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Effectiveness of magnetic therapy versus exercise in elderly patients with chronic mechanical neck pain: A randomized clinical trial

Randa Mohammed Awad Almasri [1], Alsayed Abdelhameed Shanb [2]*

[1] King Fahd General Hospital, Ministry of Health, Jeddah, SAUDI ARABIA
[2] Department of Physical Therapy, College of Applied Medical Sciences, Imam Abdulrahman Bin Faisal University, Dammam, SAUDI ARABIA
*Corresponding Author: aashanb@iau.edu.sa

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ABSTRACT

Background: Mechanical neck pain (MNP) affects all age groups, it has a substantial physical, psychological, and economic impact, especially in elderly. This study aimed to evaluate effect of addition of magnetic therapy (MT) to exercise versus exercise therapy alone on neck pain (NP), proprioception, and balance in elderly patients with chronic MNP.

Materials & Methods: 50 elderly patients with chronic MNP were assigned to magnetic group (25 patients who practiced exercise program for 35-40 minutes/session three sessions per week for four weeks in addition exposure to MT for 20 minutes each session three sessions per week for four weeks) and control group (25 patients who practiced only the exercise program). The severity of pain, cervical joint position sense (JPS) and balance performance were measured by using the visual analogue scale (VAS) goniometer and the both single-leg stance time (SLST), and timed up and go (TUG) tests, respectively. ANOVA and Independent t-tests were used to determine significant differences within and between two groups for normal variables, whereas the Mann-Whitney and Kruskal-Wallis tests were used for not normal variables.

Results: The results show significant improvements in VAS, SLST (with open and closed eyes), TUG, and JPS after interventions in both groups, p-value <0.05, while addition of MT to exercise program induced only significant differences in VAS, SLST (with open & closed eyes), TUG, except JPS, p-value = 0.002, 0.047 & 0.037, 0.001, and 0.928 respectively, in favor to the magnetic group.

Conclusions: Multi-dimensional exercise program is effective in relieving NP and improving balance in elderly with MNP, addition of MT to exercise program could induce superior effects only on pain and balance for elderly patients with MNP.

Keywords: chronic neck pain, exercise training, proprioception, elderly

INTRODUCTION

Neck pain (NP) is a common musculoskeletal condition, which is characterized by pain in the posterior area of the neck radiating up to the head and down to the arms and chest wall [1]. NP can be classified as non-mechanical and mechanical neck pain (MNP) [2], 80.0% of NP cases are MNP [3] in which the pain extends posteriorly from the nuchal line to the thoracic region without neurological manifestations [4]. NP affects approximately two-thirds of people worldwide; women are more affected with NP than men [5]. Globally, NP affects many people as much as 78.3% of the general population, its prevalence varies between 2.6% and 14.6% [6, 7].

In Saudi Arabia, NP represents 64.0% of musculoskeletal conditions of office workers [8], also NP represents quarter of the treated patients in out-patient clinics of the physical therapy [9]. NP constitutes the fourth major cause of disability after low back pain (LBP) [10], as it has a high financial impact, it increases both absenteeism and costs of medical services [11], 48.0% of those who seek medical advice for NP are older adults [12] with increasing age, 30.0% of acute cases progress to chronicity with several comorbidities, e.g., headache, back pain, or depression [5], which has severe impact among older adults. Elderly who are perceived to have higher levels of pain, may suffer from dizziness, balance disturbance, headache [13], depression, and other mental health issues [13, 14].

NP particularly MNP is common in elderly[6, 15] as a result of the associated musculoskeletal alterations with aging process [16] including formation of cross-linking, redistribution of muscle fiber types, degenerative changes in the inter-spinous ligaments, decrease of oxygen and nutrition in intervertebral disks, release of inflammatory substances, narrowing of spinal foramina, irritation of the nerve roots [15], loss of elasticity and increases of joints stiffness [16] in addition, reductions in estrogen level particular in older females, loss of muscle mass and weakness [17], obesity [13], crystal deposition in ligaments and muscles [18], overuses

This work is derived from a master thesis of Randa Mohammed Awad Almasri (e.g., house & office workers) and psychological disorders (e.g., depression and anxiety) which are linked to NP in elderly [19].

Proprioception is the cumulative neural input to the central nervous system from mechanoreceptors (joints, muscles, and tendons). The vestibular system includes semicircular canals and otolith organs that provides information about head rotation and body acceleration movements [20], while vision provides visual information about the position and direction of the movements of body parts in space [21]. Proprioception is very important for older adults to coordinate and maintain their body movements, static and dynamic balance [22]. Afferent inputs to the nervous systems and proprioception are affected with advancing age, so the risk of falls increases [22] in presence of cervical muscle weakness. NP aggravates the disturbances in the joint position sense (JPS), proprioception, and balance performance [23] in other meaning JPS impaired in patients with chronic NP [10]. Even healthy older adults have impaired proprioception [24], in Saudi population 50.0% of elderly experienced at least one fall incidence in their lives [25].

