequently, at the discretion of the physiotherapist and based on clinical reasoning, grade II-III segmental postero-anterior mobilizations to the upper thoracic spine (Griswold et al., 2015) and postero-anterior and/or antero-posterior mobilizations to the cervical spine were applied; these were applied following the movement plane of the zygapophyseal joints (Lascurain-Aguirrebeña et al., 2018a,b, 2021).

#### 2.2.2. Exercise

Patients in the exercise group completed a program of neck-specific exercises adapted from a previous protocol (G. Jull et al., 2018; Sremakaew et al., 2018). The program comprised of thirteen exercises targeting the activation of neck flexor and extensor muscles, and aimed to address disturbances in neck muscle activation reported previously in NSNP patients (Grip et al., 2008; Page et al., 2023; Sjölander et al., 2008; Woodhouse and Vasseljen, 2008).

The protocol involved four physiotherapist-led individual 30-min sessions (once a week) and daily home exercises for four weeks and involved exercises which were progressed by load and the level of difficulty over four weeks.

During each face-to-face session, patients engaged in supervised exercise practice under the guidance of the physiotherapist to ensure a thorough understanding and accurate execution of the prescribed exercises. Subsequently, patients received instructions to independently perform the exercises daily at home, with a duration of approximately 20 min per day. The exact dose was tailored to the patient, in that the number of repetitions and the level of difficulty were adapted to the individual needs, which were assessed at the beginning of each face-to-face treatment session. To facilitate adherence and precise exercise execution (Himler et al., 2023; Yaşarer et al., 2023), video recordings illustrating the prescribed exercises were provided to patients in this group via an instant messaging application installed on their mobile devices. The treatment protocol was individualized, tailoring the number of repetitions and the level of difficulty of each exercise to each patient's unique needs; this was assessed at the beginning of every treatment session. To evaluate adherence, patients in the exercise group were provided with a diary and asked to record the days on which they completed the prescribed exercises, and the physiotherapist who administered the treatments recorded the attendance of patients to the face-to-face sessions in both groups. Participants in both experimental groups were explicitly instructed to refrain from seeking any additional treatment for a minimum period of 12 weeks following the conclusion of the assigned intervention.

A full description of the exercise program can be found in Supplementary Material 1.

### 2.3. Outcome measures

All self-reported measures and performance on the craniocervical flexion test were evaluated at baseline (except GROC), two weeks after treatment commencement and within 48 h from the last treatment completion. In addition, GROC, NDI and maximum pain during the last week and last 24 h were evaluated 12 weeks after the last treatment completion. Furthermore, due to the fact that patient expectation has been associated with treatment outcome in NSNP (Bishop et al., 2013; Malfliet et al., 2019), patients were asked to rate their expectation prior to treatment commencement using a 0–100 scale, where a greater number is indicative of a higher expectation of recovery.

Prior to treatment commencement, patients' age, gender, symptom duration and number of non-specific physiotherapy sessions in the previous 12 months was recorded.

Maximum intensity of neck pain during last week and last 24 h and intensity of pain during active neck movements were measured with a 11-point numerical pain rating scale ranging from 0 (no pain) to 10 (most excruciating pain) (Chiarotto et al., 2019; Cleland et al., 2008; Modarresi et al., 2021; Young et al., 2019). The numeric pain rating scale has good to excellent test-retest reliability (Modarresi et al., 2021). Maximum neck range of movement in sitting was measured using a validated smartphone application securely fastened onto the forehead with a rigid Velcro strap (Elgueta-Cancino et al., 2022; Stenneberg et al., 2018). This device has demonstrated high concurrent validity and interrater reliability (Stenneberg et al., 2018).

Disability and function were measured using Neck Disability Index (NDI). (Bobos et al., 2018; Jones and Sterling, 2021; Murphy and Lopez, 2013). The NDI comprises 10 items that are evaluated using a Likert scale. The total score ranges from 0 to 100, and a greater total score corresponds to a higher perceived degree of disability (Bobos et al., 2018; Jones and Sterling, 2021; Murphy and Lopez, 2013). The NDI has good internal consistency and test-retest reliability (Saltychev et al., 2024).

Tampa scale of Kinesiophobia (TSK) and the Pain Catastrophizing Scale (PCS) were used to assess fear of movement or re-injury and the presence of catastrophizing thoughts respectively (Sullivan et al., 1995; Wheeler et al., 2019). TSK is a 11 item self-report questionnaire where total scores range from 11 to 44, with higher scores indicating greater levels of fear related to movement-associated pain (Cleland et al., 2008; Gómez-Pérez et al., 2011; Weermeijer and Meulders, 2018; Woby et al., 2005). PCS is a self-report 13 item questionnaire, total scores range from 0 to 52, and higher scores indicate higher levels of pain-related catastrophizing (Sullivan et al., 1995; Wheeler et al., 2019). The PCS has good internal and test–retest reliability (Wheeler et al., 2019).

Quality of life was assessed using the Short Form Health Survey questionnaire (SF-36) (Ware, 2000; Ware et al., 1993) and the European Quality of Life - 5 Dimensions questionnaire (EQ-5D) (Badia et al., 1999, 2001; Balestroni and Bertolotti, 2012). The SF-36 is a health survey comprising 36 questions, which provide a measure of physical and mental health, enabling participants to assess their perceived physical and mental health status using a scale from 0 to 100, where 0 represents the lowest possible and 100 represents the highest possible health status. (Ware, 2000; Ware et al., 1993). The SF-36 provides an acceptable measure of two independent constructs of physical and mental health (LoMartire et al., 2020). EQ-5D allows respondents to report their perceived health status on a scale of 0–10, with 0 being the worst and 10 being the best possible health status (Badia et al., 1999, 2001; Balestroni and Bertolotti, 2012). The EQ-5D is reliable and demonstrates moderate to strong correlations with global health measures (Feng et al., 2021).

