Balance, dizziness and proprioception in patients with chronic whiplash associated disorders complaining of dizziness: A prospective randomized study comparing three exercise programs

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ABSTRACT

Background: Dizziness and unsteadiness are common symptoms following a whiplash injury.

Objective: To compare the effect of 3 exercise programs on balance, dizziness, proprioception and pain in patients with chronic whiplash complaining of dizziness.

Design: A sub-analysis of a randomized study.

Methods: One hundred and forty subjects were randomized to either a physiotherapist-guided neck-specific exercise (NSE), physiotherapist-guided neck-specific exercise, with a behavioural approach (NSEB) or prescription of general physical activity (PPA) group. Pre intervention, 3, 6 and 12 months post baseline they completed the University of California Los Angeles Dizziness Questionnaire (UCLA-DQ), Visual Analogue Scales (VAS) for, dizziness at rest and during activity and physical measures (static and dynamic clinical balance tests and head repositioning accuracy (HRA)).

Results: There were significant time by group differences with respect to dizziness during activity and UCLA-Q favouring the physiotherapy led neck specific exercise group with a behavioural approach. Within group analysis of changes over time also revealed significant changes in most variables apart from static balance. Conclusion: Between and within group comparisons suggest that physiotherapist led neck exercise groups including a behavioural approach had advantages in improving measures of dizziness compared with the general physical activity group, although many still complained of dizziness and balance impairment. Future studies should consider exercises specifically designed to address balance, dizziness and cervical proprioception in those with persistent whiplash.

INTRODUCTION

It is estimated that between 10-40% of persons sustaining neck trauma as a result of a motor vehicle crash will go on to have chronic persistent problems (Sterling et al. , 2003, Kamper et al. , 2008) and it is this group, that present considerable challenges to all professionals involved in their management. After pain, dizziness and unsteadiness are the next most frequent complaints in those with persistent problems following a whiplash trauma, with up to 70% reporting these complaints (Treleaven et al. , 2003). These symptoms are thought to reflect a mismatch of afferent input from the proprioceptive, visual and or vestibular systems to the sensorimotor control system and have been associated with objective deficits in proprioception, head and eye movement control and balance in those with persistent whiplash (Sjöström et al. , 2003, Treleaven et al., 2003, Treleaven et al. , 2005b, a]). Abnormal cervical afferent input, due to factors such as pain (Le Pera et al., 2001; Thunberg et al., 2001; Flor, 2003), altered neuromotor control (Falla, 2004), muscle fatigue, (Stapley et al. 2006) and psychosocial stresses (Passatore and Roatta, 2006), is suggested be one of the main causes of these disturbances (Treleaven., 2008).

Further, dizziness, proprioceptive and balance deficits do not appear to be a consequence of long term problems but occur early after injury (Sterling et al., 2003, Dehner et al. , 2008, Cobo et al. , 2009) and may be related to persistent symptoms and a poorer prognosis following a whiplash injury often termed whiplash associated disorder (WAD) (Pleguezuelos et al. , 2008, Schreiber and Fried, 2009, Cobo et al. , 2010, Phillips et al. , 2010). Nevertheless, high pain levels and the presence of dizziness have often been combined as predictors of a poorer outcome following whiplash trauma and may be related factors (Cobo et al., 2010, Phillips et al., 2010).

To date there is modest evidence for the effect of exercise in the management of WAD on neck pain and disability (Verhagen et al. , 2007, Hurwitz et al. , 2008). The suggested exercise interventions for chronic WAD include neck-specific exercise (Seferiadis et al. , 2004), general activity, (Swedish National Institute of Health) and more recently neck-specific exercises in conjunction with a cognitive behavioural approach (Soderlund and Lindberg, 2001, Landén Ludvigsson et al. , 2015) delivered by a single clinician. The inclusion of a behavioural approach in the treatment in the latter studies was reasoned to address factors such as low self-efficacy, psychological distress and fear of re-injury, which have been reported to negatively affect recovery in WAD (Stewart et al., 2007, Söderlund &

Lindberg 2007). Despite this, in Landén Ludvigsson et al's study, subjects with chronic WAD reported a substantial reduction of both pain and neck specific disability in the physiotherapist led groups of neck specific training with or without the behavioural therapy approach when compared with self-administered general physical activity. Whilst these interventions seem to address some of the known causes of abnormal cervical afferent input, these treatments do not specifically address dizziness, proprioception and balance and it is unknown whether such interventions improve these signs and symptoms in those with chronic WAD who complain of these problems. Thus the aim of this study was to perform a secondary analysis of the data from Landén Ludvigsson et al's study to compare the effect of the three exercise programs specifically on balance, dizziness and proprioception in the patients with chronic (6 months to 3 year of duration) WAD who complained of dizziness. It was hypothesized that interventions incorporating neck specific exercises would be superior to prescription of physical activity in improving dizziness, balance and proprioception.

