Adıyaman Üniversitesi Sağlık Bilimleri Dergisi, 2023;9(2):82-94
doi:10.30569.adiyamansaglik.1268397

E-ISSN: 2458-9176

ADIYAMAN ÜNİVERSİTESİ SAĞLIK BİLİMLERİ DERGİSİ
JOURNAL OF HEALTH SCIENCES OF ADIYAMAN UNIVERSITY

Research Article/Özgün Araştırma

Comparison of the effectiveness of spinal stabilization exercises and chiropractic spinal manipulation in healthy individuals: Randomized controlled trial

Sağlıklı bireylerde spinal stabilizasyon egzersizleri ve kayropraktik spinal manipulasyonun etkinliklerinin karşılaştırılması: Randomize kontrollü çalışma

Mesut ARSLAN[1], Figen YILMAZ[2]

[1]Bitlis Eren University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, 13000, Bitlis-Turkey
[2]University of Health Sciences, Hamidiye Faculty of Medicine, Department of Physical Medicine and Rehabilitation, 34000, İstanbul-Turkey

Atıf gösterme/Cite this article as: Arslan M, Yılmaz F. Comparison of the effectiveness of spinal stabilization exercises and chiropractic spinal manipulation in healthy individuals: Randomized controlled trial. *ADYÜ Sağlık Bilimleri Derg*. 2023;9(2):82-94. doi:10.30569.adiyamansaglik.1268397

Abstract

Aim: The aim was to investigate the effects of exercise, manipulation and its combined application on endurance, muscle strength, joint position sense and balance.

Materials and Methods: Eighty healthy people aged 18-45 years were included in the study. Individuals were divided into chiropractic manipulation, stabilization exercises, combined application and control group. Participants were evaluated with endurance, muscle strength, joint position sense and balance tests before, after and 1 month after the application.

Results: After the application, significant improvement was observed in the endurance parameters in Group 3 compared to the other groups. There was a significant increase in quadriceps muscle strength in all groups compared to Group 4.

Conclusion: The combined program may be more effective than other **programs** in improving muscular endurance and balance. All training programs are effective in improving quadriceps muscle strength, but do not have the same effect on knee joint position sense.

Keywords: Exercise therapy; Activator Method; Chiropractic, Spinal manipulation; Physical fitness.

Öz

Amaç: Egzersiz, manipulasyon ve kombine uygulamasının endurans, kas kuvveti, eklem pozisyon hissi ve denge üzerindeki etkilerini araştırmaktı.

Gereç ve Yöntem: Çalışmaya 18-45 yaş arası 80 sağlıklı kişi alındı. Bireyler kayropraktik manipulasyon, stabilizasyon egzersizleri, kombine uygulama ve kontrol grubu olarak ayrıldı. Katılımcılar uygulama öncesi, uygulama sonrası ve uygulamadan 1 ay sonra endurans, kas kuvveti, eklem pozisyon hissi ve denge testleri ile değerlendirildi.

Bulgular: Uygulama sonrasında Grup 3'te endurans parametrelerinde diğer gruplara göre anlamlı iyileşme gözlendi. Tüm gruplarda kuadriseps kas kuvvetinde Grup 4'e göre anlamlı artış saptandı.

Sonuç: Kombine uygulanan program, kas dayanıklılığını ve dengesini geliştirmede diğer programlara göre daha etkili olabilir. Tüm eğitim programları, kuadriseps kas gücünü geliştirmede etkilidir, ancak diz eklemi pozisyon hissi üzerinde aynı etkiye sahip değildir.

Anahtar Kelimeler: Egzersiz tedavisi; Aktivatör metod; Kayropraktik; Spinal manipulasyon; Fiziksel uygunluk.

Yazışma Adresi/Address for Correspondence: Mesut ARSLAN, Bitlis Eren University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, 13000, Bitlis-Turkey, E-mail: fzt.mesutarslan@gmail.com

Geliş Tarihi/Received:21.03.2023 **Kabul Tarihi/Accepted:**21.06.2023 **Yayım Tarihi/Published online:**30.08.2023

Introduction

Chronic low back and neck pain, with its biopsychosocial components, is an important public health problem that negatively affects the daily life activities of the person and causes labor and economic losses.[1] Globally, low back pain was the most common (36.8%) musculoskeletal disorder, while the incidence of neck pain was 18.4 %.[2] Low back and neck pain are among the most common reasons for visiting a general practitioner or physical therapist in primary care in Europe.[3]

Many treatment methods such as education, bed rest, exercise, manual therapy, thermotherapy, electrotherapy, pharmacological and surgical treatments are applied for low back and neck pain.[3,4] In this context; in addition to providing treatment opportunities for sick individuals, it is necessary to develop strategies to prevent chronic diseases that are "preventable" in healthy individuals.[5]

Coordination of muscle activity around the lumbopelvic region is of great importance in providing mechanical spine stability.[6] Spinal stabilization system; It consists of a passive subsystem (vertebrae, facet joints, intervertebral disc, ligament and joint capsule), active subsystem (muscles and tendons) and neural subsystem, which are functionally interdependent.[7] Deep stability muscles such as multifidus, transversus abdominus, pelvic floor muscles and diaphragm, which constitute the active subsystem, play an important role in motor control by providing dynamic stability of the lumbopelvic region.[8,9] Abdominal bracing technique increases spinal stability by co-activating deep stability muscles.[10] Spinal stabilization exercises can be used to protect health, prevent injuries, and in disease states.[11]

Traditional and complementary medicine has a long history.[12] Chiropractic manipulation has been shown to improve activation of the transversus abdominus[13] and sensorimotor function associated with fall risk and quality of life in the elderly.[14]

There are studies in the literature on spinal stabilization or manipulation alone in healthy individuals.[15-18] However, there were no studies in which both were used together in healthy individuals. In addition, studies comparing the two applications in healthy individuals have not been found.

Therefore, in this study, the effects of spinal stabilization exercises, chiropractic spinal manipulation and their combination on endurance, muscle strength, joint position sense, and balance parameters were investigated in healthy individuals.

In this way, it is planned to provide social benefit in reducing labor losses, frequency of hospital admissions and treatment costs in society with exercises and manipulations that can be performed as preventive physiotherapy applications in healthy individuals.

Materials and Methods

Study design

Eighty healthy subjects aged 18-45 years who voluntarily participated in the study were included in this randomized controlled study.

