Cukurova Medical Journal
ÇUKUROVA ÜNİVERSİTESİ TIP FAKÜLTESİ

Cukurova Med J 2020;45(3):985-991
DOI: 10.17826/cumj.731554

ARAŞTIRMA / RESEARCH

Effects of Pilates exercises on pain, disability and postural control in patients with chronic neck pain: randomized controlled trial

Kronik boyun ağrılı hastalarda Pilates egzersizlerinin ağrı, özürlülük ve postüral kontrole etkisi: randomize kontrollü çalışma

Melda Soysal Tomruk[1], Bilge Kara[2]

[1]Burdur Mehmet Akif Ersoy University, Faculty of Health Sciences, Dept. of Physiotherapy and Rehabilitation, Burdur Turkey
[2]Dokuz Eylül University, School of Physical Therapy and Rehabilitation, Inciraltı, Izmir, Turkey

Cukurova Medical Journal 2020;45(3):985-991

Abstract

Purpose: Chronic spinal pain is a condition that causes loss of postural control. Exercise is useful to improve postural control however there has been lack of evidence that Pilates exercises increases postural control in patients with chronic neck pain (PwCNP). The aim of the study was to determine the effects of Pilates exercises on postural control in PwCNP.
Materials and Methods: Thirty-six PwCNP randomly divided into two groups: Pilates (n=18) and home exercise (control) group (n=18). Eight-week Pilates and home exercise training performed for both groups. Limits of stability, postural stability and clinical test for sensory interaction balance tests were used to evaluate postural control. Evaluations were repeated in 8th week, when training sessions were completed.
Results: Pain, disability, overall limits of stability and overall postural stability scores were improved for both groups. Anteroposterior postural stability and eyes open-eyes closed firm surface sensory interaction for balance showed significant improvement only in Pilates group. Pilates training showed superior effect over home exercise group for improving anteroposterior postural stability in between group analysis.
Conclusion: Pilates exercises can be useful to provide improvement in anteroposterior postural stability and sensory interaction for balance. Pilates training should be included physical therapy programs when postural control improvement is desired in PwCNP.
Keywords:. Postural balance, exercise, neck pain

Öz

Amaç: Kronik spinal ağrı postural control kaybına yol açan bir durumdur. Egzersiz, postural kontrolü artırmada kullanışlıdır fakat kronik boyun ağrılı hastalarda (KBAH) Pilates egzersizlerinin postural kontrolü artırdığına yönelik kanıtlar yetersizdir. Çalışmanın amacı KBAH'da Pilates egzersizlerinin postural kontrole etkisinin araştırmaktı.
Gereç ve Yöntem: Otuz altı KBAH randomize olarak iki gruba ayrıldı: Pilates (n=18) ve ev egzersiz (kontrol) grubu (n=18). Her iki gruba sekiz haftalık Pilates ve ev egzersiz eğitimi uygulandı. Postüral kontrolü değerlendirmek için kararlılık sınırları, postural stabilite ve klinik duyusal etkileşim denge testleri kullanıldı. Değerlendirmeler eğitim seanslarının tamamlandığı 8. haftada tekrarlandı.
Bulgular: Ağrı, özürlülük, toplam kararlılık sınırları ve toplam postural stabilite skorları her iki grupta da gelişti. Anteroposterior postural stabilite ve gözler açık-kapalı sert zemin duyusal etkileşim denge sadece Pilates grubunda anlamlı şekilde gelişme gösterdi. Gruplar arası analizlerde Pilates eğitimi, anteroposterior postural stabiliteyi artırmada control grubuna göre üstün etki gösterdi.
Sonuç: Pilates egzersizleri anteroposterior postural stabilite ve duyusal etkileşim dengenin gelişmesini sağlamada kullanışlı olabilir. Pilates eğitimi, KBAH'da postural kontrolü geliştirmek istendiğinde fizyoterapi programlarına dahil edilebilir.
Anahtar kelimeler: Postural denge, egzersiz, boyun ağrısı

