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ORIGINAL ARTICLE

Comparison of the effectiveness of resistance training in women with chronic computer-related neck pain: a randomized controlled study

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Abstract
Background Chronic computer-related neck pain is common among office workers. Studies have proposed neck strengthening exercise as a therapy to pain relieving and function improvement. The aim of this study was to compare the efficacy of different loading resistance trainings and we hypothesized that women with work-related neck pain could benefit more from progressive resistance training for pain and function recovery.
Methods A randomized controlled trial was conducted and subjects characterized by monotonous jobs were recruited. One hundred and nine employed women with chronic neck pain were randomly allocated into three groups, namely, progressive resistance training (PRT), fixed resistance training (FRT), and control group (CG). In PRT and FRT, four exercises for neck muscles with an elastic rubber band were performed on regular basis for 6 weeks. The therapeutic effectiveness was then evaluated at pretreatment, 2, 4, and 6 weeks during training period, and 3-month post-treatment. Assessment tools included visual analog scale (VAS), Neck Disability Index (NDI), pressure pain threshold (PPT), and maximal isometric neck strength.
Results The outcomes were significantly better in PRT and FRT than those in CG at 6-week timepoint and 3-month follow-up ($p = 0.000$), in terms of VAS, NDI, PPT, and neck muscle strength. Besides, there were statistically significant decreases observed in VAS scores of PRT group compared with those in FRT at 4-, 6-week timepoints, and 3-month follow-up ($p < 0.05$).
Conclusions The neck resistance training was an effective method for pain relieving, mobility improving, pain threshold, and neck muscle strength enhancing in women with chronic computer-related neck pain. Thus, our study provided evidence that women with work-related neck pain might benefit more from PRT, which may have important implications for future clinical practice.
Trial registration The study was qualified and registered in the Chinese Clinical Trial Registry as ChiCTR-TRC-12002723.

Keywords Chronic computer-related neck pain · Resistance training · Women · Progressive

Background

Computer has gained popularity in modern society, both at workplace and home. Because of large amount daily repetitive computer work, the prevalence rates of work-related neck disorders have increased considerably among office workers over the past few decades. Approximately 43–69% of office workers experienced neck pain in the preceding 12 months (De Loose et al. 2008; Cagnie et al. 2007a), and women are more likely than men to develop and suffer from persistent neck pain (Borisut et al. 2013). Pain

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and restricted mobility of the cervical spine have negative effects on individual functional status, work activities, and quality of life. Moreover, heavy economic burden on society was also caused by these disorders due to costs in long-term sick leave, poorer work performance, and reduced productivity (Jose 2012).

Physical exercise has been constantly suggested as a treatment of musculoskeletal pain. Randomized controlled intervention studies have found positive effects of specific neck/shoulder muscle exercises on neck/shoulder pain (Chiu et al. 2005; Waling et al. 2000; Ylinen et al. 2003), whereas generalized exercise interventions without focusing on symptomatic or target muscles failed to ease these pain conditions (Takala et al. 1994; Viljanen et al. 2003). Researches have demonstrated that pain can be reduced to some extent by strength training (Chiu et al. 2005; Ylinen et al. 2003; Andersen et al. 2008), endurance training (Waling et al. 2000; Ylinen et al. 2003), and muscle coordination training (Waling et al. 2000). Since chronic neck pain is frequently associated with decreased neck muscle strength (Silverman et al. 1991; Cagnie et al. 2007b), strength training is attracting increasing attention in reducing neck pain and its related disability (Chiu et al. 2005; Ylinen et al. 2003; Andersen et al. 2008). Moreover, progressive resistance training has been proved necessary to stimulate further adaptation towards specific training goals (Kraemer et al. 2002). However, the therapeutic effects of fixed resistance training vs progressive training on chronic neck pain were not compared in previous studies (Zebis et al. 2014). Recently, daily resistance training with elastic band has been widely adopted for neck pain. As little as 2 min of daily resistance training has been proved to provide modest benefit in adults with frequent neck/shoulder pain (Andersen et al. 2011; Jay et al. 2013). Progressive resistance and fixed resistance training have been reported to produce different effects due to the different characteristics (Ataee et al. 2014). However, issues about musculoskeletal pain symptoms, training dose, and their interactional with neck muscle strength were rarely analyzed or stated in detail. The aim of our study was to investigate the efficacy of neck resistance training with different intensities in rehabilitation of women with chronic, nonspecific neck pain.

