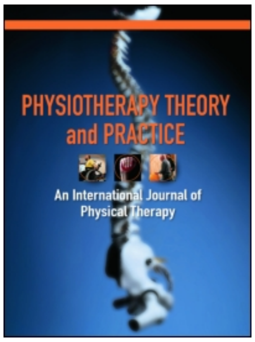

Taylor & Francis
Taylor & Francis Group

Physiotherapy Theory and Practice
An International Journal of Physical Therapy

ISSN: 0959-3985 (Print) 1532-5040 (Online) Journal homepage: http://www.tandfonline.com/loi/iptp20

The effect of foot plantar massage on balance and functional reach in patients with type II diabetes

Eylem Tütün Yümin PT, PhD, Tülay Tarsuslu Şimşek PT, PhD, Meral Sertel PT, PhD, Handan Ankaralı MD & Murat Yumin MD

PHYSIOTHERAPY THEORY AND PRACTICE
http://dx.doi.org/10.1080/09593985.2016.1271849

Taylor & Francis
Taylor & Francis Group

RESEARCH REPORT

The effect of foot plantar massage on balance and functional reach in patients with type II diabetes

Eylem Tütün Yümin, PT, PhD[a], Tülay Tarsuslu Şimşek, PT, PhD[b], Meral Sertel, PT, PhD[c], Handan Ankaralı, MD[d], and Murat Yumin, MD[e]

[a]Abant İzzet Baysal University, School of Physical Therapy and Rehabilitation, Bolu, Turkey; [b]Dokuz Eylül University, School of Physical Therapy and Rehabilitation, İzmir, Turkey; [c]Kırıkkale University, Faculty of Health Sciences, Department of Physical Therapy and Rehabilitation, Kırıkkale, Turkey; [d]Düzce University, Faculty of Health Science, Düzce; [e]Mudurnu Family Medicine, Mudurnu

ABSTRACT

Objective: The aim of this study was to investigate the effect of manual foot plantar massage (classic and friction massage) on functional mobility level, balance, and functional reach in patients with type II diabetes mellitus (T2 DM). ***Methods***: A total of 38 subjects diagnosed with T2 DM were included in the study. A healthy control group could not be formed in this study. After the subjects' socio-demographic data were obtained, Timed Up & Go (TUG) Test, functional reach test (FRT), one-leg standing test with eyes open-closed, and Visual Analogue Scale (VAS) to measure foot pain intensity were performed. The results were also divided and assessed in three groups according to the ages of the individuals (40–54, 55–64, and 65 and over). ***Results***: As a result of statistical analysis, a difference was found in the values obtained from TUG, FRT, and one-leg standing test with eyes open and closed ($p < 0.05$). Following the massage, TUG values significantly decreased comparison with those before the massage, whereas the values of FRT and one-leg standing test with eyes open and closed significantly increased compared with those before the massage ($p > 0.05$). According to age groups, there were statistical differences ($p < 0.05$) between the TUG, one-leg standing test with eyes open and closed test values of the individuals before and after the massage. ***Conclusions***: The results of our study indicated that application of plantar massage to patients with T2 DM caused an improvement in balance, functional mobility, and functional reach values. An increase in body balance and functional mobility may explain the improvement in TUG. Foot massage to be added to rehabilitation exercise programs of DM patients will be important in improving balance and mobility of patients.

ARTICLE HISTORY
Received 7 May 2015
Revised 28 December 2015
Accepted 28 December 2015

KEYWORDS
Balance; diabetes mellitus; foot; plantar massage; plantar cutaneous information

Introduction

Type II diabetes mellitus (T2 DM) is considered one of the most serious health problems, with great impact on the social and economic life of the country (Zhang et al., 2010). Primary and secondary effects of impaired insulin secretion on the body include microvascular (i.e. diabetic nephropathy, and diabetic retinopathy) and macrovascular (i.e. atherosclerosis, hypertension, myocardial infarction, cerebrovascular accident) complications (Chudyk and Petrella, 2011). In the case of DM, which is a chronic disease, due to problems secondary to the disease (e.g. diabetic neuropathy and functional limitation), reduced functional performance in the lower extremity and falls can be seen in patients (Cimbiz and Cakir, 2005; Cordeiro, Jardim, Perracini, and Ramos, 2009; Yamamoto et al., 2001).

