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THE EFFECT OF TRADITIONAL MAT EXERCISES VERSUS REFORMER PILATES AND HAMMOCK YOGA ON PAIN, ENDURANCE, BALANCE, DISABILITY, AND QUALITY OF LIFE IN INDIVIDUALS WHO HAD CHRONIC BACK PAIN

KRONİK BEL AĞRISI OLAN BİREYLERDE GELENEKSEL MAT EGZERSİZLERİ İLE REFORMER PİLATES VE HAMAK YOGANIN AĞRI, DAYANIKLILIK, DENGE, ENGELLİK VE YAŞAM KALİTESİ ÜZERİNDEKİ ETKİSİ

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ABSTRACT

Objective: The aim of this study to examine the effects of traditional mat exercises, Reformer Pilates (RP) and Hammock Yoga (HY) approaches on pain, endurance, balance, disability, and quality of life of individuals who had Chronic low back pain (LBP).

Method: 60 individuals who had Chronic LBP were participated and randomly attended into 3 groups as RP group (n=20, mean age:31.85±8.89 years), HY group (n=20, mean age:29.90±6.70 years), and mat group (n=20, mean age:30.40±8.21 years). All exercise training was applied twice a week for 4 weeks (45 minutes). The pain was evaluated with VAS and McGill, endurance was evaluated with plank tests and single leg hip bridge test, static balance was assessed with standing on single leg, and dynamic balance was assesed with the Star Excursion Balance Test. The Oswestry Disability Questionnaire and World Health Organization Quality of Life (WHOQOL-Bref) were used for disability and quality of life measurements, respectively.

Results: Improvements were observed on a group basis in all evaluated parameters ($p<0.05$). In the mat group, the McGill score improved more than the HY group, and Oswestry and WHOQOL-Bref improved more than the HY and RP groups ($p<0.05$). The performance of standing on single leg improved in the HY group more than the mat group ($p<0.05$).

Conclusion: Traditional mat exercises can be preferred primarily to reduce disability and improve the quality of life in individuals with Chronic LBP in a short time. The HY can be added to the content of individual exercise programs for the development of balance.

Key Words: Low Back Pain, Pilates Training, Yoga, Disability, Quality of Life

ÖZ

Amaç: Bu çalışmanın amacı geleneksel mat egzersizleri, Reformer Pilates (RP) ve Hamak Yogası (HY) yaklaşımlarının kronik bel ağrılı (KBA) bireylerin ağrı, dayanıklılık, denge, engellilik ve yaşam kalitesi üzerindeki etkilerini incelemekti.

Yöntem: KBA'sı olan 60 birey çalışmaya katıldı ve rastgele randomizasyon yöntemi ile RP grubu (n=20, ortalama yaş:31.85±8.89 yıl), HY grubu (n=20, ortalama yaş:29.90±6.70 yıl) ve mat grubu (n=20, ortalama yaş:30.40±8.21 yıl) olmak üzere 3 gruba ayrıldı. Tüm egzersiz eğitimleri 4 hafta boyunca haftada iki kez (45 dakika) uygulandı. Ağrı VAS ve McGill ile endurans plank testi ve tek bacak kalça köprüsü testi ile statik denge tek ayak üzerinde durma testi ile dinamik denge yıldız denge testi ile değerlendirildi. Engelilik Oswestry Özürlülük Anketi ile yaşam kalitesi ise Dünya Sağlık Örgütü Yaşam Kalitesi (WHOQOL-Bref) ile değerlendirildi.

Bulgular: Değerlendirilen tüm parametrelerde gruplar bazında gelişme saptandı ($p<0.05$). Mat grubunda McGill skoru HY grubuna göre, Oswestry ve WHOQOL-Bref skorları ise HY ve RP gruplarına göre daha fazla iyileşti ($p<0.05$). Tek ayak üzerinde durma performansı HY grubunda mat grubuna göre daha fazla gelişti ($p<0.05$).

Sonuç: Geleneksel mat egzersizleri KBA'sı olan bireylerin engelliliğini azaltmak ve yaşam kalitesini kısa sürede artırmak amacıyla öncelikle tercih edilebilir. Denge gelişimi için bireysel egzersiz programlarının içeriğine HY eklenebilir.

