Araştırma

The Effects of Pilates Exercise Training on Knee Proprioception – A Randomized Controlled Trial

PİLATES EGZERSİZ EĞİTİMİNİN DİZ PROPRİOSEPSİYONU ÜZERİNE ETKİLERİ - RANDOMİZE KONTROLLÜ ÇALIŞMA

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ÖZET

Amaç: Literatürde pilates egzersiz eğitiminin pozisyon duyusu üzerine etkisi ile ilgili yeterli veri yoktur. Bu çalışmanın amacı pilates egzersiz eğitiminin diz eklemi pozisyon duyusu üzerine etkisini araştırmaktır.

Gereç ve yöntem: Yaş ortalaması 20,91 ± 0,99 yıl olan 31 olgu (Pilates grubu =15 olgu, Kontrol grubu = 16 olgu) çalışmayı tamamladı. Pilates egzersiz grubundaki olgular haftada üç gün sıklığında sekiz hafta süresince alt ekstremite pilates egzersizleri yaptı. Diz eklemi pozisyon duyusu; açık kinetik zincir pozisyonunda ve 60° diz fleksiyonunda, başlangıçta ve sekiz hafta sonunda olmak üzere iki grupta da ölçüldü.

Bulgular: İki yönlü ANOVA analizi sonucunda grup ve ölçüm zamanı etkileşiminin anlamlı olduğu görüldü (p=0,00). 60° Fleksiyon pozisyonunda ölçülen diz eklemi pozisyon duyusu Pilates Grubunda gelişme göstermesine karşın, Kontrol Grubunda bozuldu (p<0,05). Pilates egzersizleri sonrasında bacak dominantlığının diz eklemi pozisyon duyusu üzerinde etkili olmadığı görüldü (p>0,05).

Sonuç: Pilates egzersiz eğitiminin diz eklemi pozisyon duyusu üzerinde olumlu etkisi olduğu görüldü.

Anahtar sözcükler: Pilates, eklem pozisyon duyusu, diz

SUMMARY

Objective: There is a lack of data regarding the effect of Pilates exercise on position sense in literature. The aim was to determine the effects of Pilates exercise training on knee joint position sense.

Meterial and method: 31 subject (Pilates group = 15 subjects, Control group = 16 subjects) mean aged 20.91 ± 0.99 years completed the study. PG did lower extremity Pilates exercises, three times a week during 8 weeks. Knee joint position sense was measured at 60° of knee flexion, in open chain position, in the beginning and at the end of the 8 weeks in both groups.

Results: The two - way interactions of group and time were significant according to

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two-way ANOVA analysis (p=0.00). The mean values of knee JPS at 60° flexion position improved in Pilates Group whereas deteriorated in Control Group (p<0.05). Leg dominancy was not effective on knee joint position sense after Pilates exercise (p>0.05).

Conclusion: It was determined that Pilates exercise training had positive effect on knee joint position sense.

Key words: Pilates, joint position sense, knee

Proprioception; an important component of balance and proper postural control, is perceiveing the position or movement of extremities and body segments in space (1,2). The sense of position of a joint depends on afferent signals from joint, muscle and skin receptors (1-4). Joint mechanoreceptors have the ability to detect the actual joint position and joint motion. Proprioception allows an individual to maintain joint stability during static and dynamic posture (5).

Theoratically, knee joint proprioception is essential for accurate modulation and activation of muscles, thus providing adequate neuromuscular control of knee joint position and joint movement, and ultimately the performance of physical tasks (6,7). Adequate proprioception is required for safe and capable movement of the body (5). Especially disturbed position sensation in lower limbs may lead to perturbation in daily activities such as walking, running, and may ultimately lead to injuries (1). When proprioceptive acuity decreases, functional ability can only be maintained if there is sufficient muscle strength to compensate for the decrease in accuracy of modulation and activation of the muscles (8). This designates that in the presence of both proprioceptive inaccuracy and muscle weakness, functional ability may be more affected.

The term proprioception encompasses both the sensations of the joint movement (kinesthesia) and the joint position sense (JPS) (9,10). JPS, one component of proprioception is clinically defined as the ability to reproduce joint angles and can be assessed using position-matching protocols with either active or passive movements (10). Both components of lower limb proprioception seem integral for the regulation of balance and postural control (10,11). A decline in lower limb proprioception may contribute to abnormal balance responses and increased falls or other similar injuries (10). It has been suggested that a decrease in proprioception could lead to abnormal joint biomechanics during functional activities such as walking (5). This condition may result in an increasing of the musculoskelatal injuries which may occur in activities of daily living.