The postural control system is based on the central integration of multisensory inputs (i.e. visual, vestibular, proprioceptive, and tactile) and on an internal representation of the body's orientation in space (Kavounoudias, Gilhodes, Roll, and Roll, 1999; Lafond, Corriveau, and Francois, 2004; Massion, 1994; Menz, Lord, George, and Fitzpatrick, 2004; Mergner and Rosemeier, 1998; Simmons, Richardson, and Pozos, 1997; Yamamoto et al., 2001). Multisensory feedback serves to regulate posture control by continuously updating the internal model of the body's position, and this model in turn forwards motor commands adapted to the environmental context and constraints. In everyday life, quiet standing is a rather simple postural task that is regulated automatically by subcortical nervous structures and spinal motoneuronal pools (Lacour and Borel, 1993). The performed studies display that there are various types of mechanoreceptors in the human foot skin area in various distributions and densities (Kavounoudias, Roll, and Roll, 2001; Ribot-Ciscar, Vedel, and Roll, 1989). Various studies by Kavounoudias et al. (1998, 1999, 2001) performed for determining the specific role of cutaneous plantar information on erect posture control highlighted that soles are dynamometric maps for

CONTACT Tülay Tarsuslu Şimşek tulay_tarsuslu@yahoo.com Dokuz Eylül University, School of Physical Therapy and Rehabilitation, İzmir, Turkey.

human balance control system, that tactile afferents from the main foot supporting areas contribute to stance control, and that superficial low-amplitude vibration is a particularly relevant stimulation to experimentally manipulate these tactile sensory inputs, and that the proprioceptive information to be provided from ankles and neck muscles can be used for two tasks: 1) balance control; and 2) body orientation, with central integration of both tasks. Importance of sensory inputs from feet and ankles for standing balance has also been described in other studies (Meyer, Oddsson, and Luca, 2004). People with impaired sensory function in the plantar region were found to have poor balance performance during static and dynamic balance tests, which may also result in a reduction of antigravity muscle activity (Leonard, Farooqui, Myers, and Myers, 2004; Silva et al., 2015). A chronic sensory-motor change can interrupt the afferences and efferences of the lower extremities, which are responsible for maintaining postural control and gait (Cavanagh, Hewitt, and Perry, 1992; Silva et al., 2015).

Increased sensorimotor failure and plantar cutaneous insensitivity that can occur in diabetes are associated with poor reach and patients should be examined in detail in terms of fall risk and plantar sensitivity (Lee, Lee, and Song, 2013). It is reported in the same study that evaluation of plantar sensitivity in patients with diabetes is important in terms of determining balance and fall risk (Lee, Lee, and Song, 2013). In the case of diabetic peripheral neuropathy diseases, loss or change of somatosensory information in the lower extremity causing dizziness and balance problems has often been reported to start from the tips of big toe or toes and move upwards (Boulton, 2005; Simmons, Richardson, and Pozos, 1997). This may lead to a reduction in tactile sensitivity and postural control deficits in a chronic period.

Recent studies on the effects of applications to foot plantar surface on plantar mechanoreceptors in a variety of populations have been receiving much attention. Bernard-Demanze, Burdet, Berger, and Rougier (2004) in their studies observed that the rotary plantar massage applied under the feet of healthy individuals increased afferent information and that this supported the postural system. In the same manner, Kavounoudias, Roll, and Roll (2001) in their studies emphasized that the tactile and proprioceptive information provided from the foot soles and flexor ankle muscles through mechanical vibration is important in postural regulation. In studies conducted with the elderly, mechanical stimulation of the foot as well as massage (i.e. massage technique involved the application of friction, static, and glide pressure focus on the sole of the foot) and manipulation applied to the foot are reported to be effective on postural control (Vaillant et al., 2008; Vaillant et al., 2009). A correlation between changed plantar sense and balance was also shown by studies conducted with patients with systemic diseases such as DM (Bretan, Pinheiro, and Corrento, 2010; Simmons, Richardson, and Pozos, 1997). It was observed that 6-week short-term whole-body vibration (WBV) training increased balance, muscle power, and HbA1c (glycosylated hemoglobin A1c) level, and reduced the risk of falling in patients at and over the age of 50 with peripheral diabetic neuropathy (Kordi Yoosefinejad et al, 2015; Lee, Lee, and Song, 2013). Effects on WBV on postural control have been discussed frequently in studies performed in recent years. In this study, it was aimed to evaluate the effectiveness of friction massage and Swedish massage applied manually on the soles (i.e. stroking and kneading). Our study had a wide age range (i.e. individuals over the age of 40) unlike other studies, and age group differences were discussed. The aim of this study was to investigate the effect of plantar massage on balance and functional reach in patients with type II diabetes.