Participants in the study were randomly (with the 'Research Randomizer' computer program) divided into 4 groups. Group 1 underwent 6 sessions of High-Velocity Low-Amplitude (HVLA) chiropractic manipulation once a week. A total of 18 sessions of spinal stabilization exercises were performed in Group 2, 3 times a week. In group 3, both spinal stabilization exercises and chiropractic manipulation were applied. All applications were done for 6 weeks. No application was made to Group 4.

Individuals were evaluated with the prone plank, side plank, Sorenson test, quadriceps muscle strength, knee joint position sense, and Y balance test before, after and 1 month after the application.

Study population and sample

The number of samples was calculated using the Y balance test [19] by taking G*Power 3.1.9.2 (Repeated ANOVA) with power=0.95, α=0.05, partial η2=0.14 and effect size=0.30. It was determined as a total of 52 individuals, with a minimum of 13 individuals for each group.

Healthy individuals between the ages of 18-45 who did not have any pain, trauma, surgical operation history in the last 6 months, did not

receive any treatment for spinal problems, did not have significant postural disorders (scoliosis, kyphosis, leg length inequality, etc.), visual and vestibular balance problems, and any chronic disease (obesity, diabetes, hypertension, osteoporosis, etc.) were included in the study.

In cases in which chiropractic spinal manipulation was contraindicated (inflammation, infection, malignancy, blood coagulation disorder, etc.), individuals who had any injury during the study or who did not regularly attend the study program were excluded from the study. Individuals who had undergone spinal manipulation or exercised regularly in the last six months were also excluded from the study. The number of individuals who participated in the study and completed the program as a result of the follow-ups and analysis is given in Figure 1.

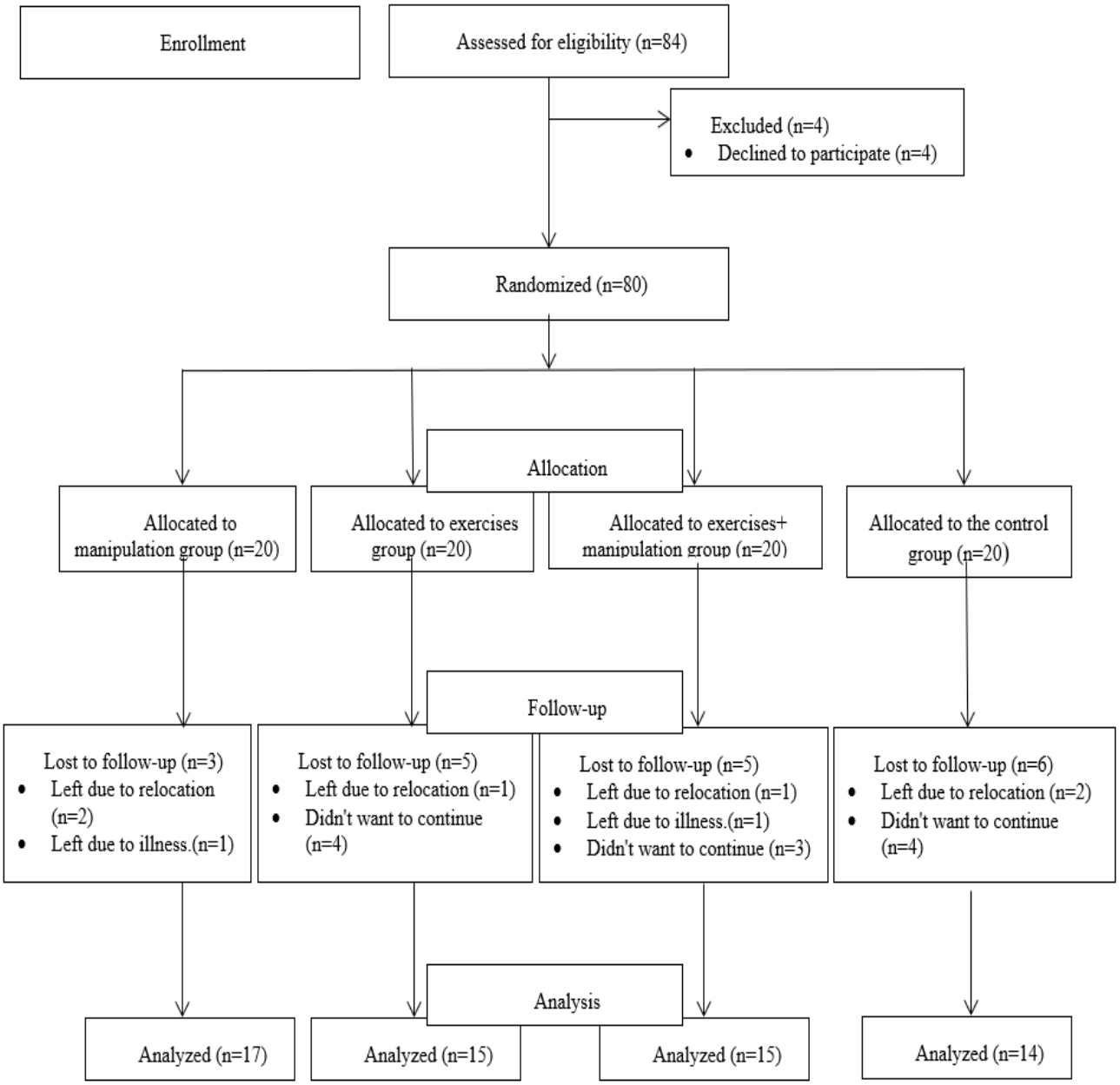

Figure 1. Number of individuals participating in the study and follow-up results

Data collection tools

Each individual was informed about the technique of administering the test before starting the test.