Methods

Participants

The participants were recruited from six work places in Guangzhou, China between July 2013 and April 2014. The inclusion criteria were as follows: (1) female; (2) 20–55 years; (3) daily computer user with constantly or frequently occurring computer-related neck pain for more than 1 year; (4) had worked on a computer for at least 3 years; (5) employed, motivated to continue working and rehabilitation; (6) not having been on sick leave for more than 1 month during the last year; (7) working for at least 20 h a week; and (8) had experienced neck pain in the previous 7 days, and self-reported pain intensity of at least 2 or 3–7 days on a scale of 0–10. Participants were excluded if they: (1) had experienced pain in more than three body regions; (2) a medical history of cardiovascular or cerebrovascular accident, hypertension, fibromyalgia, rheumatoid arthritis, cervical disc herniation, whiplash, other serious traumatic injury of the neck, severe psychiatric illness, and other serious chronic disease; (3) pregnancy; (4) performing more than 2 h per week of vigorous physical exercise; and (5) had experienced neck pain for fewer than 8 days in the last 1 year. To make sure that inclusion and exclusion criteria were fulfilled, each subject was examined by a medical doctor and a physical therapist. All subjects were informed about the purpose and content of the study, including the randomization process. They also received a written informed consent, which was approved by the ethics committee of authors' university, before participating the study. The study was qualified and registered in the Chinese Clinical Trial Registry as ChiCTR-TRC-12002723.

Randomization

An independent statistician performed the random allocation of participants using a computer-generated random-numbers' table. The statistician was not aware of the eligibility of the participants and performed the randomization procedure following the baseline examination of all participants, and then informed the participants via e-mail about group allocation. The randomization codes were stored in a sealed opaque envelope until the study ended. Unfortunately, it was impossible to blind participants and counselors for the treatment allocation. However, the physiotherapists who performed the follow-up measurements were not aware of the treatment allocation of participants. In addition, participants were instructed not to reveal their particular intervention during follow-up examination. Before randomization, we explained to the participants that none of the three interventions was known to be superior to the other two.

Interventions

Participants received no other specific treatment for their neck pain during the course of the study and were randomly allocated to three intervention groups: progressive resistance training (PRT), fixed resistance training (FRT), and control group (CG). Each participant was given a

standard instruction booklet about the principles of office ergonomics. Those in the two training groups (PRT and FRT groups) were also supplied with training diaries to monitor their compliance with assigned intervention program. All participants in three groups started interventions from the first week after recruitment.

The subjects in PRT group performed four cervical isometric exercises (flexion, extension, left lateral flexion, and right lateral flexion). Different colors of elastic rubber bands, including red, green, and blue thera-bands (Thera-band, Hygiene Corp, Akron, Ohio, USA), were used in the present research. The training began with one set (10 min) of warm-up exercise, including neck movement towards each direction and upper body exercise as shrugs and lateral raise. The neck exercises were performed in a sitting position with the cervical spine in the anatomical neutral position. A rubber band was positioned around the forehead of the participants and connected to a scale that was either handheld or secured to a hook fixed to the wall. They were then instructed to perform neck resistance exercises for repetitions of 5 s duration. The training session included 8–12 repetitions for each exercise and the whole training program was performed at least three times a week. During the 6-week intervention period, the training load was progressively increased according to the principle of periodization and progressive overload (Kraemer et al. 2002). The beginning loading was 30% of the participant's maximal strength as recorded at baseline and then increased to 50 and 70% maximal strength as recorded at 2- and 4-week follow-up visits, respectively. Every loading period was 2 weeks. The load was examined by a hand-held dynamometer once a week for recording the progress of the training (Salo et al. 2010). In addition, the OMNI-resistance exercise scale was used for monitoring the intensity of exercise elastic rubber band in the rest of training (Colado et al. 2012).

The FRT also performed the isometric training as PRT. While the training load was fixed at 70% of the participant's maximal strength as recorded at baseline during the 6-week intervention, training instruction and counsel was provided once a week in the two training groups by the same physical therapists.

The CG also received information and had weekly discussions about workplace ergonomics, stress management, relaxation, meditation, and diet. Staff from our study supported these work and organized presentations for control group. The participants in this group received an equal amount of attention compared with the participants in the two training groups.

Outcome measures

All five assessments were carried out prior to the intervention and then at 2, 4, and 6 weeks, respectively, during intervention. For all three groups, the participants enrolled were visited by investigators and received the follow-up field tests at their own workplaces. The measurements included visual analog scale (VAS), Neck Disability Index (NDI), pressure pain threshold (PPT), and maximal isometric neck strength. Three months after the intervention, the participants were reassessed using the same measurement tools. Very few participants complained about the arm or shoulder pain when stretching the thera-bands. No other side effects were heard in the process of training.

The pain intensity was evaluated by VAS, which was 10-cm long scale anchored with the words "no pain" and "worst pain imaginable" at the two ends. Each participant was requested to mark a point along the scale that best represented the pain intensity she experienced (Pietrobon et al. 2002).

The Chinese version of NDI was used to assess neck pain and disability. NDI contains ten self-reported items covering pain (two items), concentration (one item), and daily activities (seven items). Each item is scored from 0 to 5, and the total score is calculated using a percentage of the maximal score, with higher values representing greater disability (Hains et al. 1998). It was proved to be a reliable and valid instrument for measuring functional status in Chinese patients with neck pain (Wu et al. 2010).

