ORIGINAL REPORT

RESISTANCE TRAINING VS GENERAL PHYSICAL EXERCISE IN MULTIDISCIPLINARY REHABILITATION OF CHRONIC NECK PAIN: A RANDOMIZED CONTROLLED TRIAL

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Objective: To investigate whether progressive resistance training using elastic resistance bands improves neck-related disability more than general physical exercise in multidisciplinary rehabilitation of chronic neck pain.

Design: Researcher-blinded, randomized controlled trial.

Methods: A total of 59 patients with non-specific, chronic neck pain (mean age 46 years, disability (Neck Disability Index 0–100): 35.4, worst neck pain last 2 weeks (numerical pain rating scale 0–10): 6.3) were randomized to 3-week multidisciplinary rehabilitation including either general physical exercise or progressive resistance training with elastic bands. Participants were instructed to continue their respective home-based training programmes for 9 additional weeks. Outcomes were assessed at baseline, after 3 weeks and after 12 weeks. Primary outcome was the between-group difference in change in the Neck Disability Index from baseline to 12 weeks.

Results: Thirty-four and 31 participants were followed up at 3 and 12 weeks, respectively. No between-group differences were observed, apart from a greater increase in shoulder abduction strength for the progressive resistance-training group at 12 weeks.

Conclusion: This study provides no evidence in favour of replacing general physical exercise with progressive resistance training using elastic resistance bands in multidisciplinary rehabilitation of chronic neck pain. We recommend clinicians to advise either of these exercise-types, based on the patient's interests and motivation.

Key words: musculoskeletal disorders; disability evaluation; chronic pain; function; muscle strength.

LAY ABSTRACT

Here, we investigated if progressive resistance training improved neck-related disability more than general physical exercise in multidisciplinary rehabilitation. To this end, patients with non-specific chronic neck pain referred to a three-week multidisciplinary rehabilitation programme, were randomly allocated to either general physical exercise or progressive resistance training using elastic bands. Afterwards, they were asked to continue with their respective exercise-program for 9 more weeks. Of the 59 who took part in the study, 31 were followed up at 12 weeks. Our main finding was that the improvement in neck-related disability were quite similar for the two groups. We therefore recommend clinicians to prescribe either of these exercise-types based on the patient`s interests and motivation.

Chronic neck pain is a main contributor to disability worldwide, and more research is needed to identify better ways of managing the condition (1). Some studies suggest that progressive resistance training (PRT) of the neck and shoulder muscles is beneficial for chronic neck and shoulder pain (2–6). Nevertheless, a recent Cochrane Review stated that, although PRT appears to be beneficial in the treatment of chronic neck pain, there is insufficient evidence to make clear recommendations (7). Similarly, current guidelines for managing chronic neck pain provide vague recommendations regarding the type of exercise that should be preferred (8).

For low back pain it has been suggested that PRT, targeting whole-body muscle strength, could be more beneficial than specific back exercises, possibly due to overall improved physical functioning (9, 10). This could also be the case for persons with chronic neck pain, as this condition frequently coexists with pain in other body regions (11), and patients with chronic pain are often deconditioned (12).

Multidisciplinary rehabilitation (MDR) is often recommended for patients with chronic and disabling neck pain to address both physical and psychosocial aspects of the condition (13–15). MDR usually includes general physical exercise (GPE), patient education, group discussions and individual meetings with therapists (14, 16–18). In Norway, the exercise-part of MDR typically entails an introduction to activities and exercises that fit with the patients' interests. However, high-intensity strength training, such as PRT, is not usually included. Considering the promising results of high-intensity strength training (2–5), it is possible that the effects of MDR could be improved by replacing GPE with PRT.

While conventional resistance-training equipment is relatively spacious and expensive, elastic resistance bands can be used as a viable alternative when performing PRT in small clinics or at home (19, 20). This study investigated the effects of replacing GPE with PRT in a 3-week MDR-programme for patients with chronic neck pain, followed by 9 weeks' home-based training (GPE or PRT). All PRT sessions were performed with elastic resistance bands. It was hypothesized that greater improvement would be achieved with PRT than with GPE in neck pain-related disability, and other health-related outcomes.

METHODS

Study design, setting and participants

This was a single-blinded (test leaders and researchers) randomized controlled trial (RCT). The trial was approved by the Regional Committee for Medical and Health Research Ethics in Central Norway and is registered in ClinicalTrials.gov (NCT02420197). The results are reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) Statement (21).

