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Review Article

Physiotherapy Section

Efficacy of Endurance Exercise on Pain and Disability in Chronic Neck Pain- A Systematic Review

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ABSTRACT

Introduction: Due to the prevalence of chronic neck pain, the international attention, in recent years, has increased to evaluate the efficacy of therapeutic exercise in the management. The course of neck pain is often characterised by exacerbations, a reduced range of motion of the cervical spine, development of chronic symptoms of pain for more than six months and weak neck-muscles. They are more common among women than men and they are related to functional limitations, disabilities and impairments. But the evidence in support of many of the standard treatment approaches in the management of neck pain is lacking.

Aim: This systematic review aimed at analysing the literature systematically and to discuss the quality of evidence of endurance exercise in reducing pain and disabilities. Also it may help in improving the Quality of Life in subjects with chronic neck pain.

Materials and Methods: Records were identified by searching multiple literature data bases, including MEDLINE, BIOMED CENTRAL, EMBASE, ACRM, Europa Medicophysica, BMJ, PEDro, Cochrane central register of controlled trials (CENTRAL), American Physical Therapy Association, Medicine and Science in sports and exercise. Additional records were searched through other sources to complement the database finding, relevant literature reviews and indexes of peer-reviewed journals were used. All published Randomised Controlled Trials (RCTs) without any restriction regarding time of publication, co-interventions, sample size and gender were referred. Study participants had to be symptomatic adults with chronic non-specific neck pain, chronic neck pain, whiplash injuries and the articles published in english.

Results: In this systematic review, the literature search initially resulted in 250 RCTs among which 23 studies fulfilled the criteria and were finally included in the review. Almost all the studies showed that there was a significant difference between the endurance training group and the other intervention group in improving the neck functional abilities and in reducing the neck pain.

Conclusion: In majority of the studies, the endurance exercises succeeded in reducing neck pain and in improving functional abilities of the chronic neck pain patients. The intensities and repetitions of the exercises should depend on progressive resistance given to the muscle. The endurance exercises were found to be promising when compared to control group; however, it yielded a less significant reduction in pain and improvement in functional abilities of neck when compared to the other strengthening exercises group.

Keywords: Musculoskeletal disorder, PEDro score, Therapeutic Exercises, Whiplash injuries

INTRODUCTION

Neck pain is one of the most common musculoskeletal disorders, with an annual prevalence of 30% to 50% among the working and general population [1]. Worldwide, this figure is up to 20% of the population reporting chronic neck pain at any one point of time [2]. Around 25% of sick leaves are directly related to musculoskeletal pain [3]. The course of the neck pain is often characterised by exacerbations, a decreased range of motion of the cervical spine, development of chronic symptoms of pain lasting more than six months and weak neck-muscle. These are more common among women than men and they are also related to functional limitations, disabilities and impairments [4-7]. Various predisposing factors, such as prolonged duration of computer use, sustained awkward posture and prolonged working with a visual display unit [8,9] tend to increase neck problems. However, the pathological mechanisms leading to chronic neck pain remains unclear, although in some studies it was found that the intra-muscular shear force leads to nociceptor sensitization [10] and promotes the over activity of low threshold motor units [11].

The endurance exercises mainly focus on training the neck muscle for endurance, by lifting the head from the bed when in a lying position by lifting 2 kg dumbbells 20 times per set followed by three sets [12,13]. These exercises are programmed by progressive resistance exercise for the neck muscles, especially the superficial neck flexors and extensor muscles with low intensity and high repetition exercises. During the endurance training of the cervical flexor muscles, flexion movement is performed at the lower cervical segment in supine and prone with proper head support to train the neck flexor muscles [14]. But the evidence for many of the quality treatment approaches to neck pain is lacking.

Therefore, this systematic review aimed to analyse review the literature systematically and to discuss the quality evidence of endurance exercise in reducing pain and disabilities and in improving Quality of Life in subjects with chronic neck pain due to various causes like whiplash injuries, neck muscle imbalance and chronic non-specific neck pain.

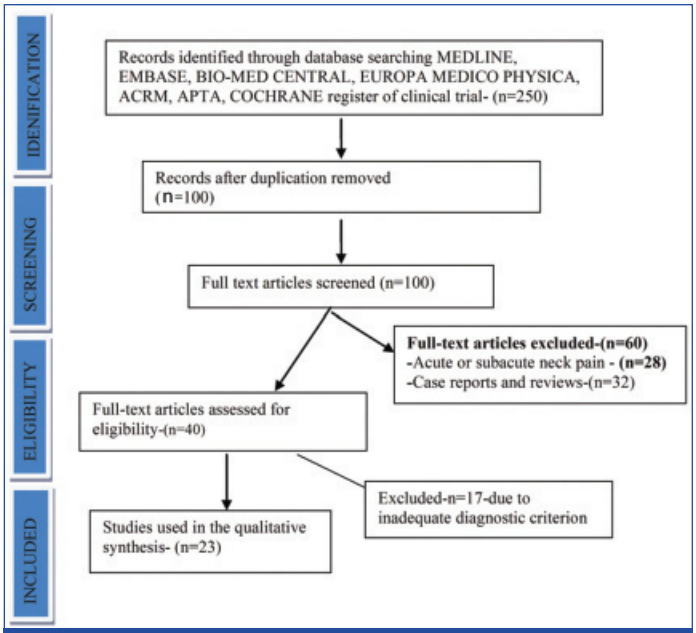
MATERIALS AND METHODS

Search Strategy

A search to identify the RCTs (Randomized Controlled Trials) examining the efficacy of endurance exercise on pain, disability and quality of life in subjects with chronic neck pain was conducted. Records were identified by searching the BIOMED CENTRAL, MEDLINE, EMBASE, ACRM, Europa Medicophysica, BMJ, PEDro, Cochrane central register of controlled trials (CENTRAL), American Physical Therapy Association, Medicine and Science in sports and exercise. The key words “neck pain”

and "endurance exercise" were used for the search. Additional records were searched through other sources to complement the database finding, relevant literature reviews and indexes of peer-reviewed journals. The interventions provided within the studies consisted of endurance exercise as a primary intervention, as a co-intervention performed strengthening exercise, stretching exercise, relaxation exercise, co-ordination exercise and cranio-cervical flexion exercise and also health promotional activities such as stress management, ergonomics and general healthy life style were included. Although, in this systematic review, there were no limitation for the outcome measures, like VAS (Visual Analog Scale), NRS (Numerical Rating Scale), HQoLQ (Health Quality of Life Questionnaire), NDI (Neck Disability Index), VNDI (Vernon Neck Disability Index), neck and shoulder pain and disability index were included.