METHODS

Design overview

This study was a secondary analysis of an assessor blinded prospective randomised controlled multi-centre study (RCT) with a 24 month follow-up (Peolsson et al. , 2013). Clinical trial NCTO15228579 http://clinicaltrialsfeeds.org/clinical-trials/show/NCT01528579. For this study, in order to assess the effects on dizziness, only subjects who reported dizziness defined as a University of California Los Angeles, Dizziness Questionnaire (UCLA-DQ) score of 5 and above were included in the analysis (Fig I). The 12 month follow-up was the measuring end point for the physical tests of proprioception and balance measured by a physiotherapist, and therefore was used for the scope of the present study. The study was approved by the Regional ethical review board in Linköping, Sweden.

Setting and Participants

Patients aged 18 to 63 (n=216, 65% female, mean age 40.5 (SD 11.4)) with chronic WAD grade II (neck problems verified in a manual clinical examination to emanate from the cervical spine) and III (history of arm pain /paresthesia with additional neurological signs in the physical examination), (Spitzer, et al 1995) that was nominated as the cause of the current symptoms, participated after informed consent in a RCT (Peolsson et al. 2013, Landén Ludvigsson et al. 2014). Patients were recruited between February 2011 and May 2012 by searches in electronic medical records from primary health care centers, orthopedic clinics and hospital outpatient services in Sweden. Patients with a WAD diagnosis at least 6 months but no more than 3 years after a whiplash injury received written and oral information about and request of interest for the study. Interested patients were screened by telephone by an experienced physiotherapist. Those who fulfilled the eligibility criteria (Table 1) attended a physical examination to ensure eligibility. Of the 216 subjects who participated in the original study, 140 patients (mean age 41.0 (SD 11.8)), 69% female) had dizziness (UCLA-DQ ≥ 5) and thus were used for the secondary analysis. One hundred and eight (77%) of the patients received treatments for their WAD before participating in the present study, with no significant differences (p=0.56) in the treatment expectations between the groups of randomisation. Treatment expectation was measured using the statement: "What kind of expectations do you have for participation in this study?" Alternatives to choose from were: "to be fully recovered", "to have great improvement", "to have some improvement" and "no expectations of recovery or improvement".

Outcome measures

All measurements (clinical and questionnaires) were conducted at baseline, 3, 6 and 12 months after baseline. Clinical, neck-related, measurements were performed in a standardised way by a well-trained investigator, who was blinded to the randomization procedure and not involved in the provision of the physiotherapy treatment.

This study was part of a RCT of 210 subjects, where NDI was considered the primary outcome measure (Peolsson et al., 2013, Landén Ludvigsson et al., 2015). For the purposes of this paper, data from only the 140 patients with dizziness (UCLA-D >5) was analysed, using the outcome measures below. . All measurements have been reported to have acceptable measurement properties (Johansson and Harnlo, 1991, Honrubia et al. 1996, Kammerlind et al., 2005a, Wibault et al. 2013).

- Self-reported dizziness intensity at rest and during movement or activity measured with VAS (0-100 mm, 0=no symptoms and 100=worst symptoms) (Carlsson, 1983, Kammerlind et al. , 2005a).
- Self-reported dizziness with the University of California Los Angeles, Dizziness Questionnaire (UCLA-DQ) (Honrubia et al. , 1996). UCLA-DQ consists of five questions of dizziness with regard to frequency, intensity, impact on daily activities, impact on quality of life and fear of dizziness giving a total score range of 5 (least severe) to 25 (most severe). No dizziness is scored as 0.
- Static clinical balance test; sharpened Romberg (tandem stance without shoes and eyes closed) with the non-dominant foot in front of the dominant foot (Kammerlind et al., 2005a). Arms were hanging alongside the body. The test-leader stood in front of the patient and measured the time in seconds with a stopwatch until the patient moved their feet from the test position, opened their eyes, touched the wall with their hand/arm or reached the maximum of 30s. The test was performed three times and the mean value was calculated.
- Dynamic clinical balance test; walking in a figure-8 (Johansson and Jarnlo, 1991). The figure-8 (two circles with inner diameter 1.5m and outer diameter 1.8m) was painted on an oilcloth. Patients were instructed to walk two circuits without shoes at a speed given by a metronome (1 step/s). Incorrect steps on or outside the line were counted by the test-leader. The average of incorrect steps from three trials was registered.
- Head reposition accuracy (HRA) (ability to reproduce the neutral head position from 30° cervical rotation with the eyes closed) was measured in degrees using the compass in the plastic helmet "cervical range of motion device" (CROM) as per Wilbault et al. (Wibault et al. , 2013) three times to the right and left, respectively. This has been shown to be a reliable clinical method of this measurement. (Wibault et al., 2013). In this study, the total score from the average error from left and right rotation was used as the measure of HRA in degrees.

