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Efficacy of cervical postural correction exercises with kinesio taping on muscular activities in mechanical neck dysfunction patients: a randomized clinical trial

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ABSTRACT
Mechanical neck dysfunction (MND) with impaired upper trapezius muscular activities is one of the most common disorders. For its treatment, postural correction exercises (PCEs) are commonly used. However, effect of kinesio tape (KT) has received considerable attention. This study was conducted to investigate the efficacy of PCEs with KT on pain, disability and upper trapezius (UT) activities in MND patients. Randomized controlled trial was conducted. For which, ninety MND patients were equally assigned in to 1 of 3 groups to receive 4 weeks treatment; group A: KT, B: PCEs and C: both. Neck pain, disability and UT normalized root mean square (RMS) indicating its amplitude and median frequency (MDF) indicating its fatigue were measured pre and post-treatment by visual analogue scale, neck disability index and EMG. Reported data were analyzed using two-way MANOVA. MANOVA indicate a statistically significant group-by-time interaction (P=0.00). Pain was significantly reduced in group C more than B (p = 0.025), disability was reduced in groups A and C more than B (p < 0.01 and 0.034). While RMS was reduced in group C when compared to B (p= 0.037), MDF was increased in group C when compared to groups A and B (P =.001 0.00). Within groups comparisons were significant for all outcomes in all groups (p= 0<01). For conclusion, cervical posture correction exercises when performed with kinesio taping would have beneficial outcomes related to pain, disability and upper trapezius muscle electromyographic characteristics.

Keywords: Cervical Pain, Exercises, Kinesio Tape, Electromyography.

1. Introduction

In spite of medical developments and growing knowledge pertaining to spinal diseases, mechanical neck pain (MNP) remains one of the most prevalent and costly health problems worldwide (Hoy et al., 2010; Genebra et al., 2017)**.** For which, numerous treatments, including manual therapies, passive physical modalities, and acupuncture, are commonly used to treat neck pain. However, few interventions have been demonstrated to be effective and most are associated with short-term benefits (Hurwitz et al., 2008).

Among complementary and alternative treatments, exercise therapy may be considered as the most widely used conservative treatment. (Cohen and Hooton, 2017) Recently, there has been a focus on postural correction exercises involving repeated cervical and scapular retractions that prove to be effective and may be superior to general exercises for management of MNP. The approach is aimed at improving the neuromuscular control, strength, and endurance of the active subsystem stabilizing the spine (Mclean, 2005; Jull et al., 2009; Elabd et al., 2017)

However, recent reviews revealed that there is still controversy regarding the evidence about the effectiveness of postural correction exercises for neck pain (Gross et al., 2012). From our point of view, the challenge that clinicians face may result from focusing on pathoanatomy as an etiological factor of MNP, ignoring the significant role of dysfunction.

Occupational tasks involving sustained posture may be associated with mechanical neck dysfunction (MND) due to impaired axioscapular muscles functions (Eltayeb et al., 2012). Altered coordination of their function influence mechanical loading of cervical structures leading to pain provocation (Zakharova-Luneva et al., 2012). In contrast, pain may cause alteration in axioscapular muscles activities (Hodges & Tucker., 2011) Amplitude of the myoelectric signal may provide some insight into the pain-spasm-pain theory of musculoskeletal dysfunction. Whatever the cause and effect direction, axioscapular muscles activities should be considered in the management of MND (Tsang et al., 2014).

Because the upper trapezius muscle is suitable for surface EMG detection due to its size and superficial location, It can be used to give rise to axioscapular muscles behavior and several studies have reported that sustained trapezius muscle activity correlates with the presence of neck pain (Westgaard et al., 2001; Hanvold et al., 2013).This concept is based on the so-called Cinderella hypothesis which states that during a prolonged low-level activity the same muscle fibers are always active. Moreover, decrease in median frequency in the EMG during tasks might be an indicator of fatigue of muscle fibers (Nicoletti et al., 2014).

