ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

DOI: 10.5336/medsci.2021-86357

Effectiveness of Proprioceptive Exercise on Balance and Sensory Function in Nursing Home Geriatric Individuals with Diabetes: Randomized Controlled Trial

Huzurevindeki Geriatrik Diyabetli Bireylerde Proprioseptif Egzersizin Denge ve Duyusal Fonksiyona Etkisi: Randomize Kontrollü Çalışma

Fatma DEMİR[a], Mustafa ŞAHİN[b], Gizem ERGEZEN[a,c]

[a]Department of Physical Therapy and Rehabilitation, İstanbul Medipol University Institute of Health Sciences, İstanbul, TURKIYE
[b]Department of Orthopaedic and Traumatology, İstanbul Medipol University Faculty of Medicine, İstanbul, TURKIYE
[c]Department of Physiotherapy and Rehabilitation, İstanbul Medipol University Faculty of Health Science, İstanbul, TURKIYE

ABSTRACT Objective: Diabetes is a chronic disease whose prevalence increases with age and causes severe damages in all systems of the body. The aim of our study was to assess the effects of proprioceptive exercises on balance and sensory function in the geriatric adults with Type 2 diabetes mellitus. **Material and Methods:** Forty individuals aged 65 and over with Type 2 diabetes mellitus were divided as a study group (n=20) and as a control group (n=20). All patients were evaluated at the baseline and after 8 weeks training. Balance was measured using Berg Balance Scale and Nintendo Wii system. Balance and gait were evaluated by Tinetti Balance and Gait Test. Semmes-Weinstein monofilament test was used for assessing tactile sensory, diapason for vibration and active matching test for joint position sense. Study group received 45 minutes long proprioceptive exercise training 3 times/week for 8 weeks and the control group only received diabetic patient education. **Results:** Study group demonstrated significant differences in Berg Balance Scale, Wii Fit balance age and Tinetti Balance and Gait Test scores (p<0.05). Vibration perception duration yielded a higher duration in the study group after treatment (p<0.05). Active matching movement and tactile sensory of the sole showed statistically improvement in the study group (p<0.05). **Conclusion:** Proprioceptive exercises recommended to individuals with geriatric diabetes can be a beneficial approach to increase balance ability to prevent falling and somatosensory loss.

Keywords: Diabetes mellitus; geriatrics; postural balance; proprioception; sensation

ÖZET Amaç: Diyabet, prevalansı yaşla birlikte artan ve vücudun tüm sistemlerinde ciddi hasarlara neden olan kronik bir hastalıktır. Çalışmamızın amacı, Tip 2 diabetes mellituslu geriatrik erişkinlerde proprioseptif egzersizlerin denge ve duyusal fonksiyon üzerine etkilerini değerlendirmektir. **Gereç ve Yöntemler:** Tip 2 diabetes mellituslu 65 yaş ve üzeri 40 birey çalışma grubu (n=20) ve kontrol grubu (n=20) olarak ayrıldı. Tüm hastalar başlangıçta ve 8 haftalık eğitimden sonra değerlendirildi. Denge, Berg Denge Ölçeği ve Nintendo Wii sistemi kullanılarak ölçüldü. Denge ve yürüme, Tinetti Denge ve Yürüyüş Testi ile değerlendirildi. Dokunma duyusunu değerlendirmek için Semmes-Weinstein monofilament testi, titreşim için diyapazon ve eklem pozisyon duyusu için aktif eşleştirme testi kullanıldı. Çalışma grubu 8 hafta boyunca haftada 3 kez 45 dk'lık proprioseptif egzersiz eğitimi aldı ve kontrol grubuna sadece diyabetik hasta eğitimi verildi. **Bulgular:** Çalışma grubu, Berg Denge Ölçeği, Wii Fit denge yaşı ve Tinetti Denge ve Yürüyüş Testi puanlarında anlamlı farklılıklar gösterdi (p<0,05). Titreşim algılama süresi, tedaviden sonra çalışma grubunda daha yüksek bir süre ile sonuçlandı (p<0,05). Aktif eşleştirme hareketi ve tabanın taktil duyusu, çalışma grubunda istatistiksel olarak gelişme gösterdi (p<0,05). **Sonuç:** Geriatrik diyabetli bireylere önerilen proprioseptif egzersizler, düşme ve somatosensoriyel kaybı önlemek için denge becerisini artırmada faydalı bir yaklaşım olabilir.