Pilates is an exercise approach developed in the early 1900s that is based on body-mind spirit interaction combined with biomechanics, motor learning, and core stability. During a Pilates exercise session, mental effort focuses on activating specific muscles in a functional sequence at controlled speeds, emphasizing quality, precision, and control of movement with specific attention to breathing and proprioception (12 - 15).

Pilates method can be defined as a comprehensive body - mind conditioning, with main goals which are efficient movement, core stability and enhanced performance (15-18). The Pilates exercises improve physical and mental conditioning thorough increasing strength, flexibility, balance and postural awareness by stretching and strengthening exercises (15-18). According to Levine et al. Pilates method focuses on building motions and activities that helps to strengthen minor muscles, which, in turn, helps to strengthen major muscles (17).

More recent use of Pilates method includes fine-tuning of performance for elite athletes and dancers (19,20). There has been a report using Pilates method in rehabilitating post-surgical patients and for recuperation of musculoskeletal conditions (17). The effects of Pilates exercises on shoulder Range of Motion (ROM) in women with breast cancer have been studied by Keays et al. and they reported that it might be an effective and safe exercise option for the restoration of joint motion and upper-extremity function (21).

We searched PubMed, MEDLINE, the Physiotherapy Evidence Database (PEDro), and Cochrane Collaboration Library from 1987 up to and including January 2009. The

researches related to effect of exercise on position sense such as eccentric exercises, or warm up exercises; showed that JPS can be altered by different type of exercises (5,22,23). In literature, there have been few researches on general effects of Pilates exercise but there is no data regarding the effect of Pilates exercise on position sense.

According to our hypothesis; Pilates exercises may affect proprioception via mental effort focuses on activating specific muscles at correct speed, quality, precision, and control of movement with specific joint awareness. Therefore the purpose of the present study is to investigate whether Pilates exercise training affects knee position sense.

MATERIAL AND METHOD

Setting and Participants

Approval was obtained from Dokuz Eylul University, Ethics Committee and written informed consent was obtained from all subjects.

Forty-one healthy untrained individuals (24 female, 17 male) participated in our study. The participants were divided into two groups as Pilates Exercise Groups(PG) (n=21) and Control Groups (CG) (n=20). The table of Random Numbers was used for randomization of exercise group and control group. However, in exercise group; 6 participants did not attain the exercise group regularly and in the control group; 4 participants did not attain the second measurements. Therefore data were obtained from 31 participants (62 knees) (Pilates Exercise Group n=15, Control Group n=16) mean aged 20.91±0.99 years, height 1.71 ± 0.07 m, weight 65.76 ± 11.57 kg.

Participants were all healthy university students without any vestibular, neurological, orthopedic or musculoskeletal injuries (past or current). Subjects had not participated in sporting activities on a regular basis or regular completion of exercise training for at least 6 months prior to the study and all of them were right handed and legged.

Interventions

They were instructed to abstain from strenuous exercise before data collection. All measurements were recorded at baseline and after 8 weeks training program. The researcher involved with group assignment was not informed about either the exercise or the control group.

All measurements were obtained by the same physiotherapist. This physiotherapist was not informed about two groups, either. The demographic information of the participants were recorded. The dominant leg was determined by this question: “Which leg would you prefer to kick a ball?”.

The JPS measurements were conducted in an isolated room away from any visual or auditory stimulation. Both dominant and non-dominant legs were measured. Measurements were obtained actively at 60° knee flexion in open chain position (3,8,22). Participants sat upright in a specially adjusted chair with back support and the hip at an angle of 80° of flexion in a comfortable position, blindfolded to remove visual input and with his or her legs hanging freely over the side of the table. To avoid cutaneous sensation, a small rubber mat (1 cm thick) with cotton cover was placed under the participant’s thighs, and the knee joint and the distal part of the hamstrings were free from the chair (8, 22). A digital goniometer with a precision of 0.5° (Guymon, Model 01129, Lafayatte Instrument, USA) was attached to the lateral aspect of the knee (Figure).