The procedure of PPT measurement, recommended by Fischer (Fischer 1987), was performed with an algometry device (Model PTH AF2, Pain Diagnostics and Thermography, Great Neck, NY 11023) by placing the plastic tip on the painful neck region. The locations for PPT assessment were determined according to Viikari-Juntura E's previous research (Viikari-Juntura 1987). Other details have been described in our previously study (Ma et al. 2010).

The maximal isometric neck strengths were evaluated by a hand-held dynamometer (MicroFET 3, HOGGAN Health Industries, Sandy, UT, USA). All strength measurements were performed by one examiner who was experienced in hand-held dynamometer. Participants were seated in the upright sitting position, supported by two adjustable bars of the vertical stand, and gazed forward. Participants were instructed to relax their shoulders, arms, and legs, with 90° hip and knee flexion. After instruction and warm-up section, strength of neck muscle groups was examined following the order of flexion, extension, left lateral flexion, and right lateral flexion. The "break" method of testing was used, as reported by Phillips et al. (2000). The tip of the dynamometer was held against subject's centre of forehead, occiput and top of the temporal for flexion, extension, and lateral flexion, respectively. In addition, the subject was asked to exert a maximum force against it. The examiner applied sufficient resistance to overcome the force exerted by the subject, and then, the tip was immediately removed and the measured force was recorded. Each trial lasted for

3 s, and a 30-s rest period was provided between trials. Each subject was asked to perform two maximal efforts in each direction, the peak force was recorded, and the mean of the two trials was used for the analysis.

Statistical methods

Statistical analysis was conducted using the SPSS 20.0 software (SPSS Inc., Chicago, IL, USA). Outcome variables were analyzed on the intention to-treat principle. Chi-square test has been performed to compare the patients' adherence between the different groups. The demographic data were examined by descriptive statistics, and the differences among groups were compared using one-way analysis of variance (ANOVA) for all the variables. The ANOVA tests were also performed to determine the differences in VAS, NDI, PPT, and neck strengths at before intervention among three groups. The results of VAS, NDI, PPT, and neck strengths were modeled using a general linear model ANOVA with repeated measures, one within-subject factor (pre-intervention and post-intervention), and a between-subject factor (group × 3). This was followed by appropriate pairwise comparisons to determine whether differences between groups were statistically significant. Spearman's correlation coefficient was used to analyze relationship between changes in maximal isometric neck strengths and reduction in VAS. The significance level was set at $p < 0.05$ for all of these tests.

The sample size was calculated before the study. A mean reduction in VAS of 2.0 cm represents a clinically important difference in pain severity that corresponds to effective treatments (Todd and Funk 1996). Based on the mean and standard deviation of VAS in preliminary experiment, with $\alpha = 0.05$ (two sided) and $\beta = 0.20$ for ANOVA with repeated measures (Chow et al. 2007), 20 cases were the least in each group for statistical analysis.

Results

Sample characteristics

A total of 206 consecutive subjects were assessed for eligibility during the study period with 109 of them enrolled and 102 completed the study. The recruitment, participation, and attrition of participants during the trial are summarized in Fig. 1. Finally, 94.7% of participants in PRT, 91.4% in FRT, and 94.4% in CG completed 6-week intervention, respectively. The demographics of the participants at baseline are summarized in Table 1, and all three groups were compared. No statistically significant differences were observed among these three groups in terms of their demographic characteristics or their computer work experience. In addition, the dropouts did not differ from the rest of the population on background variables as age, pain duration, rated pain, or cervical function. Data of PRT and FRT training load during 6 weeks are presented in Table 2.

Overall results of therapeutic effectiveness for three groups

All the outcome measurements of VAS, NDI, PPT, and maximal isometric neck strengths are shown in Tables 3, 4, 5, 6, 7, and 8, respectively. The last observation was carried forward for participants who did not complete the study at the four follow-up evaluations. No statistically significant differences were observed among the three groups in pain intensity ($p = 0.913$), neck disability scores ($p = 0.800$), pain threshold ($p = 0.594$), and neck muscle strength ($p = 0.438$–0.960) before the intervention. After 6 weeks of exercise, both the training groups had an significant decrease in pain intensity (VAS), along with improvements in neck disability (NDI), pain threshold, and neck muscle strength compared with baseline ($p = 0.000$). Three-month follow-up assessment demonstrated that the significant improvements of all indicators mentioned above were maintained in both training groups ($p = 0.000$). While there was no significant change in CG ($p > 0.05$), besides, all these positive effects in the PRT and FRT were significant compared with the control group at 6-week and 3-month assessment ($p = 0.000$).

VAS assessment

As a result of sphericity on VAS, it was found that sphericity assumption was not satisfied. Based on the repeated measure ANOVA carried out by Wilks' Lambda, it was found that there was significant difference in accordance with groups ($p < 0.001$), time effect ($p < 0.001$), and reciprocal action effect ($p < 0.001$). The VAS scores of the participants in the PRT and FRT dropped dramatically started at the fourth week and continued to fall at the sixth week and 3-month follow-up illustrating that the perceptive pain began to decrease after the first treatment. Effect of the group was found to be significant, resulting in lower VAS scores in PRT in comparison with FRT and CG at 4-week, 6-week, and 3-month follow-up timepoints ($p < 0.05$). As a result of contrast test on the reciprocal action, there was a significant difference prior to commencement, following the 2-week, 4-week, 6-week, and 3-month treatment, illustrating that the treatment effect in the PRT group was greater than that in the FRT and CG since the first treatment (see Tables 3, 6).