Prone Plank Test: It is a valid and reliable test used to evaluate the endurance of core region muscles. While the individual is asked to lie face down and rise on his elbows and toes, he is asked to keep the body in a straight

line. The total time is recorded. If the participant drops or lifts his body, the time is stopped.[20]

Side Plank Test: Evaluates the endurance of the lateral trunk flexor muscles. The individual is asked to lie on the elbow with the legs extended. He is asked to raise his torso and maintain this position so that the lower extremities, hips and back are in line. The total time is recorded. If the participant drops his hip, the timer is stopped. Measurements are repeated on both sides, right and left.[21]

Sorenson test: The individual lies face down with the body hanging off the stretcher (above the level of the anterior superior iliac spine). Lower extremity stabilization is provided by using bands. He then places his hands diagonally on the shoulders and is asked to raise his body so that it is level with the table. He is asked to hold this position for as long as possible and the total time is recorded. The test is terminated when the body is lowered by approximately 10 degrees or 240 seconds is reached in the relevant position.[22]

Quadriceps muscle strength: Individuals are seated on the bed with theirs arms crossed on the chest. The "make test" technique, which requires isometric contraction, was applied (Make test is the protocol in which the participant applies maximum force against the device while the practitioner holds the dynamometer (Lafayette Hand-held Dynamometer) steady). The average of 3 consecutive maximum contraction measurements taken at 30-second intervals is taken. Measurements are repeated on both sides, right and left.[23]

Joint position sense: The participants are asked to perceive this angular position by positioning their knees at 60-degree flexion joint angle for 5 seconds while their eyes are closed. Then, the knee is relaxed and the person is asked to return to the perceived joint position and hold it for five seconds at that point. The difference is evaluated as the error angle. The error angle is calculated by taking the average of 3 trials. Measurements are repeated on both sides, right and left.[24]

Y balance test: Evaluates the dynamic balance of individuals. The individual is asked to stand on one foot at the midpoint of the test setup and touch the tip of the toe with the other foot while maintaining balance in the anterior, posteromedial and posterolateral directions. The test is repeated 3 times in each direction and the average is taken and recorded in cm. Measurements are repeated on both sides, right and left.[25]

Spinal stabilization exercise protocol: Individuals included in Group 2 and Group 3 underwent stabilization exercises, 3 times a week for 6 weeks, for a total of 18 sessions, each session being 45-minutes. Sessions started with 5 - 10 minutes of warm-up and stretching exercises, followed by a 45 minute stabilization program and ended with 5 - 10 minutes of cooling and stretching exercises. Individuals were taught anatomy, postural straightness, functions of transversus abdominus and multifidus muscles and how to activate these muscles. Posture straightness was emphasized for the cervical, thoracic and lumbar regions. In addition, information about respiratory control during exercise was given.

In our study, after the activation of the transversus abdominus and multifidus muscles, motor learning was achieved in all motor development stages and automatic control was achieved. The abdominal brace technique was used for Transversus Abdominus and Multifidus Activation.[15]

The exercise program was planned as 2 phases. Static Phase; using stable surfaces and postures; It is aimed to improve proprioceptive awareness and increase strength, endurance, flexibility and coordination. Dynamic Phase; using unstable surfaces and postures, functional movement patterns and postures, and thera-band; It is aimed to improve strength, endurance, coordination and to achieve a controlled and safe function in multi-directional axes. The exercise protocol was created and applied by a physiotherapist, using the literature and considering the motor learning model. [15,26,27]

Chiropractic spinal manipulation protocol: Individuals included in group 1 and group 3 underwent 6 sessions of HVLA chiropractic manipulation once a week for 6 weeks.[28] The Activator Method Basic Screening Protocol

was applied as chiropractic spinal manipulation.[29] Individuals were informed about the activator device (Figure 2) and the activator basic screening protocol. Chiropractic manipulation practices were performed by a physiotherapist with a master's degree in chiropractic.

Figure 2. Activator device

The Activator Method provides a systematic clinical approach in the form of protocols for neuroarticular dysfunctions to identify and treat a wide variety of common complaints of neuromusculoskeletal origin. The core of the Activator Method Basic Scanning Protocol consists of tests and manipulations of specific segmental levels of the spine as well as the foot, knee, pelvis, and shoulder regions.[29]

Data analysis

In this study, NCSS (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA) package program was used. In the analysis of the data, besides the descriptive statistical analyzes (mean, standard deviation), the distribution of the variables was examined with the Shapiro – Wilk test of normality.

Paired one-way analysis of variance (Repeated ANOVA) was used for time comparisons of normally distributed variables, Newman Keuls multiple comparison test was used for subgroup comparisons, one-way analysis of variance (ANOVA) was used for intergroup comparisons, and Tukey multiple comparison test was used for subgroup comparisons.

Friedman test was used for time comparisons of non-normally distributed variables, Dunn's multiple comparison test was used for subgroup comparisons, Kruskal Wallis test was used for intergroup comparisons, Dunn's multiple comparison test was used for subgroup comparisons, and chi-square test was used for qualitative data comparisons. The significance level of the results was determined as $p<0.05$.

Ethical aspects of the research

The study program was explained to the participants in line with the Informed Consent Form. The research was conducted in accordance with the Declaration of Helsinki. Approval was received from Gümüşhane University Scientific Research and Publication Ethics Committee with the number 2020/06 dated 11.06.2020. The study was also registered on ClinicalTrial.gov (Registration number: NCT04830098).

Results

There was no statistically significant difference in the intergroup comparison of descriptive data (Table 1).

Table 1. Intergroup comparison of descriptive data.

		Group 1 (n:17)		Group 2 (n:15)		Group 3 (n:15)		Group 4 (n:14)		*p*
Age		27.88±6.53		28.6±7.24		28.8±8.31		28.08±7.72		0.984*
Gender	**Male**	11	64.71%	7	46.67%	11	73.33%	4	28.60%	0.071+
	Female	6	35.29%	8	53.33%	4	26.67%	10	71.40%	
Body mass index		24.52±3.42		24.62±4.32		24.85±4.48		23.22±2.65		0.706*
Dominant	**Right**	14	82.35%	9	60.00%	12	80.00%	11	78.60%	0.456+
Side	**Left**	3	17.65%	6	40.00%	3	20.00%	3	21.40%	
Smoking	**No**	9	52.94%	10	66.67%	12	80.00%	12	85.70%	0.253+
	Yes	8	47.06%	5	33.33%	3	20.00%	2	14.30%	
Exercise	**No**	13	76.47%	8	53.33%	10	66.67%	12	85.70%	0.424+
Habit	**Yes**	4	23.53%	7	46.67%	5	33.33%	2	14.30%	
Exercise Time		157.5±15		158.57±51.13		146±63.09		230.00±98.99		0.351*

*One Way Analysis of Variance, +Chi-Square test

It was determined that the prone plank and right/left side plank scores of Group 3 were statistically significantly higher than those of Group 1 and Group 4, and Sorenson scores of Group 1 and Group 2 after the application (Table 2, 5, 6).