Yazışma Adresi/Address for Correspondence: Dr. Melda Soysal Tomruk, Burdur Mehmet Akif Ersoy University, Faculty of Health Sciences, Physiotherapy and Rehabilitation Department, Burdur, Turkey E-mail: meldasoysaltomruk@gmail.com
Geliş tarihi/Received: 03.05.2020 Kabul tarihi/Accepted: 27.05.2020 Çevrimiçi yayın/Published online: 12.09.2020

INTRODUCTION

Postural control relies on the ability of the central nervous system to focus on the multisensory afferent input[1]. Sensorimotor control of static and dynamic upright postures affected by information from the vestibular, visual and proprioceptive systems. Whole body afferent information is integrated via central nervous system for daily postural adjustments[2,3]. Prolonged pain and disability in chronic neck pain can affect postural stability. Similar with presence of muscle fatigue that altered muscle contractile efficiency, proprioceptive signals deteriorate the postural control[4-7].

Like other chronic pain conditions, patients with chronic neck pain often seek different exercise interventions to improve postural control. Evidence supports the use of cervical, scapulothoracic and upper extremity exercises which are components of Pilates training for strengthening, stretching and stabilizing muscles in patients with chronic neck pain[8-11]. Pilates exercises focus on core stability and spinal alignment. Its principles provide not only improvements in static and dynamic postural alignment, but also developments in spinal mobility. Furthermore, Pilates exercises are popular form of exercise that use stabilizing muscles of the body and postural stability however there is lack of scientific evidence to support the effectiveness of Pilates exercises on postural control in patients with chronic neck pain[12-14].

The primary aim of this study was to determine the effects of Pilates exercises on pain, disability and postural control in patients with chronic neck pain while secondary aim was to compare them with home exercises. Our hypothesis was a modified clinical Pilates exercises that specifically addresses postural stability could be more effective to decrease pain and disability and improve postural control when compared home exercises.

MATERIALS AND METHODS

A randomized controlled design was used. Ethical approval has been gained from Dokuz Eylül University Ethics Committee with 1367-GOA protocol number in 20.02.2014 and written informed consent was obtained from all participants in accordance with the Declaration of Helsinki. Thirty-six chronic neck patients were recruited from a university hospital between March 2015 and December 2015. Participants were randomly divided into two groups by means of simple randomization using sealed, opaque, and sequentially numbered envelopes: Pilates group and home exercise (control) group. Each participant was joined to 8-week individual exercise program. Participants were included if they had chronic neck pain for 12 weeks or more. Exclusion criteria were having cervical radiculopathy symptoms (numbness, tingling or weakness), cervical stenosis, previous spinal surgery, whiplash, severe spinal deformities, history of visual impairment, vestibular or respiratory disorders, cognitive deficits, diabetes, recent lower limb injuries, joining current physical therapy, massage, chiropractic, Pilates sessions or taking any medicine that could affect balance.

Exercise procedure

Patients in study group underwent 8-week modified clinical Pilates training which were designed to improve their ability to integrate multisensory inputs and challenge postural control. Pilates exercises were applied by an Australian Physiotherapy and Pilates Institute (APPI) certified physiotherapist. Activation of transversus abdominis in neutral spinal alignment and basic principles of Pilates was informed in first session. Exercises were performed in front of the mirror and different positions (supine, prone, side lying, sitting and upright position). Special exercises like shoulder bridge, swan dive, clam, one leg circle, spine twist, arm openings, the saw, dumb waiter and toy soldier were applied. The difficulty of exercises was gradually increased and focused on keeping neutral positions of the spine in different gravity orientations. Pilates instructor provided verbal and tactile cueing during the exercise routine and participants were given feedback to help them correct wrong movements while emphasizing core stability. Modified clinical Pilates exercises applied one hour a day, twice a week and every exercise were done with 10 repetitions by 5 years experienced pilates instructor.