The RCT was carried out at an outpatient hospital back- and neck-pain clinic (hereafter termed "the clinic") at the Department of Physical Medicine and Rehabilitation, St Olavs Hospital, Trondheim, Norway. This trial has a similar design and recruitment procedure as a previous RCT in patients with low back pain, and the methods are partly overlapping (22, 23). Patient characteristics were registered at baseline, while primary and secondary effect measures were obtained at baseline, week 3 and week 12.

A physician at the clinic screened patients for eligibility to the MDR programme and to the RCT. Inclusion criteria were: (*i*) chronic (≥3 months) or recurrent (≥2 episodes with duration ≥4 weeks the past year) non-specific neck pain, (*ii*) worst neck pain during the last 2 weeks ≥4 on numerical rating scale (NRS 0–10), and (*iii*) 16–70 years of age. Exclusion criteria were: (*i*) awaiting neck surgery, (*ii*) a severe somatic condition (e.g. cancer, inflammatory rheumatic disease, severe osteoporosis), (*iii*) insufficient comprehension of Norwegian language to participate in group sessions and complete questionnaires, (*iv*) psychiatric condition expected to severely impair group functioning, (*v*) alcohol or drug abuse, (*vi*) ongoing compensation claim or applying for disability pension due to neck pain, (*vii*) engaged in high-intensity strength training on a regular basis for the last 6 months, and (*viii*) contra-indications for high-intensity strength training (e.g. shoulder complications severely limiting the ability to conduct the training programme). In addition, as usual at the clinic, patients were only enrolled to MDR if the physician considered it beneficial for the patients, based on their clinical history, whether sufficient treatment had been attempted in primary care, and whether patients were motivated to participate in the programme.

Eligible patients were informed (in writing and orally) about the study. Those who were willing to participate signed a written consent form before baseline testing. Patients were consecutively randomized to either the PRT group (intervention) or the GPE group (comparison). Randomization (1:1) was performed with blocks of unknown sizes varying from 10 to 20, using a web-based program provided by the Unit for Applied Clinical Research, Norwegian University of Science and Technology.

Patients who were enrolled in the MDR programme, but were excluded from the RCT or declined participation, were asked to participate in a reference group to assess the generalizability of the results. Those who accepted to participate in this group signed a consent form and completed the baseline questionnaire.

Intervention and comparison programme

All participants received a 3-week MDR programme for chronic neck pain at the clinic. The MDR was managed by professionals working at the clinic (physiotherapists, physicians, social workers, and psychologists) and consisted of individual consultations, exercise, group discussions, and patient education targeting stress management, goal-setting, physical activity, work participation and enhanced understanding of neck symptoms and neck anatomy. The only difference between the groups was the exercise component, which consisted of PRT in the intervention group and GPE (i.e. usual practice) in the comparison group. Participants in both groups were instructed to continue with their respective exercise programmes for the 9 weeks following completion of the MDR, i.e. 12 weeks of PRT or GPE in total. Participants in both groups were offered 3 group-based booster sessions in weeks 5, 7 and 9. The booster sessions were administered by physiotherapists from the clinic, and were used to assist participants with motivation, technique and progression related to their respective programmes.

Participants in the intervention group performed PRT with Theraband® Elastic bands (colours: yellow-gold) 3 times per week (supervised during weeks 1 and 3). They were also given door anchors and handles to use with the elastic bands, and were instructed to record all training sessions in a diary (Fig. 1). The PRT programme consisted of the exercises stiff-legged deadlifts, flies, unilateral rows, reversed flies, lateral pulldown, unilateral shoulder abduction (22), and specific neck flexion and extension (Fig. 2). Each exercise was be performed until muscular failure, i.e. unable to complete 1 more repetition with good form, for 2 sets of 15–20 repetitions in weeks 1–2, 2 sets