Several approaches are used for treatment of NP. They are classified into conservative as medication and physical therapy, and/or invasive as injection or surgery [5]. Physical therapy includes manual therapy, exercise training, education, and electrotherapy while medication as anti-inflammatory drugs [26]. Magnetic therapy (MT) is widely applied to improve blood circulation, relief headaches, depression, accelerate healing of bed sores [27] and to treat multiple musculoskeletal conditions but its usage on proprioception, and balance in elderly with NP is very limited.

MT was applied in adult patients with a 20 hertz (Hz), a 0.8 µT intensity for 20 minutes two times per week for six weeks in patients with MNP (age 20-30 years). Significant improvements were achieved in NP severity and functional disability [28]. Also, it was applied with an intensity of 0.8 mT for 20 minutes, three sessions per week for four weeks, in addition, hot packs and exercise training in patients with MNP (age 18-40 years). Their results show significant improvements in severity of NP, functional disability, and neck range of motion (ROM) [29]. In addition, the usage of MT with a 50 Hz, a 2.5 µT intensity for 10 minutes, three times a week for four weeks, in combination with ultrasound therapy, transcutaneous electrical nerve stimulation (TENS), hot packs and exercises in patients with cervical radiculopathy (age 30-45 years) achieved significant improvements in NP, functional disability, ROM, and neck proprioception[30], while other authors applied MT in patients with wide range of age, they applied MT for 30 minutes /session for four days in patients with MNP (age 27-89 years). Significant reduction in pain severity was achieved [31].The authors used MT with a 0.1- 64 Hz frequency, a 40 µT intensity for 30 minutes twice daily for three weeks in patients with NP (age 30-70 years). Their results show significant improvements in ROM, pain intensity, and functional disability [32].

Also, MT was applied with a 50 Hz, a 0.6 µT intensity for 20 minutes, five days a week for three weeks, in addition hot packs and TENS, in patients with MNP (age 18-65 years) [33]. The authors gained significant improvements in NP, sleeping quality, and quality of life (QoL) with non-significant results for functional disability, depression, and emotional subscale of QoL [33]. Whereas it was found that application of MT with a frequency of 10-100 Hz for 15 sessions over three weeks, in addition, usage of TENS, hot packs, and exercise, for patients with MNP (age 25-59 years), did not achieve any significant results for severity of NP, functional disability, and QoL [34]. MT was applied with a frequency of 25 Hz, intensity of 5 µT for 15 minutes for four weeks. The findings did not confirm any significant improvements in severity of NP (age 18-65 years) [35]. Also, MT did not show any significant results on balance, NP and functional disability in patients with MNP (age 25-55 years) after application of MT five times a week for eight weeks, with a frequency of 5-25 Hz and intensity of 5-70 µT [36].

However, several authors in previous studies used different devices for MT with wide variations in the chosen parameters for MT application. The sample of patients was also characterized with wide range of age such as in [28-30], while other studies included different categories of age in their samples, which results in wide potential variations of responses and outcomes to therapeutic intervention [31-36]. Only one study investigated effects of MT on NP and proprioception as outcome measures in adult patients (age 30-45 years) with cervical disc prolapse [30]. Therefore, the current study aimed to evaluate the effects of adding MT to exercise therapy versus exercise therapy alone on severity of NP, JPS, and balance in elderly patients with chronic MNP.

MATERIALS & METHODS

Study Design

A randomized clinical trial registered with ID: NCT05600647.

Randomization

The blocking randomization was done by the primary investigator using a random number generator with computer program software: http://mahmoodsaghaei.tripod.com/Softwares/randalloc.html#Generate. Allocation of patients was done by using concealed opaque envelopes.

Blinding

It is a single blind study. Outcome measures were assessed by an independent assessor (research assistant) who was blinded to study's aim and allocation of the groups of patients.

Patients Sample

Prior to recruitment all patients were screened by an orthopedic consultant. 54 male and female patients with chronic MNP were enrolled from the out-patient clinics of physical therapy, King Fahd General Hospital and King Abdullah Medical Complex on Jeddah, Saudi Arabia. Their ages are 60 years and above. They were randomized and equally assigned to magnetic group: 27 patients practiced the constructed exercise program in addition to being exposed to MT. Control group: 27 patients practiced the constructed exercise program alone.

Sample size calculation

It was calculated using an online tool (https://www.stat.ubc.ca/~rollin/stats/ssize/n2.html) that used the pain variable in the previous study [28] as a primary outcome measure (mean 1 = 2.17 and mean 2 = 3.033; standard deviation [SD] = 0.79). The significant value was 0.05 with a power of 0.80. Total sample size was 44 patients. After allowing a dropout rate of 20.0%, number of recruited patients was increased to 54 [37].