Kinesio taping (KT) is a thin elastic tape which can be stretched up to 130-140% of its original length thereby providing constant shear force on the skin. According to its creators, KT has beneficial effects and possible useful mechanisms to suppress pain, relax muscles, support joints, and improve circulation (Kase et al., 2003). Pain relief by KT has been reported in a number of previous studies involving different conditions such as myofascial pain syndrome (Hashemirad et al., 2016), shoulder impingement syndrome (Kaya et al., 2011), acute whiplash (González-Iglesias et al., 2009) , and chronic low back pain (Paoloni et al., 2011). The interaction of KT on muscle's function has also been reported (Saavedra-Hernandez et al., 2012)

Determining the most appropriate intervention for individuals with MND remains a priority for researchers. While conflicting results emerged from studies examining the effect of KT for MND (Greenstein et al., 2017), further research is recommended focusing on the development of new predictions about its efficacy and/or combination of interventions (Vanti et al., 2015).

We hypothesized that kinesio taping of cervical paraspinal muscles of mechanical neck dysfunction (MND) patients combined with postural correction exercises interferes with muscles functions, thereby influencing MND. On the basis of this hypothesis, the aim of our study was to investigate the efficacy of kinesio taping with or without postural correction exercises on pain intensity, neck disability and cervical muscles electromyographic (EMG) activities in form of upper trapezius normalized root mean square (RMS) as an indication of activation amplitude and median frequency (MDF) as an indication of muscular fatigue.

2. Material and methods

The study was conducted in accordance with the 1964 helsinki declaration and its later amendments, approved by the research ethics committee of physical therapy college, Cairo University and reported with respect to CONSORT guidelines provided by EQUATOR Network. Participation was voluntary and Informed consent was obtained from each patient before participation in the study.

2.1. Design of the study

Randomized controlled clinical trial with 3 parallel groups

2.2 Participants

Participants in this study were ninety patients of both sexes (47 males) diagnosed by orthopedist with MND, their age ranged from 20-40 years. They had a history of neck pain that last for more than three months duration. They were recruited during the period from October 2015 to October 2016 from the students and employee of faculty of Physical Therapy Cairo University and also from patients referred to its out- patient clinic, where the data was collected. Other inclusion criteria were score above 15 in the neck disability index (NDI); which indicate the presence of at least a mild neck disorder. While, exclusion criteria were: any defined muculo-skeletal, neuro-muscular, inflammatory or traumatic diseases, and any tape allergy.

2.3. Sample-Size Determination

Sample-size calculations were performed for neck pain as a primary outcome measure using G power 3.1 software. The calculations were based on .343 effect size (partial eta squared measured in our pilot study = 0.105), an alpha level of .05, a desired power of 80%, numerator degree of freedom of 2 and 3 experimental groups. The estimated desired total sample size for the study was 86 patients. To accommodate the expected dropouts before the study's completion, a total of 90 participants were included in the study.

2.4. Study protocol:

Patients were instructed to avoid anti-inflammatory drugs for 72 hours before the study. They received a standardized physical examination by an assessor blinded to patients' allocation. They provided demographic and clinical information and completed self-report measures at baseline. All patients were examined for taping allergy before allocation as follow; a small portion of tape was applied on inner part of patient's arm and kept for a day. Next day the tape was removed and if there was reaction, the patient was excluded.

2.5. Outcome measures:

The primary outcome measure was neck pain intensity, with disability and UT muscle EMG parameters (normalized RMS for muscular activity and MDF for muscular fatigue).

2.5.1. *Pain intensity:*

The visual analogue scale (VAS) was used (a 10 cm horizontal line anchored by ''no pain'' on the left and ''worst imaginable pain'' on the right). Patients indicated their pain intensity by marking on the point at the line that reflect their pain. Then the score was determined by measuring from the left end of the line to the point that the patient marked. It is a simple and efficient measuring tool with established reliability and validity (Van Roo et al., 2010).