Week 9 – 8-10 reps

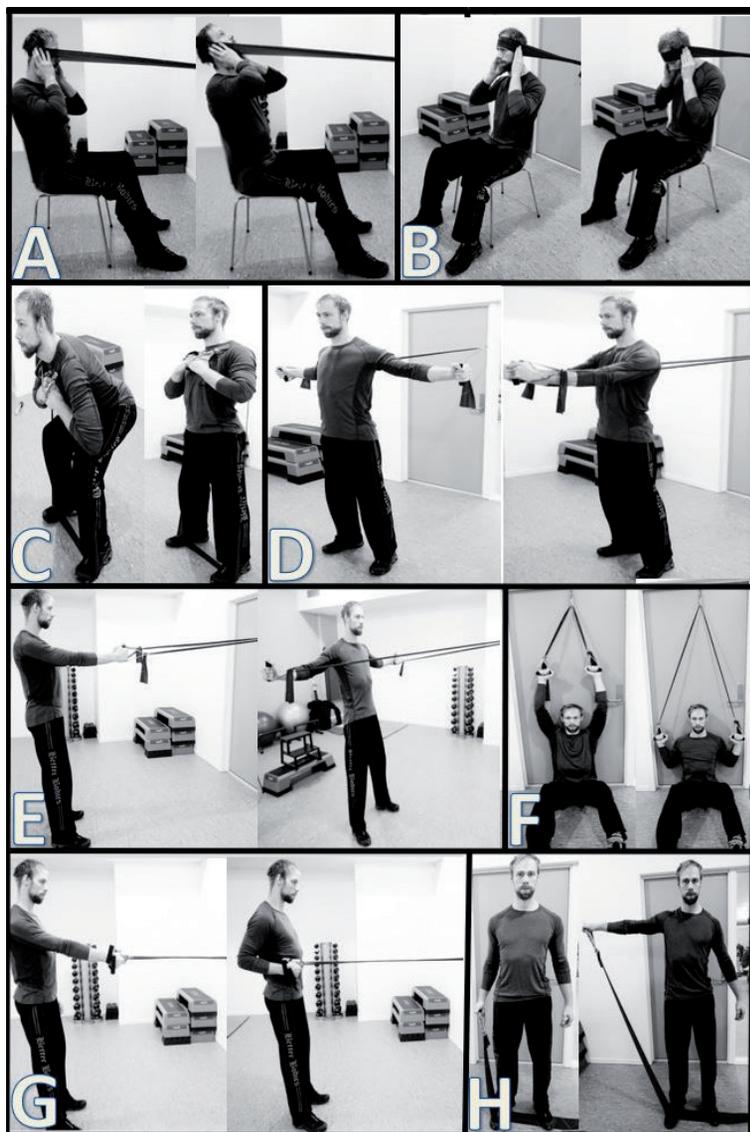| Exercise:	Day 1	Date:					Borg
	Set 1		Set 2		Set 3		
	Repetitions	Band(s) colour	Repetitions	Band(s) colour	Repetitions	Band(s) colour	CR10
Stiff-legged deadlifts							
Flies							
Unilateral rows							
Reversed flies							
Lateral pulldown							
Shoulder abduction							
Neck flexion							
Neck extension							
Comments							

Fig. 1. Training diary.

Fig. 2. Elastic resistance band exercises: (A) neck extension, (B) neck flexion, (C) squats, (D) flies, (E) reversed flies, (F) lateral pulldown, (G) unilateral row, and (H) shoulder abduction.

programme could be to walk to work every day instead of driving, do some housework every day, and participate in a spinning class once a week.

Questionnaires

The primary outcome was the between-group difference in neck pain-related disability from baseline to 12 weeks, assessed by the Neck Disability Index (NDI 0–100). The NDI is a questionnaire with 10 items covering pain, personal care, lifting, reading, headaches, concentration, work, driving, sleeping and recreation (25).

Secondary outcomes included the between-group difference in NDI from baseline to 3 weeks, and the between-group changes from baseline to 3 and 12 weeks for: (*i*) current neck pain and worst neck pain in the last 2 and 4 weeks, as assessed by the Numerical Pain Rating Scale (NPRS 0–10), higher score indicates more pain (25), (*ii*) number of additional pain sites indicated on a pain drawing (0–11) (26), (*iii*) anxiety and depressive symptoms assessed by Hopkins Symptom Checklist (1–4), higher score indicates stronger symptoms (27), (*iv*) health-related quality of life assessed by EQ-5D-5L (<0–1), higher score indicates better health (28), (*v*) limitation in function assessed by the patient specific functional scale (0–10), higher score indicates more limitation (29), (*vi*) fear-avoidance beliefs regarding physical activity (0–24) and work-related activities (0–42) assessed by the Fear-avoidance beliefs questionnaire, higher score indicates higher fear avoidance (30), (*vii*) workability assessed by a single item from the Workability Index "current workability compared with lifetime best" (0–10), higher score indicates better workability (31).