Complementary measures:

- Neck specific disability was measured with the Neck Disability Index (NDI) (Vernon, 1996). Scoring ranged from 0% (no disability) to 100% (highest score for disability on all 10 items).

- Worst neck pain intensity over the last week measured with VAS (0-100 mm, 0=no pain and 100 is worst imaginable pain) (Carlsson, 1983).

Procedure

Randomisation

Randomisation was conducted following the baseline measurements. Eligible patients were independently and consecutively randomised into one of the three alternatives of exercise as described previously and below (Peolsson et al., 2013). The randomisation was formed by a computer generated list made by a statistician and was administrated by a researcher not involved in the study. This researcher placed the individual's randomization result in a sealed completely opaque envelope for distribution to the treating physiotherapist. The assessor was blinded to the treatment groups. Due to the nature of the treatment it is impossible for the participant and treating physiotherapist to be blinded.

Intervention

Treatment was provided in primary care facilities or private clinics by physiotherapists for the physiotherapy led interventions. The physiotherapy visits were made within the publicly funded reimbursement system. All physiotherapists, involved in the physiotherapy led interventions, were experienced in managing neck pain disorders and trained by the project leaders. Compliance to interventions was registered in exercise dairies both regarding physiotherapy appointments and home exercises. There were no adverse events from the interventions. For a more detailed description of the interventions see Table 2.

A) Physiotherapist-guided neck-specific exercise (NSE). This consisted of neck-specific exercises (twice weekly at the physiotherapy clinic plus home training) for 3 months. The exercise therapy focused on motor re-learning training, neck stabilization and endurance. After 3 months the participant received prescribed physical activity similar to the PPA group, but with neck specific exercises included.

B) Physiotherapist-guided neck-specific exercise in conjunction with a behavioural approach (NSEB). This was performed by a physiotherapist and consisted of a 3 months (twice weekly) cognitive behavior program in combination with neck-specific exercises performed at the physiotherapy clinic and at home (as group NSE). Patients had lectures in pain neuroscience, exercises for ability to improve daily activity and to set progressive goals. Beliefs and barriers to recovery as well as how to handle a relapse of pain was discussed. After 3 months they were prescribed physical activity with neck-specific exercises included as group NSE.

C) Prescription of general Physical Activity (PPA). The participant had one (if needed two) appointments with physical examination and motivational interviewing at the physiotherapy clinic. This included the mapping of willingness to change and motivation for change, information of benefit with physical activity (such as walking, exercise bike) and a set of patient-specific goals. Individual accessible physical activity recipes that did not include neck-specific training, with the aim of increasing the general level of physical activity was printed and given to the participant. The participant was able to phone the physiotherapist to ask questions.

Compliance: Compliance was defined as at least 50% attendance to the prescribed activities, which was evaluated with exercise diaries collected up to 6 months for the PPA group. In the 2 neck-specific groups, data from the physios of the number of appointments up to 3 months, + exercise diaries from baseline to 6 months was used. At one year only self-rated adherence to post-intervention exercise (full, fair (more than 50%), some (less than 50%) or no adherence) was obtained.

Statistical analysis: Fishers exact test was used to determine baseline differences between the groups for non-parametric data and Anova was used for parametric data.

A mixed design ANOVA was used on each of the outcome variables, analysing four time points (baseline, 3, 6 and 12 months) with treatment group (NSE, NSEB, PPA) as a between subject factor and gender as a controlling factor. The ANOVA p-values were reported for the main effect of time (with-in group differences over time); interaction between group and time (groups changing over time) and between group differences (estimated total mean differences from all the four time points).

In addition simple contrast analysis was conducted when main effects were significant. Estimated marginal means were calculated to analyse the within group effects.

The size of effect (small=0.01, medium=0.06, large=0.14 (Cohen, 1996) was calculated with Partial Eta Squared (PES) from repeated measure ANOVA. The PES is the interpretation of the proportion of the total variance accounted for in the variable of interest.

Correlation between change (baseline to 12 months) in NDI and change in the other variables was analysed with Pearson correlation coefficient.

For patients lacking a maximum of one measuring point out of the four, the closest value in time (baseline data was not replaced) was imputed.

The significance level was set at 5% for all analyses and corrected to allow for multiple post-hoc tests using a Bonferroni adjustment. SPSS version 22 was used for statistical analysis.