2.5.2. Functional neck disability:

NDI was used. It includes 10 questions of which 7 examine functional activities, 2 ask about symptoms and a question considers concentration. Each Patient circled one of the six options describing the severity of each item (0–5). The marks were counted and divided by 50 or 45 if one section was missing with total score from 0 (no disability) to 50 (complete disability). NDI has established validity and reliability (Swanenburg et al., 2014).

2.5.3. Upper trapezius EMG activities:

MyoSystem 1400A, delesyInc, Scottsdale, USA was used for measuring upper trapezius normalized RMS and MDF. The sites of the electrodes placement had been shaved when needed. then, The skin was cleaned by a piece of cotton and alcohol to reduce skin impedance at the site of the electrodes placement, Electrodes sites were located on each subject's dominant side as follows: Active electrode was located 2 cm lateral to the midpoint of a line drawn between C_7 spinous process and the posterolateral acromion while the reference one was located over the C_7 spinous process. Raw EMG was amplified (bandwidth = 20-450 Hz, common mode rejection ratio >80 db at 60 Hz, input impedance = 10 GΩ) and collected with a ±2.5 V rang. EMG signals had systemic bias were removed, and were full wave rectified prior to being filtered. The resulting linear envelope signals were then normalized to maximal voluntary isometric contractions (MVIC). Assessment of the MVIC of upper trapezius (UT): was performed as described by Mclean (2006); the subject performed isometric shoulder abduction with the arm at 90^0 abduction and neutral rotation. Each contraction was maintained for 7 seconds and repeated three times against manual resistance with 30 seconds rest between repetitions.

After assessment of the MVIC, participants were asked to write for 15 minute; this task was chosen because it is the most common daily task for participants and it involve semi static load which aggravate their symptoms. During the examination, the patient remained seated in a chair with back completely supported, feet flat and supported on the floor and hips and knees flexed 90^0. Positioning of head, neck, shoulder and the spine had been standardized to avoid their effect on the activities of UT (Szeto et al., 2009). **(Figure 1)** Normalized RMS was calculated as follow: Normalized RMS %= EMG amplitude during writing task / (average of the 3 trials of MVIC)*100. The median frequency was calculated from the raw EMG signals. All outcomes were collected at baseline and 4 weeks after the intervention by an assessor blinded to the patients treatment allocation. Patients were blinded to their allocation and uninformed of what intervention the other group would receive**.**

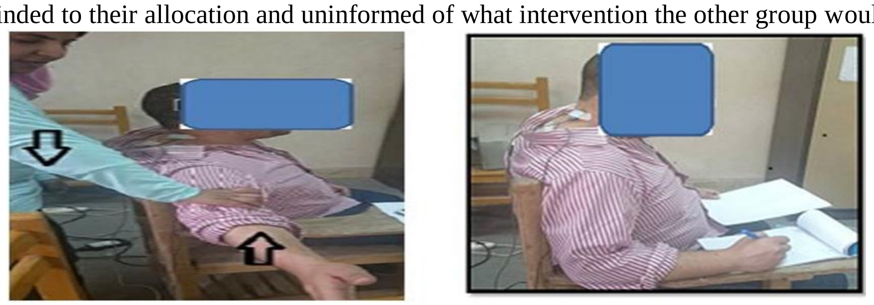

Figure 1: Assessment of UT MVIC and the writing task

2.6. Concealed Allocation:

After the baseline examination, patients with eligibility criteria were assigned with simple randomization to receive Kinesio taping (group A), postural correction exercises (group B) or both (group C). A researcher not involved in either recruitment or treatment of the patients used a computer-generated randomized table of numbers created prior to the start of data collection for Concealed allocation. Sequentially, individually numbered index cards containing the randomly assigned intervention group were folded and placed in opaque, sealed envelopes. The envelope was opened by a second therapist blinded to baseline examination findings .the treatment was preceded according to the group assignment on the day of the initial examination.