Inclusion criteria

All patients were recruited if they had chronic MNP that caused only by mechanical factors, e.g., cervical spondylosis, muscle weakness or tenderness, or poor posture [36], had pain in the neck and referred to the shoulders and between the scapulae at rest or with movement for at least >three months [28]. Also, its intensity should be at least three out of 10 on the visual analogue scale (VAS) [38]. They did not receive any physical therapy interventions in the last five weeks [36], and their age is 60 and above.

Exclusion criteria

Patients were excluded if they had cognitive impairment; rheumatic diseases; infected joints; uncontrolled cardiovascular or pulmonary diseases; neurological conditions, e.g., multiple sclerosis, stroke, or Parkinson's disease, disk herniation, or malignancy [32, 38], and previous cervical spine surgery [28], patients with any causes of NP other than muscular or degeneration causes, e.g., fractures, ligamentous instability, cervical myelopathy, vascular deficiency, cervical canal stenosis, whiplash injury [9], and patients with cardiac pacemakers [38], patients had dizziness or disturbances due to vestibular system dysfunction, who received corticosteroid injections in the last 12 weeks before participation [39], and those suffering from any conditions that contradict with the conduction of the study were excluded.

Assessment Procedure

A. **Severity of neck pain** was measured by using VAS. On a 10-cm line, zero represents no pain, and 10 is the maximum level of pain severity. VAS is a reliable and valid measure for pain severity in patients with chronic musculoskeletal problems [40].

B. **Cervical proprioception** was measured by determination of JPS error for cervical ROM. It was calculated as the active relocation of a specific angle determined by the research assistant. It can be measured using a ROM goniometer device [41]. The test has high intertester reliability for patients with NP [42].

C. **Balance** was measured in both static and dynamic aspects.

   1. *Single-leg stance time (SLST)* was used to measure static balance [43]. The recommended time for standing was 90 seconds [44, 45]. SLST is an effective tool to identify people at high risk of falling, i.e., a score <30 seconds [44]. It is a reliable and valid tool for measuring static balance in older adult populations [46]. The minimum detectable change is 4.03 seconds [45].
   2. *Timed up and go (TUG)* test was used to measure dynamic balance [47]. The minimum detectable change is 3.01 seconds [45]. TUG test is practical and can be implemented quickly [48]. It is a valid test for measuring functional balance and it has high interrater reliability [47]. Normal values range between eight and 12.7 seconds for people aged 60 and above [49].

Therapeutic Procedure

Every patient in both groups practiced the exercise training program for 35-40 minutes/session, three sessions/week for four weeks. It included the following exercises.

A. **Posture exercises:** Every patient was asked to sit up straight by keeping the head, neck, and back straight and keep the ears in line with the shoulders and gently squeeze the shoulders backward [50].

B. **Range of motion exercises:** Every patient was asked to move the neck gently in all directions of neck movements' flexion, extension, lateral flexion, and rotation beyond the point of restriction within the limit of tolerated pain. Each movement was repeated 10 times for three sets [28].

C. **Strengthening exercises:** All patients were asked to tuck in the chin and then progress to lifting the head from the supine position. Deep extensor muscles were strengthened from the supine position, with the patient tucking in the chin while pushing the head back. This movement was repeated from a prone position as a progression. Each exercise was repeated five times for three sets [28].

D. **Stretching exercises:** Every patient was asked to move the head to the side in lateral flexion and hold that position with the opposite hand to add stretch while the other handheld the edge of a chair to prevent upward movement of the shoulder. The stretch was held for 20 seconds and repeated two-three times [28].

E. **Proprioceptive exercises:** These exercises were performed with a laser pointer worn on the head while sitting roughly a meter away from a board. For the first exercise, the patient was asked to move the light on the trace lines in a zig-zag pattern while focusing on movement accuracy. The exercise progressed by moving the head faster while maintaining accuracy. For the second exercise, the patient was instructed to move the light on the crossed lines from the edge and then back to the center point on the board with the eyes open. To progress, the exercise was repeated with the eyes closed. The patient was provided with feedback to improve their performance. All exercises were repeated five times in three sets [51].

F. **Balance exercises:** Static balance training consisted of asking the patient to stand on one leg as long as possible. The second exercise involved a tandem stance. Each patient was asked to place one foot in front of the other and hold that position as long as possible. For safety, the patient stood next to a steady chair. Each exercise was repeated five-10 times. Dynamic balance training consisted of asking the patient to walk as long as possible while moving the head to the left and right. The second exercise was a tandem walk for as long as possible. The progression for all the exercises required performing the same exercise with closed eyes [51].