The global rating of change scale (GROC) was used to measure the patient perceived overall improvement following treatment (Bobos et al., 2018, 2019). GROC is a 15 point scale where change is rated from −7 (a very great deal worse) through 0 (no change) to +7 (a very great deal better) (Bobos et al., 2018, 2019). GROC is reliable (Bobos et al., 2019) and widely used to evaluate change in neck pain (Lascurain-Aguirrebeña et al., 2018a,b, 2019, 2021) because of its validity and clinical relevance, and correlation with self-rated importance of change and patient satisfaction measures (Kamper et al., 2009).

Function of the deep cervical flexors was assessed using the cranio-cervical flexion test. The test was repeated three times and considered positive if the patient was unable to reach 26 mmHg without compensatory strategies (e.g. neck retraction or excessive activity of sternocleidomastoid or scalene muscles (Araujo et al., 2020; G. A. Jull et al., 2008; Juul et al., 2013)).

The outcome assessor was blind to patient treatment allocation.

### 2.4. Statistical analysis

In addition to evaluating treatment induced changes in each individual outcome, patients were also categorized into either *responders* or *non-responders* according to their treatment outcome at each time point (two weeks, treatment completion and 12 weeks post treatment completion). Patients were categorized as *responders* if they demonstrated an improvement equal or above the minimum clinical important difference in at least two of the following three outcome measures: 24-h neck pain intensity, disability (NDI) and patient perceived improvement (GROC). This was considered the primary outcome. Previously reported minimum clinical importance differences of 1.5 points for pain intensity (Young et al., 2019), 10 points for NDI (Holly et al., 2009; MacDermid et al., 2009) and a score of five (feeling at least "quite a bit better") on the GROC scale (Cleland et al., 2007; Kamper et al., 2009; Saavedra-Hernández et al., 2011) were used.

For each of the study aims, we conducted different generalized linear mixed models with Gaussian response for the continuous dependent variables, Poisson response for the discrete dependent variable and binomial response for the dichotomous dependent variables. The independent variables were the intervention and exercise adherence.

Statistically significant differences were observed between manual therapy and exercise groups for their baseline symptom duration and age, hence all subsequent analyses for between-group differences were adjusted for the effect of these variables. In addition, we also controlled for baseline disability (NDI) and neck pain intensity (maximum pain during the last week and last 24 h) as these have been associated previously with treatment outcome (Lascurain-Aguirrebeña et al., 2018a, b). The main analysis included all participants. Given the association between treatment adherence and effectiveness of exercise interventions, the analysis was then repeated including all participants in the manual therapy group and only those in the exercise group that achieved equal or greater than 95 % adherence (n = 18).

Given the complexity of our models, we performed inferences using a Bayesian framework. In particular, we followed the Integrated Nested Laplace Approximation (INLA) approach (Rue et al., 2009, 2017).

Changes were interpreted in relation to the minimum clinical important differences for pain intensity (1.5 points (Young et al., 2019)), disability (10 points (Holly et al., 2009; MacDermid et al., 2009)), quality of life (EQ (5D) 0.75 points (Del Corral et al., 2023); SF36 4.1 points (Carreon et al., 2010)), catastrophization (reduction of 38 % from baseline (Scott et al., 2014)), kinesiophobia (4 points (Woby et al., 2005)) or GROC (feeling at least "quite a bit better" (Cleland et al., 2007; Kamper et al., 2009; Saavedra-Hernández et al., 2011)).

## 3. Results

Seventy-seven participants were assessed for eligibility between July 1, 2020 and November 8, 2022; 65 met the inclusion/exclusion criteria and were included in the study (Fig. 1). Baseline characteristics of study participants in each group are detailed in Table 1.

All outcome measures at each timepoint are reported in Table 1. Whole group changes in maximum neck pain intensity during the last week and last 24 h, intensity of pain during neck active movements, disability, pain catastrophization and quality of life as well as between group differences in these measures are reported in Table 2. The secondary analysis including all participants in the manual therapy group and only participants in the exercise group whose treatment adherence