Scapulothoracic and cervical stretching and strengthening exercises were applied along 8 weeks to improve postural alignment and stability in patients who performed home exercises in home exercise group. Neutral position of the spine was explained to patients. Patients in home exercise group were asked to perform their home exercises in lying, sitting and standing positions (which focused on improvements of stability, muscle strength and flexibility) two times a week with 10 repetitions during eight weeks regularly.

Measures

The demographics of participants were noted before test trials. Each participant was assessed by the Pilates instructor (MST). Outcomes were measured prior to the start of exercise intervention and repeated after completion of exercise interventions (in week 8).

Visual Analogue Scale (VAS)

The level of resting pain on the day of investigation was determined by Visual Analogue Scale (VAS from 0 to 100 mm) [15].

Neck Disability Index (NDI)

The NDI has 10 questions scored on a Likert scale (0 to 5), with higher total scores out of 50 indicating greater levels of perceived difficulty with activities of daily living due to neck pain. The NDI is a commonly used clinical outcome measure with good internal consistency, excellent test–retest reliability [16].

Postural control evaluation

The Biodex Balance System (BBS; SD 12.1" Display 115 VAC) was used to assess postural control. Postural stability test and limits of stability test were used to assess static and dynamic postural control, respectively. In addition, clinical test for sensory interaction on balance (CTSIB) were applied for evaluation sensory interaction deficits. For each test, the foot position was recorded using the platform rail. Three trials with a rest period of 10 seconds were performed in each condition. Postural tasks were explained to each participant before starting the measurements. Participants were fully briefed on all testing procedures.

For postural stability test (overall, mediolateral and anteroposterior score) patients were evaluated for static postural control in stable surface when their eyes open during a period of 20 seconds. Participants stood barefoot and were not permitted to touch the handrails during the tests. The platform locked and the patients were asked to control themselves keeping the indicator in the center of target on the screen for postural balance position.

Limits of stability (LoS) test examines dynamic postural control so it challenges participants to move and control their center of gravity within their base of support. In this test, targets on the screen blink in random order. Participants were asked to shift their weight to move the cursor from the center target to a blinking target and back as quickly and with as little deviation as possible. The same process was repeated for each of eight targets. Test repeated three times with 10-second resting between trials. The overall score was recorded. One hundred is the maximum score for the test. Higher scores indicate better balance and greater control of participants' stability.

Table 1. Baseline demographic and clinical characteristics of the groups

	Pilates group (n=18) Median IQR (25-75%)	Home exercise group (n=18) Median IQR (25-75%)	p value
Age (Year)	47.50 (42.70-51.00)	46.00 (33.00-52.20)	0.443
BMI (kg/m2)	24.98 (23.05-28.27)	25.87 (23.63-27.59)	0.938
Pain	6.50 (5.20-8.00)	7.00 (5.00-8.00)	0.542
Disability	28.00 (21.50-34.50)	30.00 (23.50-32.50)	0.815
LoS overall score	47.50 (42.00-52.00)	44.00 (40.00-52.50)	0.308
PS overall score	0.40 (0.30-0.40)	0.30 (0.30-0.40)	0.650
PS anteroposterior score	0.30 (0.20-0.30)	0.30 (0.20-0.30)	0.673
PS mediolateral score	0.10 (0.10-0.20)	0.10 (0.10-0.20)	0.864
CTSIB EO firm (SwI)	0.37 (0.30-0.42)	0.34 (0.31-0.47)	0.864
CTSIB EC firm (SwI)	0.74 (0.66-0.92)	0.85 (0.62-0.97)	0.888
CTSIB EO foam (SwI)	0.50 (0.40-0.55)	0.43 (0.35-0.51)	0.226
CTSIB EC foam (SwI)	0.84 (0.59-1.06)	0.81 (0.71-0.94)	0.913

Mann-Whitney U test analysis; BMI Body Mass Index, LoS Limits of stability, PS Postural Stability, CTSIB Clinical Test of Sensory Interaction of Balance, EO Eyes opened, EC Eyes Closed, SwI Sway Index.