Magnetic group

Twenty-five male and female patients with MNP practiced the exercise program for 35-40 minutes/session, three sessions/week for four weeks, in addition exposure to MT for 20 minutes each session via using a bio-electro-magnetic-energy-regulation (BEMER) therapy device. BEMER 3000 is a device for generating MT. It was applied only for patients of magnetic group from supine comfortable lying position after finishing

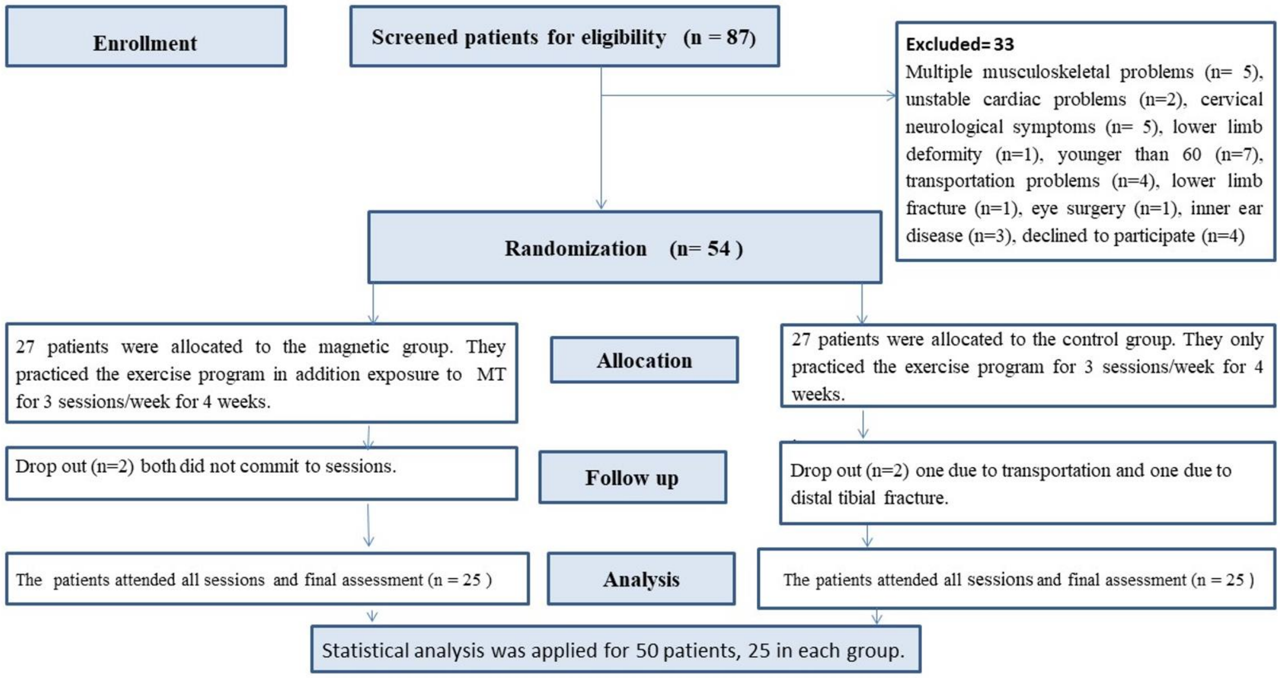

Figure 1. Flow chart of the patient's recruitment (Source: Authors' own elaboration)

the exercise program. It generates a weak pulsed electromagnetic field through a connected coil mat to the device. According to device's manual, program four is the maximum program setting, which was chosen, to provide 20 minutes of deep MT for deep tissues, bones, and joints at a flux density of 35 µT (level 10) and a frequency of 50-60 Hz [52].

Control group

Twenty-five male and female patients with MNP only practiced the exercise program for 35-40 minutes/session, three sessions/week for four weeks. These exercises were adapted from previous studies on chronic NP [28, 51] and adjusted according to the patient's physical abilities and progressed after two weeks or according to the patient's performance. All patients of both groups were asked to practice the prescribed exercise once a day for 20 to 30 minutes on the other days as a home program and the regular medications for pain were allowed [36].

Statistical Analysis

The collected data were analyzed using SPSS software (version 25). The descriptive and interferential analysis of data was expressed as Mean±SD. Shapiro–Wilk test was used to test normality of data distribution. Pearson's Chi-squared test was used to compare the categorical variables between the two groups. ANOVA and independent t-tests were used to determine significant differences after interventions within group and between groups for normal variables while Mann-Whitney and Kruskal-Wallis tests were used for not normal variables. The level of significance was determined at p-value <0.05 with a confidence interval of 0.95.

RESULTS

Out of 87 screened patients, only 54 met the inclusion criteria. Four patients dropped out, two from magnetic group, as they did not commit to the sessions, and two from control group one for transportation difficulties, and the second had a right distal tibial fracture. The final analysis was applied for 50 patients, 25 in each group (**Figure 1**).