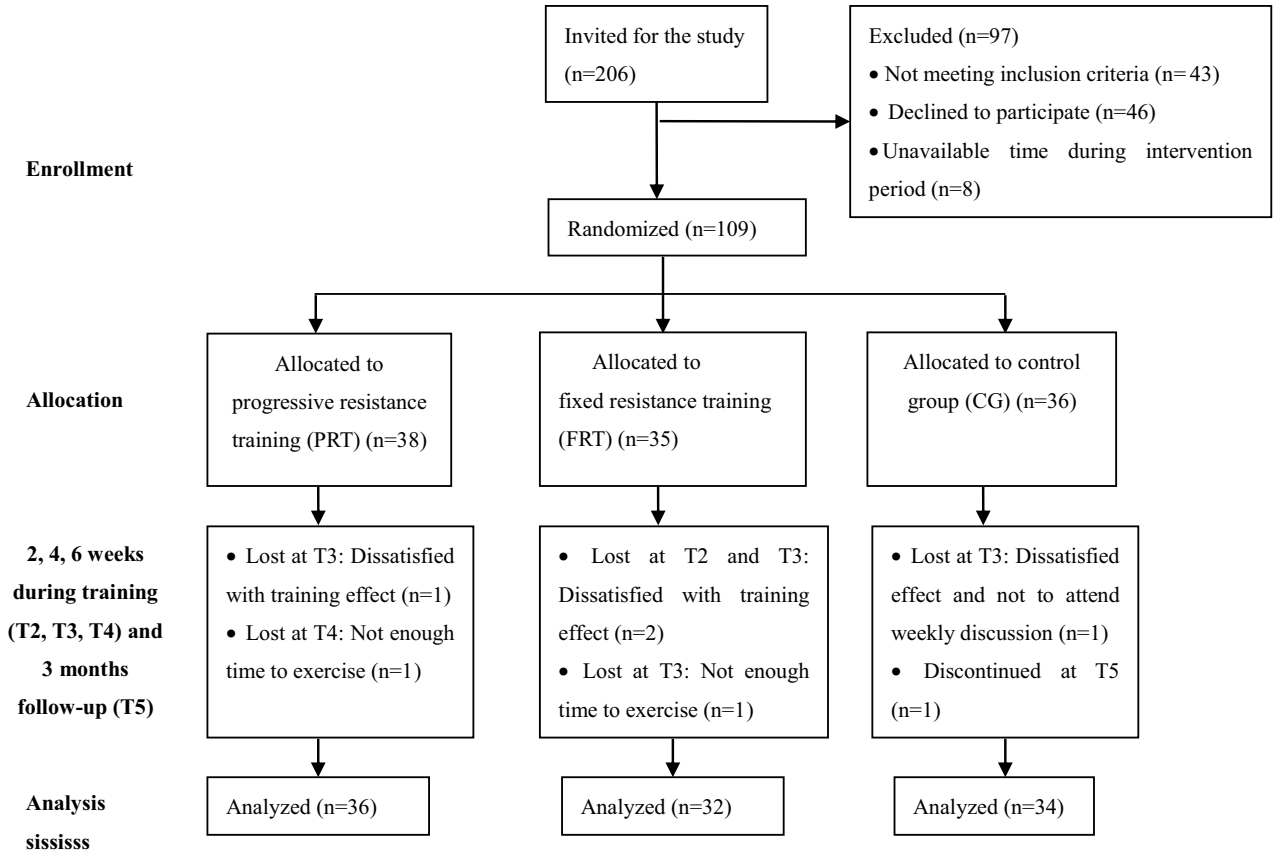

Fig. 1 Participant recruitment and follow-up flow diagram

Table 1 Demographics of the three groups at baseline

Demographic factor	PRT	FRT	CG	*p*
Subject (*n*)	36	32	34	
Age (year)	35.6 ± 7.9	33.7 ± 9.0	34.1 ± 8.2	0.893
Height (cm)	163.2 ± 7.5	163.7 ± 6.2	165.8 ± 7.9	0.269
Weight (kg)	55.7 ± 8.4	58.7 ± 9.6	59.6 ± 9.0	0.380
BMI (kg/m^2)	21.0 ± 3.7	22.1 ± 4.20	21.9 ± 3.9	0.521
Job experience (year)	9.2 ± 5.8	8.6 ± 6.1	9.7 ± 5.5	0.593
Pain history (year)	3.4 ± 1.9	3.5 ± 2.2	3.8 ± 2.4	0.796
Work (day/week)	5.3 ± 0.6	5.5 ± 0.5	5.1 ± 0.4	0.086
Computer use (h/day)	7.3 ± 2.5	7.6 ± 2.3	7.0 ± 1.8	0.325