Anahtar Kelimeler: Bel Ağrısı, Pilates Eğitimi, Yoga, Engellilik, Yaşam Kalitesi

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INTRODUCTION

Low back pain (LBP) is one of the leading musculoskeletal problems worldwide impacting healthcare system and causing socio-economic burden [1]. It can affect people of all ages in the community, but it is common in individuals between the fourth and fifth decades of life [2,3]. Low back pain is divided into 3 subclasses according to the duration of the symptoms as Acute (lasting only a few weeks), Subacute (lasting about 6 to 12 weeks), and chronic (lasting more than 12 weeks) [4,5]. Clinicians cannot make a specific diagnosis in approximately 90% of chronic LBP cases, and for this reason, it is classified as mon-specific chronic LBP [6]. Approximately 33% of individuals who have LBP say that they face permanent pain and activity restriction after one year [7]. Many people who have this disability are more limited in daily living activities such as walking, running, and bending over compared to healthy people [1]. In addition to the unpleasant feeling, chronic pain also affects the quality of life, cognitive and emotional state of the individual [8]. When the etiology of chronic LBP is examined, it is seen that it is not only a mechanical problem, but physical and psychosocial factors also play major roles [1,8,9].

Traditional mat exercises (ground-based strenght and strecthing exercises) were effective in the management of chronic LBP as an extremely valuable approach to preventing movement limitation, controlling existing pain, and regaining motor functions [10]. Reformer Pilates is another valuable exercise approach for the treatment of LBP. The only difference from Pilates is that it is used as an auxiliary tool. Reformer Pilates consists of a sliding platform working with the help of a pulley system specific to the use, allowing the individual to apply certain resistances, and providing the opportunity to exercise sitting, standing, or lying down. Pilates activates the lumbopelvic muscles, reduce the load on the spine and supports functional movement as an effective factor in reducing pain [11]. Yoga is a mind-body exercise discipline that includes both physical and mental aspects of pain with core strengthening, flexibility, relaxation, and breathing modalities [12,13]. The Hammock Yoga, on the other hand, is performed with a silk hammock, which is an auxiliary equipment just like Reformer Pilates. The most distinctive characteristic that makes Hammock Yoga different from other exercises is the spine traction provided by the upside-down posture, and the smooth and shiny silk hammock allows strengthening exercises [14]. The Hammock Yoga aims to reduce the load on the spine by upside-down postures that defy the laws of physics.

It was shown that Pilates exercises are more effective than other conservative modalities (e.g., resting, thermal agents such as ice-heat, analgesics, and Nonsteroidal Anti-Inflammatory Drugs) used in the treatment of chronic LBP [15]. It was found that yoga exercise is quite effective for individuals with chronic LBP who do not engage in any other exercises [16]. In another study, it was proven that yoga exercise reduces pain, the need for analgesics, and disability, and also increases the spinal mobility [17]. When the literature was reviewed, no study was detected examining the effectiveness of Hammock Yoga and Reformer Pilates in people who have chronic LBP and compares it with traditional mat exercises. The present study was conducted to examine the effects of traditional mat exercises, Reformer Pilates, and Hammock Yoga on pain, endurance, balance, disability, and quality of life in individuals with chronic LBP.

METHOD

Study Design and Participants

This parallel, 3-group, randomised control trial design was conducted in 60 patients aged 25-60 years with persistent low back pain in the previous 12 months. The study was carried out in a private health clinic in Gaziantep between April 2022 and June 2022. Participants with a low back pain intensity of 40 mm or worse in the previous 6 months as demonstrated by VAS (0-100 mm) were included in the study.

The diagnosis of chronic LBP was made by a physical medicine and rehabilitation specialist with 13 year of experience in the clinical assessments, laboratory testing and radiological screening. Patients underwent a detailed assessment that include motor and sensory functions, special diagnostic testing. A suspecion occured base on clinical assessment and anamnesia, the blood tests and EMG were used for clarity.

Participants with a history of surgery in the lumbar region in the last 1 year, inflammatory arthritis, axial spondyloarthropathies, radiculopathy or polyneuropathy, malignancy, performed regular physical activity, systemic or physiological disorders, and those who were using steroids and anti-inflammatory drugs in the physiotherapy program were excluded from the study.