Anahtar Kelimeler: Diabetes mellitus; geriatri; postural denge; propriosepsiyon; duyu

Diabetes is a chronic disease whose prevalence increases with age. According to 2019 data from the International Diabetes Federation, while the number of people with diabetes was 382 million in 2013 in the world, it increased to 415 million in 2015 and it is predicted to reach 578 million in 2030. In 2019, the International Diabetes Federation calculated that 9.3% of adults live with diabetes in the world, equiv-

Correspondence: Mustafa ŞAHİN
Department of Orthopaedic and Traumatology, İstanbul Medipol University Faculty of Medicine, İstanbul, TURKIYE/TÜRKİYE
E-mail: msahin@medipol.edu.tr

Peer review under responsibility of Turkiye Klinikleri Journal of Medical Sciences.

Received: 24 Sep 2021 ***Received in revised form:*** 03 Nov 2021 ***Accepted:***23 Nov 2021 ***Available online***: 26 Nov 2021

alent to 463 million.[1] Diabetes in geriatrics is associated with decreased level of functional condition, increase in hospitalization rate and high mortality and causes severe damages in all systems of the body like eyes, kidneys, cardiovascular system and nervous system in long-term association with high blood glucoses.[2] The old people with diabetes are always under high risk in terms of acute and chronic complications along with physiologic effects of ageing.[3] By ageing deformation in somatosensorial systems, one of the important systems for balance control, sensory and motor loss occurring in lower extremity causes unsuccessful transmission of proper proprioceptive sense and leads disruption of the balance control of the individuals during statistical and dynamic conditions. Impairment in balance control increases the risk of falling.[4-7] Symptoms such as pain, numbness, and loss of sensation, especially the increasement of vibration and thermal perception threshold on distal lower extremity may be indicative of neuropathy and it affects approximately 50% of the individuals with diabetes.[8-11]

Proprioceptive exercises are included in rehabilitation in order to reduce somatosensory loss and increase balance abilities.[12-14] However, disruption in balance control of geriatric individuals are not only associated with diabetic neuropathy. Balance control may be deteriorated due to changes depending on aging in the sensorimotor system. Loss of sense may occur in people with diabetes with or without neuropathy, so balance control may be deteriorated.[15-17]

Although different effects of lower extremity proprioception exercises have been investigated in geriatrics with Type 2 diabetes, as far as we know, there is no study investigating the effectiveness of exercises on balance and sensory function. The primary aim of this randomized clinical trial was to evaluate the effectiveness of proprioception exercises for balance in geriatrics with Type 2 diabetes. The secondary aim was to evaluate the effectiveness of proprioception exercises for sensory function in geriatrics with Type 2 diabetes.

MATERIAL AND METHODS

This study was designed as a single blinded, prospective, randomized case-control study and approved by the İstanbul Medipol University Institutional Non-interventional Review Board for Human Subjects Committee at 23.06.2017 (No: 10840098-604.01.01-E. 15399, Decision no: 237). The procedures followed during the study were in accordance with the Helsinki Declaration of 2008.

PARTICIPANTS

Sample size calculations were performed using cross-tabulation and chi-square test. Study group (SG) and control group (CG) were assessed using cross tabulation percentages of their methods used to treat diabetes and estimated counts have been found (power=0.80, a=0.05). The effect size of 0.95 was required for a group sample size of 19, total of 38 of which the allocation ratio is 1. Significance was set a priori at an alpha value of 5% ($p<0.05$). Considering that individuals may quit the training in the follow up period, we included 40 people in our study in line with this power analysis.

The eligibility criteria for the interventional study were determined to be at age of 65 and over, to be able to walk independently or with the support of assistant equipment, to have Type 2 diabetes at least for 2 years. Having cognitive, chronic renal impairments, cardiac insufficiency, loss of hearing and vision, history of lower extremity orthopaedic surgery or trauma which will affect proprioception, and being diagnosed by diabetic neuropathy considered as exclusion criteria. Those with a mini mental test score below 25 were considered to have cognitive impairment and were excluded from the study. Individuals, who were diagnosed with Type 2 diabetes, staying in nursing homes, were included in the study and it was conducted between March 2018 and January 2019. Written consent of each subject was received. Of the 127 diabetic geriatrics, 78 patients who met our inclusion criteria were evaluated, 38 were excluded or did not agree to take part in the study, and at last, a total of 40 individuals with Type 2 diabetes were included in the study. Randomization was performed using a “random number table” and numbers were given according to the order of the patients’ room number. They were allocated into SG and CG with a 1:1 ratio by a blinded physiotherapist. After being informed about the content and context of the study, patients granted their formal approval and filled out the participant diagnostic form that consisted of demographic information such as age, sex, height, weight, smoking habits, medical comorbidities, educational status, duration of diabetes, dominant side, the method used to treat diabetes and prescription history were taken by reviewing the patients' medical records.