Patients and methods

Participants

A total of 38 subjects with T2 DM followed by family medicine clinic in Mudurnu were included in the study. During the power analysis performed to estimate the sample size, in Epi Info ™ 7 (7.1.1.14) program, the minimum sample size to ensure that the power of the study was 80% with a margin of error of 0.05 at 95% confidence level was found as 35 people. The inclusion criteria were as follows: age ≥ 40 years; a diagnosis of T2 DM; individuals that could give logical answers to questions and had the cooperation level to perform given instructions; volunteered to participate in the study; and no vision, hearing, or speech problems. The exclusion criteria were as follows: lack of communication and cooperation to fulfill given instructions; heart failure; musculoskeletal problem; defect in the peripheral sensory system of the lower extremities; plantar dermatological disease; edema in the feet; neurological disorders or vestibular impairment; ambulation difficulties; and upper or lower extremity amputation at any level.

This study was primarily planned to evaluate the instantaneous effect of massage applied under the soles, and therefore no control groups were formed. Results were provided as pretest and posttest values. The individuals included in the study were divided into three age groups (40–54, 55–64, and 65 and over), and results from the statistical analysis were also interpreted as changes seen based on age distribution.

The institution's ethics committee (Düzce University Clinical Research Ethics Committee, decision number: 2014/55) approved this research. All volunteers signed an informed consent form.

Patient evaluation form was used to determine the findings, including: the subject's socio-demographic data (age, gender, weight, height, BMI, occupation, marital status, social security); whether the subject had any systemic disease other than T2 DM, if s/he does, what it is; smoking and alcohol intake; presence of high cholesterol; glycosylated hemoglobin A1c (HbA1c) value, fasting, and 2-h postprandial blood glucose values (FPG and 2hPG); when s/he was diagnosed with T2 DM; whether s/he is on insulin or oral antidiabetic medications; and whether s/he has foot burning and/or foot pain accompanying diabetes. Visual analogue scale (VAS) was used to determine the severity of foot pain (Table 1). HbA1c value, and fasting and postprandial blood glucose values of the patients were traced from patient files and recorded. In addition, it was asked of the patients whether they had foot pain, and if any, for how many years, and they were asked to determine their value according to VAS. Intensity of pain was marked by the subjects on a VAS. A score of 0–1 was considered as "low/no pain"; 2–4 was labeled as "low-mild pain"; 5–7 as "moderate pain"; and 8–10 as "severe pain" (Williamson and Hoggart, 2005). The feeling of burning in the feet is among the major symptoms in diabetics (particularly in diabetic neuropathy). Patients were asked whether they had a burning feeling in their feet, and a burning feeling in their feet at night; answers were recorded as "yes-no".

In order to determine the subjects' balance and functional mobility levels, Timed Up and Go Test (TUG), one-leg standing test with eyes open and closed test, and functional reach test (FRT) were conducted (Lin, Chen, Liao, and Chou, 2010; Lin et al., 2004; Lynch et al., 2007).

Assessments

Pretests were conducted for balance, functional mobility, and FRTs. The tests were applied to individuals with the below order: immediately after 10-minute massage application; posttest TUG; one-leg standing test with eyes open-closed; and FRT, which were conducted to assess balance and functional reach, were repeated in the same order.

Table 1. Socio-demographic characteristics of the subjects.

	X ± SD, %
Age (years, X ± SD)	58.63 ± 9.46
40–54 age (n = 12, years, X ± SD)	48.08 ± 5.12
55–64 age (n = 15, years, X ± SD)	58.86 ± 2.89
65 and ↑ age (n = 11, years, X ± SD)	69.81 ± 4.42
HbA1c (%)	7.21 ± 1.76
Fasting blood glucose values (FPG) (mg/dl)	136.89 ± 34.98
Postprandial blood glucose values (2hPG) (mg/dl)	176.55 ± 47.99
Duration of DM (year)	6.56 ± 5.46
Use of insulin (year)	3.25 ± 2.51
Use of medication (year)	6.17 ± 4.90
Foot pain (year)	3 ± 1.09
Visual Analogue Scale	3.61 ± 2.43