The lower leg of the subject was moved from full extension 0° to 90° knee flexion in order to familiarize subject with the range of motion. Then, the physiotherapist asked subject to position the leg at the reference angle (60° flexion), maintain it for 10 s, and return the lower leg to the initial position (full extension).

This procedure was repeated for three times. Afterwards, subjects were asked to remember where the reference position was (60° flexion) and reproduce it. Subjects actively moved their limb to the target angle and, when they were satisfied with the angle they’ve selected, they were told to hold it for about 2 seconds. The degrees deviating from the reference angle were recorded ignoring the direction of error. This error is the Absolute Error (AE) and an average of the three measurements was calculated to be the Absolute Mean (AM). The AM was used for statistical analysis. Three efforts were performed with 10 seconds rest periods between each test.

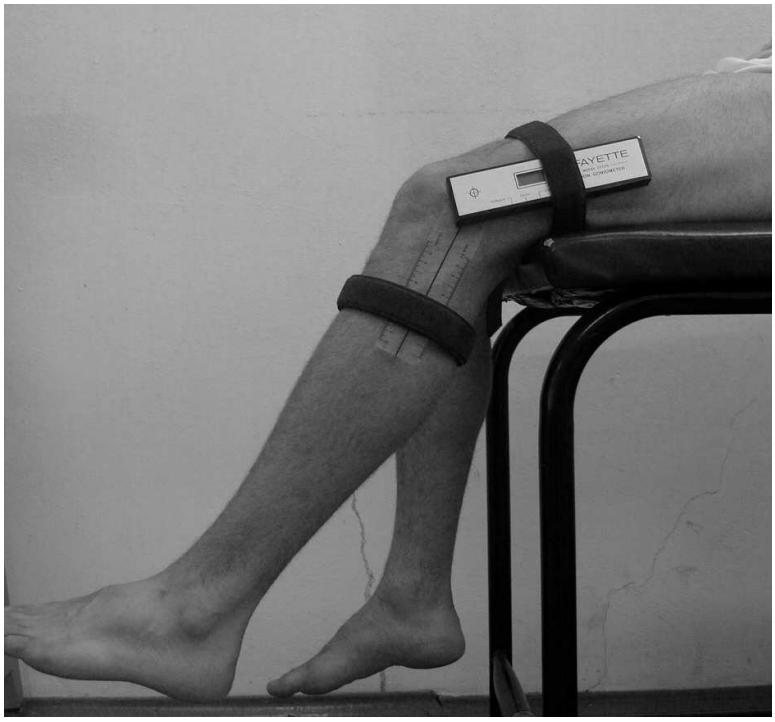

Figure. The test position of the knee joint position sense

Pilates exercise program

Pilates exercise program was made following the six main principles:

" 1. *Centering* is the foundation of all movements, requiring core muscle stabilization prior to initiating arm or leg movements.

2. *Control* refers to the ability to monitor movements, while performing them with the correct mindful intent, from the appropriate muscle groups.

3. *Precision* relates to the focus on completing an exercise using the proper form and execution.

4. *Concentration* places form and the mental fortitude to perform an exercise as the focal point.

5. *Breath* refers to maintaining proper breathing techniques crucial to performing these exercises (Inhalation is used to prepare for the movement and exhalation is used to execute the movement, activate core muscle support, and intensify the movement).

6. *Flow* is the connection of one movement to the next and is developed over time as the patient becomes familiar with the exercises." (24).

Exercise group did lower extremity Pilates exercises for three days a week during 8 weeks. All Pilates sessions were given and supervised by the same experienced physiotherapist. Pilates exercise program was developed by the researchers of the study, based on Levine et. al.'s Pilates training (17). Each session lasted one hour. The class consisted of 20 minutes warm up and cool down (10 minutes before and 10 minutes after the exercises) and 40 minutes (increased gradually from 20 minutes) of Pilates exercises. The repetitions of Pilates exercises were increased gradually from 5 repetitions. In the second week the participants did 6 repetitions, in the third week 7 repetitions and in the fifth week 8 repetitions were done. Between the sixth and eighth weeks, the participants performed 10 repetitions. Pilates exercise program is as illustrated in Table I.