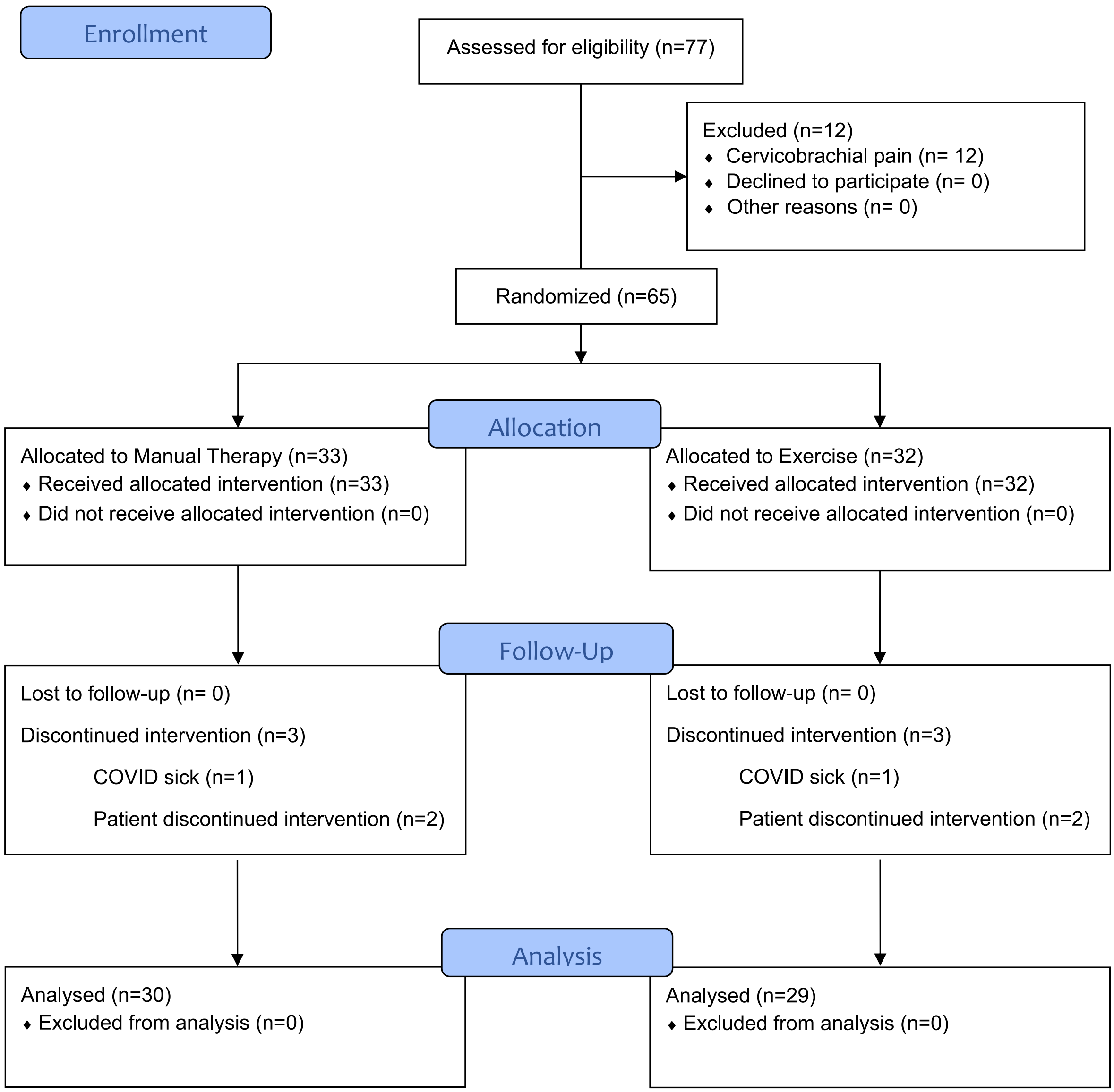


**Fig. 1.** Patient flow diagram.

was ≥95 % (n = 18) is reported in Table 3.

### 3.1. *Baseline to two weeks post treatment commencement*

Patients demonstrated significant (Prob >0.95) reductions in maximum neck pain intensity during the last week and last 24 h, intensity of pain during neck active movements, disability, pain catastrophization and quality of life. There were significant (Prob >0.95) increases in the range of motion for cervical side flexion and rotation, but not extension or flexion. No changes were observed for kinesiophobia. At baseline, 86 % of patients had a positive craniocervical flexion test; there was a significant (Prob >0.95) reduction in the number of positive tests to 70 % at two weeks post treatment commencement. Seventeen percent of patients reported feeling between *quite a bit better* and *a great deal better* on the GROC scale; 53 % reported feeling between a *tiny bit better* and *moderately better,* and 29 % reported feeling *about the same*. Based on whether or not patients had achieved a minimum clinical importance difference in pain intensity, NDI or GROC, twelve patients (20 %) were classified as *responders* and 47 (80 %) as *non-responders*.

After adjusting for the effect of age, gender, disability, pain intensity and the baseline value of the outcome of interest, there were no differences between groups in all outcome measures but one; patients receiving manual therapy were more likely to be classified as *responders* than those receiving exercise (adjusted odds ratio: 0.14; 95 % CI: 0.02–0.79; P = 0.987). However, when the analysis was repeated, only participants whose exercise adherence was ≥95 %, there were no longer differences between interventions in this outcome. In this secondary analysis, significant differences were found in the effect of interventions on neck muscle function; patients that received exercise were less likely to show a positive craniocervical test when compared to those that received manual therapy (adjusted odds ratio: 0.35; 95 % CI: 0.08–1.48; P = 0.953).

### 3.2. *Baseline to treatment completion*

Patients demonstrated significant (Prob >0.95) reductions of maximum neck pain intensity during the last week and last 24 h, intensity of pain during neck active movements, disability, pain catastrophization, quality of life and kinesiophobia. There were significant (Prob >0.95) increases in cervical range in all movements but flexion. The number of patients with a positive craniocervical flexion test