Table 2 Training load of different groups (PRT group vs FRT group)

	PRT group			FRT group
	0–2 weeks	2–4 weeks	4–6 weeks	0–6 weeks
Flexion	13.17 ± 1.65	24.71 ± 2.51	37.24 ± 3.75	30.97 ± 3.15
Extension	20.37 ± 1.85	36.34 ± 3.31	53.20 ± 4.89	47.87 ± 3.60
Left flexion	16.04 ± 1.27	28.47 ± 2.69	41.24 ± 3.65	36.97 ± 3.27
Right flexion	16.24 ± 1.40	28.24 ± 2.31	43.52 ± 3.86	39.06 ± 3.78

NDI assessment

Sphericity assumption was found to be unsatisfactory based on the result of sphericity on NDI ($p < 0.05$). As a result of repeated measure ANOVA carried out by Wilks' Lambda, it was found that there was a significant difference in accordance with groups ($p < 0.01$), time effect ($p < 0.001$), and reciprocal action effect ($p < 0.001$). The effect of the group was found to be significant in PRT and FRT compared with CG ($p < 0.05$), while there was no significant difference of NDI between the PRT and FRT except for 4-week assessment. As a result of contrast test on time, a significant difference prior to commencement and following timepoints was observed in the PRT and FRT compared with CG, illustrating that NDI was reduced significantly since the first treatment (see Tables 4, 6).

Table 3 Outcome measurements on the VAS scores, NDI scores (%), and PPT (kPa) among patients at different timepoints before and after treatment

	Baseline	2 weeks	4 weeks	6 weeks	3 months		*F*	*p*
VAS								
Group A	5.25 ± 1.29	4.69 ± 0.98	3.58 ± 1.10	2.39 ± 0.82	1.92 ± 0.90	Group (*G*)	15.572	<0.001
Group B	5.37 ± 1.11	5.09 ± 1.03	4.76 ± 1.22	2.96 ± 0.70	2.51 ± 0.88	Time (*T*)	117.446	<0.001
Group C	5.21 ± 1.24	5.07 ± 1.25	5.10 ± 1.15	4.87 ± 0.88	5.10 ± 0.95	*G* × *T*	26.300	<0.001
Mauchly's Sphericity test $W = 0.452$ ($p = 0.000$)								
NDI								
Group A	28.25 ± 6.30	24.92 ± 5.13	19.86 ± 4.53	15.72 ± 4.83	14.93 ± 4.85	Group (*G*)	8.448	0.001
Group B	28.93 ± 6.74	26.92 ± 5.72	23.52 ± 5.32	16.87 ± 5.10	15.80 ± 4.77	Time (*T*)	95.333	<0.001
Group C	27.76 ± 6.50	27.28 ± 5.85	26.88 ± 5.98	27.42 ± 6.37	26.55 ± 5.35	*G* × *T*	23.150	<0.001
Mauchly's Sphericity test $W = 0.551$ ($p = 0.001$)								
PPT								
Group A	211.68 ± 57.82	238.14 ± 63.70	254.80 ± 66.64	339.08 ± 68.60	397.88 ± 58.81	Group (*G*)	21.392	<0.001
Group B	200.90 ± 50.96	221.48 ± 56.84	259.70 ± 70.56	317.52 ± 58.80	384.16 ± 66.64	Time (*T*)	112.512	<0.001
Group C	196.00 ± 54.88	186.20 ± 56.84	198.94 ± 65.66	203.84 ± 63.70	205.80 ± 65.60	*G* × *T*	32.567	<0.001
Mauchly's Sphericity test $W = 0.070$ ($p = 0.000$)								

Group A progressive resistance training group (PRT), *Group B* fixed resistance training group (FRT), *Group C* control group (CG)

Table 4 Outcome measurements on the VAS scores among patients at different timepoints before and after treatment

	Group A: PRT	Group B: FRT	Group C: CG	1-way ANOVA *P*	Post-hoc comparison**	LSD *p*
Baseline	5.25 ± 1.29	5.37 ± 1.11	5.21 ± 1.24	0.913		
2 weeks	4.69 ± 0.98*	5.09 ± 1.03	5.07 ± 1.25	0.639	A vs B	0.420
					A vs C	0.446
					B vs C	0.904
4 weeks	3.58 ± 1.10*	4.76 ± 1.22*	5.10 ± 1.15	0.000	A vs B	0.031#
					A vs C	0.000#
					B vs C	0.012#
6 weeks	2.39 ± 0.82*	2.96 ± 0.70*	4.87 ± 0.88	0.000	A vs B	0.035#
					A vs C	0.000#
					B vs C	0.000#
3 months	1.92 ± 0.90*	2.51 ± 0.88*	5.10 ± 0.95	0.000	A vs B	0.026#
					A vs C	0.000#
					B vs C	0.000#

* $p < 0.05$ during comparison of different values with baseline in the same group