		n	%
Gender	Female	15	39.5
	Male	23	60.5
Occupation	Officer	3	7.9
	Worker	3	7.9
	Self-employed	15	38.5
	Housewife	14	36.8
	Unemployed	3	7.9
Educational level	Primary school	20	52.6
	Secondary School	9	23.7
	High school	3	7.9
	University	3	7.9
	Illiterate	3	7.9
Medication	Insulin	9	23.7
	Oral antidiabetic	23	60.5
	Insulin + oral antidiabetic	6	15.8
The presence of the systemic disease	Yes	22	57.9
	No	16	42.1
Use of tobacco	Yes	9	23.7
	No	29	76.3
Use of alcohol	Yes	3	7.9
	No	35	92.1
The presence of the cholesterol	Yes	27	94.4
	No	1	5.6

Timed-up and Go test

Participants were timed in seconds, starting from a seated position, standing up, walking 3 m, turning, walking back, and sitting down again. The longer the time, the poorer was considered the mobility (Lynch et al., 2007).

One-Leg standing test

The one-leg standing test was performed for the right and left legs in two positions: with eyes open or closed. The subject started the test with eyes open and arms alongside the body on the support bases/he feels comfortable, then s/he stood on one foot unaided. The test time started as soon as the foot was lifted from the ground and ended when it touched the ground back again. The longer the time, the better the balance ability. Moving the foot from its original position or lowering the lifted foot was considered criteria for stopping the clock. Time was recorded in seconds. Each test was performed three times and the mean value was considered for statistical analysis in the study (Lin et al., 2004).

Functional reach test

The subject was instructed to turn sideways to the tape measure affixed to the wall and position the arm that is closer to the wall at 90 degrees of shoulder flexion. At this position, the starting point at the 3rd finger was recorded on the wall. The subject was instructed to reach as far as s/he can forward without taking a step by maintaining his/her arm's position and the location of the 3rd finger was recorded. The distance between the two marks was recorded as the functional reach distance in centimeters (cm). This evaluation was repeated three times on the subject and the average of the measurements was taken (Lin, Chen, Liao, and Chou, 2010).

Intervention (Massage)

After the evaluation, classic massage, known as Swedish technique (included stroking and kneading), and deep-friction massage (pain-free) were applied to the subjects. The classic massage was applied to the right and left foot dorsum, medial, lateral regions of the foot, the toes, and the plantar region, while the patient was in supine position. The deep-friction massage was applied to the same areas of the feet by moving the toes rapidly and strongly forward and backwards. The massage was applied bilaterally to each lower extremity for 10 minutes in the following sequence: 1) classic massage; 2) deep friction; and 3) classic massage. The massage was applied to the extremities, one after the other. The massage was applied by a trained physiotherapist with clinical experience performing massage.

Statistical analysis

Statistical analyses were performed using the SPSS software version 20. The variables were investigated using histograms, probability plots, and analytical methods (Kolmogorov–Smirnov/Shapiro–Wilk test) to determine whether or not they were normally distributed. Descriptive values of the obtained data were calculated as mean ± SD, number, and percentage frequencies, and are given in tables. While comparing the values obtained from the TUG test, one-leg standing test with eyes open or closed, and the FRT test individually for right and left foot of diabetic subjects (pretest/posttest), paired Student's t-test was used. Single-way variance analysis was used to compare the groups, which were separated according to ages (40–54, 55–64, 65 and over), in terms of numeric characteristics. Levene test was used to assess the homogeneity of the variances. When an overall significance was observed, pairwise post hoc test was performed using post hoc Tukey test. If the *p*-value calculated as a result of hypothesis testing was smaller than 5%, the result was considered statistically significant. SPSS (ver. 18) software package was used for calculations.