EVALUATION PROTOCOLS

All patients underwent a baseline balance and gait examination, vibration, tactile and joint position sense tests prior to treatment. A physiotherapist who was blinded to the treatment allocation of the patient's data performed measurements. The primary outcome was balance, which was evaluated with Berg Balance Scale (BBS), power platform of Nintendo Wii fit® (WBB; Nintendo, Kyoto, Japan) software and Tinetti Balance and Gait Test (TBGT). Secondary outcome measures were vibration, tactile and joint position sense. Vibration sense was evaluated with diapason (128 Hz) on medial malleoli, base of big and fifth toe. Tactile sensory assessments were performed with Semmes-Weinstein monofilaments on four plantar evaluation points. The first point was the plantar surface of the big toe, 2nd was the first metatarsal base, 3rd was the fifth metatarsal base and 4th one was under the calcaneus (Figure 1). Joint position sense was evaluated with active matching tests. While performing the active matching test, a manual goniometer with 2° sensitivity was used. Normal ankle range of motion of the individual was detected, and then 6° less of this maximum dorsiflexion and 6° less of the ankle maximum plantar flexion were tested. However knee flexion at 30° and hip abduction at 30° were also evaluated. All evaluations were repeated at the end of the post-treatment session which is at the end of the 8th week.

EXERCISE INTERVENTION

After all baseline evaluations had been done, the individuals were explained within the scope of the exercise training and its importance for preventing diabetes complications. SG (n=20) received a personalized exercise prescription which is planned by a physiotherapist and 10-15 grams of carbohydrate intake was provided before exercise. They were also

FIGURE 1: Plantar tactile sensory evaluation points.

informed about foot care and selection of shoes. Lower extremity proprioceptive exercise program was arranged according to condition of the patient, consisted of the following: ball rolling under foot, standing on one leg, activities which includes taking steps on bosu ball, antero-posterior and medio-lateral weight transfer on bosu, star excursion gait and balance exercises such as walking without support consisting of different grounds, heel to toe walking, side walking, cross walking exercises were chosen and applied. Sessions progressed from supported to unsupported exercise and from eyes open to eyes closed exercises. Exercises for 30-45 min. sequences of a session were applied 3 days a week for 8 weeks long. Only diabetic patient education provided for CG (n=20) and they were asked to continue their daily life activities without any restriction. Individuals in this group were not included in any exercise program.

STATISTICAL ANALYSIS

All statistical analyses were completed using "Statistical Package for Social Sciences" (SPSS) version 22.0 (SPSS Inc. Chicago, IL, USA). Descriptive statistics in the form of means, standard deviations and counts were used to describe baseline characteristics across subject and CGs. Normality was assessed using the Shapiro-Wilk test. Significance was set a priori at an alpha value of 0.05 ($p<0.05$). To analyse the influence of experimental training, student's paired t test and to compare baseline and post exercise values of control and SG, student's independent test was used.

RESULTS

Demographic characteristics of the geriatric individuals with Type 2 diabetes were given in Table 1. There was no significant difference among the groups in terms of mean age, height, weight and disease period ($p>0.05$) (Table 1).

The comparison of the balance test results evaluated at the baseline and end of the treatment within and between groups is given in Table 2. In the in-group comparisons, the SG showed a significant improvement in all BBS, TGBT and Wii scores compared to the baseline scores ($p<0.05$) (Table 2). In the CG, while no significant difference was found in the BBS and TGBT evaluations ($p>0.05$), a significant increase was observed in the Wii scores ($p<0.05$). In the inter-group comparison, the SG showed a significant superiority in all measurements ($p<0.05$) (Table 2).

When the duration of feeling vibration was compared between groups using an independent sample t-test, it showed a significant difference in the medial malleolus and base of 5th toe ($p<0.05$) and no difference in the base of big toe measurements ($p>0.05$) (Table 3). In the inter-group comparison, the SG showed a significant superiority in all measurements ($p<0.05$) (Table 3).