** Post-hoc comparisons refer to the between-group comparisons between Groups A, B, and C

# Indicates significant differences in one-way ANOVA and least significant difference (LSD) tests ($p < 0.05$)

PPT assessment

As a result of the repeated measure ANOVA carried out on PPT Assessment, there was a significant difference in accordance with groups ($p < 0.001$), time effect ($p < 0.001$), and reciprocal action effect ($p < 0.001$). PPT on the painful neck muscle also increased after training. PPT values in PRT showed a significant increase at 2-, 4-, 6-week timepoints and 3-month follow-up assessment compared with CG ($p < 0.05$), while PPT values in FRT showed a significant increase at 4-, 6-week timepoints and 3-month follow-up assessment compared with CG ($p < 0.05$).There were no significant differences in PPT between the PRT and the FRT at all the timepoint posttreatments ($p > 0.05$) (see Tables 5, 6).

Table 5 Outcome measurements on the NDI scores (%) among patients at different timepoints before and after treatment

	Group A: PRT	Group B: FRT	Group C: CG	1-way ANOVA *p*	Post-hoc comparison**	LSD *p*
Baseline	28.25 ± 6.30	28.93 ± 6.74	27.76 ± 6.50	0.800		
2 weeks	24.92 ± 5.13*	26.92 ± 5.72	27.28 ± 5.85	0.212	A vs B	0.136
					A vs C	0.120
					B vs C	0.988
4 weeks	19.86 ± 4.53*	23.52 ± 5.32*	26.88 ± 5.98	0.000	A vs B	0.022#
					A vs C	0.000#
					B vs C	0.036#
6 weeks	15.72 ± 4.83*	16.87 ± 5.10*	27.42 ± 6.37	0.000	A vs B	0.259
					A vs C	0.000#
					B vs C	0.000#
3 months	14.93 ± 4.85*	15.80 ± 4.77*	26.55 ± 5.35	0.000	A vs B	0.436
					A vs C	0.000#
					B vs C	0.000#

* $p < 0.05$ during comparison of different values with baseline in the same group

** Post-hoc comparisons refer to the between-group comparisons between Groups A, B, and C

# Indicates significant differences in one-way ANOVA and least significant difference (LSD) tests ($p < 0.05$)

Table 6 Outcome measurements on the PPT (kPa) among patients at different timepoints before and after treatment

	Group A: PRT	Group B: FRT	Group C: CG	1-way ANOVA *p*	Post-hoc comparison**	LSD *p*
Baseline	211.68 ± 57.82	200.90 ± 50.96	196.00 ± 54.88	0.594		
2 weeks	238.14 ± 63.70*	221.48 ± 56.84	186.20 ± 56.84	0.046	A vs B	0.536
					A vs C	0.017#
					B vs C	0.075
4 weeks	254.80 ± 66.64*	259.70 ± 70.56*	198.94 ± 65.66	0.000	A vs B	0.481
					A vs C	0.000#
					B vs C	0.001#
6 weeks	339.08 ± 68.60*	317.52 ± 58.80*	203.84 ± 63.70	0.000	A vs B	0.520
					A vs C	0.000#
					B vs C	0.000#
3 months	397.88 ± 58.81*	384.16 ± 66.64*	205.80 ± 65.60	0.000	A vs B	0.625
					A vs C	0.000#
					B vs C	0.000#

* $p < 0.05$ during comparison of different values with baseline in the same group

** Post-hoc comparisons refer to the between-group comparisons between Groups A, B, and C

# Indicates significant differences in one-way ANOVA and least significant difference (LSD) tests ($p < 0.05$)

Maximal isometric neck strength evaluation and relationship between strengths improvement and VAS reduction

The repeated measure ANOVA showed that a significant difference existed in reciprocal action effect ($p < 0.001$) in all four directions, so the simple effects were needed to be analyzed. The muscle strengths of flexion, extension, left lateral flexion, and right lateral flexion in age-matched healthy women without neck pain were (52.52 ± 2.67)N, (81.44 ± 5.34)N, (63.64 ± 4.11)N, and (63.06 ± 4.06)N, respectively, with a significant increased muscle strength than the 109 participants involved in the present study ($p < 0.05$). Neck strength showed a significant increase in all four directions tested in both training groups at the 6-week timepoint and 3-month follow-up assessment compared with the baseline (Tables 7, 8). In PRT, maximal isometric neck strengths increased by 17.5% in flexion,

Table 7 Outcome measurements on the maximal isometric neck strengths (*N*) among patients at different timepoints before and after treatment