Table 2. Comparison of endurance parameters between groups and measurement times

		Group 1 (n:17)	Group 2 (n:15)	Group 3 (n:15)	Group 4 (n:14)	*p*‡
Prone Plank Test	**Before Application**	28.91±15.85	32.47±18.79	32.08±19.62	31.6±24.46	0.943
	After Application	30.8±17.49	42.68±22.74	51.67±25.99	26.99±20.84	**0.011**
	1 month	33.88±18.25	42.85±19.63	51.93±29.33	32.18±31.9	0.066
	***p*†**	0.290	0.133	**0.001**	0.307	
Sorenson Test	**Before Application**	27.45±15.97	32.1±18.62	46.55±34.4	43.13±35.98	0.450
	After Application	35.4±19.78	43.1±24.23	72.29±36.75	48.97±32.84	**0.019**
	1 month	46.15±27.37	39.55±22.34	68.52±39.24	57.42±33.68	0.184
	***p*†**	**0.002**	0.148	**0.005**	**0.038**	
Right Side Plank Test	**Before Application**	20.34±10.17	20.39±14.23	27.02±23.03	23.29±26.15	0.798
	After Application	18.68±9.13	31.39±17.03	38.31±21.57	13.23±6.14	**0.0001**
	1 month	23.96±12.99	25.23±11.2	32.14±20.35	16.45±13.14	**0.04**
	***p*†**	0.208	**0.017**	**0.005**	0.148	
Left Side Plank Test	**Before Application**	18.65±9.24	22.23±13.93	25.54±23.48	19.3±12.5	0.879
	After Application	22.18±12.08	34.62±19.53	39.09±23.14	15.77±8.5	**0.003**
	1 month	24.1±11.75	29.96±14.53	27.6±16.18	17.46±13.51	0.078
	***p*†**	0.147	**0.003**	0.53	0.178	

‡Kruskal Wallis test, †Friedman test

It was determined that the right/left quadriceps muscle strength scores of Group 1, Group 2 and Group 3 were statistically significantly higher than Group 4 after the application. In addition, in the 1st-month measurement, Group 2 right quadriceps muscle strength score and Group 3 right/left quadriceps muscle strength score were found to be statistically significantly higher than Group 4. In the knee joint position sense parameter; There was no significant difference between the groups in the post-application and 1st-month measurement (Tables 3, 5, 6).

It was determined that the right anterior balance and right posterio lateral balance scores of Group 1, right posterior lateral balance score of Group 2 and right anterior balance, right/left posterio medial balance and right/left posterio lateral balance of Group 3 were statistically significantly higher than Group 4 after the application (Tables 4, 5, 6).

Discussion

In this study, the effects of spinal stabilization exercises, chiropractic spinal manipulation and their combination on endurance, muscle strength, joint position sense, and balance parameters in healthy individuals were investigated.

Table 3. Comparison of muscle strength and joint position sense parameters between groups and measurement times.

		Group 1 (n:17)	Group 2 (n:15)	Group 3 (n:15)	Group 4 (n:14)	*p**
Right Quadriceps Muscle Strength	**Before Application**	143.64±27.95	154.75±23.39	138.17±27.03	151.56±20.95	0.309*
	After Application	157.11±27.06	161.06±20.4	165.12±23.33	132.45±10.24	**0.0001***
	1 month	147.01±29.42	158.76±18.11	162.11±19.42	140.33±9.69	**0.01***
	p‡	**0.035**	0.231	**0.001**	**0.028**	
Left Quadriceps Muscle Strength	**Before Application**	142.82±30.37	147.59±27.61	137.31±24.8	143.23±20.85	0.876*
	After Application	156.26±34.52	161.73±27.21	169.72±25.77	129.61±14.9	**0.002***
	1 month	150.91±34.02	162.45±24.66	164.51±20.81	142.31±1.,02	**0.049***
	p‡	0.084	**0.001**	**0.0001**	**0.046**	
Right Knee Joint Position Sense	**Before Application**	12.06±8.94	5.67±3.35	11.4±10.58	9.67±7.44	0.104⁑
	After Application	7.53±5.66	4.93±3.95	6.33±4.97	8.42±6.36	0.281⁑
	1 month	6±4.92	4.53±2.5	6.8±5	7±2.98	0.305⁑
	p†	**0.008**	0.550	0.140	0.774	
Left Knee Joint Position Sense	**Before Application**	9.41±8.34	5.53±2.75	9.53±8.22	7.5±4.72	0.452⁑
	After Application	7.35±6.33	7.4±8.22	6.47±5.54	6.25±3.82	0.932⁑
	1 month	5.06±3.11	5.6±2.8	4.4±2.5	5.75±2.9	0.532⁑
	p†	**0.049**	0.559	**0.011**	0.447	

***One-Way Analysis of Variance ‡Paired One-Way Analysis of Variance ⁑Kruskal Wallis test †Friedman test**

Table 4. Comparison of balance parameters between groups and measurement times.

		Group 1 (n:17)	Group 2 (n:15)	Group 3 (n:15)	Group 4 (n:14)	*p**
Right Y Balance Test Anterior	**Before Application**	57.68±6.73	57.1±11.38	58.33±6.79	57.5±8.06	0.983
	After Application	63.76±5.53	62.6±5.28	64.13±4.63	58.33±8.11	**0.047**
	1 month	63.35±4.42	63±4.72	62.8±4.75	59.04±7.52	0.150
	***p*‡**	**0.0001**	**0.005**	**0.0001**	0.744	
Right Y Balance Test Posterio Medial	**Before Application**	55.29±9.87	59.43±15.75	62.33±10.31	53.13±11.7	0.191
	After Application	64.35±8.2	63.6±7.4	67.4±8.6	56.58±12.18	**0.027**
	1 month	64.06±7.55	64.6±6.9	66.47±7.98	60±10.47	0.241
	***p*‡**	**0.0001**	0.058	**0.009**	**0.047**	
Right Y Balance Test Posterio Lateral	**Before Application**	45.24±10.01	47.67±16.62	54.77±9.05	45.29±13.63	0.139
	After Application	57.97±8.7	59.07±5.9	63.13±7.19	48.46±11.08	**0.0001**
	1 month	58.47±8.06	58.47±5.32	62.77±6.42	53.17±11.02	0.057
	***p*‡**	**0.0001**	**0.0001**	**0.0001**	**0.01**	
Left Y Balance Test Anterior	**Before Application**	57.18±5.85	56.37±9.86	58.2±6.37	57.67±8.61	0.929
	After Application	62.59±5.83	62.87±5.33	63.93±3.79	58.67±9.62	0.182
	1 month	63.24±5.32	62.6±4.55	63.93±5.06	59.63±7.97	0.247
	***p*‡**	**0.0001**	**0.0001**	**0.0001**	0.354	