Means and standard deviations of both soles pressure perception senses baseline and post-treatment values of study SG and CG were shown in Table 4. In-group results showed that there was a significant difference in line of pressure perception of the left foot in the SG at the point of 1st metatarsal base, 5th metatarsal base and under calcaneus ($p<0.05$), also right and left feet both showed a significant improvement in the SG from baseline to post-treatment assessments ($p<0.05$) (Table 4). Conversely, according to the Semmes Weinstein monofilament testing, there was no significant change of pressure perception in both feet of subjects in the CG ($p>0.05$) (Table 4).

Study and CGs' active matching results of both lower extremities were compared in baseline and at the end of 8 weeks, means and standard deviations were shown in Table 5. A significant difference was found in the SG compared to CG after the 8 sessions of exercise training in foot dorsiflexion, plantar flexion, knee flexion and hip abduction evaluation parameters ($p<0.05$) (Table 5). On the contrary, active matching tests of foot plantar flexion and knee flexion, a significant deterioration was observed in the CG compared to the baseline scores at week 8 ($p<0.05$) (Table 5).

TABLE 1: General characteristics of subjects.

	SG (n=20) Mean±SD	CG (n=20) Mean±SD	p value
Age (year)	73.50±7.08	72.45±7.25	0.646
Sex (F/M)	7/13	7/13	1.000
Height (cm)	165.00±7.19	163.75±6.41	0.565
Weight (kg)	78.60±18.72	71.05±11.19	0.130
Duration of diabet (year)	9.90±6.68	10.80±6.04	0.658

SG: Study group; CG: Control group; SD: Standart deviation.

TABLE 2: Comparison of balance tests baseline and post-treatment intervention 2 groups.

		Baseline Mean±SD	Post-treatment Mean±SD	In-group t value	In-group p value*	Inter-group p value**
BBS	SG	37.30±11.10	45.40±6.60	4.402	**0.000**	**0.00**
	CG	41.60±9.20	41.70±8.20	0.301	0.767	
TB	SG	11.25±3.40	13.50±2.10	4.187	**0.001**	**0.00**
	CG	11.95±3.10	11.80±3.12	-1.371	0.186	
TG	SG	5.35±3.48	7.70±2.02	5.042	**0.000**	**0.00**
	CG	6.80±3.60	6.70±3.59	-1.00	0.330	
TBGT	SG	16.50±6.31	21.20±3.80	5.104	**0.000**	**0.00**
	CG	18.75±6.64	18.60±6.65	-1.371	0.186	
Wii age	SG	75.40±8.90	70.40±7.30	7.752	**0.000**	**0.00**
	CG	73.50±8.90	74.80±9.10	-2.481	**0.023**	

*Paired t-test, p<0.05; **Independent t-test, p<0.05; SD: Standart deviation; BBS: Berg Balance Scale; SG: Study group; CG: Control group; TB: Tinetti Balance Test; TG: Tinetti Gait Test; TBGT: Tinetti Balance and Gait Test total score.

TABLE 3: Comparison of duration of feeling vibration between baseline and post-treatment intervention 2 groups.						
		Baseline Mean±SD	Post-treatment Mean±SD	In-group t value	In-group p value*	Inter-group p value**
Right medial malleol	SG	5.75±5.31	8.10±4.36	3.508	**0.002**	**0.00**
	CG	8.20±2.68	6.25±3.14	-2.942	**0.008**	
Left medial malleol	SG	5.55±4.04	7.00±3.69	3.507	**0.002**	**0.00**
	CG	7.95±2.85	5.65±2.79	-5.205	**0.000**	
Right base of big toe	SG	6.65±4.63	7.05±3.39	0.477	0.639	0.036
	CG	6.65±3.01	4.90±2.07	-3.349	**0.003**	
Left base of big toe	SG	5.55±4.32	6.05±3.91	0.684	0.502	0.73
	CG	6.35±2.77	5.15±3.70	-2.143	**0.045**	
Right base of fifth toe	SG	6.85±4.34	8.25±3.56	1.677	**0.010**	**0.003**
	CG	7.75±3.10	6.10±2.38	-3.273	**0.040**	
Left base of fifth toe	SG	6.25±4.66	8.70±4.18	3.352	**0.003**	**0.00**
	CG	7.35±3.24	5.55±2.76	-3.187	**0.005**	

*Paired t-test p<0.05; **Independent t-test p<0.05; SD: Standard deviation; SG: Study group; CG: Control group.