**Table 1**
Outcome measures in each timepoint. Values are mean ± SD or number of cases (/).

| Outcome | Week | MT (n = 30) | EX (n = 29) |
|---|---|---|---|
| Age (years) | 0 | 55.22 ± 15.32 | 48.66 ± 11.89 |
| Gender (male/female) | 0 | 11/19 | 8/21 |
| BMI (kg/m2) | 0 | 23.92 ± 3.51 | 24.32 ± 3.27 |
| Symptom duration (years) | 0 | 6.35 ± 7.34 | 10.68 ± 9.6 |
| Number of non-specific physiotherapy last year | 0 | 9.19 ± 13.2 | 10.31 ± 10.87 |
| NDI (0–100) | | | |
| | 0 | 27.63 ± 11.92 | 30.85 ± 16.38 |
| | 2 | 21.97 ± 9.62 | 25.44 ± 13.91 |
| | 4 | 19.7 ± 13.95 | 21.7 ± 14.81 |
| | 12 | 18.91 ± 12.54 | 21.18 ± 16.12 |
| NPRS 1w (0–10) | | | |
| | 0 | 6.36 ± 1.82 | 6.16 ± 2.07 |
| | 2 | 5.48 ± 2.24 | 5.17 ± 1.96 |
| | 4 | 4.33 ± 2.35 | 4.34 ± 2.72 |
| | 12 | 4.47 ± 3.19 | 4.84 ± 2.93 |
| NPRS 24 h (0–10) | | | |
| | 0 | 5.53 ± 2.49 | 4.8 ± 2.06 |
| | 2 | 4.55 ± 2.06 | 4.38 ± 2.39 |
| | 4 | 3.33 ± 2.51 | 3.24 ± 2.43 |
| | 12 | 3.03 ± 2.93 | 4.02 ± 2.99 |
| Painful Mov (0–10) | | | |
| | 0 | 5.27 ± 2.49 | 5.79 ± 1.86 |
| | 2 | 4.35 ± 2.03 | 4.05 ± 2.34 |
| | 4 | 3.81 ± 2.3 | 3.08 ± 2.15 |
| ROM Flex (degrees) | | | |
| | 0 | 51.01 ± 13.61 | 48.41 ± 12.35 |
| | 2 | 55.37 ± 16.24 | 48.31 ± 11.89 |
| | 4 | 50.89 ± 12 | 53.9 ± 13.31 |
| ROM Ext (degrees) | | | |
| | 0 | 53.35 ± 13.63 | 53.06 ± 15.36 |
| | 2 | 52.87 ± 15.37 | 54.92 ± 14.14 |
| | 4 | 49.44 ± 14.34 | 57.09 ± 14.37 |
| ROM SFR (degrees) | | | |
| | 0 | 27.14 ± 7.84 | 28.59 ± 10.81 |
| | 2 | 31.54 ± 10.13 | 33.31 ± 9.32 |
| | 4 | 29.77 ± 9.86 | 32.31 ± 7.66 |
| ROM SFL (degrees) | | | |
| | 0 | 26.24 ± 7.31 | 26.35 ± 11.16 |
| | 2 | 30.23 ± 8.37 | 31.02 ± 9.23 |
| | 4 | 29.55 ± 9.06 | 30.44 ± 8.04 |
| ROM RotR (degrees) | | | |
| | 0 | 54.89 ± 15.03 | 54.34 ± 13.98 |
| | 2 | 59.81 ± 14.56 | 55.95 ± 15.15 |
| | 4 | 60.26 ± 14.46 | 60.58 ± 12.06 |
| ROM RotL (degrees) | | | |
| | 0 | 54.74 ± 12.78 | 57.47 ± 13.41 |
| | 2 | 59.44 ± 12.77 | 60.12 ± 14.83 |
| | 4 | 59.49 ± 14.15 | 61.69 ± 12.66 |

**Table 1** (*continued*)

| Outcome | Week | MT (n = 30) | EX (n = 29) |
|---|---|---|---|
| EQ (5D) (0–10) | | | |
| | 0 | 6.67 ± 1.7 | 6.46 ± 1.81 |
| | 2 | 7.24 ± 0.98 | 6.71 ± 1.51 |
| | 4 | 7.6 ± 1.3 | 7.19 ± 1.56 |
| PCS (0–52) | | | |
| | 0 | 15.83 ± 9.11 | 13.78 ± 10.08 |
| | 2 | 12.75 ± 9.04 | 12.26 ± 9.03 |
| | 4 | 10.13 ± 9.2 | 11.03 ± 10.42 |
| TSK (11–44) | | | |
| | 0 | 23.45 ± 4.39 | 24.28 ± 7.16 |
| | 2 | 24.58 ± 7.72 | 22.07 ± 6.9 |
| | 4 | 22.73 ± 7.75 | 21.44 ± 6.52 |
| SF-36 P (0–100) | | | |
| | 0 | 66.51 ± 13.37 | 65.81 ± 16.87 |
| | 2 | 71.12 ± 15.27 | 70.19 ± 13.33 |
| | 4 | 73.4 ± 15.53 | 74.31 ± 14.23 |
| SF-36 M (0–100) | | | |
| | 0 | 67.18 ± 13.72 | 61.61 ± 19.28 |
| | 2 | 73.17 ± 14.25 | 68.93 ± 16.1 |
| | 4 | 72.88 ± 15.54 | 71.32 ± 15.21 |
| GROC (-5-5) | | | |
| | 2 | 2.47 ± 2.5 | 1.93 ± 1.62 |
| | 4 | 2.9 ± 2.7 | 2.52 ± 2.55 |
| | 12 | 3.37 ± 2.49 | 2.79 ± 2.41 |
| CCFT (positive/negative) | | | |
| | 0 | 27/3 | 23/5* |
| | 2 | 23/6 * | 17/11* |
| | 4 | 19/11 | 15/14 |
| PatExp (0–100) | | | |
| | Pre. | 80.91 ± 20.21 | 76.07 ± 18.67 |
| | Post. | 85.66 ± 18.22 | 80 ± 16.66 |