Results

The mean age and BMI of the study subjects with diabetes were 58.6 ± 9.5 years and 21.4 ± 5.5 kg/cm^2, respectively. Of the individuals included in the study, 12 were between the ages of 40 and 54, 15 were between 55 and 64, and 11 were 65 and over. The individuals had a low level of education: 7.9% were illiterate and 52.6% were primary school graduates. Of the rest; 23.7% were secondary school and 15.8% were high school or university graduates (7.9% in each group). The study subjects' HgA1c values, fasting blood glucose, postprandial blood glucose, and DM years were as follows: 7.2 ± 1.8; 136.9 ± 35.0; 176.6 ± 48.0; and 6.6 ± 5.5 years, respectively. Most of the individuals (60.5%) were using oral antidiabetic medicines, 23.7% were using insulin, and 15.8% were using both insulin and oral antidiabetic medicines. The patients who were taking medicines used them for 6.2 ± 4.9 years, and insulin users used insulin for 3.3 ± 2.5 years. With regard to tobacco and alcohol use, 23.7% smoked and 7.9% consumed alcohol. Alcohol and smoking are major risk factors of T2 DM. A vast majority of the individuals had high cholesterol (94.4%), 57.9% had systemic illnesses (i.e. 45% had hypertension (n=17), 11% had hypertension and heart failure (n=4) and 0.3% had (n=1) hypertension. Socio-demographic characteristics of the subjects are shown in Table 1.

Table 2. The other findings of the subjects.

		n	%
Whether has foot burning	Yes	19	50
	No	19	50
Night foot burning	Yes	14	36.8
	No	24	63.2
Foot pain	Yes	11	28.9
	No	27	71.1
How to relax foot pain	Rest	4	36.4
	Rest+analgetics	3	27.3
	Rest+massage	2	18.2
	Cold water washing	1	9.1

Around 28.9% of the patients had foot pain and their VAS average value was found as 3.61 ± 2.43 (low-mild pain). Around 36.4% of the patients with foot pain stated that they coped with the pain by resting, 27.3% by resting and medication, 18.2% by resting and massage, and 9.1% by washing with cold water. The feeling of burning in the feet was found in 50% of the patients. 36.8% of them had increased feeling of burning at night. The other findings of the subjects with diabetes are shown in Table 2.

The post-intervention analysis found a statistical difference in the values of TUG, FRT, and one-leg standing with eyes open or closed (for the right and left foot) tests ($p < 0.05$). After the massage treatments, TUG values significantly decreased as compared to those before the massage; the values of FRT and one-leg standing test with eyes open or closed significantly increased as compared to those before the massage ($p >$ 0.05, Table 3). The TUG values were 7.5 ± 2.1 seconds before the massage, which reduced to 7.1 ± 1.8 after the massage. The FRT value was 29.3 cm ±7.2 before the massage, which increased to 29.7 ± 7.3 after the massage. In the same manner, the standing time significantly increased after the massage for both left and right legs with both open and shut eyes. This increase was acquired more in the tests with open eyes according to the closed-eye test and more in right foot according to left foot.

In the analysis performed for evaluating the changes of balance, functional extension, and functional mobility according to age, a significant difference was found in the test values for pre- and post-massage application between TUG, one-leg standing with eyes open or closed (for the right and left feet) test results ($p <$ 0.05). No difference was found in the FRT test values ($p > 0.05$) (Table 4). Before and after the massage, the TUG values were significantly lower in the younger 40–54 age group, while it was higher in individuals at age 65 and higher ($p < 0.05$). In one-leg standing with eyes open or closed (for the right and left foot) tests, pre- and post-massage values of individuals between the age of 40–54 were found to be significantly higher,

Table 3. The comparison of TUG, FRT, and one-leg-standing test values before and after massage treatment.

		Before massage X ± SD	After massage X ± SD	t	*p*
TUG (sec)		7.45 ± 2.07	7.05 ± 1.76	3.556	≤.001
FRT (cm)		29.34 ± 7.21	29.73 ± 7.32	−7.404	<.001
Eyes open (sec)	Right OLT	26.75 ± 24.32	44.08 ± 33.10	−9.464	<.001
	Left OLT	26.52 ± 25.43	41.03 ± 31.77	−1.468	<.001
Eyes closed (sec)	Right OLT	6.11 ± 6.55	9.16 ± 9.80	−1.318	<.001
	Left OLT	5.89 ± 7.34	8.79 ± 8.97	−4.447	≤.001

*$p < 0.05$, paired Student's *t*-test, TUG: Time-Up and Go test; OLT: One-leg test; FRT: Functional Reach Test.

Table 4. The comparison of TUG, FRT, and one-leg-standing test values before and after massage treatment according the age groups of the subjects (ANOVA analysis).