2.7. Interventions:

2.7. 1. Kinesio taping:

Subjects seated in a chair in standard neutral comfortable position. Part to be taped was exposed and the skin was shaved and cleaned with alcohol then the first layer of the tape (black one) was cut with length equal to the distance from T_1-T_2 spinous process to occiput in toy shape keeping a base of 3 cm and the edges were rounded. Base of the "y" strip was applied on T_1 - T_2 spinous processs without any tension then, each tail of the first (black) y strip was applied over the posterior cervical extensor muscles from the insertion to origin with a paper-off tension while the patient's neck in a position of maximum contralateral side-bending and rotation**.**

The paper-off tension tape is manufactured and applied to its paper backing with approximately 15% to 25% stretch. And the ends of the tape were applied without any tension on upper cervical region $C_{1\text{-}2}$. The overlying I-strip (pink) was a space-tape (opening) around 10 cm length with rounded edges placed perpendicular to the Y-strip over the mid-cervical region (C_3-C_6) with a moderate tension at the middle part and without any tension at the ends, while the patient's cervical spine in maximum available flexion to apply tension to the posterior neck structures. (Figure2) Then, the applied Y and I strips were wrapped by the therapist fingers for seconds. The tape was replaced every 4 days. This technique was used in previous studies (González-Iglesias et al., 2009; Dawood et al., 2013).

Figure 2: Application of kinesio tape

2.7. 2. Postural correction exercises:

This program was conducted according to the protocols of Pearson and Walmsley (1995). Each exercise was performed as 3 sets of 10 repetitions each for 2 times/ week for 4 weeks. The patients were instructed to continue the exercises as a daily home program to influence the self-correction kinesthetic awareness. Exercises were performed while the patients in a neutral sitting posture obtained as recommended by Falla, et al (2007); Participants were asked to sit on a chair where their feet were flat on the floor and their buttocks were fully supported. The chair's height was set so that the hips were approximately in 100^0 of flexion. In this position hypomobility in some patients posterior hip structures would not prevent them from comfortably anteriorly rotating the pelvis to achieve a neutral lumbar spine posture.

A) Cervical retraction exercises:

The patient was asked to pull the head and neck into a position in which the head is aligned more directly over the thorax (chin in) while the head and eyes remain level (as if hiding behind the wall) for 10 seconds. (Figure 3)

B) Scapular retraction exercise:

While sitting, patient was instructed to take deep inspiration and expand the chest. Then, move his or her shoulders backward bringing the scapulae together for 10 seconds. (Figure 3)

C) Instructions for daily activities:

Patients were given home instructions regarding proper sitting, computer and telephone using, lifting and reading.

Figure 3: Posture correction exercises

2.8. Statistical analysis:

Reported data were analyzed using Statistical Package for Social Sciences (SPSS) computer program (version 24 windows) (Charles R Flint, New York, USA) using an intention-to-treat analysis (it constitutes an analysis of the results based on the treatment arm to which the patients belong due to the initial random allocation, and not on the treatment actually received). When post intervention data for one patient were missing, baseline scores were used. Potential differences in baseline demographic and clinical variables between groups were examined using one way ANOVA.

Two ways MANOVA was used to examine the effects of of treatment on pain, self-reported disability, and muscle activities (RMS, MDF). The variable of interest was the group-by-time interaction at an a priori alpha level of .05. A bonferroni post hoc test was used to determine which group was superior when the interaction was significant. Individual paired t tests (two tailed) for each group were done to determine the magnitude of changes within each group. Effect size was determined using G power 3.1 software. All measurements were based on 95% confidence interval and 95% confidence level.