BMI: Body mass index; CCFT: craniocervical flexion test; EQ (5D) VAS: EuroQuol 5D visual analogue scale; Ext: extension; Flex: flexion; GROC: global rating of change scale; NDI: Neck disability index; NPRS 1w: Numeric pain rating scale last week; NPRS 24 h: Numeric pain rating scale last 24 h; PatExp: patient expectation; PCS: Pain Catastrophizing Scale; ROM: range of movement; RotL: left rotation; RotR: right rotation; SF-36 M: SF-36, mental domain; SF-36 P: SF-36, physical domain; SFL: left side flexion; SFR: right side flexion; TSK: Tampa Scale for Kinesiophobia; * one missing value.

demonstrated a further significant (Prob >0.95) reduction to 58 % (in comparison to 86 % at baseline). Thirty-six percent of patients reported feeling between *quite a bit better* and *a very great deal better* on the GROC scale; 34 % reported feeling between *a tiny bit better* and *moderately better*, 27 % reported feeling *about the same*, and 3 % reported feeling *moderately* or *somewhat worse*. Twenty-four patients (41 %) were classified as *responders* and 35 (59 %) as *non-responders*.

After adjusting for the effect of age, gender, disability, pain intensity, baseline value of the outcome of interest and outcome at 2 weeks, there were no differences between groups in all outcome measures but one; patients receiving manual therapy were more likely to be classified as *responders* than those receiving exercise (adjusted odds ratio: 0.31; 95 % CI: 0.12–0.82; P = 0.99). However, when the analysis was repeated, including only participants whose exercise adherence was ≥95 %, no significant differences between interventions were found. In this secondary analysis, significant differences were found in the effect of interventions on neck muscle function. Patients that received exercise

**Table 2**
Whole group changes and between group differences.

| Outcome | | Whole group changes | | | Difference between groups [c] | | |
|---|---|---|---|---|---|---|---|
| | | Coefficient[a] | 95 % Credibility Interval | P | Coefficient[b] | 95 % Credibility Interval | P |
| NDI | | | | | | | |
| | 0-2w | −4.88 | −6.93 to −2.83 | 1 | 1.22 | −2.73 to 5.17 | 0.730 |
| | 0-4w | −8.76 | −11.99 to −5.53 | 1 | 0.55 | −9.88 to 10.98 | 0.540 |
| | 0-12w | −9.57 | −12.79 to −6.35 | 1 | 0.55 | −7.45 to 8.55 | 0.552 |
| NPRS 1w | | | | | | | |
| | 0-2w | −0.94 | −1.54 to −0.33 | 0.998 | −0.02 | −1.11 to 1.07 | 0.514 |
| | 0-4w | −2.04 | −2.72 to −1.37 | 1 | −0.33 | −1.3 to 0.64 | 0.750 |
| | 0-12w | −1.58 | −2.42 to −0.74 | 0.999 | 0.01 | −0.86 to 0.88 | 0.509 |
| NPRS 24 h | | | | | | | |
| | 0-2w | −0.65 | −1.39 to 0.08 | 0.949 | −0.06 | −1.3 to 1.17 | 0.542 |
| | 0-4w | −1.91 | −2.66 to −1.16 | 1 | −0.19 | −1.17 to 0.78 | 0.654 |
| | 0-12w | −1.53 | −2.33 to −0.74 | 0.999 | 0.33 | −0.53 to 1.19 | 0.772 |
| Painful Mov | | | | | | | |
| | 0-2w | −1.5 | −1.99 to −1.01 | 1 | −0.48 | −1.59 to 0.63 | 0.805 |
| | 0-4w | −2.29 | −2.95 to −1.63 | 1 | 0.24 | −0.74 to 1.22 | 0.683 |
| ROM Flex | | | | | | | |
| | 0-2w | 2.17 | −1.35 to 5.69 | 0.888 | −4.78 | −11.52 to 1.96 | 0.919 |
| | 0-4w | 2.64 | −0.55 to 5.83 | 0.948 | −3.63 | −24.49 to 17.25 | 0.634 |
| ROM Ext | | | | | | | |
| | 0-2w | 0.68 | −2.14 to 3.49 | 0.683 | 0.87 | −4.21 to 5.96 | 0.633 |
| | 0-4w | 0 | −3.25 to 3.24 | 0.501 | −1.75 | −23.12 to 19.64 | 0.564 |
| ROM SFR | | | | | | | |
| | 0-2w | 4.56 | 2.51 to 6.61 | 0.999 | −0.87 | −4.05 to 2.3 | 0.708 |
| | 0-4w | 3.17 | 1.06 to 5.27 | 0.998 | −0.07 | −3.88 to 3.74 | 0.515 |
| ROM SFL | | | | | | | |
| | 0-2w | 4.33 | 2.22 to 6.44 | 0.999 | −0.74 | −4.36 to 2.88 | 0.659 |
| | 0-4w | 3.7 | 1.37 to 6.03 | 0.998 | 0.6 | −2.94 to 4.14 | 0.630 |
| ROM RotR | | | | | | | |
| | 0-2w | 3.29 | 0.15 to 6.44 | 0.979 | −4.52 | −10.26 to 1.21 | 0.940 |
| | 0-4w | 5.8 | 2.89 to 8.7 | 0.999 | −1.52 | −24.77 to 21.74 | 0.552 |
| ROM RotL | | | | | | | |
| | 0-2w | 3.69 | 1.08 to 6.31 | 0.996 | −3.24 | −8.25 to 1.77 | 0.899 |
| | 0-4w | 4.49 | 1.38 to 7.6 | 0.997 | −0.88 | −24.17 to 22.41 | 0.530 |
| EQ (5D) | | | | | | | |
| | 0-2w | 0.33 | −0.08 to 0.74 | 0.944 | −0.54 | −1.19 to 0.12 | 0.947 |
| | 0-4w | 0.85 | 0.43 to 1.28 | 0.999 | 0.02 | −0.6 to 0.64 | 0.524 |
| PCS | | | | | | | |
| | 0-2w | −2.94 | −4.67 to −1.22 | 0.999 | 0.8 | −2.25 to 3.85 | 0.699 |
| | 0-4w | −4.56 | −6.63 to −2.5 | 0.999 | −1.35 | −5.22 to 2.52 | 0.755 |
| TSK | | | | | | | |
| | 0-2w | −0.4 | −1.96 to 1.16 | 0.696 | −1.92 | −5.29 to 1.45 | 0.871 |
| | 0-4w | −1.84 | −3.11 to 0.57 | 0.997 | −0.09 | −9.96 to 9.77 | 0.508 |
| SF-36 P | | | | | | | |
| | 0-2w | 4.55 | 2.15 to 6.95 | 0.999 | −1.76 | −6.44 to 2.92 | 0.773 |
| | 0-4w | 7.77 | 5.32 to 10.22 | 0.999 | −0.91 | −28.87 to 27.05 | 0.526 |
| SF-36 M | | | | | | | |
| | 0-2w | 6.48 | 4.16 to 8.8 | 0.999 | −1.65 | −6.39 to 3.1 | 0.755 |
| | 0-4w | 7.76 | 4.84 to 10.69 | 0.999 | −1.14 | −28.96 to 26.69 | 0.532 |