Left Balance	**Before Application**	53±16.08	59.43±13.32	60.7±9.4	54.92±12.58	0.782
Test Posterio	**After Application**	64.06±8.24	64.13±8.3	68.73±6.47	58±9.73	**0.015**
Medial	**1 month**	65.41±8.29	64.33±7.21	68.33±5.89	61.92±8.68	0.184
	***p*‡**	**0.0001**	**0.025**	**0.0001**	**0.02**	
Left Y Balance	**Before Application**	45.68±10.24	46.87±14	53.03±7.97	45.25±16.69	0.285
Test Posterio	**After Application**	56.15±10.2	56.8±5.23	62.47±7.37	50.54±12.64	**0.014**
Lateral	**1 month**	57.82±8.6	56.37±6.69	61.8±7.27	54.25±13.44	0.177
	***p*‡**	**0.0001**	**0.0001**	**0.0001**	**0.024**	

***One-Way Analysis of Variance ‡Paired One-Way Analysis of Variance**

Table 5. Subgroup comparison of endurance, muscle strength and balance parameters.

Dunn's Multiple Comparison Test*****/ Tukey Multiple Comparison Test**+**	**AA PPT***	**AA ST***	**AA Right SPT***	**AA Left SPT***	**AA Right QMS+**	**1 month Right QMS+**	**AA Left QMS+**	**1 month Left QMS+**	**AA Right YBT A+**	**AA Right YBT PM +**	**AA Right YBT PL+**	**AA Left YBT PM+**	**AA Left YBT PL+**
Group 1/ Group 2	0.434	0.880	0.160	0.247	0.953	0.392	0.938	0.557	0.942	0.995	0.983	0.999	0.997
Group 1/ Group 3	**0.048**	**0.004**	**0.009**	**0.041**	0.715	0.184	0.489	0.414	0.998	0.779	0.321	0.374	0.232
Group 1/ Group 4	0.269	0.352	.057	0.230	**0.002**	0.170	**0.021**	0.250	**0.048**	0.112	**0.034**	0.121	0.458
Group 2/ Group 3	0.683	**0.042**	0.679	0.913	0.954	0.971	0.845	0.996	0.888	0.662	0.556	0.415	0.349
Group 2/ Group 4	0.065	0.770	0.052	0.096	**0.001**	**0.006**	**0.002**	0.076	0.153	0.244	**0.02**	0.201	0.153
Group 3/ Group 4	**0.012**	0.070	**0.001**	**0.001**	**0.0001**	**0.002**	**0.0001**	**0.008**	**0.042**	**0.014**	**0.001**	**0.004**	**0.011**

AA: After Application, **PPT:**Prone Plank Test, **ST:**Sorenson Test, **SPT:** Side Plank Test, **QMS:** Quadriceps Muscle Strength, **YBT:** Y Balance Test, **A:**Anterior, **PM:**Posteromedial, **PL:**Posterolateral

Table 6. Comparison of measurement times of endurance, muscle strength, joint position and balance parameters according to groups.

Dunn's Multiple Comparison Test	**Prone Plank Test**	**Sorenson Test**		**Right SPT**			**Left SPT**	
	Group 3	**Group 1**	**Group 3**	**Group 4**	**Group 2**		**Group 3**	**Group 2**
BA / AA	**0.001**	**0.026**	**0.008**	**0.001**	**0.015**		**0.011**	**0.007**
BA/1 month	**0.002**	**0.009**	**0.019**	0.176	0.232		0.164	**0.045**
AA/1 month	0.949	**0.025**	0.555	**0.034**	**0.047**		**0.001**	0.078
Newman Keuls Multiple Comparison Test	**Right QMS**			**Left QMS**			**Right KJPS ***	**Left KJPS ***	
	Group 1	**Group 3**	**Group 4**	**Group 2**	**Group 3**	**Group 4**	**Group 1**	**Group 1**	**Group 3**
BA / AA	**0.035**	**0.003**	**0.035**	**0.004**	**0.0001**	**0.041**	**0.01**	0.269	0.057
BA/1 month	0.575	**0.005**	0.112	**0.004**	**0.002**	0.695	**0.025**	**0.028**	**0.02**
AA/1 month	**0.005**	0.539	**0.01**	0.796	0.221	**0.019**	0.313	0.135	0.110
Newman Keuls Multiple Comparison Test	**Right YBT A**			**Right YBT PM**			**Right YBT PL**			
	Group 1	**Group 2**	**Group 3**	**Group 1**	**Group 3**	**Group 4**	**Group 1**	**Group 2**	**Group 3**	**Group 4**
BA / AA	**0.0001**	**0.015**	**0.002**	**0.0001**	**0.014**	0.143	**0.0001**	**0.004**	**0.001**	0.124
BA/1 month	**0.001**	**0.026**	**0.012**	**0.0001**	**0.044**	**0.014**	**0.0001**	**0.005**	**0.001**	**0.008**
AA/1 month	0.684	0.643	**0.038**	0.813	0.140	**0.037**	0.697	0.610	0.730	**0.002**

Newman Keuls Multiple Comparison Test	Left YBT A			Left YBT PM				Left YBT PL			
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3	Group 4	Group 1	Group 2	Group 3	Group 4
BA / AA	**0.0001**	**0.001**	**0.001**	**0.007**	**0.029**	**0.0001**	0.324	**0.0001**	**0.005**	**0.0001**	**0.034**
BA/1 month	**0.0001**	**0.003**	**0.001**	**0.002**	**0.041**	**0.005**	**0.016**	**0.0001**	**0.001**	**0.001**	**0.016**
AA/1 month	0.482	0.728	0.999	0.185	0.899	0.732	**0.042**	0.150	0.750	0.637	0.055

BA: Before Application, **AA:** After Application**, SPT:** Side Plank Test**, QMS:** Quadriceps Muscle Strength, **KJPS:** Knee Joint Position Sense,* Dunn's Multiple Comparison Test**, YBT:** Y Balance Test, **A:**Anterior, **PM:**Posteromedial, **PL:**Posterolateral

In our study, it is thought that the combined program in which chiropractic manipulation and stabilization exercises are applied together may be more effective in improving muscular endurance and balance. In addition, it was determined that all three training programs were more effective in improving quadriceps muscle strength compared to the control group, while stabilization exercises were found to maintain the increase in muscle strength for longer when applied alone or in combination with chiropractic manipulation. However, in our study, although the training programs provided improvement in knee joint position sense scores within the group, they did not provide a significant difference in the control group. In these results, it can be thought that the individuals participating in our study are already healthy individuals, that the parameters that do not change are already within normal limits, and that the duration of the training program we applied may not be sufficient.