3. Results:

One hundred and eight consecutive patients were screened for eligibility criteria. Ninety patients (mean ± SD age, 27.49 ± 4.513 years; BMI, 28.21 ± 3.24; 47 males) satisfied the eligibility criteria, agreed to participate, and were randomized to group A: Kinesio Tape (n = 30) (age, 27.3 ± 4.46 years; BMI, 28.05 ±3.34; 17 males) , group B (n = 30): posture correction (age, 27.633 ± 3.96 years; BMI, 28.85 ± 2.99; 14 males) , and group C (n = 30): both modalities (age, 27.53 ± 5.18 years; BMI, 27.731 ± 3.38; 16 males). The reasons for ineligibility are found in a flow diagram of patient recruitment and retention (Figure 4). There was no significant difference between groups for both demographic (age, BMI, sex) and measured variables at base line (Table 1).

Multivariate tests for outcome measures indicate a statistically significant group by time interaction ($F= 3.61$, $P=0.00$). The univariate group- by- time interaction was statistically significant for VAS ($F= 4.63$, $p =0.011$), NDI ($F= 5.37$, $P = 0.005$) and MDF ($F = 9.594$, $P= 0.00$) but there was no statistical significant group by time interaction for RMS ($F = 1.55$, $P =.215$).

Post hoc tests revealed that mean values of VAS was significantly reduced in patients received both modalities (groups C) when compared to patients in group B who received posture correction exercises ($p = 0.025$), regarding disability, mean values of NDI was significantly reduced in groups A and C when compared to group B ($p < 0.01$ and $p = 0.034$). While mean values of RMS was significantly reduced in group C when compared to group B ($p= 0.037$), MDF was significantly increased in group C when compared to either group A ($P =.001$) or B ($P = 0.00$).

Paired t test revealed that there was a statistical significant decrease in the mean values of VAS, NDI, RMS and significant increase in mean values of MDF in all groups (p= 0<01).