Physical measurements

Secondary outcomes also included between-group changes in maximum voluntary isometric contraction (MVC) in shoulder abduction, neck flexion and neck extension (performed as described in Vannebo et al. (32)), and pressure pain threshold.

During shoulder abductor MVC (Fig. S1[1]) participants sat on a stool with their back against a wall, arms held straight out from the side of the body just below shoulder height, and elbows held in approximately 90° angle in the transverse plane with the palm facing downwards. The elbow to floor distance was registered, to ensure reliable testing conditions from time to time. Force was recorded only for the dominant arm, where a strap attached around the elbow joint formed a straight line down to the force transducer, bolted to a platform. For balance, the setup was identical for the non-dominant arm, but without the force transducer. Participants then performed 3 shoulder abductor MVCs with 1 min rest between attempts. Force (newton) was recorded and analysed using MuscleLab software (version 10.3.26.0, Ergotest Technology AS, Langesund, Norway). The highest value was used in the analysis.

of 12–15 repetitions in weeks 3–5, 3 sets of 10–12 repetitions in weeks 6–8, and 3 sets of 8–10 repetitions in weeks 9–12. Participants` should progress to heavier resistance bands when they performed more repetitions than prescribed, or if they rated a set lighter than 7 on the Borg CR10 scale (24).

The GPE programme was provided as usual at the clinic: 4 sessions in week 1, and 3 sessions in week 3. To reduce attention bias, the intervention group also had 1 session of GPE in week 1 to match the number of supervised sessions. During the GPE sessions, participants were introduced to various group-based and individual activities, including circle-training, low-intensity resistance exercises, endurance training, ball games, body awareness, stretching, and relaxation techniques. Participants were provided a home-based activity programme upon completion of the rehabilitation at the clinic, reflecting their interests and the physiotherapists` recommendations. The content of the programme varied considerably, but was focused largely on normalizing activities of daily living. An example of a home-based

Pressure pain threshold (Fig. S2[1]) was assessed by an algometer (Type II Somedic Production, Sweden), using a contact area of 10 mm. The algometer was applied at a speed of pressure equal to 40 kPa/s, and held in a perpendicular angle to the pressure point during testing. Pressure pain threshold for musculus tibialis anterior was measured midway between the lateral condyle of the tibia and the lateral malleolus of the fibula. The test was performed 3 times, with 1-min rest between tests. The mean value was used in the analysis. A similar method has been used to assess pain sensitivity in non-painful regions of the body for neck patients in a previous study (33).

Statistical analysis

From pilot data of the present population, sample size was calculated for the mixed linear model analysis of the primary outcome, NDI. The minimal detectable change for NDI has been proposed to be 3.5 on a 0–50 scale (corresponding to 7 on a 0–100 scale) (25). However, a decrease in NDI was expected for both groups, as they participated in MDR in the specialist care. Hence, the sample size was calculated to detect an additional difference of 5 points between groups (0–100 scale). With 80% power for a delta of 5 points and assuming a standard deviation of 9 (based on pilot data), and a 0.5 within-participant correlation between baseline and 12 weeks, an estimated 40 participants in each arm (80 in total) was necessary to detect a difference between groups ($p < 0.05$). To take dropouts into account (34), we aimed to include 50 participants in each group (100 in total).

Effect-differences between groups for each of the primary and secondary outcomes were assessed separately using mixed linear analysis with multilevel modelling. This model of analysis does not require imputation of missing data (35). The group means at baseline were combined to optimize statistical power (35). The following levels were used in the analysis: baseline, GPE after 3 weeks, PRT after 3 weeks, GPE after 12 weeks, and PRT after 12 weeks. The outcome variable was included as the dependent variable, group × time interaction effects were included as the fixed effect, and participant ID was included as random effect (to allow for different levels for participants in the analysis). The EQ-5D index was calculated using a crosswalk index calculator based on the Danish tariff (36). Cohens d effect sizes were calculated for all changes from baseline to 12 weeks, with effect sizes of 0.2, 0.5 and 0.8 representing small, medium and large effects, respectively.

The results are presented as means with 95% confidence intervals (CI). A *p*-value <0.05 was considered to indicate statistical significance. All statistical analysis was performed with STATA 14 for Windows (StataCorp LP, USA).