Table 1. Demographic characteristics of recruited patients for both groups

Variables	Magnetic group: M±SD	Control group: M±SD	p-value
Age (in years)	62.76±2.85	63.12±2.96	0.663†[b]
BMI (in kg/m^2)	27.31±2.86	25.87±3.68	0.129†[b]
Gender (n [%])			
Male	10 (40%)	11 (44%)	0.774†[a]
Female	15 (60%)	14 (56%)	
Affecting diseases or comorbidities (n [%])			
One disease	6 (24%)	7 (28%)	0.945†[a]
Two diseases	14 (56%)	13 (52%)	
Three diseases	5 (20%)	5 (20%)	
Used medications (n [%])			
Two drugs	7 (28%)	7 (28%)	0.915†[a]
Three drugs	15 (60%)	14 (56%)	
Four drugs	3 (12%)	4 (16%)	

Note. [a]Pearson Chi-square test was used for categorical variables; [b]Independent t-test was used for continuous variables; BMI: Body mass index; & † (non-significant difference) p-value >0.05, Sig. p-, Z-, or t-value

Demographic Data of Recruited Patients

The results show non-significant differences in the demographic data between patients of both magnetic and control groups including age, BMI, gender, chronic diseases, and used medications. The percentage of male to female was 40.0%-60.0% & 44.0%-56.0% in magnetic & control groups respectively. All patients in both groups had one or more chronic diseases as comorbidities, including hypertension, asthma, diabetes, hyperlipidemia, and osteoporosis (**Table 1**).

Adherence Rate

Adherence rates to interventions were 91.67% (11 sessions) and 83.33% (10 sessions) in the magnetic and control groups respectively, with no significant difference between the groups (p-value=0.147).

Table 2. Mean values of VAS of both magnetic & control groups

Variables	Magnetic group: M±SD	Control group: M±SD	Significance
	Pain (VAS)		
Pre	7.56±1.15	7.40±1.38	0.803†[M]
Post-I	4.96±0.97	5.68±0.94	0.016*[M]
Post-II	3.12±0.88	3.96±0.84	0.002*[M]
Significance	<0.001*[K]	<0.001*[K]	
Pre vs. post-I	0.001*[P]	<0.001*[P]	
Pre vs. post-II	<0.001*[P]	<0.001*[P]	
Post-I vs. post-II	<0.001*[P]	0.007*[P]	

Note. Pre: Baseline assessment; Post-I: Assessment after two weeks; Post-II: Final assessment after four weeks; [K]Kruskal-Wallis's test; [P]Pairwise comparison for repeated measures; [M]Mann-Whitney test; VAS: Visual Analoge Scale; *p-value <0.05 (significant differences); & †p-value >0.05 (non-significant differences)

The results show non-significant differences between two groups in mean values of VAS at pre assessment p-value >0.05, whereas significant reductions were obtained in mean values of pain at post-I & post-II, p-value <0.05, the results show significant differences in mean values of VAS within each group, p-value <0.05 (**Table 2**).

There are non-significant differences in mean values of neck flexion and extension JPS between two groups at pre, post-I, & post-II interval assessments p-value >0.05, whereas significant differences were obtained within magnetic and control groups p-value<0.05 (**Table 3**). The results of pairwise comparison show significant differences only in mean values of neck flexion & extension JPS between pre and post-II in magnetic and control groups p-value <0.05 (**Table 3**).

There are non-significant differences in mean values of the neck right and left lateral flexion JPS between two groups at pre, post-I & post-II interval assessments p-value >0.05, whereas significant differences were obtained within each group p-value <0.05. The results of pairwise comparison show significant differences only in mean values of neck right and left lateral flexion JPS between pre- and post-II in both magnetic and control groups p-value <0.05 (**Table 4**).

There are non-significant differences in mean values of neck right and left rotation JPS between two groups at pre, post-I, & post-II interval assessments p-value >0.05, whereas significant differences were obtained within each group p-value <0.05. Pairwise comparison show significant differences only in mean values between pre- and post-II in both magnetic and control groups p-value <0.05 (**Table 5**).

The results show non-significant differences in mean values of TUG test at pre assessment (12.65±2.29, 12.48±2.16), p-value=0.777, whereas significant differences were obtained in mean values at both post-I (11.39±1.84, 12.18±1.79) and post-II (6.99±1.46, 8.02±1.19), p-value=0.004 & <0.001 between both magnetic and control groups respectively, while repeated measures analysis show significant differences within magnetic and control groups respectively P-value=<0.001.

The results of pairwise comparison show significant differences between pre & post-I and between pre & post-II in mean values of TUG test interval assessments of the both magnetic and control groups p-value<0.05 except non-significant difference was determined between post-I & post II of the control group, P-value=0.99.