RESULTS

The 140 participants in this study reported more disability (p<0.0001) on the Neck Disability Index, but otherwise no significant differences in age, gender distribution, body mass index, pain intensity, kinesiophobia, psychological function or health related quality of life compared to subjects in in the original RCT which also included participants with UCLA-DQ scores of 0. (Landén Ludvigsson, et al 2015). Table 3 shows the numbers and demographics of each group and the percentage who had a UCLA-DQ score of 5 and above at baseline and at 12 months post intervention. For flow chart of patients through the study and those specifically used for the current analysis see Figure 1. There were more females (p=0.02) in the NSE compared to PPA group but no others significant differences between the groups at baseline.

Between treatment group and within-group differences over time

For all outcome measurements (, Dizziness during rest and activity, UCLA-DQ, dynamic clinical balance, HRA, NDI and neck pain intensity), except static balance, there were significant total main effects (improvement) over time (p<0.001 to 0.04) as presented below. For UCLA-DQ and dizziness during activity there were also significant time by group interaction effects (p=0.01 and p=0.003). but no between group effect on the average measure for any of the outcome measurements (p > 0.19). For descriptive data at each of the four time points and for each of the three groups, please see Table 4.

Dizziness during rest

There was a total main effect over time for dizziness at rest (F(2.5, 271.7)=5.1, p=0.003, PES=0.04). Simple contrast analysis revealed significant improvements from baseline to 6 month (p=0.009) and the 12 month (p=0.002) follow-up. There was no time by group interaction effect (Fig 2a).

Dizziness during movement/ activity

There was a total main effect over time for dizziness during activity (F(3, 324)=3.8, p=0.011, PES=0.03). There was a significant time by group interaction effect (F(6, 324)=3.4, p=0.003, PES=0.06), where dizziness during activity in the NSEB group significantly decreased from baseline to 3, 6 and 12 months follow up compared to the PPA group (p ≤ 0.008),(p≤0.012). NSEB was the only treatment group with significant improvements over time, measured from baseline to each separate follow-up (p<0.004), but with no significant further improvement after 3 months (p=1.0) (Figure 2b).Between group effect on the average dizziness during activity score was non-significant (p=0.80).

UCLA-DQ

There was a total main effect over time for UCLA-DQ (F(3, 315)=7.6, p<0.001, PES=0.07). There was a significant time by group interaction effect (F(6, 315)=2.7, p=0.015, PES=0.06). where the NSEB group significantly improved from baseline to 6 months follow up compared to the NSE group (p = 0.004) and from baseline to 3, 6 and 12 months follow up compared to the PPA group. NSEB was the only treatment group with significant improvements over time, measured from baseline to each separate follow-up (p≤0.001), but with no significant further improvement after 3 months (p>0.66) (Fig 2c).Between group effect on the average UCLA-DQ score was non-significant (p=0.62).

Static clinical balance test – Sharpened Romberg

There was no total main effect over time for static balance (F (2.8, 312) = 1.1, p > 0.34) and no time by group interaction effect (F (5.5, 312) = 1.6, p > 0.13), (Fig. 2d).

Dynamic clinical balance test – Figure-8

There was a total main effect over time for dynamic balance (F(1.8, 184.4)=4.4, p=0.02, PES=0.04). Simple contrast analysis revealed significant improvements from baseline to 12 months (p<0.001). There was no time by group interaction effect (2e).

HRA

There was a total main effect over time for HRA (F(2.6, 270.5)=7.2, p<0.001, PES=0.06). Simple contrast analysis revealed significant improvements from baseline to all follow-ups (p<0.003). There was no time by group interaction effect (Fig 2f).

NDI

There was a total main effect over time for NDI (F(2.2, 338.9)=3.2, p=0.04, PES=0.03). Simple contrast analysis revealed significant improvements from baseline to 3 months (p=0.02). There was no time by group interaction effect (Fig 2g).

Neck pain

There was a total main effect over time for neck pain (F(2.8, 304.7)=7.3, p<0.001, PES=0.06). Simple contrast analysis revealed significant improvements from baseline to 6 month (p<0.001) and the 12 month (p=0.005) follow-up. There was no time by group interaction effect (Fig 2h).

Correlations between change in NDI and change in the other variables

Change (baseline to 12 months) in NDI was significantly correlated to change in neck pain intensity (r=0.59, p<0.0001), UCLA (r=0.33, p<0.0001) and to VAS dizziness during activity (r=0.37, p<0.0001) and rest (r=0.23, p=0.01) but not to the physical measures.

Exercise compliance

Compliance (at least 50 % attendance to the intervention sessions) in the physiotherapist led groups (NSE, NSEB) was 77% and 72% respectively. Forty-seven percent of the physical activity group (PPA) reported compliance to their prescribed physical activity.