[a] Coefficient is absolute change in outcome from baseline.
[b] Coefficient is difference between groups in absolute change in outcome from baseline.
[c] Adjusted for the effect of age, sex, body mass index, and baseline value of outcome. Coefficient indicates difference with respect to reference intervention, exercise.
CCFT: craniocervical flexion test; EQ (5D): EuroQuol 5D visual analogue scale; Ext: extension; Flex: flexion; NDI: Neck Disability Index; NPRS 1w: Numeric pain rating scale last week; NPRS 24 h: Numeric pain rating scale last 24 h; Painful Mov: Pain intensity in most painful movement; PCS: Pain Catastrophizing Scale; ROM: range of movement; RotR: right Rotation: RotL: left Rotation; SF-36 M: SF-36, mental domain; SF-36 P: SF-36, physical domain; SFL: left Side Flexion; SFR: right side flexion; TSK: Tampa Scale for Kinesiophobia.

were less likely to show a positive craniocervical test when compared to those that received manual therapy (adjusted odds ratio: 0.36; 95 % CI: 0.14–0.92; P = 0.983).

### 3.3. Baseline to 12 weeks after treatment completion

Patients demonstrated significant (Prob >0.95) reductions of maximum neck pain intensity during the last week and last 24 h, and disability. Thirty-six percent of patients reported feeling between *quite a bit better* and *a very great deal better* on the GROC scale; 39 % reported feeling between *a tiny bit better* and *moderately better*, 24 % reported feeling about the same, and 2 % reported feeling *a little bit worse*. Twenty-three patients (39 %) were classified as *responders* and 36 (61 %) as *non-responders*.

After adjusting for the effect of age, gender, disability, pain intensity, baseline value of the outcome of interest and outcome at treatment completion, there were no differences between groups in all outcome measures but one; patients receiving manual therapy were more likely to be classified as *responders* than those receiving exercise (adjusted odds ratio: 0.19; 95 % CI: 0.05–0.65; P = 0.995). However, when the analysis was repeated, including only participants whose exercise adherence was ≥95 %, no significant differences between interventions were found.