TABLE 4: Comparison of tactile sensory between baseline and post-treatment intervention 2 groups.							
			Baseline Mean±SD	Post-treatment Mean±SD	In-group t value	In-group p value*	Inter-group p value**
Point 1	R	SG	5.38±1.11	4.34±0.36	4.515	**0.000**	**0.000**
		CG	4.92±0.81	5.04±0.91	-0.723	0.478	
	L	SG	5.53±0.96	4.72±0.96	4.268	**0.000**	**0.004**
		CG	5.08±0.98	5.04±0.91	0.254	0.802	
Point 2	R	SG	5.02±1.10	4.60±0.84	1.905	0.072	**0.010**
		CG	5.04±0.91	5.46±1.00	-1.952	0.660	
	L	SG	5.49±1.00	4.69±0.92	3.840	**0.001**	**0.009**
		CG	5.03±1.00	5.11±0.88	-0.304	0.764	
Point 3	R	SG	5.09±0.88	4.80±0.89	1.248	0.227	**0.050**
		CG	5.26±1.00	5.57±1.02	-1.690	0.107	
	L	SG	5.65±0.95	4.66±0.82	4.547	**0.000**	**0.001**
		CG	5.07±0.89	5.24±0.86	-0.811	0.427	
Point 4	R	SG	5.10±0.87	4.85±1.04	1.323	0.202	0.530
		CG	5.10±0.98	5.44±0.95	-1.499	0.150	
	L	SG	5.54±0.84	4.86±0.76	3.517	**0.002**	**0.000**
		CG	5.15±0.99	5.53±1.09	-2.061	0.530	

*Paired t-test p<0.05; **Independent t-test p<0.05; SD: Standard deviation; SG: Subject group; R: Right; CG: Control group, L: Left; Point 1: Plantar surface of the big toe; Point 2: First metatarsal base; Point 3: Fifth metatarsal base; Point 4: Under the calcaneus.

DISCUSSION

To the authors' knowledge, this is the first controlled trial using lower extremity proprioception exercises to develop balance and improve senses of foot on geriatric patients with Type 2 diabetes. Forty geriatric individuals of similar age, length and weight with Type 2 diabetes were included in the study and randomly divided as a SG and a CG. We assessed the individuals in terms of balance, vibration, tactile sensory and joint position sense in baseline, applied proprioceptive exercises to the SG, assessed post-treatment examination and compared them with the CG. We observed that with personalized exercise program application, diabetic geriatric patients of SG showed significantly better progression of feet in line of balance, vibration sense, tactile sense and joint position senses.

TABLE 5: Comparison of the baseline and post-treatment active matching test results of the groups.

			Baseline Mean±SD	Post-treatment Mean±SD	In-group t value	In-group p value*	Inter-group p value**
DF	R	SG	6.18±1.75	3.15±1.62	7.927	**0.000**	**0.000**
		CG	5.85±2.10	6.06±2.42	-0.631	0.536	
	L	SG	5.72±1.54	2.79±1.78	7.295	**0.000**	**0.000**
		CG	5.66±1.88	6.02±2.08	-0.988	0.335	
PF	R	SG	10.05±2.75	7.46±3.40	4.443	**0.000**	**0.000**
		CG	9.22±3.73	10.76±3.90	-2.976	**0.008**	
	L	SG	9.96±3.87	7.09±3.58	4.517	**0.000**	**0.000**
		CG	9.19±3.42	11.12±3.98	-4.618	**0.000**	
Knee	R	SG	15.44±5.56	11.25±4.93	4.936	**0.000**	**0.000**
		CG	15.79±5.27	18.76±5.20	-2.440	**0.025**	
	L	SG	15.85±6.37	10.72±5.82	6.469	**0.000**	**0.000**
		CG	15.76±5.13	19.06±4.63	-2.551	**0.020**	
Hip	R	SG	6.90±4.19	3.06±2.81	4.857	**0.000**	**0.000**
		CG	8.22±3.94	8.69±4.17	-0.637	0.532	
	L	SG	6.65±3.33	2.86±2.75	5.292	**0.00**	**0.000**
		CG	8.08±3.15	9.12±4.09	-1.473	0.157	

*Paired t-test, p<0.05; **Independent t-test, p<0.05; SG: Study group; R: Right; DF: Dorsiflexion; L: Left; CG: Control group; PF: Plantar flexion; SD: Standard deviation.