DISCUSSION

The results of this study demonstrated few significant time by group differences (2/8 measures). The NSEB was the only group that significantly improved over time. The behavioral program included relaxation technics, education for pain neuroscience and graded activity despite pain and thus may have had an effect on stress and anxiety, which is known to be associated with the symptoms of both dizziness and pain (Furman and Jacob, 2001, Cobo et al., 2010). However, such factors were not assessed in the current study and more research will be required to understand the reasons for this finding.

There was also a trend in the data for more improvements between the NSE compared with the PPA group but this did not reach statistical difference. The advantages to the groups who performed the specific neck exercises and especially those that included a behavioural approach is likely due to the intervention addressing some of the possible causes of altered cervical afferent input, such as neck pain, muscle fatigue, altered neuromotor control and improvement of psychological distress and kinesiophobia that may have led to the symptom of dizziness and changes in sensorimotor control. Previous research has suggested that improving neck muscle endurance improves postural stability in those with WAD (Stapley et al. , 2006) and that exercises to address neuromotor control of the deep neck flexor (DNF) musculature improves HRA and/or dizziness in those with neck pain (Jull et al. , 2007) (Thoomes-de Graaf and Schmitt, 2012). Similarly reduction in pain can influence balance measures (Dehner et al., 2008).

Nevertheless, despite these positive changes with the NSEB intervention exercise interventions used in this study, the size of effect was low and dizziness and balance complaints persisted in the majority of patients (at least 60%) in each group at 12 months post (Table 3). Since balance has been known to decline with ageing (Speers et al. , 1998) it would be important to address this to avoid premature decline in those with WAD, which ultimately could have implications for things such as falls. This would suggest that some patients might need tailored directed management towards managing the complaint of dizziness and sensorimotor control deficits such as postural stability and head and eye movement control training (Treleaven, 2008a).

There is some evidence that programs that emphasize gaze stability, eye head co-ordination and cervical position sense and balance tasks without local cervical spine treatment have resulted in either decreased medication intake, improved neck pain and disability, HRA and or balance in those with neck pain (Revel et al. , 1994, Fitz-Ritson, 1995, Humphreys and Irgens, 2002, Jull et al., 2007, Treleaven, 2010). Improvements in balance and symptoms of dizziness have also been observed following a vestibular or oculomotor rehabilitation program or tailored sensorimotor program in patients with persistent WAD (Hansson et al. , 2006, Storaci et al. , 2006, Treleaven, 2010). Thus these findings would warrant future research to consider the effect of this approach on dizziness and sensorimotor control in those with chronic WAD.

Further, the positive trends and findings of some improvement in these variables only in the groups who performed neck specific exercises in the current study would support the notion that management of dizziness and sensorimotor control disturbances in those with neck pain include both local treatment to the neck in combination with tailored sensorimotor control exercises in addition to a behavioural approach. (Treleaven, 2008b). This combined approach is recommended as it is thought to address the local causes of altered cervical afferent input and consider the important links between the cervical, vestibular and ocular systems and any secondary adaptive changes. Thus future research should also consider any additional benefit of sensorimotor control training to specific neck exercise training with a behavioural approach as performed in the current study.

Limitations

A limitation of this study was that the sample size calculation was based on the NDI as the primary outcome measure using both subjects complaining and not complaining of dizziness as per (Peolsson et al., 2013), with the risk to be underpowered for this subgroup analysis of secondary outcomes. Other limitations relate to the clinical rather than laboratory nature of some of the measures such as the HRA and postural stability but these have been shown to be reliable and facilitated multi-site collection of data and would be relevant for use in clinical practice (Johansson and Jarnlo, 1991, Kammerlind et al., 2005a, Kammerlind et al. , 2005b). Change in NDI was significantly, but only mildly correlated to change scores in the other self-rated measures, but was not found to be correlated to the physical measures. This may have been due to a ceiling effect in several of the physical measures. For example, at baseline, there was a ceiling/ floor effect in 20% of the patients´ tests in the sharpened Romberg test, 35% in the dynamic clinical balance test and about 50% in the HRA, with no chance of further improvements with the possibility of hiding effects of exercises for those with problems. This highlights the heterogeneity among WAD patients and the need for future studies to be specifically designed to address problems of dizziness and balance as primary outcome measures with appropriate inclusion criteria to limit these floor and ceiling effects. A further limitation was that patients were not objectively screened for vestibular pathology or other potential causes of dizziness.

Future research

Future research could consider the effect of adding exercises specifically designed to improve cervical sensorimotor control to determine if there is any added benefit with this approach, considering that dizziness and balance disturbances were still evident in many participants 12 months post–intervention.

CONCLUSION

The results of this study demonstrated few significant time by group differences. The NSEB group who performed specific neck exercises supervised in conjunction with a behavioural component by a physiotherapist was the only group that significantly improved over time, when compared to the other groups Many participants still complained of dizziness and balance impairment 12 months post intervention and future study should explore any additional benefit of exercises specifically designed to address balance, dizziness and cervical proprioception in those with chronic WAD.