Participants were recruited in Gaziantep through direct referral from primary care clinicians, social media and advertisements. Patients meeting the inclusion criteria were divided into 3 groups (n=20 Mat, n=20 Reformer Pilates, n=20 Hammock Yoga) using a closed envelope randomisation method. The same clinician repeated the baseline assessment and the final assessment after 8 sessions (4 weeks). Only pain severity (VAS) was assessed at baseline, and in the 1st, 2nd, 3rd, and 4th weeks (total of 5-time intervals). No one dropped out of any group while studying (Figure 1).

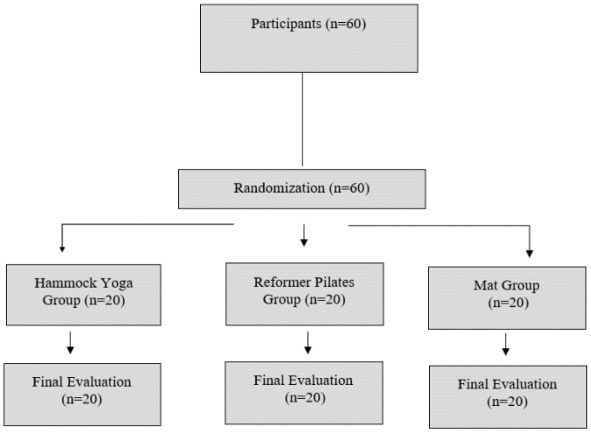

Figure 1. Study flow chart

Assessments

The sociodemographic and physical characteristics of the participants (i.e., ages, heights, body weights, pain complaints, and physical activity levels) were recorded before the study.

Pain

McGill Short Form was used at the beginning and end of the study to evaluate the qualitative characteristics of pain. The language validity of the McGill Pain Scale was conducted by Yakut et al. [18]. The scale helps to learn about the sensory, emotional, and intensity component of pain. Fifteen items in the scale help define pain (11 sensory descriptors and 4 emotional descriptors). The participants were asked to rate their pain as 0=none, 1=less, 2=moderate, and 3=extreme, according to the intensity level. The total score was obtained by summing the scores given [18].

A Visual Analog Scale (VAS, 0-100mm) was used to evaluate pain intensity 5 times (at the beginning, weekly (in the first, second, and third weeks), and at the end of the study).

Endurance

The endurance of the trunk muscles was evaluated with Plank Tests and Single Leg Bridge Tests. Oral information about the tests was given to the individuals and a demonstration was made by the physiotherapist before the test.

Plank Tests

The prone plank test position was initiated on the prone bridge over the forearm and toes and the individuals were instructed to position their elbows just below their shoulders with their fingers reaching forward. Feedback was given to keep the spinal region in a neutral position so that they were in a proper alignment from head to heels. Once the correct position was taken, the physiotherapist started the stopwatch, and the duration they could stand until the position was broken was recorded [19].

The Lateral Plank Test was used bilaterally on the right and left sides. The participants were asked for a side-lying position, stand on forearms with arms perpendicular to the ground. Then, wanted elbows flexed at 90o, put the other hand on the waist, extending lower extremities with both feet on top of each other. When the individuals took this position, the timer was started and they were asked to maintain this position as much as possible, if they could not, the test was terminated and the time was recorded [19].

Single Leg Bridge Test

The participants were asked to go to the bridge position with their supine hands-free at their sides and hips in the air, and while they were in this position, they were asked to keep the hip and knee flexion of the tested side and take the other leg into the air with the sole on the ground, and maintain the neutral position of the pelvis. When the test position was taken, the physiotherapist initiated the stopwatch and recorded the time until the participant broke the pelvis position [20].

Balance

Static Balance

Before starting the test, the physiotherapist knelt behind the participant and helped the participants to find the neutral pelvis position by placing their hands on the iliac crest. The participants were then asked to pull their knees towards the abdomen and maintain this position while keeping their hands on their waists without disturbing the neutral pelvis [21]. The time that passed until the position was broken was calculated and this test was repeated three times in total for both the right and left legs, and the maximum time was recorded in seconds.