In the study where Vaz et al. examined the effect of diabetes on functional strength and postural control, the differences between individuals with neuropathy and without neuropathy, although diabetic neuropathy does not occur, postural control is observed to decrease in individuals with diabetes.[18] In our study, we applied proprioceptive exercise in diabetic patients without diabetic neuropathy, assuming the possibility of impairment of postural control. One thousand six hundred ninety one diabetes patients were examined in the meta-analysis investigating the risk of falling in elderly individuals with diabetes. Elderly people with diabetes have been associated with a 64% higher risk of falling, and those who use insulin have been shown to increase up to 94%. It was concluded that falls in elderly adults could be considered as an independent risk factor.[19] To improve the gait and balance of patients with Type 2 diabetes, an exercise program consisting of walking and balance exercises was applied by Allet et al. In the intervention group, significant differences were found in walking tests and Biodex balance scores in the Performance-oriented Mobility Assessment test compared to the CG.[20] In the study of Lee and Shin, the program which includes video games for balance and muscle strength, was applied to individuals with diabetes aged 65 and over.[21] At the end of the treatment, significant differences were obtained in the balance and gait analysis compared to the CG.[21] In our study, similar improvements were obtained in our balance evaluations in our treatment program in which we used proprioceptive exercises in the clinical setting. Pérez-Ros et al. investigated the effects of proprioceptive exercises on falling and balance in 564 elderly individuals.[22] Exercises lasted about 40-50 minutes 5 days a week. Proprioceptive exercises following warm-up, walking, stretching and mobilization exercises; stretching and relaxation exercises were performed. The exercises include dynamic and static positions, and their intensity and stages are adapted to the abilities of the participants. At the end of the 12-month period, proprioceptive exercises have been proven to reduce the incidence of falls and improve Tinetti scores. We also noted that the risk of falling decreased, Tinetti scores improved, and sensory improvements were also achieved with the proprioceptive exercises we applied to diabetic patients in the geriatric population. Thus, as a result of these studies, we can say that proprioceptive exercises in metabolic diseases such as diabetes in geriatric individuals can reduce falls and improve sensory improvement.

According to the study in which Song et al. examined the effect of the exercise program on balance and proprioception in elderly individuals with diabetic neuropathy, there was a significant difference in balance evaluations and trunk proprioception evaluation at the end of the treatment in the SG.[14] Significant improvements in antero-posterior oscillation values and tactile sensitivity values were obtained in the study in which Santos et al. examined the effects of proprioceptive training on pressure oscillations and pressure perception.[23] In the study in which Morrison et al. examined the effects of Wii fit balance education in elderly people with Type 2 diabetes, it was concluded that the training involving balance and postural control were effective in improving the proprioception and balance abilities in the reaction time.[24] In our study, significant improvements were obtained in lower extremity proprioception evaluation and pressure sense values in the group where proprioceptive exercises were performed. When we examined the studies, we observed that our data were in parallel with these studies.

In the study conducted by Fu et al., the balance and strength training program was applied to 50 healthy individuals for 12 weeks.[25] Positive significant differences were noted in balance, tactile perception, and vibration sensation threshold and muscle strength compared to the CG. In the study of Dixit et al. examining the effects of exercise therapy on the vibration perception threshold in individuals with Type 2 diabetic neuropathy, a minimum of 150 minutes of aerobic exercise program was applied to the individuals per week for 8 weeks.[13] It was observed that there was a significant difference in the lower extremity vibration threshold in the SG compared to the CG. In a study investigating the effects of long-term exercise in 78 diabetic individuals with no evidence of diabetic neuropathy, positive significant differences were obtained in the sural nerve conduction velocity and lower extremity vibration perception threshold in the exercise group.[26] Twenty one individuals with diabetic peripheral neuropathy (DPN) were included in the preliminary study of Kanchanasamut et al. examining the effects of weight transfer exercise on a mini trampoline on foot mobility, plantar pressure and plantar sensation.[27] The exercise group received a foot care training program and eight-week home exercises using a mini trampoline. The CG received only foot care training. Metatarsophalangeal joint motion, peak plantar pressure, and the feeling of pressure and vibration were evaluated. The number of subjects with insufficient perception of pressure and vibration in the exercise group decreased significantly for both feet. There was no significant change in the CG. The study showed that weight-shedding exercise on a trampoline can increase the sensation of vibration in people with DPN.[26] Similar to these studies, we observed that 8-week balance and proprioceptive exercises performed on different surfaces increase the perception of pressure and vibration in elderly people with diabetes. In the SG, we found a statistical increase in the time to feel the vibration. The reason why these gains make a significant difference in the calcaneus and 5th toe base but not on the base of the big toe may be due to the greater load on the calcaneus and 5th toe base during standing.[28] For this reason, the amount of load transferred is higher on the calcaneus and 5th toe base, while fewer loads may have been exercised on the big toe base, suggesting that the benefit obtained from exercises may be greater under the higher weights.