Muscular endurance is an important component of health-related physical fitness parameters. In our literature review, a thoracic spine stabilization exercise program was applied 3 days a week for 8 weeks in a randomized controlled study in healthy individuals. Stabilization exercises have been found to significantly increase endurance in healthy individuals.[15] In a different randomized controlled study conducted in healthy individuals; the effect of dynamic stabilization training applied 3 days a week for 3 weeks on trunk endurance was investigated. It has been shown that the exercise group provided a significant increase in the sit-up and Sorenson test compared to the control group.[30] In our study, unlike other studies in the literature, a stabilization exercise program covering all of the cervical, thoracic and lumbar regions was applied instead of an exercise program belonging to a single region. Therefore, it should be kept in mind that more meaningful results can be obtained if exercise practices are performed for a longer period time and combined with manipulation.

No study was found that investigated the effect of chiropractic spinal manipulation on endurance in healthy individuals. However, since abnormal afferent input from the deep paraspinal muscles can lead to long-term cortical remodeling and changes in the top-down control of sensorimotor systems, [31] it is thought that longer-term spinal manipulation applications may improve the results.

The importance of spinal stability for optimal generation, transmission and control of force and movement in the trunk and extremities during an integrated kinetic chain activity is well known.[32] In a study conducted on healthy individuals in the literature, the effect of aerobic and spinal stabilization exercises on the hamstring-quadriceps muscle strength ratio (H/Q) was examined. Both aerobic and stabilization exercises have been reported to improve the total work H/Q ratio.[17] Although we applied short-term exercise, the results are similar.

Spinal manipulation is known to alter afferent input by activating mechanoreceptors. It is thought that with the change of afferent input, more motor neurons and muscle fibers are activated, increasing muscle strength.[33] A randomized controlled study conducted in healthy individuals; It has been observed that a single session of lumbopelvic joint manipulation is more effective than sham manipulation in developing quadriceps muscle strength.[16] While a single session of spinal manipulation was applied in the related studies in the literature, in our

study, a total of 6 sessions of spinal manipulation were applied, one session per week. However, the results obtained are similar. In a meta-analysis study conducted in healthy individuals; It has been reported that spinal manipulation is more effective in improving muscle strength than the sham or control group.[34]

Proprioceptive information provides the appropriate motor response in the movement system.[35] Therefore, a healthy and proper proprioception means a healthy movement system and a healthy body. There are no studies in the literature investigating the effect of spinal stabilization exercises on knee joint position sense in healthy individuals. In studies in the literature, it has been observed that special devices, isokinetic dynamometers, goniometers, inclinometers, and motion analysis systems developed for this purpose are used to evaluate joint position sense.[36] In our study, a goniometer was used because it is easy to use and easily accessible. There was no significant improvement in joint position sense in any of the treatment groups compared to the control. It may be thought that this result may be because since the goniometer device we used in the evaluation was not sensitive enough to detect small changes in proprioception. Therefore, it may be recommended to use more sensitive measurement methods evaluating proprioception in studies.

Motor control deficits reduce joint position sense. It has been reported that by providing motor control with spinal manipulation, improvement in joint position sense can be achieved.[37] In a double-blind randomized controlled study in healthy individuals; a single session of pelvic manipulation did not provide a statistically significant difference on knee joint position sense (assessed by isokinetic dynamometer).[18] In another randomized controlled study conducted in healthy individuals; It has been reported that a single session of cervical manipulation is more effective in improving neck joint position sense compared to the control group.[38]

In a randomized controlled study in elderly individuals; It has been found that chiropractic practice, performed twice a week for 12 weeks, is effective in improving ankle joint position sense.[14] This study shows that spinal manipulation can be applied safely and even longer in elderly individuals, suggests that long-term spinal manipulation may improve the sense of joint position, especially. Therefore, it is thought that neural plasticity will be better with long-term spinal manipulation, and thus, motor control will be provided and joint position sense will be improved.[31]

Postural control and balance are the main parameters of general body stability. In a randomized controlled study in healthy individuals; a thoracic spine stabilization exercise program was applied 3 days a week for 8 weeks and postural oscillations were evaluated with a Biodex balance device. Postural sway was reported to be significantly reduced in the exercise group compared to the control group.[15] In a different randomized controlled study conducted in healthy individuals; the effect of dynamic stabilization training applied 3 days a week for 3 weeks on the Y balance test was investigated. It has been shown that the exercise group provided significant improvement in some parameters of the Y balance test compared to the control group.[30] Unlike the studies in the literature, the exercise program in our study included different exercises for the cervical, thoracic and lumbar regions, rather than exercises belonging to a single region, and it is thought that different results may have been obtained.

Since spinal manipulation can change afferent information, it is thought to affect postural control mechanisms.[31] There are no studies in the literature investigating the effect of chiropractic spinal manipulation on balance in healthy young individuals. However, in different studies conducted in elderly individuals; chiropractic spinal manipulation did not produce a significant improvement in postural stability/balance.[14,39] When the studies in the literature are examined, it is thought that there may be some changes in the central processing of sensory information with spinal manipulation, but it does not change the main balance control scheme from the upper centers.[40]

It is recommended to use different applications together in sick or healthy

individuals. Therefore, in our study, spinal stabilization exercises along with chiropractic spinal manipulation were applied to Group 3 for 6 weeks. In randomized controlled studies on individuals with low back/neck pain; Significant improvement in pain and functionality scores was demonstrated in the 3 groups in which exercise, spinal manipulation and both applications were used together compared to the pre-application. However, it was stated that the difference between the groups was not statistically significant.[41,42] There are studies on sick individuals in the literature, but no studies on healthy individuals have been found. It is thought that spinal stabilization exercises together with chiropractic spinal manipulation may provide more effective results on neuromuscular control in the short and long term. For this reason, with the thought that spinal dysfunctions that can be detected in healthy individuals may cause musculoskeletal pathologies in the future, it is of great importance to detect them in the early period and restore normal spinal function.