The mean time values of SLST with open and closed eyes show non-significant differences at pre- and post-I of both magnetic and control groups p-values=0.288, 0.303, 0.938, & 0.922, whereas significant differences were detected at post II, p-value=0.047, 0.037 between both magnetic and control groups, respectively. The results of Kruskal-Wallis's test show significant differences within magnetic and control groups during both open and closed eyes, P-value=<0.001, 0.013 & <0.001, 0.003. The pairwise comparison show presence of significant differences between pre & post-I and between pre- & post-II interval assessments of the both magnetic and control groups P-value=0.011, 0.006, & 0.007, 0.003 and P-value=<0.001, 0.020, & <0.001, <0.001 except non-significant

Table 3. Mean values of neck flexion & extension JPS within & between two groups

Variables	Magnetic group: M±SD	Control group: M±SD	Significance	Magnetic group: M±SD	Control group: M±SD	Significance
	Neck flexion JPS			Neck extension JPS		
Pre	1.78±0.74	2.34±1.34	0.119†[M]	2.64±1.41	2.76±1.39	0.475†[M]
Post-I	1.50±0.50	2.06±1.35	0.105†[M]	2.30±1.36	2.32±1.35	0.827†[M]
Post-II	1.04±0.70	1.88±1.31	0.163†[M]	2.10±1.31	2.10±1.29	0.928†[M]
Significance	0.005*[K]	0.006*[K]		0.045*[K]	0.020*[K]	
Pre vs. post-I	0.112†[P]	0.155†[P]		0.708†[P]	0.833†[P]	
Pre vs. post-II	0.004*[P]	0.005*[P]		0.038*[P]	0.017*[P]	
Post-I vs. post-II	0.757†[P]	0.668†[P]		0.574†[P]	0.276†[P]	

Note. Pre: Baseline assessment; Post-I: Assessment after two weeks; Post-II: Final assessment after four weeks; [K]Kruskal-Wallis's test; [P]Pairwise comparison for repeated measures; [M]Mann-Whitney test; *p-value <0.05 (significant differences); & †p-value >0.05 (non-significant differences)

Table 4. Mean values of neck lateral flexion JPS within & between both groups

Variables	Magnetic group: M±SD	Control group: M±SD	Significance	Magnetic group: M±SD	Control group: M±SD	Significance
	Right neck lateral flexion JPS			Left neck lateral flexion JPS		
Pre	3.00±1.75	3.10±1.70	0.678†[M]	2.79±2.23	3.03±2.13	0.364†[M]
Post-I	2.70±1.69	2.76±1.58	0.664†[M]	2.48±2.06	2.76±2.07	0.338†[M]
Post-II	1.46±1.12	1.81±1.37	0.399†[M]	1.36±1.36	1.56±1.28	0.538†[M]
Significance	0.006*[K]	0.023*[K]		0.031*[K]	0.029*[K]	
Pre vs. post-I	0.722†[P]	0.743†[P]		0.467†[P]	0.453†[P]	
Pre vs. post-II	0.004*[P]	0.019*[P]		0.011*[P]	0.010*[P]	
Post-I vs. post-II	0.134†[P]	0.344†[P]		0.068†[P]	0.067†[P]	

Note. Pre: Baseline assessment; Post-I: Assessment after two weeks; Post-II: Final assessment after four weeks; [K]Kruskal-Wallis's test; [P]Pairwise comparison for repeated measures; [M]Mann-Whitney test; *p-value <0.05 (significant differences); & †p-value >0.05 (non-significant differences)

Table 5. Mean values of neck rotation JPS within & between both groups

Variables	Magnetic group: M±SD	Control group: M±SD	Significance	Magnetic group: M±SD	Control group: M±SD	Significance
	Right neck rotation JPS			Left neck rotation JPS		
Pre	3.48±3.08	3.40±2.95	0.849†M	3.64±3.35	3.96±3.16	0.279†M
Post-I	3.16±2.91	2.88±2.50	1.000†M	3.26±3.20	3.60±3.02	0.196†M
Post-II	1.52±1.49	1.66±1.81	0.725†M	1.72±1.57	1.96±1.61	0.527†M
Significance	0.016*K	0.031*K		0.049*K	0.025*K	
Pre vs. post-I	0.547†P	0.359†P		0.474†P	0.521†P	
Pre vs. post-II	0.019*P	0.028*P		0.017*P	0.028*P	
Post-I vs. post-II	0.101†P	0.281†P		0.094†P	0.150†P	

Note. Pre: Baseline assessment; Post-I: Assessment after two weeks; Post-II: Final assessment after four weeks; KKruskal-Wallis's test; PPairwise comparison for repeated measures; MMann-Whitney test; *p-value <0.05 (significant differences); & †p-value >0.05 (non-significant differences)