Table 2. Changes in assessed variables throughout training period

		Pilates group (n=18) *Median IQR (%25-75)*	Home exercise group (n=18) *Median IQR (%25-75)*	*p value*† *(between group)*
Pain	Pre-intervention	6.50 (5.20-8.00)	7.00 (5.00-8.00)	0.542
	Post-intervention	3.00 (0.00-3.00)	3.00 (3.00-5.00)	0.068
	Δ	3.50 (2.75-5.25)	3.00 (1.75-4.25)	0.339
p value (within group)*		0.001	0.001	
Disability	Pre-intervention	28.00 (21.50-34.50)	30.00 (23.50-32.50)	0.815
	Post-intervention	21.00 (17.50-34.50)	24.00 (20.00-30.00)	0.068
	Δ	6.00 (4.00-8.50)	5.00 (3.50-6.50)	0.171
p value (within group)*		0.001	0.005	
LoS overall score	Pre-intervention	47.50 (42.00-52.00)	44.00 (40.00-52.50)	0.308
	Post-intervention	57.50 (50.20-61.00)	53.00 (47.00-58.00)	0.265
	Δ	-10.50 (-13.25- -1.25)	-7.00 (-14.00- -0.50)	0.650
p value (within group)*		0.003	0.007	
PS overall score	Pre-intervention	0.40 (0.30-0.40)	0.30 (0.30-0.40)	0.650
	Post-intervention	0.30 (0.20-0.40)	0.30 (0.30-0.30)	0.839
	Δ	0.05 (0.00-0.10)	0.00 (0.00-0.10)	0.791
p value (within group)*		0.026	0.031	
PS anteroposterior score	Pre-intervention	0.30 (0.20-0.30)	0.30 (0.20-0.30)	0.673
	Post-intervention	0.20 (0.20-0.20)	0.30 (0.20-0.30)	0.048
	Δ	0.10 (0.00-0.10)	0.00 (-0.02-0.10)	0.042
p value (within group)*		0.008	0.589	
PS mediolateral score	Pre-intervention	0.10 (0.10-0.20)	0.10 (0.10-0.20)	0.864
	Post-intervention	0.10 (0.10-0.20)	0.10 (0.10-0.10)	0.839
	Δ	0.00 (-0.02-0.10)	0.00 (0.00-0.02)	0.913
p value (within group)*		0.564	0.414	
CTSIB EO firm (SwI)	Pre-intervention	0.37 (0.30-0.42)	0.34 (0.31-0.47)	0.864
	Post-intervention	0.31 (0.26-0.40)	0.30 (0.29-0.47)	0.673
	Δ	0.04 (0.02-0.08)	0.04 (0.00-0.11)	0.815
p value (within group)*		0.015	0.178	
CTSIB EC firm (SwI)	Pre-intervention	0.74 (0.66-0.93)	0.85 (0.63-0.97)	0.888
	Post-intervention	0.59 (0.51-0.74)	0.69 (0.54-0.82)	0.239
	Δ	0.19 (0.05-0.30)	0.08 (0.04-0.20)	0.111
p value (within group)*		0.002	0.107	
CTSIB EO foam (SwI)	Pre-intervention	0.50 (0.40-0.55)	0.43 (0.36-0.51)	0.226
	Post-intervention	0.45 (0.34-0.57)	0.40 (0.35-0.50)	0.501

	Δ	0.03 (-0.04-0.12)	0.03 (-0.04-0.06)	0.584
p value (within group)*		0.177	0.285	
CTSIB EC foam (SwI)	Pre-intervention	0.84 (0.60-1.06)	0.81 (0.71-0.94)	0.913
	Post-intervention	0.81 (0.60-0.99)	0.81 (0.63-0.92)	0.963
	Δ	0.06 (-0.01-0.06)	0.04 (-0.06-0.43)	0.719
p value (within group)*		0.055	0.338	