The first is that the dysfunctional segments detected in the activator scanning protocol cannot be standardized and this situation creates a question mark about the improvement of the evaluation parameters. Second, since multiple parameters (endurance, muscle strength, balance, joint position sense) were evaluated in our study, data were collected from a single joint or muscle for each parameter. In addition, the shortening of the application period and follow-up period due to pandemic conditions, and the fact that the individuals participating in the study and the therapist are not blind are the limitations of this study.

Conclusion

Spinal stabilization exercise program combined with chiropractic manipulation may be more effective in improving muscular endurance and balance than chiropractic manipulation or stabilization exercise programs alone.

After 6 weeks of practice, all training programs are effective in improving quadriceps muscle strength. However, a spinal stabilization exercise program combined with chiropractic manipulation and spinal stabilization exercise program alone can maintain the increase in muscle strength for a longer period time.

Training programs were not effective in improving knee joint position sense. Since our study was conducted in healthy individuals and it is considered that these scores were in the average value before the study, this result can be considered normal. However, it can be considered that chiropractic manipulation and stabilization exercise programs applied for a longer period time may affect knee joint position sense.

Ethics Committee Approval

The research was conducted in accordance with the Declaration of Helsinki. Approval was received from Gümüşhane University Scientific Research and Publication Ethics Committee with the number 2020/06 dated 11.06.2020.

Informed Consent

The study program was explained to the participants in accordance with the Informed Consent Form and consent was obtained.

Author Contributions

Concept: MA, FY. Design: MA, FY. Resources and Materials: MA. Data Collection and Analysis: MA, FY. Literature Search and Writing: MA, FY. Critical Review: FY.

Conflict of Interest

No.

Financial Disclosure

No.

Statements

This study was presented as a Doctoral Thesis at Health Sciences University, Hamidiye Institute of Health Sciences on December 2, 2021. In addition, legal permission was obtained from the person for the photographs used in the research.