Selection criteria: The randomised controlled trials published in English and presented in full text were eligible for inclusion in the systematic review. The included RCTs were analysed, the participants who were symptomatic adults aged 18 years or older, who were diagnosed with or self reported chronic neck pain, CNSNP, trapezius myalgia or whiplash injury were included in this systematic review. Trials were excluded if any of the participants received a selected intervention for radiculopathy, infection, fracture, myelopathy and inflammatory disease. Neck pain associated with trauma, fibromyalgia, cervicobrachialgia, degenerative changes, or osteoporosis were excluded. Studies that were not classified as RCT, such as observational, descriptive design, were also excluded from the review [Table/Fig-1].



[Table/Fig-1]: Articles retrieval process.

RESULTS

A brief summary of the RCTs, regarding the study characteristics, study design, baseline characteristics of the participants and the outcomes for all the reviewed article, types of co-intervention, population and follow up period; clinical outcome measures, and findings is tabulated in [Table/Fig-2] [15-37]. The plots in the figures [Table/Fig-3-6], represents the mean values of pain and disability outcomes in endurance training group, other intervention group and control group. Majority of the studies reported a highly significant difference in the post-test measurement on pain and disability in the endurance training group. Mean while, on comparing it with the other intervention group, the significant difference between the groups was less [Table/Fig-3,5]. When the endurance training groups were compared with the control group, most of the studies support the endurance training exercise due to its impact on pain and disability. But in some studies both the intervention group and control group yielded a similar significant difference in pain and disability. The methodological quality of studies were assessed by PEDro scale [Table/Fig-7], which has been shown to be most reliable [38] and valid [39] for rating the quality of the included RCTs.

Author Name/ study design	Study duration/sample size/Inclusion criteria	Baseline characteristics	Intervention	Outcome measures/ variables	Result
1. Borisut S and Sirinavarat MV. [15] RCT	100-female subjects, 12 week intervention. History of intermittent work related neck pain lasting for more than 6 months, aged between 20 and 35, worked with a computer at least 4 hrs each working day, pain level exceeding 30 mm a VAS of 0-100 mm.	Group 1-VAS 55±10.93, NDI-28.20±5.56, Group 2=VAS-56.04±22.6, NDI-29.9±4.51. Group 3-VAS-61.48±16.68, NDI-29.23±5.27. Group 4=VAS-59.04, NDI-31.56.	Randomised into 4-groups Group-1 (N=25)=strength-endurance exercise group. Group-2 (N=25)=craniocervical flexion exercise. Group-3 (N=25)=combination of endurance and strength and craniocervical exercise. Group-4 (N=25)=control group.	VAS, NDI, surface electromyography of upper trapezius, cervical erector spinae, sternal head of sternocleidomastoid and anterior scalene. VARIABLES: pain, disability level in neck, and changes in the muscle activity.	The neck pain and disability index significantly improved after 12 weeks of exercise intervention in all the exercise groups. The decrease in VAS-16-32 mm, in G1, G2-13 mm, G3-44.6 mm. The decrease in the NDI score were G1-13.51, G2-15.55, G3-13.52. This indicates that the exercise caused the changes in VAS and NDI score of females who had chronic neck pain. The reduction in pain and disability index was significantly different among the control and all exercise group.
2. Salo PK et al., [16] RCT	180 female subjects, duration-12 months, Female, aged-25 to 53 yrs, office worker, permanently employed, motivated to continue working, motivated for rehabilitation, constant or frequently occurring neck pain for more than 6 months.	G1: duration of neck pain (yrs)-8±6, neck pain, mm (VAS)-57±20. G2: duration of neck pain (yrs)-9±6, neck pain, mm (VAS)-56±22. G3: duration of neck pain (yrs)-8±5, neck pain, mm (VAS)-58±20.	Randomised in to three groups, G1: strength training group (n=60), G2-endurance training group (n=60), G3-control group (n=60). Both of the training group participated in the 12 day rehabilitation program. The STG performed high intensity isometric neck strengthening exercise with associate elastic band, the ETG performed lighter dynamic neck muscle exercise.	Health related quality of life questionnaire, was assessed using the generic 15D questionnaire at baseline and after 12 months.	Training led to statistically significant improvement in the 15D total scores for both training groups, whereas no changes occurred for the control group (P=0.012, between groups). The STG improved considerably in 5 of fifteen dimensions, whereas the ETG improved considerably in 2 dimensions. Effect size (and 95% confidence intervals) for the 15D total score was 0.39 (0.13 to 0.72) for the STG, 0.37 (0.08 to 0.67).