Table I. Pilates exercise protocol

	Exercises
Week 1	Hundreds 1/2/3
Week 2	Week 1 + One leg stretch 1, Double leg stretch 1/2, Clam
Week 3	Week 2 + One leg stretch 2, Shoulder bridge 1
Week 4	Week 3 + Shoulder bridge 2, Hip twist
Week 5	Week 4 + Scissors 1, One leg kick
Week 6	Week 5 + Scissors 2, Side kick 1
Week 7	Week 6 + Side kick 2, One leg circle 1/2
Week 8	Week 7

Control group did not do exercise during 8 weeks. Subjects were told not to change their lifestyle and not to participate a regular exercise program or a sport, during the study. Additionally they've been checked periodically by researches.

Statistical Analysis

The data obtained from the measurements were recorded in the SPSS Windows (13.0) software package. Two-way analysis of variance (ANOVA; group x time) with repeated measurements was used to analyze pure exercise effect. The Paired Samples *t*-test was used to determine the intra-group exercise effectiveness on knee JPS. Mann-Whitney U Test was used to investigate whether dominancy has any effect on position sense. The level of significance was set at $p = 0.05$.

RESULTS

The data were obtained from 31 participant (62 knees) (Exercise Group n=15, Control group n=16). Table II illustrates the comparison of demographic data of the groups. There were no significant differences in any of the outcome variables between exercise and control groups (Table II).

We used the repeated measures ANOVA test to compare the mean absolute error values of knee position sense of the participants. The two way interactions of group x time were significant ($p=0.00$, $F = 1.17$). The Paired Samples *t*-test showed that the mean values of knee JPS at 60° knee flexion significantly improved in exercise group whereas it significantly deteriorated in control group ($p<0.05$) (Table III).

Exercise Group; knee JPS significantly improved at target angle in open kinetic chain position after 8 weeks once compared with the baseline mean values ($p<0.05$) (Table III). In this group, right leg and left leg compared before and after training by using Mann Whitney-U test, there were no difference between right leg and left leg (before training $p=0.45$, after training $p=0.95$).

Control Group; the mean values of knee JPS at target angle were negatively altered after 8 weeks, compared with initial measurements in control group and a significant difference was determined ($p<0.05$) (Table III).

Table II. Demographic variables at the baseline for the groups

	Exercise Group (n=15) F=7 M=8	Control group (n=16) F=7 M=9	*p*
	Mean ± SD	Mean ± SD	
Age (year)	20.80 ± 0.86	21.79 ± 1.27	0.53
Height (m)	1.71 ± 0.05	1.71 ± 0.08	0.99
Body weight (kg)	64.80 ± 11.33	66.53 ± 12.00	0.50
Body Mass Index (kg/m^2)	22.23 ± 4.40	22.53 ± 2.73	0.42

F-Female,M-Male

Table III. Knee joint position sense values of the exercise and control groups at the baseline and 8th week

Groups	MAE of JPS (°)		*p*
	Baseline	After 8 weeks	
	Mean ± SD	Mean ± SD	
Exercise group (n=15)	4.17 ± 2.06	2.24 ± 1.32	0.000*
Control group (n=16)	4.27 ± 2.52	4.78 ± 2.42	0.001*

MAE: Mean Absolute Error, JPS: Joint position sense, ***p*<0.05**

DISCUSSION

In the present study, we investigated the effects of 8 weeks Pilates exercise training on knee joint position sense and our results showed that the Pilates exercises improved JPS. The strength of the study is; being the first work investigating the effect of Pilates exercises, a popular technique, on knee JPS.

Pilates method is a new approach for clinical setting. There are only two studies as randomized controlled trials including Pilates in the literature. Rydeard et al. gave a 4-weeks program consisting of training on specialized (Pilates) exercise equipment, while the control group received the usual care. Treatment sessions were designed to train the activation of specific muscles thought to stabilize the lumbar-pelvic region. The individuals in the specific-exercise-training group showed a significant improvement. They suggested that the treatment with a modified Pilates-based approach was more efficacious for decrease in pain and disability, which was maintained over a 12-month follow-up period than usual care in a population with chronic, unresolved LBP (26). The second study reported that a significant reduction in pain intensity and improvement for disability level in both back school and Pilates exercise samples. Additionally, Pilates method group showed better compliance and subjective response to treatment. They suggested that this method was a valid alternative in the treatment of non-specific low back pain (27).