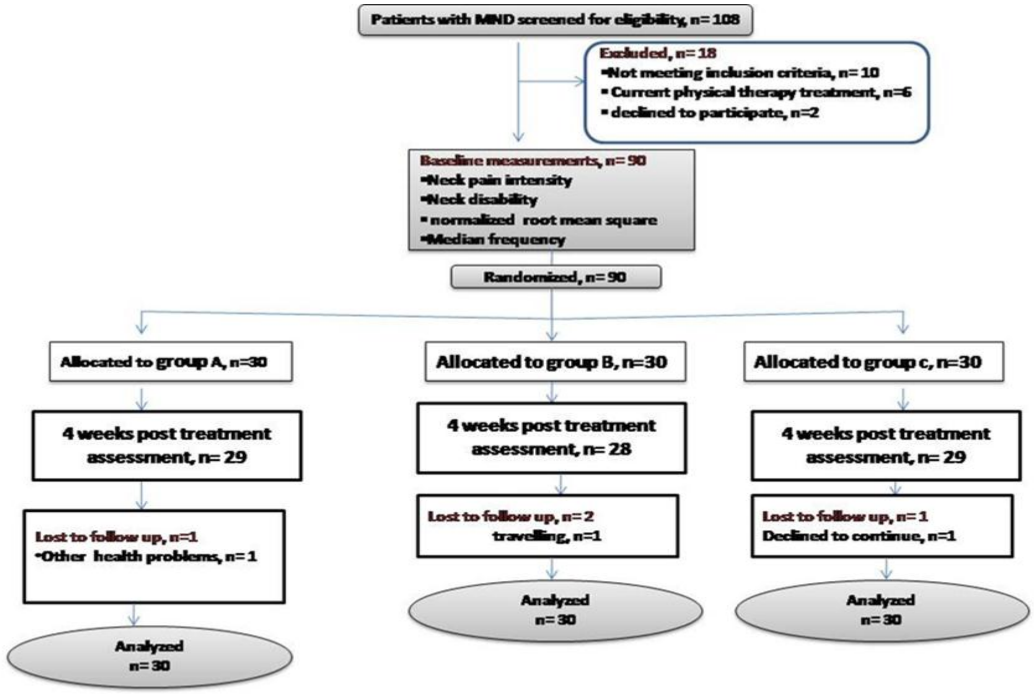

Figure 4: A flow diagram of patient recruitment and retention

Table 1: Demographic and base line features of the three studied groups

	Group A (n= 30)	Group B (n= 30)	Group C (n= 30)	P value
Sex	17 males and 13 females	14 males and 16 females	16 males and 14 females	.59
Age (yrs.)	27.3 ± 4.46	27.63 ± 3.96	27.53 ± 5.18	.959
BMI (Kg/m^2)	28.05 ± 3.34	28.85 ± 2.99	27.73 ± 3.38	.39
Pain intensity	6.17 ± 1.15	6.2 ± 1.06	6.2 ± 1.08	.974
Neck disability	27.43 ± 6.31	30.74 ± 8.2	30.71 ± 6.09	.110
UT RMS	10.22 ± 3.68	9.84 ± 4.79	9.9043 ± 4.65	.938
UT MDF	59.43 ± 21.21	57.27 ± 11.46	59.15 ± 11.68	.842

Data are expressed as mean ± SD.
p> 0.05= not significant.
UT: Upper trapezius
RMS: root mean square.
MDF: median frequency.

Table 2: Multivariate Analysis of Variance (MANOVA) for all dependent variables at different measuring periods between studied groups.

Source of Variation	F-value	P-value
Groups	5.19	0.000*
Measuring periods	127.78	0.000*
Interaction (group*time)	3.6	0.000*

*Significant at alpha level <0.05.

Table 3: post intervention, within-group and group by time interaction for pain intensity, disability, UT RMS and UT MDF

Variable and Group	Pre-ttt	Post- ttt	Within group change			Group * time interaction	
			t	p	MD (95%CI)	F	P
Pain						4.63	0.01*
A	6.1 ± 1.25	3.06 ± 0.85	18.33	0.001*	3.03 (2.8-3.27)		
B	6.1 ± 1.2	3.45 ± 0.96	24.05	0.00*	2.65 (2.31-2.98)		
C [b]	3.5 ± 0.96	2.41± 0.71	21.25	0.00*	3.75 (3.46-4.04)		
Disability						5.37	0.005*
A	26.93 ± 6.39	15.32± 2.32	45.08	0.00*	11.62 (9.4-13.8)		
B[A]	30.7 ± 8.1	20.1 ± 8.2	83.56	0.00*	10.7 (9.6-11.8)		
C[,B]	31.2 ± 6.4	13.9 ± 3	104.2	0.00*	17.3 (15.7-18.9)		
UT RMS						1.55	0.215
A	11.05 ± 8.46	4.35 ± 2.94	13.32	0.00*	6.7 (4.2-9.2)		
B	11.68 ± 7.13	6.87 ± 4.34	15.92	0.00*	4.8 (3.4-6.2)		
C[B]	10.9 ± 5.3	2.7 ± 1.27	16.02	0.00*	8.2 (6.2-10.2)		
UT MDF						9.59	0.00*
A	61.59 ± 23	76.1 ± 21.7	3.46	0.00*	14.5 (4.2-23)		
B	57 .3 ± 11.3	75.6 ± 10.92	9.9	0.00*	18.3 (22.7-14.6)		
C[A,B]	60.4 ± 14.53	111.1± 48.7	7.36	0.00*	50.7 (64.7-36.6)		

Data are expressed as mean ± SD.
F value= 2 way ANOVAtest.
t value= paired t test.
*p< 0.05= significant.
[B,C] = significant difference relative to groups B and C (p< 0.05)

4. Discussion

This study was conducted to examine efficacy of kinesio tape with and without postural correction exercises on pain, disability, UT muscle activity and fatigue in patients with MND. Our results suggest that KT with or without postural correction exercises may be an alternative treatment option in the treatment of MND. However, we recommend treatment of MND by both modalities combined because it has better effects to decrease pain, disability and also to normalize cervical muscle activities than application of either intervention alone. There are a number of explanations for these findings. Neck pain is commonly associated with protective spasm in the surrounding muscles producing pressure within the muscle, thus developing ischemia, more pain, and abnormal neck posture. This vicious cycle that can occur in reverse, may be broken by relieving the pain, by reducing the muscle spasm, or by correcting the abnormal neck posture (Genebra et al., 2017).