3. Stewart MJ et al., [17] RCT	134 Subjects, duration -6 weeks. Patients with chronic WAD (>3 mths, <12 mths), classified WAD I-III, having significant pain or Disability.	Patients with chronic WAD (>3 mths, <12 mths), classified WAD I-III, having significant pain or Disability.	1) Advice alone group (n=68), received education, reassurance and encouragement to participate in light activity alone, and two follow-up phone contacts (2) Advice and exercise group (n=66), individualized, progressive, sub maximal programme designed to improve functional activities, endurance, strength, aerobic, speed, coordination, principles of cognitive behavioral therapy	Pain intensity and pain intensity rated on a 0-10 VAS scale, PSFC	Exercise and advice were more effective than advice alone at 6 wks for all primary Outcomes but not at 12 months. The effect of exercise on pain intensity scale was -1.1 (95% CI -1.8 to -0.3, p=0.005) at 6 wks and -0.2 (0.6 to -1.0, p=0.59) at 12 mths; on the bothersomeness scale the effect was -1.0 (-1.9 to -0.2, p=0.003) at 6 wks and 0.3 (-0.6 to 1.3, p=0.48) at 12 months.
4. O'Leary S et al., [18] RCT	An independent repeated measure. N=48 Females. Chronic neck pain, all the subjects reported a history of neck pain of 3 or more months, and scored 5 or greater of 50 on the NDI.	CCF group NDI-13.4±5, CF group, NDI-13.3±4.2.	Group 1 (n=24)-craniocervical flexion coordination exercise group (CCF). Group 2 (n=24)-cervical flexion endurance group (CF). In the CF training pressure biofeedback device is used.	VAS at rest and during active cervical motion, PPT, TPT over the cervical spine and at a remote site on the leg, SNS-skin conductance, blood pressure, heart rate, blood flow, skin temperature. Variables: pain, TPT, PPT, SNS responses. The measures of pain and SNS responses measured immediately before and after exercise intervention.	Immediately after single session of exercise, there was a reasonably sized increased of 21% (p<.001) and 7.3% (p=0.3) in PPT locally at the neck for the CCF group and CF group. There was no change in the local neck TPT with both the exercise. PPT and TPT and SNS responses did not changed after exercise. Only the CCF exercise demonstrated a small improvement in the VAS during active mvts (p=.04). It shows that immediate mechanical change hyperalgesia local to neck with translation into perceived pain relief on movement.
5. Falla D et al., [19] RCT	58 female subjects, duration-6 weeks. History of chronic, non-severe neck pain of greater than 3 months, ≤15 (out of 50) on the Neck Disability Index (NDI), subjects with palpable cervical joint tenderness and demonstrated poor performance (unable to achieve 24 mm Hg) on the cranio-cervical flexion clinical test.	Group 1=length of neck pain history (yrs)-.5±5.9, neck pain intensity (0-10 cm) -3.6±2.0, NDI (0-50)-9.8±3.3. Group 2=length of neck pain history (yrs)-8.3±7.0, neck pain intensity (0-10 cm)-4.7±2.0, NDI (0-50)-10.4±3.4.	Allocated into two groups. In Group 1 (N=29)-intervened with craniocervical flexion exercise (CCF), Group 2 (N=29)-underwent endurance-strength exercise. The subjects were guided by the feedback from the pressure sensor to sequentially reach 5 pressure targets in 2-mm Hg increments from a baseline of 20 mm Hg to the final level.	NDI, NRS, the angle of forward head posture was measured from a line drawn from the tragus of the ear to the $C7^{th}$ vertebra, lateral photograph taken with a digital camera. VARIABLES; pain, disability index, cervical and thoracic angles.	Both intervention groups demonstrated a reduction in average intensity of pain, group 1_0.9±2.3, G2_1.1±2.8, and NDI score (G1_3.5±4.8, G2_2.8±4.0). However, there was no difference between groups for change in pain (NRS) or disability (NDI) (P>.05). at 6^{th} week Significant reduction; P<.01; when compared with the endurance-strength training group. However, there was no significant difference b/t the 2 intervention groups.
6. Ylinen J et al., [20] RCT	180 female subjects, 3 year follow up study. Permanently employed female office workers with working age with neck pain for more than 6 months.	G1: duration of neck pain-8±6 yrs, VAS-58(43-72), neck and shoulder pain and disability index-35(25-45), VNDI-22(16-26). G2: duration of neck pain-9±6, VAS-57(42-74), neck and shoulder pain and disability index-36(28-46), VNDI-20(16-28).	Group 1-strength training group (n=60), Group 2-endurance training group (n=60), Group 3-control group (n=60). Strength group: 80% maximum isometric neck resistance training with elastic rubber band in sitting, a single series of 15 repetitions; dynamic exercise with 2 kg-dumbbell, flies, Endurance group: lifting head up in supine position in 3 series of 20 repetitions. Follow-up: 12 months (all groups) and 36 months (no control group).	VAS, NDI, handheld isometric strength testing device, multidimensional neck ROM device, handheld electronic pressure algometer. VARIABLES: pain, disability index, Passive cervical ROM, strength, PPT.	After 3 year follow-up, G1- pain (VAS)-14, neck and shoulder pain and disability index-12, VNDI-12. G2-pain (VAS)-19, neck and shoulder pain and disability index-13, VNDI-14.
7. Nikander R et al., [21] RCT	180 female subjects, duration-12 months. Aged 25–55 yr, working in an office, permanently employed, motivated to continue working, motivated for rehabilitation, and constant or frequently occurring neck pain for more than 6 months.	G1: Maximal oxygen uptake-31±4, Leisure time physical activity-58.3±44.9, neck pain-57±21, disability index-38±14. G 2: Maximal oxygen uptake-32±5, Leisure time physical activity-77.6±69.2, neck pain-57±20, disability index-35±13. G 3: Maximal oxygen uptake-31±5.	A total of 180 female office workers were selected and randomly assigned into two training groups and a control group with 60 patients in each group. Group 1-endurance training, group 2-strength training, group 3-control group	Sub maximal bicycle ergometer test, was estimated by a 1-month (28 d, 4 wk) all-time recall questionnaire, METs by specific software, seven-point scale, VAS. VARIABLES: Pain, energy expenditure, maximal O_2 uptake, MET.	In the post treatment, neck, shoulder, and upper-extremity training for more than 8.75 METlhlwkj1 was an effective training dose for decreasing neck pain. One MET-hour of training per week accounted for 0.8-mm decrease of neck pain on a (VAS) and a 0.5-mm decrease on a disability index. Both strength and endurance training decreased perceived neck pain and disability. Declines in neck pain and disability correlated positively with the amount of specific training. (VAS; were 57 (20), 57 (21), and 58 (20) at baseline and 18 (22), 23 (22), and 42 (23) at 12- month follow-up of the three groups, respectively.