Moreover, in other studies emphasized that Pilates exercises have positive effects on body weight control, pregnancy, scoliosis and walking control (16,28-30). Levine et. al. suggested that Pilates exercises can be used after arthroplastic surgeries because strength and flexibility is increased by this method (17).

Our hypothesis was that Pilates exercise which aimed to improve whole body awareness might be effective on knee position sense, although it's one local joint area. Our findings indicated that Pilates exercises training improves knee JPS. Some mechanisms might be related to effect of Pilates exercises on knee position sense. It is generally agreed that signal of from muscle spindles contribute to the sense of position and movement of the limb (5). The muscle spindles may activate after eccentric exercise (1) and stretching exercises in Pilates training (15,18). Pilates method might increase the sensitivity of mechanoreceptors which provide the necessary enhancement of reflex neuromuscular protective mechanisms.

There are several studies investigated the effects of different type of exercises on the restoration of proprioception in knee injuries (5,22,23). Subasi et al. reported that warm up exercises improve knee position sense. They pointed out that warm-up exercises may improve mechanoreceptor sensitivity by improving proper viscoelastic properties of the muscle tissue, enhanced oxygenation, and increased body temperature caused from vasodilatation (5). According to Boue Et et al, these alternations may improve the functioning of these receptors and kinesthetic sensibility Increased temperature decreases the threshold of the mechanoreceptors and improves tactile sensibility by exercise (22). In addition, the central factors are also effective on joint position sense (5). The muscular response probably differs after exercise; this could be affected by a modification of either corollary discharges likely involved in position sense, fusimotor commands, and spindle activity. Therefore, muscular exercises improve proprioception by enhancing motor performances due to not only the improved mechanical properties of the muscles but also to better kinesthetic sensibility. The effects of different types of exer-

cises on position sense and possible mechanisms are quite known whereas there is a lack of information about the effects of Pilates exercises on JPS in literature.

Activities of daily living are composed of static and dynamic conditions such as sitting or walking in various knee flexion and extension angles. We used active knee JPS testing at 60° flexion position for the measurements. To assess the effects of Pilates exercises which consists strength and stretching components on contractile structures we choose active position testing. Olsson et al suggested that the test angle should be in the middle (suggested from 40° to 80° flexion) of the knee joint's range of motion to perform a more reliable measurement. They explained that the detection of the JPS at near terminal extension degrees is quite difficult and might be incorrect, rather than wider angles (25).

We also investigated whether dominancy is effective on knee JPS to determine the pure effect of exercise. The analysis showed that the knee JPS for both legs were similar before and after 8 weeks training. Dominancy may not be an important parameter for knee JPS, even after Pilates exercise.

In the scientific literature for Pilates exercise, there is no valid data regarding the length of Pilates exercise program (15,17,18,26). The length of the exercise program in researches examined the effect of the exercise program on joint position sense was mostly between 3 and 8 weeks (23,3). We carried out an 8 weeks program and found a significant difference for the knee JPS. Therefore we may suggest that this length of the training program could be sufficient to gain improvements for knee JPS.

The advantage of this study is that our participants enjoyed Pilates exercises. Additionally, the originality and variety of this method may have encouraged a more trusting attitude to the program. Originality of Pilates method stimulated their interest and involving the participants in this technique. The regular participation of the program and supervision by a physiotherapist might have positive effects on our results.

CONCLUSION

Our findings show that Pilates exercise training improved knee JPS. We may suggest Pilates exercises to restore the normal position sense by activating specific muscles at optimum speed and quality and control of movement with specific joint awareness. Thus injuries and re-injuries can be prevented and this might be advantageous for physical or sportive activities. Our study may highlight for further studies on this subject.

Additionally, the results of this study suggeste that Pilates exercises might be used as a strong therapeutic or prophylactic method because the participants enjoyed the program and attended regularly.

Clinical implications:

1. Pilates exercise program which consisted of specific lower extremity exercises may be an alternative intervention to improve knee joint position sense.
2. 8 weeks Pilates training is sufficient to gain such improvement.

Future studies need to be conducted on a larger sample of subjects and investigate the effects of different types of Pilates exercises to determine the optimum program in order to attain more definite results and. The effects of Pilates exercises on proprioception should be investigated in the injured populations and also in amateur and professional athletes.

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