			Before massage			After massage		
			X ± SD	F	*p*	X ± SD	F	*p*
TUG		40–54 age (n = 13)	6.44 ± 0.95	4.39	0.02	6.18 ± 0.80	4.20	0.02
		55–64 age (n = 14)	7.29 ± 1.41			6.95 ± 1.48		
		65 and ↑ (n = 11)	8.78 ± 2.99			8.14 ± 2.35		
FRT		40–54 age (n = 13)	31.16 ± 7.75	0.68	0.51	31.33 ± 7.90	0.55	0.58
		55–64 age (n = 14)	29.13 ± 6.90			29.66 ± 7.20		
		65 yaş ve ↑ (n = 11)	27.63 ± 7.21			28.09 ± 7.13		
Eyes open (sec)	Right OLT	40–54 age (n = 13)	41.30 ± 27.64	4.21	0.02	62.94 ± 34.50	3.86	0.03
		55–64 age (n = 14)	23.93 ± 19.84			40.93 ± 27.62		
		65 and ↑ (n = 11)	14.72 ± 19.29			27.81 ± 30.73		
	Left OLT	40–54 age (n = 13)	44.75 ± 29.13	5.95	≤0.01	56.19 ± 35.59	3.63	0.03
		55–64 age (n = 14)	20.80 ± 16.44			42.26 ± 28.16		
		65 and ↑ (n = 11)	14.45 ± 21.75			22.81 ± 24.25		
Eyes closed (sec)	Right OLT	40–54 age (n = 13)	10.89 ± 11.03	5.00	0.01	15.66 ± 12.72	6.21	≤0.01
		55–64 age (n = 14)	4.69 ± 3.23			8.50 ± 7.52		
		65 and ↑ (n = 11)	2.09 ± 1.75			3 ± 2.23		
	Left OLT	40–54 age (n = 13)	10.21 ± 9.41	5.54	≤0.01	15.98 ± 11.96	9.16	≤0.01
		55–64 age (n = 14)	7.29 ± 4.74			5.53 ± 3.90		
		65 and ↑ (n = 11)	2.45 ± 2.20			3 ± 2.52		

*$p < 0.05$, ANOVA; TUG: Time-Up and Go test; OLT: One-leg test; FRT: Functional Reach Test.

and such values of individuals at the age of 65 were found to be significantly lower ($p < 0.05$) (Table 4).

Discussion

The results of our study showed that the massage applied to the plantar region of diabetic patients led to an improvement in balance, timed performance, functional mobility level, and functional reach values of the patients.

Cutaneous afference from plantar mechanoreceptors can provide detailed spatial and temporal information about contact pressures on the foot and postural control (Perry, 2006; Perry, McIlroy, and Maki, 2000), and interventions to stimulate mechanoreceptors are emphasized to have positive effects on postural control (Taylor, Menz, and Keenan, 2004; Vaillant et al., 2009). Previous studies on the subject suggest that the human proprioceptive system has a high degree of adaptive functional plasticity, at least as far as perceptual and motor aspects are concerned (Brandt et al., 2002; Collins et al., 1995; Roll et al., 1998).

Bernard-Demanze et al. (2004) investigated the effects of changes in plantar cutaneous information on upright quiet stance following a 10-minute plantar rotatory massage applied to 10 healthy subjects with a mean age of 22.7 ± 8.2 years. At the end of the study, the authors reported that the rotatory massage applied to the plantar region enhanced cutaneous afferent information, which in turn ensured recalibration of somesthetic cues. These results were explained by the influence of enhanced integrative mechanisms in the central nervous system provided by increased plantar cutaneous information with the massage applied. In the same study, emphasis was placed on the importance of applying plantar massage in addition to rehabilitation exercises, especially in the treatment of patients suffering from loss of plantar cutaneous sensitivity or those with balance problem as in having difficulties distributing their body weight evenly on their feet. Similarly, in the study by Vaillant et al. (2009) on the elderly, ankle mobilization and plantar massage were demonstrated to be important in the development of balance in that they caused significant improvement in the subjects' one-leg standing and TUG scores. In another study, the same authors reported that in the elderly, manipulation of feet and ankles improves postural control in standing, and thus it is an important application that can be recommended for functional limitations arising from sensory loss, which may be induced by especially age and/or a disease (Vaillant et al., 2008). Wandell et al. (2012) carried out a study to evaluate the effect of tactile massage, studied individuals with type II diabetes aged 35–75 years by dividing them into two groups. They applied tactile massage to one group on their foot plantar and relaxation exercises to the other group once a week for 10 weeks. At the end of the study, the authors discovered that tactile massage and relaxation exercises caused an increase in the subjects' quality of life. Silva et al. (2015) demonstrated that a 12-week somatosensory training was beneficial in regulating anterior-posterior oscillations of the center of pressure and increasing balance in elderly patients with T2 DM. Similarly, in a case study conducted by Finch, Baskwill, Marincola, and Becker (2007) to determine the effectiveness of lower extremity massage in patients with type II diabetic neuropathy, they bilaterally applied a combination of Swedish techniques, trigger point release, myofascial techniques, and passive stretching that lasted for 80 minutes (40 minutes for each extremity) to the whole lower extremity in supination and pronation positions. At the end of the study, they found that the variability of mean peak pressures and mean value pressure picture was significantly increased below the hallux and that foot contact time was significantly decreased. It was emphasized that the massage therapy intervention had positive effects in terms of velocity and fluidity, and thus such interventions would be important in improving the mobility of patients and reducing the incidence of neuropathic ulcerations in patients with diabetic neuropathy.