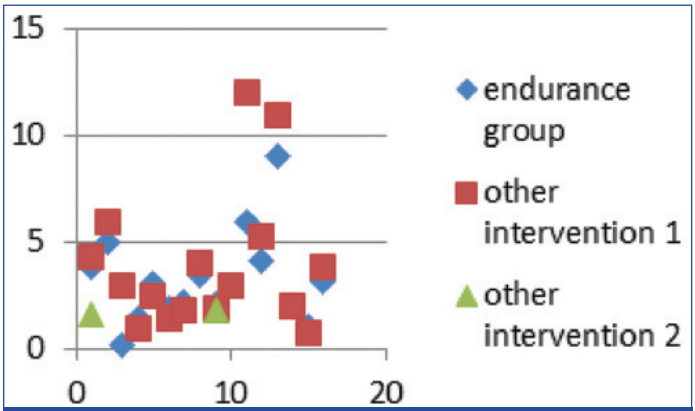
8. Ylinen J et al., [22] RCT	180 women subjects, duration-12 months. Subjects with chronic neck pain, history of pain >6 months, average of 8 yrs	Mean age-46 yrs, G1= neck pain during previous week in VAS-58(43-72), neck and shoulder pain and disability index-35(24-45). G2= neck pain during previous week in VAS-57(43-74), neck and shoulder pain and disability index-36(28-46). G3=neck pain during previous week in VAS-58(42-74), neck and shoulder pain and disability index-38	Group 1= high intensity strength training group. Group 2= local muscle endurance training group. Group 3= control group. The neck training consist of isometric exercises in the STG (strength training group), and dynamic exercises in the endurance training group (ETG). Both groups performed dynamic	Strength test, neck pain, disability indices were evaluated at the baseline. VARIABLES: pain, disability, strength.	After 12 months follow up, in both the groups the greatest gain in neck strength, as well as decrease in neck pain and disability, were achieved during the first two months. However, the improvements continued up to 12 months. The STG achieved the greatest strength gains at all follow ups. The control group showed only minor changes and significant difference were found in favor of the training groups in all measures. The change in neck pain and disability indices correlated with the isometric neck strength r=0.22
9. Falla D et al., [23] RCT	58 female subjects, duration-6 weeks. Patients with chronic neck pain.	Subjects with chronic neck pain, females, working population.	GROUP1-endurance-strength training regime for cervical flexor muscles, Group 2-referent exercise intervention involving low load retraining of the cranio-cervical flexor muscle. Twice daily, 12 repetitions maximum, 10-20 minutes daily over 6 weeks.	Maximum voluntary contraction (MVC), change of the initial value and rate of change of the mean frequency, average corrected worth, and physical phenomenon speed detected from sternocleidomas-toid and AS muscles throughout sub-maximal isometric cervical flexion contractions at fifty, twenty five and ten MVC.	At the seventh week follow-up assessment, the endurance-strength group discovered a major increase in MVC force and a reduction within the estimates of the initial rate of amendment of the mean frequency for each the SCM and AS muscles ($p<0.05$). each the exercise cluster according a reduced average intensity of neck pain and reduced neck incapacity index score ($p<0.05$). AN endurance-strength exercise regime for the cervical skeletal muscles is effective in reducing myoelectric manifestations of superficial cervical flexor muscle muscle fatigue further as increasing cervical flexion strength in a group of patients with CNP.
10. Ylinen J et al., [24] RCT	180 subjects, 12-month follow up study. Chronic non-specific neck pain.	Subjects with chronic non-specific neck pain.	180 women subjects were randomly allocated into three groups-G1-neck muscle endurance training, G2-neck muscle strength training, and G3-control group.	Pain was assessed by VAS-visual analog scale, pressure pain threshold (PPT), at six muscle sites and on sternum.	At the 12-month follow-up statistically considerably higher pressure absolute threshold values were obtained in each training groups in the least muscle sites compared to the baseline, whereas no vital change occurred within the controls, considerably higher changes in pressure absolute threshold were detected in the least six sites within the strength training group and at four out of six sites within the endurance group compared to the control group.
11. Ylinen J et al., [25] RCT	180 females, 12 month intervention. Age of 25 to 53 yrs with chronic, non-specific neck pain, office workers, constant or frequent neck pain occurring for more than 6 months.	G1=VAS-58±42.74, Neck and shoulder disability index-38(26-49), VNDI-22(16-31). G2-=Neck and shoulder disability index 36(28-46), Vernon neck disability index--22(16-28). G3=age 45±6, height-165±5, weight-67±11, BMI-25(3), VAS-58(43-72), Neck and shoulder disability index-35(24-45), Vernon neck disability index-21	Group 1 (N=60) = control group, Group 2 (N=60) = endurance group, Group 3 (N=60) = strength group. Each the group performed dynamic exercise for the shoulder and higher extremity with dumb bell. All the teams were suggested to try to to aerobic and stretching exercise often three times every week	VAS, modified neck and shoulder pain and disability, Vernon neck disability index, goniometer. VARIABLES: pain, disability, range of motion, maximal isometric neck strength.	At the 12 month visit, VAS-G1 (-16), G2 (-35), G3 (-40), the NSPDI-G1 (-12), G2 (-22), G3 (-23), VNDI-G1 (-3), G2 (-8), G3 (-9)] both neck pain and disability had decreased in both training groups compared with control group ($p<.001$). Maximal isometric neck strength had improved flexion by 110 %, rotation by 76%and extension by 69% within the strength training group. The improvement within the endurance group was 28%, 29%, and 16 PF and within the control were 10%, 7%. ROM had additionally improved in each group when compared to control.