RESULTS

Recruitment started on 4 December 2014 and continued until 2 November 2016. Inclusion was stopped without reaching the desired number of participants, due to slow recruitment rate and upcoming changes at the clinic. In total, 74 patients consented to participate, but 15 of these dropped out prior to baseline testing (i.e. no data acquired). Thus, baseline data was obtained from 30 and 29 participants in the PRT and GPE groups, respectively, and these were included in the main analysis. In total, 34 participants participated at the 3-week follow-up, while 31 participants participated at the 12-week follow-up (see Fig. 3 for flow-chart).

Participants` characteristics

Baseline characteristics for the GPE and PRT group were similar at baseline (Table I). Participants mean age was 46 (SD 10) years, 68% were women and 78% were employed. A leisure-time exercise index score of 2 (range 0.78–3) indicated that participants were moderately active at baseline (37). In addition, participants generally reported moderate disability (NDI 35.4, SD 10.3) and moderate to strong pain in the last 2 weeks (NRS 6.3, SD 2.1). Finally, no significant differences were observed in the baseline characteristics between
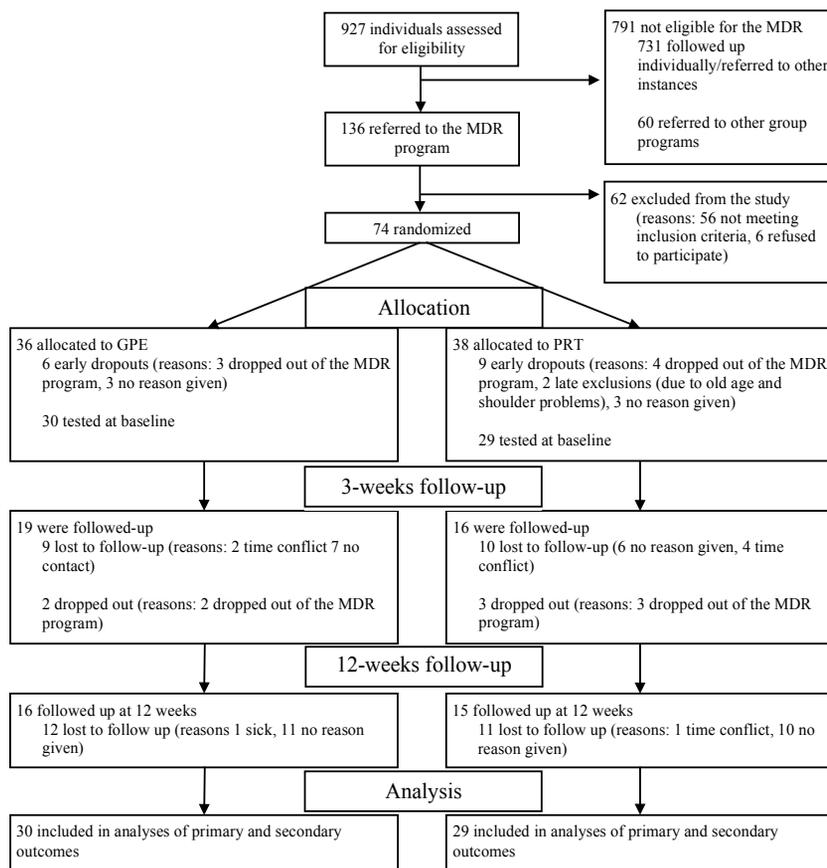

Fig. 3. Participant flow. MDR: multidisciplinary rehabilitation; GPE: general physical exercise; PRT: progressive resistance training.