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Table 1: Inclusion and exclusion criteria for the study.

Inclusion criteria
• Age 18-63 years • WAD II-III • Continuing problems (>20mm on 100mm Visual Analogue Scale (VAS) and >20% on Neck Disability Index (NDI, 0-100%)) at least 6 months after a whiplash injury but not for more than 3 years. • University of California, Los Angeles dizziness questionnaire (UCLA-DQ) score of at least 5
Exclusion criteria
• Known or suspected serious physical pathology as myelopathy, spinal tumour, spinal infection or ongoing malignancy • Earlier fracture or subluxation of the cervical column, earlier neck trauma with persistent injury • Surgery in the cervical column • Neck pain causing more than 1 month´s work absence the year before the trauma • Signs of traumatic brain injury at the time of WAD (unconsciousness, retrograde and post-traumatic amnesia, disorientation and confusion) • Generalized or more dominant pain elsewhere in the body • Diseases or other injuries that might prevent full participation in the study • Diagnosed severe psychiatric disorder • Known drug abuse • Insufficient knowledge of the Swedish language (with inability to answer the questionnaires)

Table 2: Summary of the intervention and timing of these for each group.

Week	Neck-specific exercise (NSE)	Neck-specific exercise with behavioral approach (NSEB)	Prescription of physical activity group (PPA)
1	Exercise to facilitate the deep neck muscles Activate 3-5 seconds 3 sets x 5, progress to 3 sets x 10 Exercise 2 to 3 times/day Basic information of neck muscle function and to exercise but not aggravate pain	Neck-specific exercise, the same as for the NSE group. Specific activity goal setting Neurophysiological and neurobiological processes to explain chronic pain education Body awareness techniques for relaxation and postural control Information on coping strategies to recover from pain relapse	Motivational interviewing Physical examination and individualized physical exercise program (Neck-specific exercise was not included)
2-3	Neck-specific exercise with isometric resistance in supine, progress to sitting Hold 3 to 5 seconds, 3 sets x 5, progress to 3 sets x 10 Exercise 2 to 3 times/day Information on postural control and to not aggravate pain Introduction to specific gym exercise twice weekly.	Neck-specific exercise with isometric resistance (same as NSE) Awareness of the influence thoughts have on pain and behavior	Continued exercise at home or location outside of health care system One follow-up with the physiotherapist was possible and the participants could phone with questions
4-6	Neck-specific gym exercise in weighted pulley, starting load 0.25 to 0.5 kg 3 sets x 5, progress to 3 sets x 30 Introduction to home-exercise, the same as in gym but with resistance rubber bands. Exercise in gym 2 times/week and home exercise 1 time/week.	Introduction to neck-specific gym and home exercise (same as NSE) Exercise in gym 2 times/week and home 1 time/week Home-exercise including exercises to reach the specific activity goal Introduction to breathing exercises for relaxation	Continued exercise at home or location outside of health care system
7-8	Continued gym and home exercise with gradual progression	Continued gym and home exercise with gradual progression. Repetition and reinforcement of pain education from week 1	Continued exercise at home or location outside of health care system
9-10	Continued gym and home exercise with gradual progression	Continued gym and home exercise with gradual progression Follow-up of the specific activity goal	Continued exercise at home or location outside of health care system
11-12	Continued gym and home exercise with gradual progression	Continued gym and home exercise with gradual progression Participant formulated strategies for dealing with pain relapse Follow-up of specific activity goal	Continued exercise at home or location outside of health care system

Table 3: Means and standard deviations for demographics and percentage of patients in each group with dizziness (UCLA-DQ score equal or greater than 5) pre and 12 months post baseline.

	Pre intervention			**12 months post baseline**		
Group	**NSE**	**NSEB**	**PPA**	**NSE**	**NSEB**	**PPA**
Measure						
Number of participants	n=41	n=44	n=55	n=32	n=36	n=42
Age (years) (mean and standard deviation)	37.6(12.4)	41.2(11.8)	43.3(10.9)			
Gender % of females	85	68	58*			
UCLA-DQ score ≥ 5 (%)	100	100	100	62.5	80.5	79.4

UCLA-DQ University of California Los Angeles- dizziness questionnaire
NSE= Neck specific exercise group
NSEB= Neck specific exercise with a behavioural approach group
PPA= Prescription of general physical activity group
* significant ($p<0.05$) differences between the groups

Table 4. Descriptive data of the measurements in the study at 4 time points and for the three intervention groups.