12. Viljanen M et al., [26] RCT	393 subjects, duration-12 month follow up study. Female office workers with chronic non-specific neck pain (>12 wks), age 30–60.	Female office workers with chronic Non-specific neck pain (>12 wks), age 30-60 (N=393), NDI-G1: 29±15.4, G2: 29±14.3, G3: 26±13.8, PAIN-G1: 11±5.7, G2: 11±6.3, G3: 10±6.6.	1) Dynamic muscle training (N=135) 2) Relaxation training (N=128) 3) Control group, ordinary activity (N=130) Groups 1 and 2 were instructed and trained 3 times a week for 12 wks followed by one week of reinforcement 6 months when organisation	Pain rated on a scale 0 (no pain)-10 (Unbearable pain), pain questionnaire, NDI-neck disability index. VARIABLS: pain, disability.	There were no statistically significant differences in effect between groups at 3, 6, and 12 mths follow up. At the 12 month follow up, the pain –G1: 3.1±2.5, G2-3.3±2.6, G3: 3.2±2.5, NDI-G1-19±15.5, G2-19±14.7, G3: 17±13.7.
13. Waling K et al., [27]	126 women subjects, 10 week follow up. The follow up assessing is also taken at 17 months and 3 years. Chronic trapezius myalgia.	Mean age: 38±6, pain >12 months. VAS-PRESENT G1: strength training group, VAS:-26±21, G2-endurance training group-VAS-28±20, G3; Coordination training group, VAS-33±21, G4; control group VAS-37±24. VAS-GENERAL-G1-39±18, G2-40±21, G3-41±17, G4-43±19.	Average age: 37.9 Strength group: n=34 Endurance group: n=34 Coordination group: n=31, Control group: n=27. Exercise Strength group: neck and shoulder exercise with 10 to 12 maximal voluntary contractions in three sets Endurance group: arm-cycling and arm exercise with rubber band (30 RM= repetition maximum). Coordination group: body awareness training. Control group: stress management, once a week, 2 hours a time, for 10 weeks.	Neck and shoulder pain-VAS, Frequency of pain, PPT-Somedic pressure Algomter. VARIABLE: Pain, PPT.	Only VAS-worst was significantly decreased in G1 vs. G4 after the intervention. No significant difference at 10 week and 3 year follow-ups. When all exercise group taken together, VAS –worst and VAS-general decreased significantly versus G4 at 10 weeks. In group-1, present pain-19%, general pain-18%, worst-20%, group-2-present pain-21%, general pain-27%, worst-17%, group-3-present pain-18%, general pain-29%, worst-26%, group-4-present pain-57%, general pain-65%, worst-23%.
14. Ryan JM et al., [28] RCT	103 subjects, duration-12 weeks. Patients with chronic WAD.	In the Australian capital territory, the most frequent accident type is the collision which constitutes around 46% of all crashes. 3% people involved in collisions who are hospitalised report acute neck pain of whom 10% progress to chronic pain.	103 subjects with neck pain were randomly allocated into two groups-GROUP1-strength training group, Group 2-endurance training group-versions of progressive resistance exercise twice a week for 12 weeks.	VAS, to assess the pain, SF-36, strength, endurance, ROM, functional limitation. VARIABLES: pain, ROM, strength, endurance.	There was no statistically significant difference found between the groups in the post-treatment.
15. Horneij E et al., [29] RCT	A prospective randomised study, 282 samples, duration-18 months.	Reported neck pain and shoulder pain, perceived physical exertion at work, Permanently employeed, swedish speaking, and working atleast 50% of full time	G1(N=90) age-43(24-62), E-(FT)-25%, PT-75, YOE-≤10 yrs-31%, >10 yrs-69%, pain in 12 months-neck(n)-54%, shoulder(s)-64%, (ub)-34%, (lb)-62%. G2(N=93) age-45(23-62), (E)-(FT)39%, -(PT)-62%, (YOE)-≤10 yrs-19%, > 10 yrs-81%, pain in 12 months-(n)-61%, (s)-68%, (ub)-25%, (lb)-60%, G3(N=90) age-44(23-62), (E)-(FT)33%, -(PT)-67%, (YOE)-≤10 yrs-25%, >10 yrs-75%, pain in 12 months-(n)-59%, (s)-63%, (ub)-29%, (lb)-59%.	G1=individually designed physical training program, G2=work-place stress management, G3=control group. An individually designed physical training programme consist of posture, balance, muscle endurance exercise for neck flexors, shoulder muscle functional exercise, stretch, cardiovascular fitness.	There is no significant differences between the three groups. physical exertion at work was reduced in the physical training groups. Improvements in neck and shoulder pain did not differ within the three groups. Dissatisfaction with work related, psychological factors were generally increased in all the groups. No significant difference is found between n the groups. Changes in neck pain, IT =6, SM =12, control = 15; Interference due to neck and shoulder pain, IT =7.6±33.3, SM = 13.4±37.8, control =6.9±4.2; physical exertion IT =0.5±2.2, SM =0.05±1.9, control = 0.1±1.8.
16. OlderVoll LM et al., [30] RCT	65 sample, 15 weeks. Pain in the neck shoulders and lower back for at least 3 months during the past year and also recurring pain during the past 30 days.	G1=age-42.6±6, weight-69.4±10.2, height-167.8±4, BMI-24.7±3, Employment-18.9±9, G2=age-42.2±6, weight-69.3±9.8, height-168.7±4.9, BMI-24.5±3, Employment-17.6±9.7, G3=age-43.9±8.8, weight-67.6±9.2, height-166.7±6.6, BMI-24.4±3, Employment-18.5±9.	65 subjects allocated into three groups, Group 1-endurance training, Group 2-strength training, Group 3-Control group. The active groups met twice a week for 60 minutes of exercise over 15 weeks. It consists of body awareness, warm up, specific training exercises (endurance\ strength), cool down, stretching,	Vo_2 max, Nordic questionnaire. VARIABLE: aerobic capacity, musculoskeletal pain.	There was no overall significant group difference in VO2 m a x and there was no significant overall difference of VO2 m ax from pre- to post-test. There was no significant group difference in pain index pre scores however the time issue yielded a overall result from pre- to post-test, p=0.0004. This was because of a reduction in pain from pre- to post-test in the ET-group p=0.0001, within the ST-group, p=0.005. Aerobic capacity considerably exaggerated within the ET group, whereas no difference was found within the ST group, and a major reduction was found within the control group.