	Baseline	6 weeks	3 months		*F*	*p*
Flexion						
Group A	43.91 ± 4.53	51.45 ± 4.30	50.01 ± 5.12	Group (*G*)	6.328	0.001
Group B	44.25 ± 4.81	50.03 ± 5.01	49.30 ± 4.96	Time (*T*)	37.295	<0.001
Group C	43.61 ± 4.76	43.80 ± 4.55	43.68 ± 4.62	$G \times T$	12.273	<0.001
Mauchly's Sphericity test $W = 0.312$ ($p = 0.000$)						
Extension						
Group A	67.91 ± 9.66	82.90 ± 8.92	81.36 ± 8.40	Group (*G*)	2.534	0.090
Group B	68.39 ± 10.15	78.08 ± 9.06	78.20 ± 8.27	Time (*T*)	27.684	<0.001
Group C	67.24 ± 9.79	67.92 ± 9.04	67.55 ± 9.01	$G \times T$	10.001	<0.001
Mauchly's Sphericity test $W = 0.210$ ($p = 0.000$)						
Left flexion						
Group A	53.48 ± 7.57	63.08 ± 7.17	62.52 ± 7.06	Group (*G*)	8.409	0.001
Group B	52.82 ± 7.21	60.85 ± 7.06	61.61 ± 6.89	Time (*T*)	63.384	<0.001
Group C	53.58 ± 6.36	52.68 ± 6.87	52.47 ± 6.54	$G \times T$	19.207	<0.001
Mauchly's Sphericity test $W = 0.449$ ($p = 0.000$)						
Right flexion						
Group A	54.16 ± 7.01	62.30 ± 7.35	61.55 ± 6.90	Group (G)	10.299	<0.001
Group B	55.80 ± 6.72	61.29 ± 7.53	60.88 ± 6.64	Time (*T*)	70.050	<0.001
Group C	54.87 ± 6.94	53.96 ± 6.80	54.62 ± 6.78	$G \times T$	17.732	<0.001
Mauchly's Sphericity test $W = 0.508$ ($p = 0.001$)						

Group A progressive resistance training group (PRT), *Group B* fixed resistance training group (FRT), *Group C* control group (CG)

Table 8 Outcome measurements of maximal isometric neck strengths (*N*) among patients at different timepoints before and after treatment

	Group A: PRT	Group B: FRT	Group C: CG	1-way ANOVA *p*
Flexion				
Baseline	43.91 ± 4.53	44.25 ± 4.81	43.61 ± 4.76	0.960
6 weeks	51.45 ± 4.30*,#	50.03 ± 5.01*,#	43.80 ± 4.55	0.000
3 months	50.01 ± 5.12*,#	49.30 ± 4.96*,#	43.68 ± 4.62	0.000
Extension				
Baseline	67.91 ± 9.66	68.39 ± 10.15	67.24 ± 9.79	0.951
6 weeks	82.90 ± 8.92*,#	78.08 ± 9.06*,#	67.92 ± 9.04	0.000
3 months	81.36 ± 8.40*,#	78.20 ± 8.27*,#	67.55 ± 9.01	0.000
Left flexion				
Baseline	53.48 ± 7.57	52.82 ± 7.21	53.58 ± 6.36	0.438
6 weeks	63.08 ± 7.17*,#	60.85 ± 7.06*,#	52.68 ± 6.87	0.000
3 months	62.52 ± 7.06*,#	61.61 ± 6.89*,#	52.47 ± 6.54	0.000
Right flexion				
Baseline	54.16 ± 7.01	55.80 ± 6.72	54.87 ± 6.94	0.852
6 weeks	62.30 ± 7.35*,#	61.29 ± 7.53*,#	53.96 ± 6.80	0.000
3 months	61.55 ± 6.90*,#	60.88 ± 6.64*,#	54.62 ± 6.78	0.000

* $p < 0.05$ during comparison of different values with baseline in the same group

# $p < 0.05$ during comparison of different values with Group C in the same timepoint

22% in extension, 18.3% in left lateral flexion, and 17.3% in right lateral flexion after 6-week training. The corresponding results in FRT were 13.9, 14.3, 15.6, and 12.6%, respectively. Moreover, at the end of the sixth week during training period, a significant correlation was also found existed between improvement in maximal isometric strengths of neck extensor and reduction in VAS from baseline. The Spearman's correlation coefficients showed

−0.61 ($p = 0.022$, for PRT) and −0.63 ($p = 0.029$, for FRT), respectively.

Discussion

The study showed that resistance training of neck muscles contributed to a considerable improvement in average neck pain, neck mobility, local pressure pain threshold, and neck strengths compared with the control group. In addition, there was a tendency for the PRT to get better results than the FRT, though some differences were not statistically significant. Considering that strength training is more acceptable for patients to start with low intensity, the authors believed that PRT could be a promising and effective training method for chronic neck pain patients.

Epidemiologic research has provided evidence that the development of musculoskeletal pain is associated with physical workplace factors, such as tiring postures, repetitive work tasks, and static contractions (Cho et al. 2012; Hakala et al. 2006). Neck pain is especially common among office workers with intensive computer-related work. Severe neck pain can also be more persistent than low back pain (Kjellman et al. 2001). In addition, decreased strength in the neck muscles has been thought to be associated with chronic neck pain, since researchers have pinpointed the neck extension muscles as sites of painfulness and weakness (Cagnie et al. 2007b). Others have found muscle weakness in neck flexor, extensor, and muscle groups that function to lateral flexion and rotation (Ylinen et al. 2004; Chiu and Sing 2002). Since women exhibit 50–80% of the maximal neck strength of men (Chiu et al. 2002; Jordan et al. 1999), it has been suggested that the relative weak neck muscles cause muscular fatigue syndrome resulting in a higher incidence of chronic neck pain in women (Cagnie et al. 2007b). The presence of persistent neck pain may cause patients to avoid daily activities, which may lead to specific physical deconditioning (e.g., loss of strength and endurance of paraspinal muscles). This may result in even more pain and disability and subsequently contribute to chronic neck pain (Smeets et al. 2006). Despite we failed to assess pain relief with more objective methods, we believe that the current results of VAS and PPT are also reliable, since patient self-reports remain the gold standard (Reading 1983).