*Wilcoxon signed rank test analysis, †Mann-Whitney U test analysis
LoS Limits of stability, PS Postural Stability, CTSIB Clinical Test of Sensory Interaction of Balance, EO Eyes opened, EC Eyes Closed, SwI Sway Index, Δ change

On the other hand, firm and foam surfaces were used for CTSIB test and patients performed the CTSIB test in two conditions in each surface: opened eyes and closed eyes. For each of the test conditions, we instructed each participant to stand as still as they possibly could for each condition. While performing the tests under foam surface conditions, we placed a Foam Pad (provided with the Biodex system) onto the platform that contained the same markings as the firm surface had, allowing the participant to reposition their feet into their previously instructed placement. We recorded the Sway Index (SwI) for each condition of each trial. Lower scores on the SwI demonstrate greater balance. Not only lower postural stability and CTSIB scores, but also higher LoS scores reflect better postural control [17].

Statistical analysis

We analyzed all data using Statistical Package for Social Sciences software (IBM Corporation, version 20.0 for Windows). While descriptive statistics were summarized as frequencies and percentages for categorical variables, continuous variables were presented as mean and standard deviation. The variables were investigated using visual (histograms, probability plots) and analytical methods (Shapiro-Wilk's test) to determine whether or not they were normally distributed.

We reported results as baseline, post-intervention and change (Δ) values. The distribution of demographic and clinical characteristics between groups were analyzed using Chi-Square Test. Since the normality assumption was violated, we used non-parametric tests for statistical analysis. Mann-Whitney U Test and Wilcoxon Test were used for between group and within group analyses, respectively. A 5% type-I error level was used to infer statistical significance ($p<0.05$).

RESULTS

Study group consisted of 16 women (88.9%) and 2 men (11.1%) while home exercise group did 11 women (61.1%) and 7 men (38.9%). A large number of patients completed 8-week exercise trainings. Therefore, exercise adherence rate was calculated as 87.5%.

There was no statistically significant difference in terms of gender between the groups ($p=0.054$, $\chi^2=3.704$, df=1, Chi-square test). The demographic characteristics like age, body mass index and pain, disability, overall limits of stability, overall, anteroposterior and mediolateral postural stability and sensory interaction scores of the patients were similar in both groups ($p>0.05$, Mann-Whitney U test, Table 1). The analyses were by original assigned groups. Post hoc power analysis with 5% type-I error was performed using effect sizes of pain score and found to be as 80%.Pain, disability, overall postural stability scores significantly decreased while overall LoS scores significantly increased in both groups. However anteroposterior postural stability score showed a significant improvement only in Pilates group when compared baseline scores ($p=0.008$). Additionally, eyes opened-eyes closed firm surface scores of CTSIB were significantly improved in Pilates group ($p<0.05$). Statistical analyses of between-group mean differences showed that there was superiority of Pilates over home exercises only in improving anteroposterior postural stability ($p=0.042$, Table 2).

DISCUSSION

The study indicated that both Pilates and home exercises improve pain, disability, overall postural control scores. However, the most striking result of our study was Pilates exercises enhance anteroposterior postural stability and sensory interaction on firm surface in PwCNP. Besides, Pilates intervention showed superior effect on anteroposterior postural stability over home exercises.

It is known that chronic neck pain causes functional disability; however, there is limited research on the role of Pilates training on postural control in patients with neck pain. Clinical experience indicates that significant sensorimotor disturbances might be an important in the maintenance of symptoms in patients with neck pain. In a clinical comment, researchers said more specific and novel treatment methods are needed which postural stability intervention approaches including sensorimotor training and they underlined currently only a limited but growing amount of research on such an approach[3].