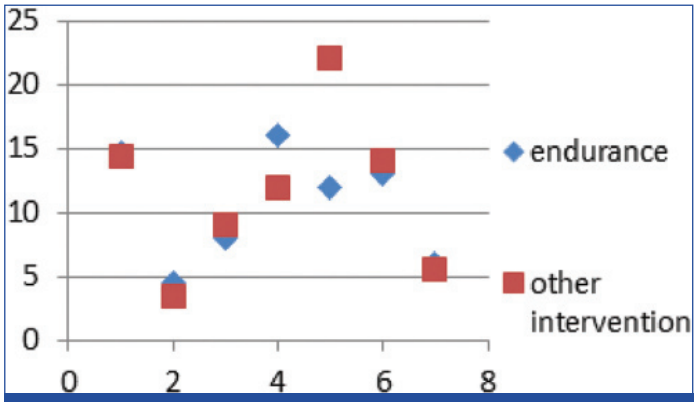
17. Ahlgren C et al., [31] RCT	102 women subjects, duration 10 weeks. The women included were less than 45 years of age and suffered from pain in the neck and shoulder muscles with duration of more than one year and yet were fully employed. The pain had to be of an intensity that caused the subjects to experience difficulty in performing their work at least once a week.	G1: age-38±6, pain duration-6.3±3.5, height-166±6, and weight-68.7±12.7. G2: age-38.5±5.6, pain duration-6.5±4.4, height-165.5±5.7, weight-66.3±8. G3: age-37.7±6.2, pain duration-6.6±4.5, height-165.4±5.7, and weight-65.9±9.4. G4: age-38.9±5.4, pain duration-7.7±4.1, height-165±5.4, and weight-64.1±9.7.	Group 1(n=29) –strength training group, Group 2-(n=28) -endurance, Group 3-(n=25) co-ordination, Group 4-(n=20)-control group.	MVC, EMG signals (mean peak torque), and mean work for contractions 60-150, SAR for the descending trapezius, anterior deltoid, and the infraspinatus, maximal O2 uptake, perceived pain was rated on 0-100 mm scale-VAS, Cybex II dynamometer. VARIABLES: muscle strength, endurance level, coordination level, aerobic power, pain.	After training, within group comparisons showed that the training groups rated less pain, and in the strength training group ratings of pain at worst differ from the non-training group. Using the non-training group as a reference, static strength increased in the strength and endurance training groups and muscular endurance in all training groups. The study indicates that regular exercises with strength, endurance of coordination training of neck and shoulder muscle might alleviate pain for women with work related trapezius myalgia.
18. Persson LCG et al., [32] RCT	81 subjects, duration-15 sessions. Patients with Chronic neck pain.	Baseline Mean: surgery 47, PT 50, collar 49, WORST PAIN (VAS, 0 to 100) Baseline Mean: surgery 72, PT 70, collar 68.	PT Group: manual therapies (massage, manual traction, gentle mobilization); modalities for pain relief like TENS, application of heat or cold (moist, ultrasound); exercise (relaxation exercises; active stretching, strengthening, endurance exercises, postural correction); ergonomic instruction]; 15 sessions of 30-45 minutes. Surgery group, collar group.	PAIN INTENSITY (VA S, 0 to 100) VARIABLES: pain.	There were no differences in postural performance or pain intensity between the groups before treatment. After treatment, the surgery group manifested significantly improved bodily property performance and reduced neck pain scores, as compared to the 2 conservative treatment teams, and their bodily property performance had improved to identical level manifested by healthy controls explanations of the improved bodily property control. SMD (PT v collar): 0.16 (SMD (PT v surgery): 0.33 (95%CI: -0.21, 0.87).
19. Hagberg M et al., [33] RCT	62 subjects. Duration – 12 weeks training. Pain in the neck-shoulder region (special cases excluded), upper trapezius tenderness, pain and tenderness present for at least 3 months, not more than 30 days of sick leave during the preceding inclusion, a job involving a constrained sitting posture with repetitive hand movements, work related pain symptoms.	Group 1-age-39.8±7.6, employed (yrs)-7.6±8.4, neck-shoulder pain worst of preceding week-43±28, present pain-42±27, pain duration(yrs)-4.6±5.0, RPE of the job-6.2±2.5. Group 2-employed (yrs)-7.0±6.7, neck-shoulder pain worst of preceding week-35±26, present pain-34±27, pain duration(yrs)-4.9±4.7, RPE of the job-6.4±2.5	62 subjects randomly allocated into two groups. Group 1 (N=31) = isometric endurance training. Group 2 (N=31) = isometric strength training.	Rating of Perceived Exertion (RPE), dynamometer, arm motion performance test, shoulder functional test, vigorimeter. VARIABLES: perceived exertion, shoulder muscle strength, grip strength.	A decrease in VAS rated worst pain during last week and pain was seen in both training groups during and after the training. We found no consistent difference in the pain rating when we compared the two training types during and after the training period. The RPE on the job decreased in the isometric shoulder strength training group during and after training. The MANOVA analysis pointed toward a difference is effective between the two training types (F= 2.81, p = 0.099). In the post test, the pain ratings were 10.6 in endurance training group, 7.4 in strength training group.
20. Waling K et al., [34] RCT	103 women with work related trapezius myalgia,	Work-related trapezius myalgia, female subjects.	103 were randomly allocated into three group, G1-strength training group, G2-endurance group, G3-Co-ordination training, G4-control group. 3 times weekly 10 weeks.	VAS-indicating pain at present, pain in general, pain at worst. Pressure algometer. VARIABLES: pain, pain thresholds.	Rated pain decreased significantly ($p<0.05$) on VAS describing pain at worst in the strength and endurance group. Pressure sensitivity decreased significantly ($p<0.05$) in four trigger points in the exercise group. All the three exercise programs showed similar decrease of pain which indicates that the type of exercise is of less importance to achieve pain deduction.
21. Taimela S et al., [35] RCT	62 subjects,(22 men, 54 women), one year follow up study. Chronic non –specific neck pain.	G1: sagittal mobility-115.4±15.7, rotational mobility-129.8±18.3, lateral flexion-73±16,. G2-sagittal mobility-118.9±19, rotational mobility-133±3, lateral flexion-76.2±14.2, trapezius pressure pain-29.6±15, rotational mobility-135.1±19.6, lateral flexion-76±7.	62 subjects-randomly allocated into three groups. Active group, home group, control group. In the active group (n=25)-endurance exercise, coordination exercise, relaxation training, behavioral support, eye fixation exercise to prevent dizziness. The level of initial loading and progression was low using modest range of motion.	VAS, CROM-total range of motion of cervical flexion, extension, lateral flexion, rotation. VARIABLE: pain, range of motion, mobility.	The average self-experiencedtotal benefit was highest in the ACTIVE group, and the HOME group rated over the CONTROL group (P 0.001). Differences between the groups in favor of the ACTIVE treatment were recorded in reduction of neck symptoms and improvements in general health and self-experienced working ability (P 0.01–0.03). Changes in measures of mobility and pressure pain threshold were minor.