	Baseline			3 months			6 months			12 months		
	N	Mean	(SD)	N	Mean	(SD)	N	Mean	(SD)	N	Mean	(SD)
Dizziness rest												
NSE	41	18.5	(22.7)	36	14.9	(20.2)	34	12.3	(19.4)	34	9.4	(15.2)
NSEB	44	22.7	(25.3)	42	15.3	(21.5)	37	15.8	(19.7)	37	10.4	(15.7)
PPA	54	15.0	(19.1)	48	15.7	(21.6)	44	11.8	(19.5)	44	10.7	(18.5)
Dizziness activity												
NSE	41	32.2	(24.0)	36	29.2	(26.4)	34	29.4	(27.8)	34	24.2	(22.0)
NSEB	44	38.1	(30.4)	42	27.5	(26.1)	37	26.7	(28.3)	37	22.9	(24.4)
PPA	53	28.9	(25.7)	48	29.6	(28.2)	44	25.5	(25.7)	44	24.1	(28.9)
UCLA-DQ												
NSE	41	10.3	(3.4)	36	8.7	(4.8)	33	9.2	(4.4)	33	6.6	(5.5)
NSEB	44	11.8	(15.8)	41	9.2	(5.4)	37	7.7	(5.9)	37	8.2	(5.1)
PPA	55	10.5	(3.2)	46	9.8	(5.4)	41	8.7	(5.7)	42	9.5	(6.0)
Static balance												
NSE	41	15.3	(11.0)	36	13.5	(10.4)	33	14.2	(9.9)	33	17.6	(11.0)
NSEB	44	13.5	(10.7)	41	15.8	(10.9)	37	14.7	(11.0)	37	15.5	(10.8)
PPA	55	12.1	(10.2)	46	13.3	(10.6)	40	12.8	(10.3)	41	12.8	(10.5)
Dynamic balance												
NSE	39	2.8	(4.2)	35	3.9	(9.3)	31	1.2	(2.1)	31	0.8	(1.6)
NSEB	44	3.8	(4.8)	41	3.0	(4.9)	37	2.8	(4.1)	37	1.4	(2.6)
PPA	54	4.4	(7.3)	44	5.1	(8.5)	38	3.8	(6.1)	40	2.6	(5.3)
HRA												
NSE	41	5.8	(4.3)	36	3.9	(2.8)	33	3.3	(2.9)	33	4.1	(3.8)
NSEB	43	7.6	(6.2)	41	5.5	(4.5)	37	4.0	(4.1)	37	4.1	(4.8)
PPA	55	7.0	(4.4)	46	5.5	(5.2)	40	5.9	(6.0)	41	5.9	(6.0)
NDI												
NSE	41	35.7	(12.3)	36	32.9	(14.5)	34	31.1	(15.8)	34	31.5	(16.7)
NSEB	44	39.2	(13.0)	42	33.4	(14.2)	37	31.4	(15.0)	37	31.1	(17.0)
PPA	55	35.1	(14.4)	48	34.6	(15.9)	44	33.5	(18.0)	44	33.4	(17.7)
Neck												
NSE	**41**	**66.2**	**(22.3)**	**36**	**57.4**	**(26.6)**	**34**	**54.3**	**(26.4)**	**34**	**50.9**	**(28.4)**
NSEB	**44**	**66.7**	**(19.8)**	**42**	**61.0**	**(25.2)**	**37**	**51.9**	**(26.3)**	**37**	**52.7**	**(28.8)**
PPA	**54**	**62.1**	**(26.8)**	**48**	**60.2**	**(28.2)**	**44**	**49.9**	**(30.6)**	**44**	**52.2**	**(29.9)**

SD=Standard Deviation; NSE= Physiotherapist guided neck-specific exercise group; NSEB=Physiotherapist guided neck-specific exercise in conjunction with a behavioural approach group; PPA=Prescription of general physical activity group; Dizziness rest=Dizziness during rest/100mm; Dizziness activity=Dizziness during activity/100mm; UCLA-DQ=the University of California Los Angeles Dizziness Questionnaire/25; Static balance test=Sharpened Romberg/30 seconds, Dynamic balance test=Walking in a figure-8/ number of steps; HRA=Head Repositioning Accuracy/ degrees; NDI=Neck Disability Index%; Neck pain=Worst neck pain intensity over the last week/100mm