Table I. Baseline characteristics

Characteristics at baseline	General physical exercise (n = 30)	Progressive resistance training (n = 29)	Reference group (n = 39)
Age, years, mean (SD)	48.2 (10.6)	44.6 (8.1)	49 (12)
Women, %	63	72	58
BMI, kg/m^2, mean (SD)	27 (5)	25 (4)	N/A
Married or live-in partner, %	67	79	67
Higher education (high school), %	30	41	37
Employed (full-time or part time), %	73	83	76
Sick listed (fully/partially), %	33	48	62
Work assessment allowance[a] or disability pension, %	33	32	15
Work description/Physical work demands			
Much sitting, %	57	59	42
Much walking, %	21	18	26
Much lifting and walking/heavy physical labour, %	22	23	32
Self-reported health right now			
Poor/Not so good, %	67	72	75
Good/Very good, %	33	28	25
Leisure-time exercise index (1.18–3.00), mean (SD)	1.98 (0.61)	2.01 (0.48)	2.01 (0.66)
Have used analgesics for neck pain the last week, %	60	55	57
≥1 year duration of current neck pain, %	87	80	82
Neck Disability Index (0–100), mean (SD)	35.4 (9.8)	35.3 (10.8)	35.9 (2.3)
Current neck pain (0–10), mean (SD)	4.4 (1.9)	4.2 (2.1)	4.8 (2.0)
Worst neck pain last 2 weeks (0–10), mean (SD)	5.9 (1.9)	6.7 (2.2)	6.1 (1.9)
Worst neck pain last 4 weeks (0–10), mean (SD)	6.8 (2.1)	7.4 (1.7)	7.0 (2.0)
Additional pain sites (0–10), mean (SD)	3.5 (3.0)	3.4 (3.0)	2.9 (2.4)
EQ-5D (<0–1), mean (SD)	0.656 (0.130)	0.702 (0.088)	0.680 (0.11)
Work Ability Index (0–10), mean (SD)	4.7 (2.2)	4.4 (2.8)	3.7 (2.5)
FABQ – Physical activity (0–24), mean (SD)	6.4 (5.5)	5.9 (3.9)	7.4 (5.0)
FABQ – Work (0–42), mean (SD)	17.2 (9.1)	17.9 (7.7)	18.8 (10.5)
Patient Specific Functional Scale (0–10), mean (SD)	6.7 (2.3)	7.3 (2.0)	N/A
Hopkins Symptoms Checklist 25 (1–4), mean (SD)	1.9 (0.5)	1.7 (0.5)	1.8 (0.4)
Shoulder abductor MVC strength (N), mean (SD)	180 (80)	175 (76)	N/A
Neck extensor MVC strength (N), mean (SD)	163 (71)	133 (53)	N/A
Neck flexor MVC strength (N), mean (SD)	119 (52)	109 (52)	N/A
Pressure pain threshold (N), mean (SD)	654 (336)	621 (287)	N/A

[a]Work assessment allowance can be applied for in Norway after being on sick leave for 1 year.
SD: standard deviation; FABQ: Fear Avoidance Belief Questionnaire, MVC: maximal voluntary isometric contraction.

participants in the RCT and the reference group (*n*=39, data not shown).

Outcomes

No statistically significant differences were found between groups on the primary outcome, between-group change in NDI from baseline to 12-week follow-up (Table II). At 12 weeks, the PRT group had increased their shoulder abductor MVC strength more than the GPE group (mean difference 17, 95% CI 2, 31). The GPE group displayed a greater improvement in fear-avoidance beliefs regarding physical activity at 3 weeks than the PRT group (mean difference 2.7, 95% CI 0.3, 5.0). No statistical differences were observed for any of the other secondary outcomes at 3 or 12 weeks, including NPRS (current pain, worst pain in the last 2 and 4 weeks), additional pain sites, Work Ability Index, Hopkins Symptom Checklist, EQ-5D, Fear Avoidance Beliefs Questionnaire, patient-specific functioning scale, neck flexor and extensor MVC strength, and pressure pain threshold. Effect sizes in change from baseline to 12 weeks are presented in Table SI[1].

Twelve participants in the PRT group submitted their training diaries at the end of the intervention.

On average, they had completed 3 PRT sessions per week during the first 3 weeks, and 2.7 sessions per week during the 9 weeks of home-based training. They trained with a mean intensity of 7.9 (SD 0.7) on the Borg CR10 scale.

DISCUSSION

This RCT does not provide any evidence to support replacing GPE with PRT in MDR for patients with non-specific chronic neck pain. No difference was observed in the change in the NDI score (primary outcome) from baseline to 12 weeks between the PRT group and the GPE group. The PRT group reported lower "worst" neck pain in the last 2 and 4 weeks at 12-week follow-up (moderate effect sizes); however, the difference did not reach statistical significance. We were unable to recruit the desired number of participants and the current trial is therefore underpowered. Nevertheless, the change in the NDI score from baseline to 12 weeks was nearly identical between the groups and it is unlikely that we would have observed a significant group difference if the desired number of patients had participated.