LIMITATIONS OF THE STUDY

The limitation of our study is that, because of not using a computer system in the measurement of proprioception, it has increased the error rate in deviation angles. Not using a computer-aided evaluation in walking evaluation restricts the acquisition of objective data.

CONCLUSION

As a conclusion, proprioceptive exercises can be prescribed to reduce loss of balance and sensation due to advanced age and diabetes. Lower limb proprioception exercises contribute to the improvement of balance and improve lower limb sensation. Thus, planning training that includes proprioceptive exercises may benefit elderly individuals staying in the nursing home. A proprioceptive exercise training plan can be created for individuals diagnosed with diabetes or preventive exercise training can be given to prevent loss of balance.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

***Idea/Concept:** Mustafa Şahin; **Design:** Mustafa Şahin, Fatma Demir; **Control/Supervision:** Mustafa Şahin; **Data Collection and/or Processing:** Fatma Demir; **Analysis and/or Interpretation:** Gizem Ergezen, Fatma Demir; **Literature Review:** Gizem Ergezen, Fatma Demir, Mustafa Şahin; **Writing the Article:** Gizem Ergezen, Fatma Demir; **Critical Review:** Mustafa Şahin; **References and Fundings:** Fatma Demir, Mustafa Şahin; **Materials:** Fatma Demir.*