The cutaneous stretch stimulation provided by KT may interfere with the transmission of mechanical and painful stimuli. KT may provide afferent impulses inhibiting pain through gait control theory. Furthermore, KT increase lymphatic and vascular flow, and aid in the correction of possible articular malalignments (Garcıa-Muro., 2010; Paoloni et al., 2011). Thus, it improves functional abilities of patients. While MND was found to be associated with altered muscular activities[13], KT may normalize muscle function through two main mechanisms. The first is mechanical; taping influence the length of muscle fibres, inducing a shift of the length-tension curve of those muscles changing the relative position of subsequent joints or directly by influencing the direction of muscle fibers. The second mechanism, called "proprioceptive", considers the amplification of kinesthetic information reaching the central nervous system through taping-induced cutaneous stimulation (Lin et al., 2011). This agrees with the results of Lin, et al (2011) who suggested effect of KT on shoulder muscles EMG. Paoloni (2011) stated that, KT alter lumber muscles activities and affect low back pain. On the other hand, the results of the systemic review conducted by Parreira et al (2014) which did not support the use of KT in clinical practice. Fu, et al (2008) showed that Kinesio taping on the anterior thigh has no effete on muscle strength in healthy non-injured young athletes. In the previous studies the possible explanation that they got different results may be due to applying kinesio tape on healthy subjects in many studies. Furthermore, the methods of assessment they used were different from that we used**.**

Frequent correction to an upright neutral posture serves two functions. First, it provides a regular reduction of adverse loads on the cervical joints induced by poor cervical and scapular postures. Second, it trains the deep postural stabilizing muscles of the spine in their supporting role. Patients are encouraged to perform these exercises repeatedly throughout the day, with the emphasis being on a change in postural habits (Mclean 2005). We suggest the effect due to neutral postural awareness that relieve the tension causing pain.

Our results agree with the results of Katherine et al (2005). Abd El-wahab, et al (2000) concluded that, Neck retractions appeared to alter H reflex amplitude so; it may be used for C_7 radiculopathy. In contrast, Willford, et al (1996) did not support correlation between head posture and neck pain. The discrepancy and conflict found in the results obtained by the previous study cannot be directly compared with the current study. It was a correlational study and not true experimental study which look for a degree of association between variables without the ability to ascribe cause and effect.

Taping may act as continuous analgesic stimulus on neck muscles as our patients were taped continuously for four weeks. The neural feedback provided to the patients can facilitate their ability to move the cervical spine with a reduced mechanical irritation on the soft tissues thus improving the efficiency of postural correction exercises. Continuous sensory feedback of the KT allows the tape to correct postural imbalance (Saavedra-Hernandez et al., 2012).

There is lack in the literature regarding studies that combine kinesio tape with postural correction exercises. However, Greenstein et al (2017) recommended application of kinesio taping immediately following cervical mobilization. Also, Added et al (2013) suggested adding KT to physical therapy program for mechanical low back pain.

Limitation of the study:

The duration of the interventions was 4 weeks to find the short term effects. No follow up was done to know the long lasting effect and recurrence of symptoms. Another important limitation may be heterogeneity related to the etiology of MND.

Conclusion:

KT with or without postural correction exercises may be an alternative treatment option in the treatment of MND. However, Application of both KT and postural correction exercises program combined lead to greater reduction in pain and related disability and to better muscle function restoration than application of either KT or exercises program.

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Conflict of Interest:

The Authors declare that there is no conflict of interest.

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