22. Kadi F et al., [36] RCT	30 Women subjects, duration-10 weeks. Out of 30 women, twenty one women completed the study. Work related neck and shoulder myalgia evaluated by the physical therapist and a physician volunteered to have a muscle biopsy taken before and after a training period.	G1=age-38±6, O_2 consumption-2.5±0.3, pain duration (yrs)-6.3±3.5. G2=age-38.5±5.6, O_2 consumption-2.3±0.7, pain duration (yrs)-6.5±4.5. G3=age-37.6±6, O_2 consumption-2.2±0.4, pain duration (yrs)-6.6±4.4.	G1 (N=9)-strength training-(shoulder press, rowing, triceps and latissimus pull down). G2 (N=7)-endurance training group, cycling on an arm ergometer. G3 (N=5)-Coordination training, performed in both standing and supine positions. Each training session began with warming up and ended with stretching exercise for the active muscle group.	VAS, bicycle ergometer to estimate maximal O_2 consumption, muscle biopsy sample from the upper part of the trapezius muscle (descending 1). Enzyme-immunohistochemical analysis, double histochemical staining for COX. VARIABLES: pain, cytochrome co-oxidase, muscle fiber activity, CAF, PH, maximum O_2 consumption.	There was an increase in the proportion of type IIA fibres in strength trained group ($P < 0.05$). Strength training elicited a preferential increase in the area of type II fibres ($P < 0.05$); both strength and endurance programs induced an increase in the number of capillaries around type I and IIA muscle fibres. Finally, all training programs induced a decrease in the proportion of COX negative fibres. The significant changes in the number of capillaries and the specific changes induced by Training at the level of muscle fibres might well explain the improvement of muscle function.
23. Lundblad I et al., [37] RCT	97 female workers, duration-16 weeks. Chronic neck pain.	Industrial workers, mean age-33±9 yrs, G1-n=32, 15 were analysed, 7 drop outs, G2-n=33, 20 were analysed, 13 drop outs, G3-n=32, 23 were analysed, 11 drop outs. VAS-usually-1.2, F-1.5, C 2.0, worst-4.1, F-4.4, C-5.5, disability-work PT-1.3, F-1.2, C-1.3, leisure-PT: 0.6, F-0.9, C-0.6.	G1: 50-min strength, endurance, coordination, stretching, rhythm, ergonomic and postural exercises; G2; Feldenkrais intervention, 50 min of coordination, postural and body awareness, G3-control Group (no intervention), duration-twice a week for 16 week for G1, once a week for 16 week for G2.	VAS (0-100)-to assess the pain, follow up at 1.5 month.	The two interventions lasted 16 weeks during paid working time. The F-group showed significant decreases in complaints from neck and shoulders and in disability during leisure time. The two other groups showed no change (PT-group) or worsening of complaints (C-group). The present study showed significant positive changes in complaints after the Feldenkrais intervention but not after the physiotherapy intervention. Possible mechanisms behind the effects in the F-group are discussed.

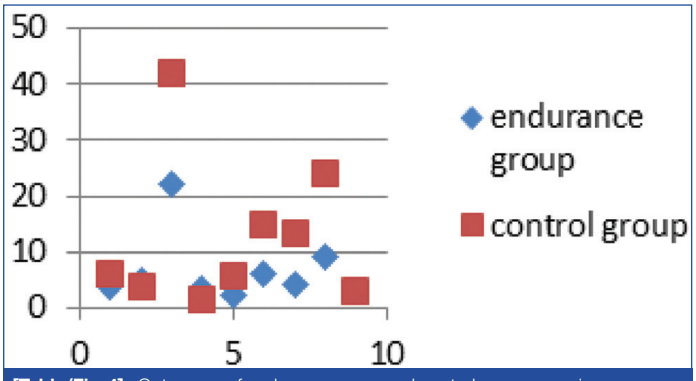
[Table/Fig-2]: Details of the twenty three studies included in the systemic analysis [15-37].
PPT: Pressure pain threshold; TPT: Thermal pain threshold; SNS: Sympathetic nervous system; UB: Upper back; LB: Lower back; STG: Strength training group; ETG: Endurance training group, VAS: Visual analog scale; NDI: Neck disability index; G: Group; MVC: Maximum voluntary contraction; FT: Full time; E: Employment; YOE: Year of employment



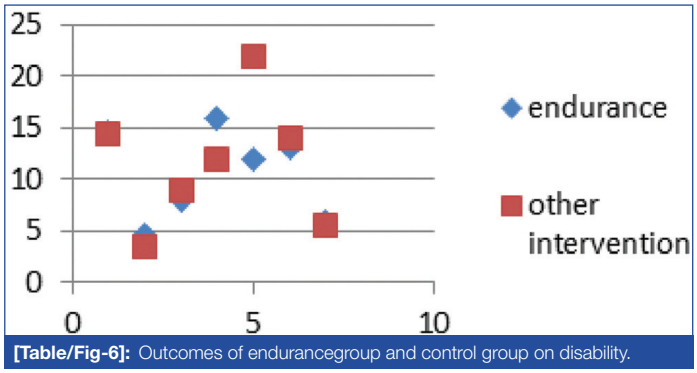
[Table/Fig-3]: Outcomes of endurance group and other interventions groups on pain.



[Table/Fig-5]: Outcomes of endurance groupand other interventions groups on disability.



[Table/Fig-4]: Outcomes of endurance groupand control group on pain.



[Table/Fig-6]: Outcomes of endurancegroup and control group on disability.