Current literature provided evidence that disturbed balance control was observed in chronic neck pain patients during the quiet standing because of neck muscle fatigue. According to this research the results inspired the development of specific exercise programs for improving postural control in patients with chronic neck pain[7].

There is limited evidence that efficiency of balance exercises on sensorimotor function and pain in patients with chronic neck pain. Available data demonstrates that balance training can effectively improve cervical sensorimotor function and decrease neck pain intensity[18].

In a pilot uncontrolled study investigated whether a 6-week matwork based Pilates program could change pain, disability and functionality in chronic neck pain patients and patients were followed up to twelfth week. Authors stated that Pilates had a role to play in reducing pain and disability in neck pain patients[13]. According to our knowledge there is only one controlled study that examine the effectiveness Pilates exercises in neck pain. Researchers divided patients into 3 groups as Pilates, Yoga and control. Pain, disability and neutral posture were assessed at sixth (after completion of exercise training) and twelfth week. They founded both exercise interventions resulted in reduced disability and pain at eighth week in this study. According to their results there were no significant differences in the decrease in pain or disability between the groups and in range of movement or postural variables over time[12].

In our study patients were trained in the form of individual treatment, not group exercises. Therefore, individual exercise sessions might provide better sensorimotor input like in the participants, accordingly postural control might be developed in not only Pilates but also home exercise group. We think the reason why Pilates made an enhancement in postural control in our study could be related to these: we applied the exercises which generally body weight is carried and used movements especially in stabilizing positions. Our study seems to be the first randomized controlled study which shows the effects of Pilates on postural control in patients with chronic neck pain. We thought that, the decrease in pain and disability could be contributed to development in postural control. The future studies which will show the relationship between pain and postural control could support our view. Using a computerized system like Biodex Balance System for evaluation of postural control might have strengthened the study in terms of objectivity of the results. Limitations include the inability to blind group assignment and small sample size. Long-term effectiveness of exercises on outcomes is clinically important question for future studies. Another limitation of the study is that home exercises were applied without physiotherapist supervision.

Pilates and home exercise interventions, applied with appropriate modifications and supervision, may be effective in limits of stability and overall postural stability in chronic neck pain. Pilates training should be advised for physical therapy programs in patients with neck pain when anteroposterior stability and sensory interaction enhancement is desired.

Yazar Katkıları: Çalışma konsepti/Tasarımı: MST, BK,; Veri toplama: MST, BK; Veri analizi ve yorumlama: MST, BK; Yazı taslağı: MST, BK; İçeriğin eleştirel incelenmesi: MST, BK; Son onay ve sorumluluk: MST, BK; Teknik ve malzeme desteği: MST, BK; Süpervizyon: MST, BK, Fon sağlama (mevcut ise): yok.
Etik Onay: Bu çalışma için Dokuz Eylül Üniversitesi Tıp Fakültesi Girişimsel Olmayan Klinik Araştırmalar Etik Kurulundan 24.02.2014 tarih ve 119 sayılı kararı ile etik onay alınmıştır.
Hakem Değerlendirmesi: Dış bağımsız.
Çıkar Çatışması: Yazarlar çıkar çatışması beyan etmemişlerdir.
Finansal Destek: Yazarlar finansal destek beyan etmemişlerdir.
Author Contributions: Concept/Design : MST, BK; Data acquisition: MST, BK; Data analysis and interpretation: MST, BK; Drafting manuscript: MST, BK; Critical revision of manuscript: MST, BK; Final approval and accountability: MST, BK; Technical or material support: MST, BK; Supervision: MST, BK; Securing funding (if available): n/a.
Ethical Approval: For this study, ethics approval was obtained from Dokuz Eylül University Faculty of Medicine non-interventional clinical research ethics committee with Decision No. 119 dated September 24.02.2014.
Peer-review: Externally peer-reviewed.
Conflict of Interest: Authors declared no conflict of interest.
Financial Disclosure: Authors declared no financial support