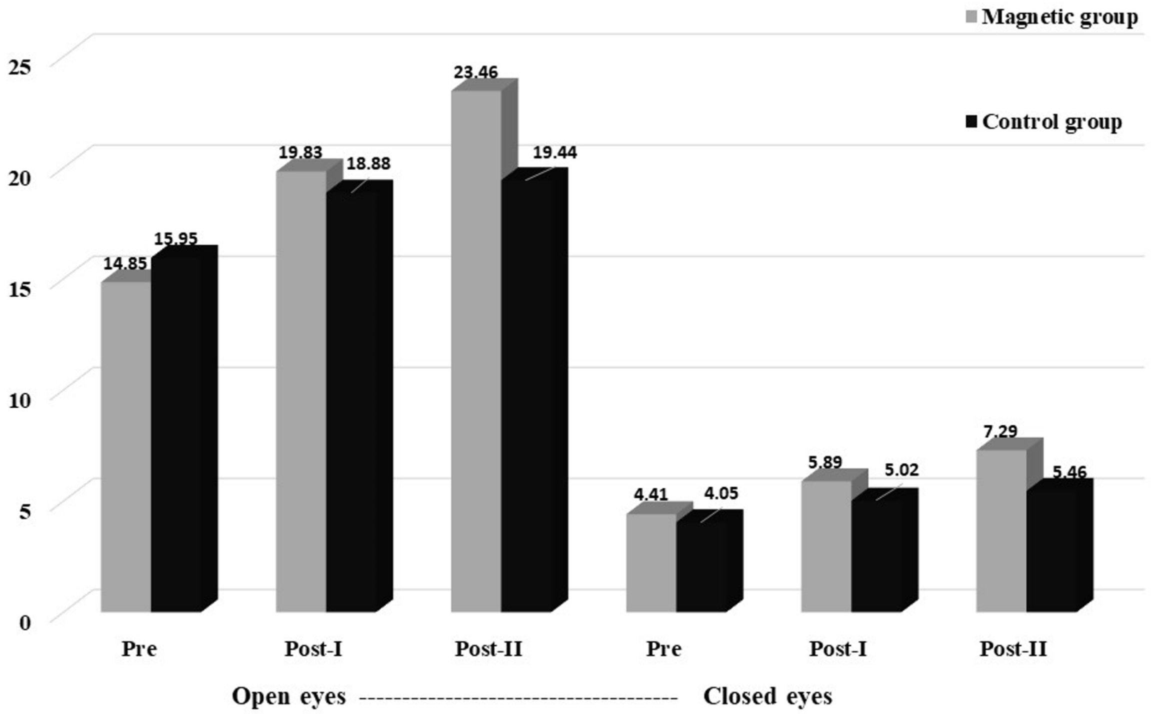

Figure 2. Mean values of SLST with open and closed eyes (Source: Authors' own elaboration)

difference was determined between post-I & post II of both magnetic and control groups, P-value=0.394, 0.699, & 0.223, 0.990 (**Figure 2**).

DISCUSSION

This study aimed to evaluate the effect of addition of MT to exercise (magnetic group) vs. exercise alone (control group) on severity of NP, proprioception (JPS), and balance in elderly with chronic MNP. The results show significant improvements after interventions within each group while the addition of MT to the exercise program induced significant differences only in reduction of NP severity and improving balance (to SLST and TUG) in favor to magnetic group.

Our findings agree with the results of previous studies [28-30]. The authors found significant improvements in NP after adding MT to an exercise program in patients with chronic MNP [28], while others obtained significantly improvements in NP and function in patients with MNP after application of MT [29], also it was proved that addition of MT to conventional physiotherapy significantly improved NP and ROM in patients with cervical radiculopathy [30]. The extra improvements and the differences in their results may be due to the age of their patients sample i not the case in our study included elderly patients, whereas they included adult patients (age 30-45 years) in their study, which may potentiate better responses to the therapeutic intervention, in addition to exercises they used conventional physiotherapy program included hot packs, ultrasound therapy, and TENS for all patients [30], which may also improve patients responses.

The results of the current study contradict the findings of [36]. They did not obtain any significant results in reducing pain and disability after application of MT combined with neck balance system in patients with MNP [36]. This may be due to they applied MT device with different parameters at a frequency of 5-25 Hz and an intensity of 5-70 µT different than that used in the current study at a frequency of 50-60 Hz and an intensity of 35 µT, also they applied MT with neck balance system, whereas in the current study MT was applied in conjunction with multi-dimensional exercise program.