There is moderate evidence supported the effectiveness of isometric resistance exercises of neck musculature for chronic or frequent neck pain (Ylinen 2007). Studies have shown that strengthening exercises for shoulders and upper extremities could reduce pain arising from the trapezius muscles and improve mobility (Andersen et al. 2011; Jay et al. 2013). Moreover, study found that the specific extension exercises could bring a significant increase in the neck muscles strength, that is, greater loading capacity in cross-sectional area (Conley et al. 1997). The resistance training with elastic band focus on neck muscles was carried out in the present study, including exercises towards four directions: flexion, extension, left lateral flexion, and right lateral flexion. The results showed that both resistance training groups had significantly better outcomes in pain (VAS), neck disability score (NDI), and maximal isometric neck strengths than those of control group after 6-week training and at 3-month follow-up. In addition, increases of the maximal isometric strength in all neck muscle groups were achieved in both resistance training groups. The neck strength of flexion, extension, left lateral flexion, and right lateral flexion was enhanced by 17.5, 22, 18.3, and 17.3%, respectively, in the PRT and 13.9, 14.3, 15.6, and 12.6%, respectively, in the FRT after 6-week training. Besides, a significantly high correlation was observed between the increased strength of neck extensor and the reduction in VAS. The positive relationship between increases in maximal strength and reductions in musculoskeletal pain has been previously reported by Ylinen et al., which is also in accord with the present research (Ylinen et al. 2006).

Though there was no statistical difference of patients' adherence between the two groups ($p > 0.05$), the authors thought the exercise program of PRT might be more suitable for the management of chronic work-related neck pain in women. In the present study, some symptomatic patients complained that training started with heavy load usually resulted in sudden and aggressive pain, which may prevent patients from producing full force because of subconscious fear of hurting themselves. Based on the principle of resistance training, a light loads is recommended for neck muscles or painful muscle (American College of Sports Medicine position stand 2009). Besides, using progressive loads appears to be more effective for long-term muscular strength training (Kraemer and Ratamess 2004). Jordan et al. reported that flexion and extension exercise with load equal to 30% maximum strength could effectively relieve pain and enhance muscle strength (Jordan et al. 1999). Therefore, the beginning loading of PRT in our study was set at 30% of the participant's maximal strength as recorded at baseline; then gradually increased to 50 and 70% maximal strength at the subsequent training. For FRT, the training load was fixed at 70% of the participant's maximal strength as recorded at baseline during the 6-week intervention. The results showed that participants in PRT reported greater pain reduction compared with those of the FRT at 4-, 6-week timepoints, and 3-month follow-up assessment. The scores may be influenced by emotion, since VAS is a subjective measurement and affected by transient aggravated pain during or immediately after the strength training. Study found that suboccipital and

trapezius muscles are often tender in office women with neck-shoulder symptoms and more likely to develop persistent pain. In addition, these subjects had significantly lower PPT values in the above areas than those without neck-shoulder symptoms. The reason for a lower PPT may be due to a pathophysiological state in the neck-shoulder muscles and psychosocial stress (Levoska 1993). In the present study, PPT were significantly increased in two resistance training groups compared with control group at 4-, 6-week timepoints, and 3-month follow-up assessment, respectively. The results showed that strength training has a positive effect on the PPT in patients with chronic neck pain, which was consistent to the other studies (Waling et al. 2000; Ylinen et al. 2005).

Due to lack of more objective pain evaluation tools, we assessed pain relief with VAS and PPT. Moreover, the limited sample size and unsupervised training method might influence the conclusion generalized.

In conclusion, progressive resistance training, which starts with light load, is recommended for the management of chronic work-related neck pain in women. Besides, elastic rubber band is a favorable tool with low cost to facilitate the progressive resistance training at home or workplace.

Conclusions

The neck resistance training resulted in clinically relevant reductions of pain and increased neck mobility, local pressure pain threshold, and neck strengths in women with chronic neck pain. In addition, the patients might benefit more from PRT. Considering that strength training is more acceptable for patients to start with low intensity, the authors believed that PRT had great clinically importance.

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Author contributions XL and CL designed the experiment and drafted the manuscript; CL analysed and interpreted of data; SK and QW were responsible for evaluation; HL and ZH were in charge of training; WX collected the follow-up data; and CM and SW conceived of the study and participated in its design and coordination. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest The authors declare no competing interests.

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