Peer-review

Externally peer-reviewed

References

1. Takmaz SA. Approach and evaluation methods for patients with chronic back and neck pain. *Journal of the Turkish Orthopaedic and Traumatological Association* 2017; 16 (2): 81-88 (in Turkish). https://doi.org/10.14292/totbid.dergisi.2017.14
2. Safiri S, Kolahi AA, Cross M, Hill C, Smith E et al. Prevalence, deaths, and disability-adjusted life years due to musculoskeletal disorders for 195 countries and territories 1990-2017. *Arthritis Rheumatology* 2021; 73 (4): 702-714. https://doi.org/10.1002/art.41571
3. Corp N, Mansell G, Stynes S, Wynne-Jones G, Morsø L et al. Evidence-based treatment recommendations for neck and low back pain across Europe: A systematic review of guidelines. *European Journal of Pain* 2021; 25 (2): 275-295. https://doi.org/10.1002/ejp.1679
4. Özcan, E., S.H. Hatik, and D. Tekin, Kronik bel ağrılı bireylerde kayropraktik manipülasyonu ile mulligan mobilizasyonu tekniğinin ağrı ve fonksiyonellik üzerine etkisinin karşılaştırılması. Ahi Evran Medical Journal, 2021. 6(1): p. 55-63.
5. Johnson PJ, Jou J, Rhee TG, H.Rockwood T, M.Upchurc D. Complementary health approaches for health and wellness in midlife and older US adults. *Maturitas* 2016; 89: 36-42. https://doi.org/10.1016/j.maturitas.2016.04.012
6. Bruno P. The use of "stabilization exercises" to affect neuromuscular control in the lumbopelvic region: a narrative review. *The Journal of the Canadian Chiropractic Association* 2014; 58 (2): 119-130.
7. Panjabi MM. The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. *Journal of Spinal Disorders* 1992; 5 (4): 383-389. https://doi.org/10.1097/00002517-199212000-00001
8. Yilmaz, E.A., Dinamik Nöromüsküler Stabilizasyon (DNS). Research in Sport Education Sciences, 2022. 24(2): p. 60-64.
9. Toprak Çelenay, Ş. and D. Özer Kaya, Relationship of spinal curvature, mobility, and low back pain in women with and without urinary incontinence. Turk J Med Sci, 2017. 47(4): p. 1257-1262.
10. Vera-Garcia, F.J., et al., Effects of abdominal stabilization maneuvers on the control of spine motion and stability against sudden trunk perturbations. J Electromyogr Kinesiol, 2007. 17(5): p. 556-67.
11. Barr KP, Griggs M, Cadby T. Lumbar stabilization: core concepts and current literature, Part 1. *American Journal of Physical Medicine & Rehabilitation* 2005; 84 (6): 473-480. https://doi.org/10.1097/01.phm.0000163709.70471.42
12. World Health Organization. General guidelines for methodologies on research and evaluation of traditional medicine. Geneva. 2000.
13. Marshall P, Murphy B. The effect of sacroiliac joint manipulation on feed-forward activation times of the deep abdominal musculature. *Journal of Manipulative and Physiological Therapeutics* 2006; 29 (3): 196-202. https://doi.org/10.1016/j.jmpt.2006.01.010
14. R.Holt K, Haavik H, L.Lee AC, Murphy B, Elley R. Effectiveness of chiropractic care to improve sensorimotor function associated with falls risk in older people: a randomized controlled trial. *Journal of Manipulative and Physiological Therapeutics* 2016; 39 (4): 267-78. https://doi.org/10.1016/j.jmpt.2016.02.003
15. T.Çelenay Ş, Ö.Kaya D. An 8-week thoracic spine stabilization exercise program improves postural back pain, spine alignment, postural sway, and core endurance in university students:a randomized controlled study. *Turkish Journal of Medical Sciences* 2017; 47 (2): 504-513. https://doi.org/10.3906/sag-1511-155
16. L.Grindstaff T, Hertel J, R.Beazell J, M.Magrum E, D.Ingersolla C. Effects of lumbopelvic joint manipulation on quadriceps activation and strength in healthy individuals. *Manual Therapy* 2009; 14 (4): 415-420. https://doi.org/10.1016/j.math.2008.06.005
17. Düzgün İ, Ö.Kaya D, Baltacı G, Karacan S, Çolakoğlu FF. Improving the hamstrings-to-quadriceps strength ratio in sedentary women: comparison of stabilization training and aerobic training after a 6-months follow-up. *Clinical and Experimental Health Sciences* 2017; 7 (2): 45-51. https://doi.org/10.5152/clinexphealthsci.2017.132
18. Paredes R, Crasto C, Magalhães B, Carvalho P. Short-term effects of global pelvic manipulation on knee joint position sense in asymptomatic participants: a double-blind randomized controlled trial. *Journal of Manipulative and Physiological Therapeutics* 2020; 43 (7): 675-682. https://doi.org/10.1016/j.jmpt.2018.11.036
19. Junker D, Stöggl T. The training effects of foam rolling on core strength endurance, balance, muscle performance and range of motion: a randomized controlled trial. *Journal of Sports Science & Medicine* 2019; 18 (2): 229-238.
20. Carneiro É, Moraes G, Terra G. Effects of isha hatha yoga on core stability and standing balance. *Advances in Mind-Body Medicine* 2016; 30 (3): 4-10.
21. Atalay G, Kafa N. Sporcu sağlığı. Ankara. 2017. Hipokrat kitabevi (in Turkish).
22. Selvaganapathy K, Rajappan R, Balachanthran CM. The Relationship between trunk muscles endurance and normal bmi among university students with sedentary lifestyle. *International Journal of Physiotherapy* 2017; 4 (6): 358-362. https://doi.org/10.15621/ijphy/2017/v4i6/163923
23. A.Telci E, B.Aslan Ü, Cavlak U. Intrarater and interrater reliability of hand held dynamometer for healthy quadriceps femoris: the effect of muscle strength. *Clinical and Experimental Health Sciences* 2011; 1 (2): 124-128.
24. Erden Z. Is there any difference in joint position sense among different knee angles? *Joint Diseases and Related Surgery* 2009; 20 (1): 47-51.
25. J.Plisky P, P.Gorman P, J.Butler R, B.Kiesel K, B.Underwoodet F, et al. The reliability of an instrumented device for measuring components of the star excursion balance test. *North American Journal of Sports Physical Therapy* 2009; 4 (2): 92.
26. Otman A, Köse N. Egzersiz tedavisinde temel prensipler ve yöntemler. Ankara. 2006. Meteksan AŞ (in Turkish).
27. Özer D. The Effects of stabilization training of the different segments of spine to the upper and lower extremity functions and balance. Doctorate Thesis, Hacettepe University, Ankara, 2009.
28. Stevens G, Campeanu M, T.Sorrento A, Ryu J, Burke J. Retrospective demographic analysis of patients seeking care at a free university chiropractic clinic. *Journal of Chiropractic Medicine* 2016; 15 (1): 19-26. https://doi.org/10.1016/j.jcm.2016.02.001
29. Fuhr A. Activator methods chiropractic technique. ABD. 1997. Mosby Incorporated.
30. Kabul EG, B.Çalik B, B.Aslan Ü, Ünver F. Effects of short-term dynamic stabilization training on flexibility, muscle endurance, and dynamic balance in healthy young people: a randomized controlled study. *Journal of Exercise Therapy and Rehabilitation* 2018; 5 (1): 1-8.
31. Haavik H, Kumari N, Holt K, K.Niazi I, Amjadet I, et al. The contemporary model of vertebral column joint dysfunction and impact of high-velocity, low-amplitude controlled vertebral thrusts on neuromuscular function. *European Journal of Applied Physiology* 2021; 121 (10): 2675-2720. https://doi.org/10.1007/s00421-021-04727-z
32. Okada T, Huxel KC, Nesser TW. Relationship between core stability, functional movement, and performance. *The Journal of Strength & Conditioning Research* 2011; 25 (1): 252-261. https://doi.org/10.1519/JSC.0b013e3181b22b3e
33. D.Chilibeck P, M.Cornish S, Schulte A, Jantz N, R.A.Magnus C, et al. The effect of spinal manipulation on imbalances in leg strength. *The Journal of the Canadian Chiropractic Association* 2011; 55 (3): 183-192.
34. Lo CN, Ng C, Au CK, W.Lim EC. The Effectiveness of spinal manipulation in increasing muscle strength in healthy individuals: A systematic review and meta-analysis. *Journal of Manipulative and Physiological Therapeutics* 2019; 42 (2): 148-158. https://doi.org/10.1016/j.jmpt.2018.10.003
35. Dıraçoğlu D, Aydın AR, Başkent A. Comparison of the sensation of proprioception between healthy persons and patients with knee osteoarthritis. *Turkish Journal of Physical Medicine and Rehabilitation* 2005; 51: 90-93 (in Turkish).
36. Ergen E, Ulkar B, Eraslan A. Proprioception and Coordination. *Turkish Journal of Sports Medicine* 2007; 42: 57-83.
37. Vining R, R.Long C, Minkalis A, Gudavalli MR, Xia T, et al. Effects of chiropractic care on strength, balance, and endurance in active-duty u.s. military personnel with low back pain: a randomized controlled trial. *The Journal of Alternative and Complementary Medicine* 2020; 26 (7): 592-601. https://doi.org/10.1089/acm.2020.0107

38. Gong W. Effects of cervical joint manipulation on joint position sense of normal adults. *Journal of Physical Therapy* Science 2013; 25 (6): 721-3. https://doi.org/10.1589/jpts.25.721
39. Hawk C, Cambron J. Chiropractic care for older adults: effects on balance, dizziness, and chronic pain. *Journal of Manipulative and Physiological Therapeutics* 2009; 32 (6): 431-437. https://doi.org/10.1016/j.jmpt.2009.06.009
40. Farazdaghi MR, Motealleh A, Abtahi F, Panjan A, Šarabon N, et al. Effect of sacroiliac manipulation on postural sway in quiet standing: a randomized controlled trial. Brazilian *Journal of Physical Therapy* 2018; 22 (2): 120-126. https://doi.org/10.1016/j.bjpt.2017.09.002
41. Nejati P, Safarcherati A, Karimi F. Effectiveness of exercise therapy and manipulation on sacroiliac joint dysfunction: a randomized controlled trial. *Pain Physician* 2019; 22 (1): 53-61. https://doi.org/10.36076/ppj/2019.22.53
42. Bronfort G, Roni E, Brian N, Peter A, Charles G, et al. A randomized clinical trial of exercise and spinal manipulation for patients with chronic neck pain. *Spine* 2001; 26 (7): 788-797. https://doi.org/10.1097/00007632-200104010-0002