REFERENCES

1. Moseley GL, Hodges PW. Are the changes in postural control associated with low back pain caused by pain interference. Clin J Pain. 2005;21:323–9.
2. Treleaven J. Sensorimotor disturbances in neck disorders affecting postural stability, head and eye movement control. Man Ther. 2008;13:2–11.
3. Kristjansson E, Treleaven J. Sensorimotor function and dizziness in neck pain: implications for assessment and management. J Orthop Sports Phys Ther. 2009;39:364–77.
4. Gosselin G, Rassoulian H, Brown I. Effects of neck extensor muscles fatigue on balance. Clin Biomech (Bristol, Avon). 2004;19(5):473–9.
5. Allen TJ, Proske U. Effect of muscle fatigue on the sense of limb position and movement. Exp Brain Res. 2006;170:30–8.
6. Knapstad MK, Goplen FK, Ask T, Skouen JS, Nordahl SHG. Associations between pressure pain threshold in the neck and postural control in patients with dizziness or neck pain - a cross-sectional study. BMC Musculoskelet Disord. 2019;20:528.
7. Cheng CH, Chien A, Hsu WL, Yen LW, Lin YH, Cheng HY. Changes of postural control and muscle activation pattern in response to external perturbations after neck flexor fatigue in young subjects with and without chronic neck pain. Gait Posture. 2015;41:801-7.
8. Yamato TP, Saragiotto BT, Maher C. Therapeutic exercise for chronic non-specific neck pain: PEDro systematic review update. Br J Sports Med. 2015;49:1350.
9. Ylinen J. Physical exercises and functional rehabilitation for the management of chronic pain. Eura Medicophys. 2007;43:119-32.
10. Tunwattanapong P, Kongkasuwan R, Kuptniratsaikul V. The effectiveness of a neck and shoulder stretching exercise program among office workers with neck pain: a randomized controlled trial. Clin Rehabil. 2016;30:64-72.
11. Bertozzi L, Gardenghi I, Turoni F, Villafañe JH, Capra F, Guccione AA et al. Effect of therapeutic exercise on pain and disability in the management of chronic nonspecific neck pain: systematic review and meta-analysis of randomized trials. Phys Ther. 2013;93:1026-36.
12. Dunleavy K, Kava K, Goldberg A, Malek MH, Talley SA, Tutag-Lehr V et al. Comparative effectiveness of Pilates and yoga group exercise interventions for chronic mechanical neck pain: quasi-randomised parallel controlled study. Physiother. 2016;102:236-42.
13. Mallin G, Murphy S. The effectiveness of a 6-week Pilates programme on outcome measures in a population of chronic neck pain patients: a pilot study. J Bodyw Mov Ther. 2013;17:376-84.
14. de Araujo Cazotti L, Jones A, Roger-Silva D, Ribeiro LHC, Natour J. Effectiveness of the pilates method in the treatment of chronic mechanical neck pain: a randomized controlled trial. Arch Phys Med Rehabil. 2018;99:1740-6.
15. Carlsson AM. Assessment of chronic pain. I. Aspects of the reliability and validity of the visual analogue scale. Pain. 1983;16:87-101.
16. Biçer A, Yazıcı A, Çamdeviren H, Erdoğan C. Assessment of pain and disability in patients with chronic neck pain and disability scale. Disabil Rehabil. 2004;26:959-62.
17. Sherafat S, Salavati M, Ebrahimi Takamjani I, Akhbari B, Mohammadirad S, Mazaheri M et al. Intrasession and intersession reliability of postural control in participants with and without nonspesific low back pain using the Biodex Balance System. J Manipulative Physiol Ther. 2013;36:111-8.
18. Beinert K, Taube W. The effect of balance training on cervical sensorimotor function and neck pain. J Mot Behav. 2013;45:271-8.