**Table 3**
Between group differences when exercise adherence is ≥ 95 %.

| Outcome | | Difference between groups [d] | | |
|---|---|---|---|---|
| | | Coefficient | 95 % Credibility Interval | P |
| NDI | | | | |
| | 0-2w | 0.12 [b] | −3.93 to 4.16 | 0.522 |
| | 0-4w | −0.22 [b] | −10.9 to 10.45 | 0.517 |
| | 0-12w | −0.88 [b] | −9.03 to 7.28 | 0.585 |
| NPRS 1w | | | | |
| | 0-2w | 0.16 [b] | −0.95 to 1.27 | 0.613 |
| | 0-4w | 0.16 [b] | −0.83 to 1.15 | 0.628 |
| | 0-12w | 0.26 [b] | −0.62 to 1.15 | 0.721 |
| NPRS 24 h | | | | |
| | 0-2w | −0.38 [b] | −1.66 to 0.91 | 0.722 |
| | 0-4w | −0.03 [b] | −1.06 to 0.99 | 0.526 |
| | 0-12w | 0.17 [b] | −0.73 to 1.08 | 0.646 |
| Painful Mov | | | | |
| | 0-2w | −0.61 [b] | −1.7 to 0.49 | 0.864 |
| | 0-4w | 0.27 [b] | −0.7 to 1.24 | 0.706 |
| ROM Flex | | | | |
| | 0-2w | −0.29 [b] | −7.38 to 6.8 | 0.533 |
| | 0-4w | −1.45 [b] | −22.92 to 20.03 | 0.554 |
| ROM Ext | | | | |
| | 0-2w | 3.56 [b] | −1.62 to 8.75 | 0.913 |
| | 0-4w | 0.4 [b] | −21.66 to 22.46 | 0.513 |
| ROM SFR | | | | |
| | 0-2w | 0.61 [b] | −2.78 to 4.01 | 0.64 |
| | 0-4w | 1.55 [b] | −12.49 to 15.59 | 0.586 |
| ROM SFL | | | | |
| | 0-2w | −0.74 [b] | −4.49 to 3.02 | 0.653 |
| | 0-4w | 0.9 [b] | −2.79 to 4.58 | 0.685 |
| ROM RotR | | | | |
| | 0-2w | −3.64 [b] | −9.62 to 2.35 | 0.886 |
| | 0-4w | −1.92 [b] | −25.85 to 22.03 | 0.564 |
| ROM RotL | | | | |
| | 0-2w | −1.06 [b] | −6.41 to 4.3 | 0.654 |
| | 0-4w | 0.05 [b] | −24.44 to 24.53 | 0.501 |
| EQ (5D) | | | | |
| | 0-2w | −0.24 [b] | −0.9 to 0.42 | 0.764 |
| | 0-4w | −0.13 [b] | −0.74 to 0.49 | 0.66 |
| PCS | | | | |
| | 0-2w | 0.88 [b] | −2.32 to 4.08 | 0.707 |
| | 0-4w | −0.51 [b] | −4.54 to 3.51 | 0.6 |
| TSK | | | | |
| | 0-2w | −0.21 [b] | −3.74 to 3.31 | 0.549 |
| | 0-4w | −0.08 [b] | −3.29 to 3.13 | 0.52 |
| SF-36 P | | | | |
| | 0-2w | −0.86 [b] | −5.69 to 3.98 | 0.639 |
| | 0-4w | −2.04 [b] | −30.61 to 26.54 | 0.557 |
| SF-36 M | | | | |
| | 0-2w | −1.64 [b] | −6.64 to 3.36 | 0.744 |
| | 0-4w | −1.81 [b] | −30.85 to 27.24 | 0.55 |

c Coefficient is difference between groups expressed as an odds ratio.
b Coefficient is difference between groups in absolute change in outcome from baseline.
d Adjusted for the effect of age, sex, body mass index, and baseline value of outcome. Coefficient indicates difference with respect to reference intervention, exercise. CCFT: craniocervical flexion test; EQ (5D): EuroQuol 5D visual analogue scale; Ext: extension; Flex: flexion; NDI: Neck Disability Index; NPRS 1w: Numeric pain rating scale last week; NPRS 24 h: Numeric pain rating scale last 24 h; Painful Mov: Pain intensity in most painful movement; PCS: Pain Catastrophizing Scale; ROM: range of movement; RotR: right Rotation: RotL: left Rotation; SF-36 M: SF-36, mental domain; SF-36 P: SF-36, physical domain; SFL: left Side Flexion; SFR: right side flexion; TSK: Tampa Scale for Kinesiophobia.

### *3.4. Association between exercise adherence and treatment outcome in the exercise group*

Mean (SD) adherence to the protocol in the exercise group was 95 % (8.2). Eighteen patients (62 %) reported an adherence of 100 %, 8 (28 %) between 80 % and 93 %, and two (7 %) between 72 % and 79 %. One patient failed to report exercise adherence. Greater exercise adherence was associated with higher reduction in disability (coefficient: −0.09; 95 % CI: −0.17 – 0.0006; P = 0.974) and maximum 24-h neck pain intensity (coefficient: 0.03; 95 % CI: −0.07 – - 0.0007; P = 0.973) at 2 weeks. Furthermore, greater adherence also increased the likelihood that the patient would be classified as *responder* at two weeks (adjusted odds ratio: 1.20; 95 % CI: 1.00–1.48; P = 0.958), 4 weeks (adjusted odds ratio: 1.14; 95 % CI: 1.02–1.27; P = 0.988) and 12 weeks (adjusted odds ratio: 1.13; 95 % CI: 1.03–1.24; P = 0.996).

## 4. Discussion

Four weeks of either manual therapy or neck specific exercise were effective at reducing disability, pain intensity, catastrophization and kinesiophobia, and increasing quality of life in patients NSNP. Changes were observed at all measured time points. Improvements were above the minimum clinical important difference for pain intensity, quality of life and were below the minimum clinical important difference for disability (albeit by a very small margin at 12 weeks), catastrophization and kinesiophobia. Pre-treatment values were mild to moderate (according to previously reported cut-offs (MacDermid et al., 2009)) for disability, which may explain the absence of larger improvements in this outcome. Changes in cervical range of movement were small, and were lower than the reported measurement error of the device (Stenneberg et al., 2018). The minimal improvements observed in range of movement may be caused by the fact that patients demonstrated no considerable pre-treatment restriction, i.e. pre-treatment values were close to those previously reported for asymptomatic participants (Lascurain-Aguirrebeña et al., 2018a,b). It is of note that patients included in this study were recruited at a secondary care spinal unit and had received an average of 10 sessions of general non-specific physiotherapy over the last 12 months prior to recruitment and had reported no benefit. In contrast, a small number of specific physiotherapy sessions undertaken in the current study provided meaningful clinical changes for a considerable number of patients. Changes observed in the short term were also maintained in the medium term.

When comparing the relative effectiveness of manual therapy and neck specific exercise, we found no differences between groups in individual outcomes related to pain intensity, disability, range of movement, catastrophization, kinesiophobia, quality of life and patient perceived overall improvement. However, differences between groups in favour of manual therapy were noted at all measured time points when using a composite outcome measure that classified patients into either *responders* or *non-responders*.