Dynamic Balance

Developed by Gray in 1995 to evaluate dynamic balance, the Star Excursion Balance Test was used in the evaluation of dynamic balance. A total of 8 lines (anterolateral, anterior, anteromedial, medial, posteromedial, posterior, posterolateral, and lateral) of 1m length were drawn on a flat surface at 45o their centers converging. The individuals were then asked to reach the farthest point possible in each line with the tip of the other foot and the foot to be tested in the middle of the star [22]. A resting period of 5 seconds was given after each stretch. If the balance was disturbed while reaching, the participants could not touch the lines, or gave full weight with their feet, the attempt was rejected and repeated. The distances that the individuals could reach and touch were recorded, and the test was repeated 3 times to record the maximum score.

Disability

Disability (e.g., walking, sitting, standing, pain intensity, and sleeping) were evaluated with the Oswestry Disability Index, which consisted of 10 sections. A total score was obtained by scoring a Likert-type design (“0” - “5” in each section. An increase in the score indicated an increased disability [23].

Quality of Life

The World Health Organization Quality of Life-Bref (WHOQOL-Bref) Questionnaire was used to evaluate the quality of life. The validity and reliability study of it was conducted by Eser et al. The questionnaire has 5 sections (Psychological Health, Physical Health, General Health, Social Relations, and Environmental Health). The total score was obtained for each question with the Likert-type scoring. The higher score was implied the higher quality of life [24].

Exercise Training

An exercise program was created for the Reformer Pilates, Hammock Yoga, and Mat groups, 2 days a week, for 4 weeks, in a total of 8 sessions. While the exercises of the Reformer Pilates and Hammock Yoga groups were given as individual sessions by the physiotherapist, the Mat group exercises were applied as a home program.

The exercise sessions include 10-minute warm-up exercises, main exercise section (30 minutes each) and 5-minute cool-down exercises, respectively. All exercises were done as a set with 10 repetitions in the first week, 12 repetitions in the second week, and 15 repetitions in the last 2 weeks. The exercise intensity (the number of repetitions and the level of movement) was increased gradually. In choosing the exercise, the purpose was to work the transversus abdominis, multifidus, and gluteus muscles both eccentrically and concentrically, and to protect the spinal stabilization and create awareness during the movement. All exercises were performed with breathing coordination. Hammock Yoga and Reformer Exercises were explained by the physiotherapist in detail to understand the movement and starting position correctly, and the participants were then asked to perform the movements. In the Mat group, the exercises were visually given with detailed explanations on a piece of paper, and they were checked by telephone every week. The participants of Reformer Pilates and Hammock Yoga groups were also asked to wear sports clothes to move freely, and attention was paid to the ventilation of the exercise room.

The exercise program was planned for each group in the following order (Figure 2).

Warm-up

-Hip flexor stretches

-Flexing hip adductors

-Hip extensor stretches

-Footwork series

Force Series

-Squat

-Bridge exercise

-Abdominal series

-Plank

-Back extensors strengthening series

-Shoulder posture

Cool-down

-Gastrosoleus strecthing

-Flexing the hip extensors

-Piriformis stretching

-Yawning in a mermaid

Ethical Approval

Ethics Committee Approval was obtained on 13.04.2022 with the number 2022/037 from Hasan Kalyoncu University Faculty of Health Sciences Non-Interventional Research Ethics Committee. Informed and signed consent forms were obtained from the volunteers who met the inclusion criteria of the study.

Statistical Analysis

The minimum total number of participants needed for the study was calculated as 53 (α=0.05) to determine the expectation that there would

be a significant difference between three different groups at the large effect level (f=0.75) with a power of 0.95. The G-Power Program version 3.9.1.7 was used in the power analysis.

Statistical analysis of the data was made with the SPSS version 23 program. Whether the data were normally distributed or not was tested with the Kolmogorov-Smirnov Test. The Kruskal Wallis Test was used for the comparison of the non-normally distributed data between the groups, and the ANOVA Test was used for normally distributed data. The Mann-Whitney U-Test was used to determine from which group the difference stemmed. The Two-Way ANOVA was used to evaluate the effects of exercise and time. The effect size (η^2) was defined as small (0.2), medium (0.5), and large (0.8). The Bonfferoni Forward Statistics were used to find the sources of the differences. Continuous variables were given as Mean±Standard Deviation and categorical variables as percentages and numbers, and $p<0.05$ was taken as the statistical significance level.