Table II. Primary and secondary outcomes, estimated means and 95% confidence intervals

Outcome	Baseline Mean (95% CI)	3 weeks GPE Mean (95% CI)	3 weeks PRT Mean (95% CI)	3 weeks Between-group comparison Difference Mean (95% CI)	3 weeks p	12 weeks GPE Mean (95% CI)	12 weeks PRT Mean (95% CI)	12 weeks Between-group comparison Difference Mean (95% CI)	12 weeks p
NDI (0–100)	35.4 (32.6, 38.2)	28.6 (24.0, 33.2)	33.6 (28.4, 38.7)	5.0 (−1.8, 11.7)	0.148	26.8 (21.8, 31.8)	27.0 (21.9, 32.1)	0.2 (−6.7, 7.1)	0.956
Current neck pain (0–10)	4.3 (3.8, 4.8)	3.5 (2.6, 4.3)	4.5 (3.5, 5.4)	1.0 (−0.2, 2.2)	0.095	4.1 (3.2, 5.1)	3.7 (2.8, 4.6)	−0.5 (−1.7, 0.8)	0.454
Worst neck pain last 2 weeks (0–10)	6.3 (5.8, 6.9)	6.7 (5.8, 7.6)	6.2 (5.3, 7.2)	−0.5 (−1.7, 0.8)	0.460	6.5 (5.5, 7.4)	5.3 (4.3, 6.2)	−1.2 (−2.5, 0.1)	0.068
Worst neck pain last 4 weeks (0–10)	7.1 (6.6, 7.6)	7.3 (6.5, 8.1)	7.5 (6.7, 8.4)	0.2 (−0.9, 1.3)	0.709	6.9 (6.0, 7.7)	5.8 (5.0, 6.7)	−1.0 (−2.1, 0.8)	0.068
Additional pain sites (0–11)	3.3 (2.6, 4.1)	3.1 (2.1, 4.1)	2.7 (1.7, 3.8)	−0.4 (−1.6, 0.8)	0.541	3.1 (2.0, 4.3)	2.4 (1.4, 3.5)	−0.7 (−2.1, 0.7)	0.313
WAI (0–10)	4.5 (3.9, 5.2)	5.0 (4.1, 5.9)	5.6 (4.6, 6.6)	0.6 (−0.6, 1.8)	0.327	5.5 (4.6, 6.4)	6.1 (5.1, 7.1)	0.6 (−0.6, 1.8)	0.360
HSCL-25 (1–4)	1.8 (1.7, 1.9)	1.7 (1.5, 1.8)	1.6 (1.4, 1.8)	−0.1 (−0.3, 0.1)	0.377	1.7 (1.5, 1.9)	1.6 (1.4, 1.8)	−0.1 (−0.3, 0.1)	0.298
EQ-5D (<0–1)	0.67 (0.64, 0.70)	0.72 (0.67, 0.77)	0.73 (0.67, 0.78)	0.01 (−0.06, 0.07)	0.883	0.70 (0.65, 0.75)	0.72 (0.67, 0.77)	0.02 (−0.05, 0.09)	0.594
FABQ Physical activity (0–24)	6.2 (5.0, 7.4)	4.6 (2.8, 6.4)	7.3 (5.4, 9.2)	2.7 (0.3, 5.0)	0.027	4.9 (3.0, 6.9)	5.4 (3.5, 7.4)	0.5 (−2.0, 2.9)	0.713
FABQ Work (0–42)	17.4 (15.3, 19.6)	18.0 (14.9, 21.1)	15.9 (12.8, 18.9)	−2.1 (−5.8, 1.5)	0.251	19.0 (15.8, 22.2)	16.0 (13.0, 19.0)	−3.0 (−6.7, 0.8)	0.123
PSFS (0–10)	7.0 (6.3, 7.7)	6.1 (5.1, 7.2)	6.9 (5.7, 8.0)	0.7 (−0.8, 2.2)	0.350	5.7 (4.5, 6.8)	5.2 (3.9, 6.5)	−0.5 (−2.1, 1.2)	0.568
Shoulder abductor MVC (N)	177 (159, 196)	191 (171, 211)	186 (165, 206)	−5 (−18, 9)	0.479	183 (163, 204)	200 (180, 221)	17 (2, 31)	0.022
Neck flexor MVC (N)	114 (101, 127)	130 (115, 144)	132 (117, 148)	−5 (−18, 9)	0.479	134 (119, 150)	137 (122, 151)	3 (−10, 16)	0.684
Neck extensor MVC (N)	147 (131, 163)	173 (155, 191)	170 (151, 188)	−3 (−20, 13)	0.674	162 (143, 181)	173 (155, 192)	12 (−6, 29)	0.192
Pressure pain threshold	636 (559, 713)	655 (562, 749)	581 (485, 675)	−75 (−170, 21)	0.126	666 (562, 769)	599 (504, 694)	−67 (−172, 39)	0.215

NDI: Neck Disability Index; GPE: general physical exercise; PRT: progressive resistance training; WAI: Work Ability Index; HSCL-25: Hopkins Symptom Checklist 25; FABQ: Fear Avoidance Beliefs Questionnaire; PSFS: patient-specific functioning scale; MVC: maximal isometric voluntary contraction.