Adherence to the exercise programme was, on average, very good. This may have been facilitated by the fact that face to face treatment sessions in the exercise group were dedicated to instructing participants in the exercise programme, and patients received video recordings of the prescribed exercises in a readily available format (Himler et al., 2023; Woodhouse and Vasseljen, 2008). However, despite such efforts, a considerable number of patients failed to reach a target of 95 % adherence. Importantly, we found that greater exercise adherence increased the likelihood of the patient being classified as a *responder* at all measured time points in the exercise group. In our secondary analysis, when patients in the manual therapy group were compared to those in the exercise group whose adherence was 95 % or greater, differences in effectiveness noted in the primary analysis (*responders* vs *non-responders*) were no longer significant. Although a type two error is possible because of a reduced sample size (Noordzij et al., 2010), considering the association noted between exercise adherence and treatment outcome in the exercise group, the superior effectiveness of manual therapy observed in the whole sample, may, in fact, be dependent upon exercise adherence.

Although evidence suggests a significant role of muscle dysfunction for the development and maintenance of NSNP (Grip et al., 2008; Page et al., 2023; Sjölander et al., 2008; Woodhouse and Vasseljen, 2008), no study has assessed the medium term relative effectiveness of manual therapy and neck specific exercise on neck muscle function. Given the findings of previous studies (Ghaderi et al., 2017; Javanshir et al., 2015;

Suvarnnato et al., 2019) regarding the effectiveness of neck specific exercise to restore adequate neck muscle function, we expected patients receiving neck specific exercise to show greater improvements on the craniocervical flexion test than those receiving manual therapy. Our primary analysis revealed no differences between interventions, suggesting no superior effectiveness. However, in the secondary analysis which included only patients in the exercise group whose adherence was equal or greater than 95 %, we found that exercise was more effective at improving control of the deep neck flexor muscles than manual therapy at all measured time points. Our findings suggest that specific exercise is more effective than manual therapy to improve muscle function, provided exercise adherence is high. It is of note that, albeit to a lesser extent, patients that received manual therapy also demonstrated an improvement on the CCFT. This may be explained by improvements in cervical mobility following treatment, which could have resulted in better performance on the CCFT.

Although we expected that exercise, a movement-based intervention, may be more effective at reducing kinesiophobia, we found no differences between interventions. The fact that patients had low (when compared to normative data (Chimenti et al., 2021)) levels of baseline kinesiophobia may explain the absence of significant differences between interventions. There were no differences either between interventions in the reduction of catastrophization, despite patients demonstrating moderate levels of catastrophization at baseline according to previously reported thresholds (Licciardone et al., 2024). In fact, no meaningful reductions in either kinesiophobia or catastrophization were observed, which suggests that specific interventions targeting these features may be required in conjunction with manual therapy or exercise.

### 4.1. Study limitations

The present study used treatment interventions of only four weeks; considering the fact that clinical improvement has been demonstrated to gradually continue within the first 15 weeks of treatment (Zebis et al., 2014), the findings of our study may have underestimated the effectiveness of manual therapy and/or exercise. This may be particularly the case for the exercise programme with previous studies implementing the same exercise programme over 8–14 weeks (Falla et al., 2013; Halvorsen et al., 2016; Ludvigsson et al., 2016).

We opted not to use a pressure biofeedback unit for cranio-cervical flexion exercise. Using a pressure biofeedback unit would have added complexity (patients would need to learn to use it correctly, requiring additional instruction and practice), which may have affected adherence, and an economic cost for the patient, acting as a further barrier to participation. While it is possible that the use a pressure biofeedback unit might have resulted in greater improvement, we opted for an exercise programme that was easily generalizable to any clinical setting.

In a society where lower treatment costs and higher efficiency is demanded, the current study provides evidence of the clinical effectiveness of each intervention with relatively low cost.

Additionally, the fact that our patients had received previous treatments may have further underestimated the effectiveness of manual therapy and exercise, as prior interventions could have already provided some benefit and reduced room for improvement.

Assessment included short term effects and a medium term follow up, however the long-term effects are unknown. Although a longer term follow up of up to a year may be useful, we consider 12 weeks post-treatment to be an adequate follow up period, in that it provides information regarding the longer lasting effects beyond those in the short term, and minimizes the risk of patients (especially those whose clinical outcome has not been favourable) engaging in alternative treatments that would confound the results of the study.

## 5. Conclusion

Our data suggests that manual therapy and specific exercise are equally effective at decreasing pain and improving function in patients with NSNP, although manual therapy may be slightly superior if a composite outcome measure is used to assess the clinical outcome. However, where high exercise adherence can be ensured, manual therapy and specific exercise are likely to be equally effective. Face to face practice sessions and exercise video recordings in easy to use formats likely help with exercise adherence. In patients with high adherence, specific exercise may offer the additional advantage of facilitating improved cervical muscle function.

## CRediT authorship contribution statement

**Iker Villanueva-Ruiz:** Writing – review & editing, Writing – original draft, Validation, Resources, Methodology, Investigation, Data curation, Conceptualization. **Deborah Falla:** Writing – review & editing, Validation, Methodology. **Marc Saez:** Writing – review & editing, Software, Formal analysis. **Maialen Araolaza-Arrieta:** Writing – review & editing, Investigation. **Jon Jatsu Azkue:** Writing – review & editing. **Ane Arbillaga-Etxarri:** Writing – review & editing. **Ana Lersundi:** Writing – review & editing, Resources. **Ion Lascurain-Aguirrebeña:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Conceptualization.

## Ethical approval

The CEISH/113/2019 Ethics Committee approved this study. All participants gave written informed consent before data collection began.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.msksp.2025.103319.

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