Figure 2. Some example for bridge exercises from the Hammock Yoga (a), Mat (b) and Reformer Pilates (c) sessions

RESULTS

Randomisation was carried out with 60 patients who were eligible for the study and no patients dropped out of the study. The attendance of the individuals was 100%. The mean age of the individuals was 31.85±8.89 for the Reformer Pilates group, 29.90±6.70 for the Hammock Yoga group, and 30.40±8.21 for the Mat group, respectively. The physical characteristics of the individuals (i.e., age, weight, height, and BMI scores) are given in Table 1. The groups were similar in terms of age, weight, height, and BMI scores ($p>0.05$).

The baseline pain score of the Mat group was found to be higher than the Hammock Yoga group. Also, the Oswestry Disability Questionnaire and the WHOQOL-Bref Questionnaire scores were higher than both groups ($p<0.05$). Time, group, and group x time effects were observed in McGill and Oswestry scores ($p<0.05$). McGill's pain score decreased more in the Mat group when compared to the Hammock group ($p<0.05$). The disability score showed more improvement in the Mat group when compared to the other groups ($p<0.05$). In terms of the WHOQOL-Bref scores, only time and group effects were found and the Mat group showed more improvement than the other two groups ($p<0.05$). There was a time effect (pain decreased in all groups) in the pain intensity (VAS) measurements at 5 different times during the study ($p<0.05$) but there was no group and group x time ($p>0.05$) (Table 2).

In the Star Excursion Dynamic Balance Evaluation on the right leg and left leg before the treatment, the posteromedial direction value of the Mat group was higher than the Reformer group ($p<0.05$). The time effect was observed in all balance parameters but the group effect was only present in the left single-foot balance test ($p<0.05$). The group x time effect was detected in right-left single-foot balance measurements, right star test anterior-posterior-posterolateral-lateral directions and left anterior-anteromedial-posterior-lateral directions, it was significant only in left single-foot balance value in the Bonferroni advanced statistical analysis. Balance on a single left foot improved more in the Hammock group than in the Mat group ($p<0.05$) (Table 3).

Only the right single-leg hip bridge score was different between the groups before the treatment in the endurance tests ($p<0.05$). The right single-leg hip bridge score of Mat group was better than the Hammock Yoga group ($p<0.05$). Time effect was detected in all endurance parameters ($p<0.05$). Group effect was not detected in any parameters ($p>0.05$). While the group x time effect was detected in the prone plank and right single-leg hip bridge parameters, no difference was detected between the groups in the Bonferroni advanced statistical analysis ($p>0.05$) (Table 4).

DISCUSSION

The present study investigated the effectiveness of traditional mat exercises in people with chronic LBP despite Reformer Pilates and Hammock Yoga approaches. Traditional mat exercises were found to be more effective than Hammock Yoga and Reformer Pilates in reducing pain, disability and improving quality of life in the short term. Hammock Yoga training further improved the static balance.

In the literature, it was found that many researchers stated that weakened core muscles (especially M. Transversus Abdominis and M. Multifidus) cause low back pain because they cannot provide spinal stability [1]. Lee et al. showed that the frequency of low back pain may be caused by insufficient and imbalance of core muscle strength, uncontrolled neuromuscular structure, and biomechanics of the spine [25]. Although the causes of low back pain are often weakness in the core area, there are also studies reporting that there are other factors (age, sex, smoking, obesity, depression/anxiety) involved [26,27]. In a randomized controlled study, 3 different exercises were applied to 44 people who had low back pain (Lumbar Stabilization, Dynamic Strengthening, and Pilates). The pain, core strength, and disability scores improved in the three exercise groups during 3 weeks, but the improvement in the lumbar stabilization group was greater than in the other groups. It was argued that the reason for this was that the exercises chosen in the Pilates were dynamic, and that abdominal hollowing could provide more transverse abdominis and multifidius activation in the lumbar stabilization exercises [9]. In our study, Reformer Pilates and mat exercises may have activated the core more than Hammock Yoga, which may have had a different effect on pain reduction. In hammock yoga, it can be difficult to retract and hold abdomen in during gravitational movements. Also, we think that the our individuals might have developed anxiety or fear against various gravitational movements during Hammock Yoga. It may also be possible that Pilates Exercises and mat exercises consisted of more horizontal movements and reduced the pain by affecting the compressive and separating forces of the spinal region. It is already known that 4-week Pilates Training has significant effects in reducing pain in the long term [15].