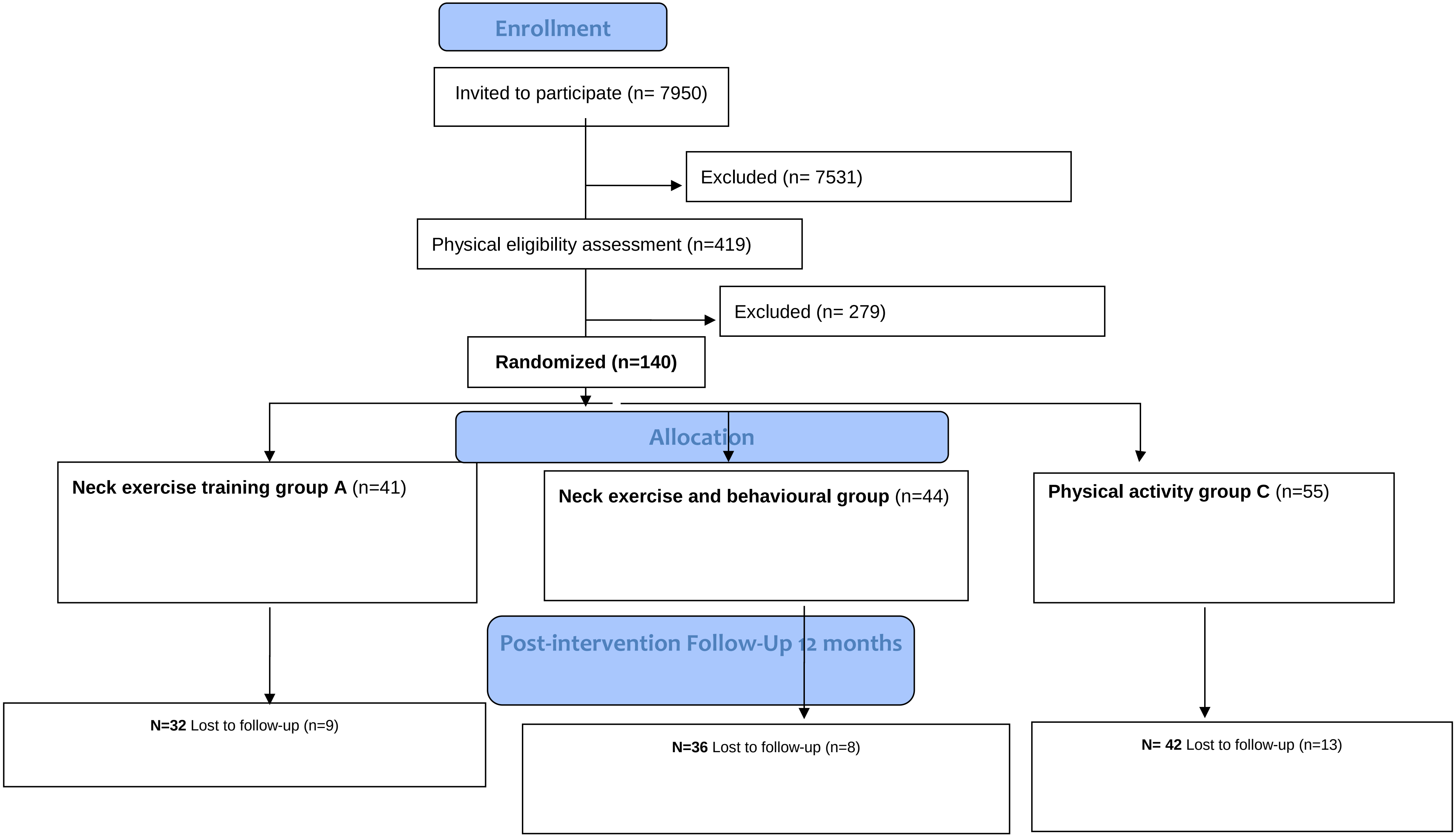
Enrollment
Invited to participate (n= 7950)
Excluded (n= 7531)
Physical eligibility assessment (n=419)
Excluded (n= 279)
Randomized (n=140)
Allocation
Neck exercise training group A (n=41)
Neck exercise and behavioural group (n=44)
Physical activity group C (n=55)
Post-intervention Follow-Up 12 months
N=32 Lost to follow-up (n=9)
N=36 Lost to follow-up (n=8)
N= 42 Lost to follow-up (n=13)

Figure 1. Flow chart describing the numbers of participants for each group, from recruitment, to group allocation, treatment, follow up and analysis, including drop outs. Only subjects with University of California Los Angeles, Dizziness Questionnaire (UCLA-DQ) scores 5 and above were used in the analysis (shown in bold) n= 140 baseline, n=110 at the 12 month follow-up.

Figure 2 a-h: The Figures show cross-sectional descriptive data (mean and 95% confidence intervals) at each time point (baseline, 3, 6 and 12 months) for each group for

a) Dizziness at rest VAS /100mm

b) Dizziness VAS during motion or activity /100mm

c) University of California Los Angeles, Dizziness Questionnaire (UCLA-DQ)/25

d) Static balance test- Romberg test /30 seconds

e) Dynamic clinical balance test (number of steps)

f) Head repositioning accuracy (HRA) in degrees

g) Neck disability index (NDI) %

h) Neck pain visual analogue score (VAS)/100mm