REFERENCES

1. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al; IDF Diabetes Atlas Committee. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas. 9th ed. Diabetes Res Clin Pract. 2019;157: 107843. [Crossref] [PubMed]
2. Cho NH, Shaw JE, Karuranga S, Huang Y, da Rocha Fernandes JD, Ohlrogge AW, et al. IDF Diabetes Atlas: Global estimates of diabetes prevalence for 2017 and projections for 2045. Diabetes Res Clin Pract. 2018;138:271-81. [Crossref] [PubMed]
3. Kirkman MS, Briscoe VJ, Clark N, Florez H, Haas LB, Halter JB, et al. Diabetes in older adults. Diabetes Care. 2012;35(12):2650-64. [Crossref] [PubMed] [PMC]
4. Ghanavati T, Shaterzadeh Yazdi MJ, Goharpey S, Arastoo AA. Functional balance in elderly with diabetic neuropathy. Diabetes Res Clin Pract. 2012;96(1):24-8. [Crossref] [PubMed]
5. Nardone A, Grasso M, Schieppati M. Balance control in peripheral neuropathy: are patients equally unstable under static and dynamic conditions? Gait Posture. 2006;23(3):364-73. [Crossref] [PubMed]
6. Gutierrez EM, Helber MD, Dealva D, Ashton-Miller JA, Richardson JK. Mild diabetic neuropathy affects ankle motor function. Clin Biomech (Bristol, Avon). 2001;16(6):522-8. [Crossref] [PubMed]
7. Yamamoto R, Kinoshita T, Momoki T, Arai T, Okamura A, Hirao K, et al. Postural sway and diabetic peripheral neuropathy. Diabetes Res Clin Pract. 2001;52(3):213-21. [Crossref] [PubMed]
8. Menezes DR, Costa RG, de Araújo GG, Pereira LG, de Medeiros GR, Oliveira JS, et al. Detoxified castor meal in substitution of soybean meal in sheep diet: growth performance, carcass characteristics and meat yield. Trop Anim Health Prod. 2016;48(2):297-302. [Crossref] [PubMed]
9. Terzi M, Cengiz N, Onar M. Diyabetik nöropati [Diabetic neuropathy]. OMÜ Tıp Dergisi. 2004;21:39-49. [Link]
10. Satılmış Borucu I, Aydın Ş, Kuloğlu Pazarcı N, Gökyiğit M, Altuntaş Y. Diyabetes mellitusta iyi glisemik kontrol ile nöropati gelişimi önlenebilir mi? [Can development of neuropathy be prevented with good glycemic control in diabetes mellitus?]. Med Bull Sisli Hosp. 2015;49(4):243-7. [Crossref]
11. Forbes JM, Cooper ME. Mechanisms of diabetic complications. Physiol Rev. 2013;93(1): 137-88. [Crossref] [PubMed]
12. Streckmann F, Zopf EM, Lehmann HC, May K, Rizza J, Zimmer P, et al. Exercise intervention studies in patients with peripheral neuropathy: a systematic review. Sports Med. 2014;44(9):1289-304. [Crossref] [PubMed]
13. Dixit S, Gular K, Asiri F. Effect of diverse physical rehabilitative interventions on static postural control in diabetic peripheral neuropathy: a systematic review. Physiother Theory Pract. 2020;36(6):679-90. [Crossref] [PubMed]
14. Song CH, Petrofsky JS, Lee SW, Lee KJ, Yim JE. Effects of an exercise program on balance and trunk proprioception in older adults with diabetic neuropathies. Diabetes Technol Ther. 2011;13(8):803-11. [Crossref] [PubMed]
15. Deshpande N, Hewston P, Aldred A. Sensory functions, balance, and mobility in older adults with type 2 diabetes without overt diabetic perip heral neuropathy: a brief report. J Appl Gerontol. 2017;36(8):1032-44. [Crossref] [PubMed]
16. Kelly C, Fleischer A, Yalla S, Grewal GS, Albright R, Berns D, et al. Fear of falling is prevalent in older adults with diabetes mellitus but is unrelated to level of neuropathy. J Am Podiatr Med Assoc. 2013;103(6):480-8. [Crossref] [PubMed] [PMC]
17. Hewston P, Deshpande N. Falls and balance impairments in older adults with Type 2 diabetes: thinking beyond diabetic peripheral neuropathy. Can J Diabetes. 2016;40(1):6-9. [Crossref] [PubMed]
18. Vaz MM, Costa GC, Reis JG, Junior WM, Albuquerque de Paula FJ, Abreu DC. Postural control and functional strength in patients with type 2 diabetes mellitus with and without peripheral neuropathy. Arch Phys Med Rehabil. 2013;94(12):2465-70. [Crossref] [PubMed]
19. Yang Y, Hu X, Zhang Q, Zou R. Diabetes mellitus and risk of falls in older adults: a systematic review and meta-analysis. Age Ageing. 2016;45(6):761-7. [Crossref] [PubMed]
20. Allet L, Armand S, de Bie RA, Golay A, Monnin D, Aminian K, et al. The gait and balance of patients with diabetes can be improved: a randomised controlled trial. Diabetologia. 2010;53(3):458-66. [Crossref] [PubMed] [PMC]
21. Lee S, Shin S. Effectiveness of virtual reality using video gaming technology in elderly adults with diabetes mellitus. Diabetes Technol Ther. 2013;15(6):489-96. [Crossref] [PubMed]
22. Pérez-Ros P, Vila-Candel R, Martínez-Arnau FM. A home-based exercise program focused on proprioception to reduce falls in frail and pre-frail community-dwelling older adults. Geriatr Nurs. 2020;41(4):436-44. [Crossref] [PubMed]
23. Santos AA, Bertato FT, Montebelo MIL, Guirro EC de O. Effect of proprioceptive training among diabetic women. Rev Bras Fisioter. 2008;12:183-7. [Crossref]
24. Morrison S, Simmons R, Colberg SR, Parson HK, Vinik AI. Supervised balance training and wii fit-based exercises lower falls risk in older adults with Type 2 diabetes. J Am Med Dir Assoc. 2018;19(2):185.e7-185.e13. [Crossref] [PubMed]
25. Fu S, Choy NL, Nitz J. Controlling balance decline across the menopause using a balance-strategy training program: a randomized, controlled trial. Climacteric. 2009;12(2):165-76. [Crossref] [PubMed]
26. Balducci S, Iacobellis G, Parisi L, Di Biase N, Calandriello E, Leonetti F, et al. Exercise training can modify the natural history of diabetic peripheral neuropathy. J Diabetes Complications. 2006;20(4):216-23. [Crossref] [PubMed]
27. Kanchanasamut W, Pensri P. Effects of weight-bearing exercise on a mini-trampoline on foot mobility, plantar pressure and sensation of diabetic neuropathic feet; a preliminary study. Diabet Foot Ankle. 2017;8(1):1287239. [Crossref] [PubMed] [PMC]
28. Luger EJ, Nissan M, Karpf A, Steinberg EL, Dekel S. Patterns of weight distribution under the metatarsal heads. J Bone Joint Surg Br. 1999;81(2):199-202. [Crossref] [PubMed]