There is no consensus in the literature on the reduction of disability. Reformer Pilates has been shown to reduce disability and pain in workers with chronic back pain [11]. However, Lim et al. reported that the Pilates were more effective for reducing pain when compared to alternative treatments, but it was ineffective for reducing disability [28]. Pereira et al. concluded that the Pilates did not reduce either pain or disability [29]. However, La Touche et al. found that the Pilates reduced pain and disability in patients with low back pain. [10]. Similarly, as in the Lim et al. study, we found that Reformer Pilates reduced pain but had no effect on disability and quality of life. Some methodological differences (population, timing and exercise principle, etc.) may explain our conflicting results with other studies. On the other hand, the improvement in pain and disability in the mat exercise group may have been due to the mat exercise being more familiar, increasing attendance for patients in this group.

The primary cause of low back pain is generally seen as insufficient endurance of the lumbar extensors and the abdominal muscles are neglected. But the most important thing is to train the lumbar and abdominal muscles together because it works together synchronously for stabilization and reduces the load on the spine. Trunk endurance training, which is used for patients with chronic back pain, has positive effects on the balance, pain, and flexibility [30].

Table 1. Descriptive variables for groups

Variables	Hammock Yoga (n=20)		Reformer Pilates (n=20)		Mat (n=20)		f	p
	X±SD	(Min-Max)	X±SD	(Min-Max)	X±SD	(Min-Max)		
Age (year)	29.90±6.70	(21-44)	31.85±8.89	(24-55)	30.40±8.21	(21-48)	0.322	0.726
BW (kg)	60.85±12.72	(45-102)	67.75±18.75	(48-130)	67.80±14.49	(44-100)	1.326	0.274
Height (cm)	164.00±6.49	(150-176)	166.15±10.85	(148-197)	165.25±6.74	(153-176)	0.341	0.713
BMI (kg/m^2)	22.58±4.14	(15.9-35.3)	24.27±4.39	(18.3-33.5)	24.76±4.66	(17.5-32.3)	1.400	0.255

*kg: Kilogram; cm: Centimeter; BW: Body Weight; BMI: Body Mass Index; *p<0.05; One-way ANOVA test*

Table 2. Comparison of pain, disability and quality of life

Variables	Hammock Yoga (n=20)		Reformer Pilates (n=20)		Mat (n=20)		ANOVA Effect Size (η^2)			Pairwise comparison (Bonferroni)
	Pre-test	Post-Test	Pre-test	Post-Test	Pre-test	Post-Test	Exercise	Time	Exercise -time	Groups
McGill (score)	13.65±11.36	8.00±6.54	17.55±9.38	7.95±4.31	25.70±14.00[b]	8.50±7.61	**0.29***	**0.47****	**0.15***	H<M
Oswestry (score)	19.05±5.01	15.35±4.23	24.50±9.16	14.80±7.50	32.60±11.07[b,c]	19.60±7.76	**0.28****	**0.46****	**0.14***	H=P<M
WHOQOL -Bref (score)	92.50±13.23	96.80±10.79	90.30±12.73	96.85±9.42	79.25±13.72[b,c]	91.15±13.79	**0.16***	**0.20****	0.04	H=P<M
VAS (socre)										
Vas Pre-test	5.95±1.79		6.30±1.66		6.55±2.14					
Vas 1.week	4.40±1.79		4.60±1.57		5.05±2.33					
Vas 2.week	3.30±1.49		3.60±1.57		4.10±2.13		0.04	**0.90****	0.05	NS
Vas 3.week	1.95±1.50		2.20±1.20		2.85±1.90					
Vas Post-test	1.25±1.29		1.20±1.01		1.65±1.53					

*WHOQOL-Bref: World Health Organization Quality of Life scale; VAS: Visual Analog Scale; NS: Non-significant; *p<0.05; **p <0.01; Data are presented as mean±SD; Pre-test differences between groups (Mann-Whitney U test); [a]p<0.05 Hammock vs. Reformer; [b]p<0.05 Hammock vs. Mat; [c]p<0.05 Reformer vs. Mat.*