Previous studies reporting the effect of PRT on neck pain have been conducted in occupational settings (2–6), while we recruited patients referred to MDR in the specialized care. Specialized care is reserved mainly for patients with substantial psychosocial impact (38), and the specialist care unit requires that sufficient medical examinations and treatment options available in the primary care setting have proven unsuccessful before referral (i.e. active physiotherapy or other relevant treatments). Supporting that our participants had a complex symptom-picture, the mean baseline scores were above the cut-off level for anxiety and depression (HSCL >1.75) (39). Furthermore, the Work Ability Index score was quite low at baseline, indicating that patients were in a state of health where they felt unable to cope with their responsibilities at work. Moreover, participants in this study reported multiple pain sites in addition to their neck pain. Widespread pain is associated with a more complex symptom picture (11), and has been reported to be inversely associated with recovery for patients with chronic low back pain (40). Finally, most participants reported more than 1-year duration of their current neck pain and had responded poorly to previous treatment in primary care. Thus, the chronicity and complexity of the participants' symptoms, in combination with the fact that all patients participated in MDR, which included some form of exercise, might have left limited room for additional improvements by PRT.

We are not aware of other studies that have evaluated the effect of PRT in combination with a comprehensive MDR programme for patients referred to specialized care. The effect of PRT on neck pain is mainly evaluated in occupational settings and/or in supervised groups (2–6), while most of the training in the current study was home-based. Jakobsen and colleagues found that training at the workplace together with colleagues had higher compliance and was more effective for reducing neck pain than home-based training (41). We found that compliance was quite high in the 12 of 30 patients who delivered the training diary after the home training period (mean 2.7 sessions per week) and the mean rating of perceived exertion indicated that the training was very heavy. It is possible that the actual training intensity and progression in resistance loading, suggested to be important for reduced neck pain and disability (42), was too low in our subjects, as we were unable to detect improvement in neck flexor and extensor MVC strength. It can also be assumed that those who returned the training diary were more compliant than those who did not.

General hyperalgesia can accompany chronic neck pain (43). A study by Andersen and colleagues found that PRT improved the sensitivity to pain in both the trapezius and the tibialis anterior muscles (33). In our

study, the pressure pain threshold of the tibialis anterior remained essentially unchanged. However, the threshold at baseline was almost double for the patients in our study than for the office workers in the study by Andersen and colleagues, reinforcing that these study populations are quite different.

This study had some limitations. Despite taking measures to maintain compliance and adherence, as recommended (34), we were unable to reach the desired number of participants, and we also experienced some dropouts, which increases the probability for a type II error. However, the results of this study probably reflect how replacing GPE with PRT would appear in clinical practice where home-based training is used and compliance will vary. The study included patients referred to a specialized back and neck pain unit and the results cannot be generalized to other populations. Due to the nature of the intervention, neither patients nor clinicians were blinded to group allocation, but assessors and researchers were blinded during testing and analyses. Furthermore, the same group of clinicians provided PRT and GPE, and carry-over effects could have occurred. In addition, it is possible that clinicians were more comfortable providing the usual GPE than the new PRT intervention, which may have favoured the former. Importantly, the clinicians at the clinic were involved with the planning of the interventions, and we had regular meetings to ensure appropriate implementation of the intervention. Finally, we cannot exclude the possibility that some participants in the GPE group performed resistance training in the home-based training period. The study sample was similar to the patients included in the reference group, indicating that our participants were representative of the study population they were recruited from.

In conclusion, the current RCT provides no evidence in favour of replacing GPE with PRT using elastic resistance bands in MDR to enhance the improvement in neck pain-related disability. Future studies with a higher number of participants should investigate whether PRT could reduce pain in the neck more than GPE. We recommend clinicians to advise either of these exercise types for patients with moderate to severe non-specific neck pain, based on the patient`s interests and motivation.

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