Only few previous studies evaluated effect of MT on proprioception and balance in older patients with lumbar canal stenosis or in patients with diabetic peripheral neuropathy [53, 54]. Aydın who conducted a trial on effect of MT at a frequency of 25 Hz and an intensity of 8 µT for 15 minutes for 10 sessions over two weeks, combined with exercises in older patients with lumbar spinal canal stenosis [53]. His findings showed significant improvements in TUG measurements. Also, significant improvements in functional balance were determined by Abdelaal et al. (2016) [54] in patients with peripheral neuropathy who were exposed to MT at a frequency of 10 Hz for 30 minutes twice a week for 12 weeks.

On contrary to our findings the results obtained by Alzayed and Alsaadi (2020) [52]. They obtained non-significant effect after using MT for 20 minutes at an intensity of 35 µT for 13 weeks in patients with LBP, whereas our findings show significant improvements in balance outcomes (TUG, and SLST) in both groups, with extra benefits in the magnetic group, whereas a non-significant difference was gained in JPS between two groups. In the current study, although proprioception (JPS) improved in both groups at final assessment, there was no significant difference between the two groups. On contrary to our findings, no significant differences were obtained after application of MT in patients with MNP between magnetic and control groups, the findings of those authors confirmed existing significant differences between study and control groups [30, 55]. The reason for this difference may be that the age of their patients sample within adult group while they are elderly in the current study, also they applied MT in addition other electrical modalities ultrasound and TENS, they referred the improvement in proprioception as additional effects for their application, whereas in the current study MT only was added to patients of magnetic group and the exercise program was applied for two groups. Also, the author determined significant improvements in knee proprioception in 30 athletes aged 18-24 years [55]. The deviation away from the current findings may be due to the differences in the age of his patients' sample was (18-24 years), they are athletes, different pathology knee problem, whereas in the current study all participants were older than 60 years with chronic MNP and not athletes.

The underlying physiological mechanisms behind these improvements may be due to MT has analgesic,anti-inflammatory, and healing stimulation effects [56], mechanical effects on cell membranes in body tissue, including bones, muscles, tendons, and ligaments, increases blood flow and has accelerated anti-inflammatory effects [57], enhances vasodilation, releases oxygen from red blood cells, increases the oxygen levels in tissues, removes inflammatory substances, increases endorphins, and eventually reduces the sensitivity of nerve endings to pain [34], enhances cellular growth in damaged intervertebral disks [58], increases bone osteoblasts and enhances bone formation [59]. It improves ROM by increasing protein synthesis and glycosaminoglycan, improves the ability of cartilage to absorb stresses [32], also it increases the excitability and conductivity of afferent nerves and sensory tactile perception of the weak motor neurons [54, 60].

Pain is the body's mechanism for alerting an area to reduce movement and prevent further damage. A lack of movement leads to muscle imbalance, stiffness, and poor posture [61]. Subsequently, there is a reduction in function, limitation in ROM, and increased disability. Eventually, QoL is reduced [33]. Compared with the shoulders girdle muscles the deep neck muscles are rich in muscle spindles [62]. Repeated exercises were found to activate the function of muscle spindles in deep cervical muscles [63]. Therefore, normalizing muscle activity through exercise reduces pain, enhances movement, and regulates proprioception [61]. Exercise practicing places stress on bones and muscles, thus it stimulates the cells within these structures to regenerate damaged tissues. In addition, loading bones with exercise increases mineral density [64]. In the current study, none of the patients reported any side effects of either practicing exercise program or exposure to MT. The reasons given for dropping out of the study were lack of transportation, and having a fracture, The rates of attendance in all sessions were 83.33% and 91.67% in the control and magnetic groups, respectively.

Limitations & Recommendations

This study has the following limitations. The sample was small, and a long-term follow-up was not included. All patients were allowed to take their regular pain medications. The results of this study should be taken with caution when generalizing the results to other populations. Future research should include a larger sample size, long time program, a standardized MT protocol, exercises/medication logbook, and lengthy follow-up periods to determine long-term effects of the interventions.

CONCLUSIONS

Multi-dimensional exercise training is effective in treatment of pain and balance in elderly with MNP, Addition of MT to exercise program could induce superior effects on both pain and balance for elderly patients with MNP.

Author contributions: RMAA: participated mainly in conducting practical part of research, draft of writing of thesis, review, material, & methods & **AAS:** formulated idea of research, wrote results & discussion, did statistical part, writing, & revising manuscript. All authors have sufficiently contributed to the study and agreed with the results and conclusions.

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Ethical statement: This study was conducted in accordance with international criteria for scientific research. The Institutional Review Board of Imam Abdualrahman Bin Faisal Universit approved the study (IRB-PGS-2020-03-082) & from Ministry of Health (H-02-J-002), Saudi Arabia. Informed consent was obtained from every participant. The ethical guidance for this study is based on the Helsinki Declaration, and all data are kept confidential.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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