Table 3. Comparison of static and dynamic balance

Variables	Hammock Yoga (n=20)		Reformer Pilates (n=20)		Mat (n=20)		ANOVA Effect Size (η^2)			Pairwise comparison (Bonferroni)
	Pre-test	Post-Test	Pre-test	Post-Test	Pre-test	Post-Test	Exer.	Time	Exer. - time	Groups
SLS-Right (sec)	67.30±51.54	92.85±70.64	70.20±40.88	113.90±45.68	105.40±49.26[c]	120.60±53.70	0.07	**0.43****	**0.11***	NS
SLS-Left (sec)	56.70±34.99	82.40±49.24	71.00±37.23	124.70±58.65	102.20±51.06[c]	122.90±55.93	**0.13***	**0.55****	**0.19***	**H>M**
SEBT Test Right (cm)										
Anterior	70.60±11.71	80.90±11.83	73.40±9.26	82.40±8.37	80.10±17.16	82.40±13.55	0.04	**0.42****	**0.15****	NS
Anteromedial	66.10±12.20	74.85±12.72	69.50±10.22	79.00±9.37	75.15±15.37	82.05±13.91	0.08	**0.50****	0.02	NS
Medial	60.90±14.09	71.05±12.69	63.05±11.24	73.70±10.85	69.85±17.47	77.40±13.24	0.06	**0.46****	0.02	NS
Posteromedial	58.95±12.37	69.15±13.26	60.75±11.07	74.00±12.51	69.05±15.80[c]	75.15±11.37	0.07	**0.54****	0.09	NS
Posterior	64.30±11.34	75.60±13.75	66.70±9.61	77.15±12.68	73.15±14.95	75.15±12.75	0.02	**0.40****	**0.16****	NS
Posterolateral	70.25±15.09	77.15±15.42	72.50±10.92	81.75±10.88	70.15±18.18	70.95±14.68	0.04	**0.23****	**0.11***	NS
Lateral	69.30±16.46	77.70±14.78	75.85±13.96	83.40±12.56	71.50±19.14	70.80±15.61	0.05	**0.19****	**0.13***	NS
Anterolateral	72.80±14.85	83.35±14.62	78.10±15.36	89.05±12.96	75.05±18.75	80.70±15.03	0.03	**0.50****	0.07	NS
SEBT Test Left (cm)										
Anterior	71.85±12.14	83.20±11.97	76.05±10.64	87.25±10.78	78.70±15.06	82.95±13.77	0.02	**0.59****	**0.16****	NS
Anteromedial	70.05±14.61	82.65±13.64	80.30±11.81	90.10±9.93	77.30±14.67	82.05±12.80	0.09	**0.51****	**0.12***	NS
Medial	72.15±12.67	79.80±11.51	78.80±11.94	89.10±9.53	76.95±16.43	81.65±12.69	0.07	**0.46****	0.07	NS
Posteromedial	68.75±11.82	77.65±11.55	74.15±11.71	85.65±10.40	75.35±16.04	80.25±12.59	0.06	**0.48****	0.09	NS
Posterior	68.55±11.48	77.90±9.14	70.55±11.27	82.20±9.24	76.75±13.95	81.55±10.08	0.06	**0.51****	**0.10***	NS
Posterolateral	63.40±13.68	73.45±10.45	68.95±11.38	80.10±9.60	70.65±17.48	76.70±13.61	0.05	**0.45****	0.05	NS
Lateral	59.75±14.14	70.30±11.69	61.60±12.94	75.50±13.17	68.75±18.22	73.55±11.34	0.03	**0.56****	**0.16****	NS
Anterolateral	66.80±13.30	78.05±11.80	71.35±13.00	84.85±12.87	75.05±15.99	86.45±26.83	0.05	**0.42****	0.01	NS

*SLS: Single leg standing; SEBT: Star excursion balance test; Sec: second; cm: Centimeter; Exer: Exercise; NS: non-significant; *p<0.05; **p<0.01; Data are presented as mean±SD; Pre-test differences between groups (Mann-Whitney U test); [a]p<0.05 Hammock vs. Reformer; [b]p<0.05 Hammock vs. Mat; [c]p<0.05 Reformer vs. Mat.*