DISCUSSION

Today a lot of exercise interventions are available in physical therapy with specific features. This review aimed to find out the effectiveness of the endurance exercise on pain, disability and quality of life in subjects with chronic neck pain. Two studies considered the effect of endurance exercise on individual's quality of life, in which both the studies have found a positive effect on QOL when compared to non intervention group, Although the strengthening exercise group showed a greater improvement in QOL than the endurance exercise group [16,21]. However, minimal effect on neck pain and functional abilities was found when intervened with the endurance type of exercises. During the endurance training program, the neck pain has decreased immediately after a training period of 10 weeks, but no significant differences were seen between the control and the training group at the eight-month and three-year

PEDro Criteria	No. of articles Meeting criterion (N)	Percent meeting criteria (%)
1. If eligibility criteria specified. (yes/no)	23	100%
2. If subjects were randomly allocated to the groups (in a crossover study, subjects were randomly allocated an order in which treatments were received). (yes/no)	21	91.3%
3. Allocation was concealed. (yes/no)	1	4.3%
4. The groups were similar at baseline regarding the foremost vital prognostic indicators. (yes/no)	17	73.9%
5. There was blinding of all subjects. (yes/no)	6	26.1%
6. There was blinding of all therapists who administered the therapy. (yes/no)	3	13%
7. There was blinding of all assessors who measured at least one key outcome. (yes/no)	12	52.2%
8. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups. (yes/no)	19	82.6%
9. All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by "intention to treat". (yes/no)	22	95.7%
10. The results of between-group statistical comparisons are reported for at least one key outcome. (yes/no)	21	91.3%
11. The study provides both point measures and measures of variability for atleast one key outcome. (yes/no)	21	91.3%

[Table/Fig-7a]: Number and percentage of studies with the PEDro criteria.

	1	2	3	4	5	6	7	8	9	10	11	Quality score
1. Borisut S et al., [15]	1	1	0	1	0	0	0	1	1	1	1	7
2. Salo PK et al., [16]	1	1	0	1	1	0	1	1	0	1	1	8
3. Stewart MJ et al., [17]	1	1	0	1	0	0	1	1	1	1	1	8
4. O Leary S et al., [18]	1	1	0	1	1	0	1	1	1	1	1	9
5. Falla D et al., [19]	1	1	0	1	1	0	0	0	1	0	0	5
6. Ylinen J et al., [20]	1	1	0	1	1	0	0	1	1	1	1	8
7. Nikander R et al., [21]	1	1	0	1	1	1	1	1	1	1	1	10
8. Ylinen J et al., [22]	1	1	0	0	0	0	0	1	1	1	1	6
9. Falla D et al., [23]	1	1	0	1	0	0	0	1	1	1	1	7
10. Ylinen J et al., [24]	1	1	0	0	1	1	1	1	1	1	1	9
11. Ylinen J et al., [25]	1	1	0	1	0	0	1	1	1	1	1	8
12. Viljanen M et al., [26]	1	1	1	1	0	0	1	1	1	1	1	9
13. Waling K et al., [27]	1	0	0	1	0	0	0	1	1	1	1	6
14. Ryan JM et al., [28]	1	1	0	0	0	0	0	1	1	1	1	6
15. Horneij E et al., [29]	1	1	0	0	0	0	1	0	1	1	1	6
16. Oldervoll LM et al., [30]	1	0	0	1	0	0	0	0	1	1	1	5
17. Ahlgren C et al., [31]	1	1	0	1	0	0	0	1	1	1	1	7
18. Persson LCG et al., [32]	1	1	0	0	0	0	1	1	1	1	1	7
19. Hagberg M et al., [33]	1	1	0	1	0	0	0	1	1	1	1	7
20. Waling K et al., [34]	1	1	0	1	0	0	0	1	1	1	1	7
21. Taimela S et al., [35]	1	1	0	1	0	1	1	1	1	1	1	9
22. Kadi F et al., [36]	1	1	0	1	0	0	0	0	1	1	1	6
23. Lundblad I et al., [37]	1	1	0	0	0	0	1	1	1	1	1	7

[Table/Fig-7b]: The PEDro scores for the studies [15-37].

follow-ups [27]. Kadi F et al., suggests that there is a significant reduction in neck pain after a training period of 11 weeks. However, no difference in pain is found between the training group and controls at the 3-month and 12-month follow ups [36]. In both the groups (endurance and strength training), the greatest gains in neck strength as well as decrease in neck pain and disability was achieved during the first two months. However, the improvements continued up to 12 months follow up [20]. On the other hand, there were no changes in the local neck Thermal Pain Threshold (TPT) with either exercise. The Pressure Pain Threshold (PPT) and TPT at the leg and Sympathetic Nervous System (SNS) remains same after the exercise. Only specific exercise like Cranio-Cervical Flexion (CCF) demonstrated a little improvement in VAS ratings during the active movement [18].

Sudarat B et al., suggested that the exercise for the cervical muscles improve pain and disability. After 12 weeks of intervention, all the three exercises (strength-endurance, CCF, combination of both exercises) group, showed improvements in the pain and disability [15]. The mechanism involved in the improvement in endurance exercise group might be due to the increased motor unit recruitment, co-ordination and increased firing rate in each unit [40], an increase in the number of capillaries in the muscle, all of which contribute to the improvement of muscle fatigue in chronic neck pain [37]. Ylinen J et al., concluded that both the strength and endurance training for 12 months were effective for decreasing pain and disability in women with chronic, non-specific neck pain [25]. Nikander R et al., reported on the effect of endurance exercise training on neck pain intensity and found a statistical significant difference favoring the intervention group [21].

According to Viljanen M et al., there is a lower work satisfaction at baseline in the intervention group compared to the control group, which influences the external validity of the study. The intervention group had a relatively greater improvement in QOL compared to the control group possibly because of the difference in baseline measurement favoring the control group [26]. The articles in this review have moderate to excellent methodological quality scores according to the PEDro score, providing trustworthy evidence. The outcome measurement tools used in the included studies are reliable and valid.

CONCLUSION

In this systematic review maximum studies showed that there was some improvement in neck functional abilities and reduction in neck pain in the endurance training group. On the other hand, the long term follow ups failed to show the improvement on neck functional ability and pain.

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