Table 4. Comparison of endurance

Variables	Hammock Yoga (n=20)		Reformer Pilates (n=20)		Mat (n=20)		ANOVA Effect Size (η^2)			Pairwise comparison (Bonferroni)
	Pre-test	Post-Test	Pre-test	Post-Test	Pre-test	Post-Test	Exer	Time	Exercise-time	Groups
Forward Plank (sec)	46.80±17.35	56.20±21.56	44.40±24.37	66.35±29.90	40.25±19.00	56.55±17.68	0.02	**0.55****	**0.11***	NS
Right Lateral Plank (sec)	18.70±7.60	24.50±12.91	17.45±11.40	25.85±12.14	16.60±11.12	20.80±11.58	0.02	**0.44****	0.06	NS
Left Lateral Plank (sec)	18.55±10.35	24.05±13.61	23.95±13.70	32.60±15.15	17.75±13.84	23.30±12.14	0.07	**0.40****	0.03	NS
Right SLHB (sec)	35.85±15.44	56.40±18.67	43.05±20.10	65.60±29.89	57.90±25.79[b]	68.60±24.99	0.09	**0.68****	**0.15***	NS
Left SLHB (sec)	39.20±21.12	58.95±21.67	46.80±21.91	70.65±29.96	55.50±20.24	69.05±20.63	0.07	**0.60****	0.07	NS

*Sec: Second; Exer: Exercise; SLHB: Single Leg Hip Bridge; NS: non-significant; *p<0.05; **p<0.01; Data are presented as mean±SD; Pre-test differences between groups (Mann-Whitney U test); [a]p<0.05 Hammock vs. Reformer; [b]p<0.05 Hammock vs. Mat; [c]p<0.05 Reformer vs. Mat.*

In a randomized study, Mat Pilates and Reformer Pilates improved abdominal endurance similarly during 8 weeks [31]. Similarly, endurance improved in all our groups and they did not have superiority over each other, which may have occurred because the exercises were targeted similar muscle groups, and the exercise duration and volumes were the same in all groups.

In the present study, Hammock Yoga improved static balance more than traditional mat exercise programs. It may be the result of the increase in postural control because of the change of the gravitational center by starting most of the exercises horizontally from the ground and continuing vertically in Hammock Yoga and Reformer Pilates groups. In previous studies that investigated the effects of Pilates Exercises on balance, dynamic and static balance results increased when compared to the control group [32,33]. In healthy elderly women, the dynamic balance improved when compared to the control group, who did nothing in Pilates Exercise, which took 60 minutes in total, 3 days a week for 3 months [34]. These results were also demonstrated by weekly training in adult healthy individuals [35]. In another study, which was designed to monitor the progress of balance ability in patients with hemiplegia, exercise training with Pilates and a suspension apparatus, similar to hammocks used here and appealing to similar purposes. These exercise protocols were applied 3 days a week for 30 minutes, and at the end of 8 weeks, exercises with suspension apparatus in hemiplegic patients improved the balance ability [36]. In another study that aimed to draw attention to the effects of exercises with suspension apparatus, elite football players participated in a total of 16 sessions, 2 days a week, and it was reported that closed kinetic chain exercises with Hanger apparatus improved balance and reduced chronic back pain [31]. We did not understand in detail why static balance, unlike dynamic balance was improved in the Hammock Yoga than mat exercises, and could not analyze it fully. It may be assumed that Hammock Yoga exercises provide more upper extremity activation and that may increased static balance.

Limitations

If modalities (e.g., EMG, etc.) could be used to evaluate transverse abdominis muscle activation objectively or evaluate the strength of the core muscles in the present study, our findings could be analyzed better. The mat exercises were followed with a home program, this could be occurred a bias. Some of the participants might have developed anxiety or kinesiophobia because all participants in the Hammock Yoga group experienced this type of exercise for the first time. In this respect, investigating the fear in the individuals while performing some movements that could be considered acrobatic so it could enable us to understand this.

CONCLUSION

It may be more effective to direct and prefer traditional mat exercises that are already known by patients in reducing pain and disability and improving the quality of life in people who have chronic back pain. All three exercise training modalities can be used to develop core endurance, but Hammock Yoga can be considered a priority for developing balance.

Ethical Approval: *2022/037 Non-Interventional Research Ethics Committee of Hasan Kalyoncu University*

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