Kordi Yoosefinejad et al. (2015) examined the effectiveness of WBV in DM patients with peripheral neuropathy type II and stated that a 6-week WBV is a method that can be used for increasing isometric muscle power and for improving mobility and balance in DM patients with mild to moderate peripheral neuropathy type II. Lee, Lee, and Song (2013) researched the effectiveness of WBV and found that there are important improvements in static balance, dynamic balance, muscle power, and HbA1c, when elderly T2 DM patients were compared with the control group. The authors stated that a short-term WBV treatment used in combination with balance exercise is an important application for preventing falls in elderly diabetic neuropathy patients. Kordi Yoosefinejad et al. (2015) and Lee, Lee, and Song (2013) worked with neuropathy patients and used WBV for plantar cutaneous stimulation. In our study, the patients did not have diabetic neuropathy, and unlike WBV, the effect of the manually and locally applied practice (sole manual massage application) was researched. The results were in agreement with the literature. The results of our study showed that plantar foot massage, applied for increasing plantar cutaneous information, was effective in patients with T2 DM without neuropathy. We believe that the positive results obtained in this study can be ascribed to the activation of effective mechanisms to increase postural control and balance, along with stimulation of mechanoreceptors in the plantar region and enhanced tactile afferent information caused by the plantar massage. As suggested by Bernard-Demanze et al. (2004) and unlike some of the studies mentioned above, our primary target was stimulation of mechanoreceptors in the plantar region so no manipulation or mobilization was performed. However, the massage therapy applied to patients with DM resulted in a significant increase in functional reach, timed performance (TUG), and balance (one-leg standing, TUG) values. Similar to the studies mentioned above, these results revealed that treatments such as massage aimed to stimulate foot plantar mechanoreceptors are particularly important in reducing, delaying and/or preventing balance and mobility problems by enhanced afferent information fed to the postural system.

Studies show that postural control strategies decrease by age (Lacour, Bernard-Demanze, and Dumitrescu, 2008; Marsh and Geel, 2000). It is stated that aging in the sensory motor system is one of the most important reasons for balance problems that cause falling in older individuals (Horak, Shupert, and Mirka, 1989; Woollacott, 2000). Studies state that balance can be improved by education, but age-based differences were also shown. In a study by Bernard-Demanze et al. (2009), it was shown that the balance recovery strategies during dynamic postural task differs according to age. Before the intervention, the statistical analysis, performed according to age distribution in parallel with the literature, found a difference in the values obtained from TUG and one-leg standing test with open and closed eyes. In the same manner, a significant difference was found in the values obtained from TUG, and one-leg standing test with open and closed eyes after the massage. Test values were found lower in individuals of age 65 and older, and higher in individuals of age 40–54. After the massage, as Bernard-Demanze et al. (2009) displayed in their studies, the individuals between the age of 40–54, representing the younger population, had increased balance and functional mobility values compared with the individuals of age 65 and elder. These results support the effect of age on balance and mobility parameters, and at the same time, show that the treatment strategies used for improving balance and mobility are more effective for young individuals compared to the elderly.

Patients in our study had a mean age of 58.6 ± 9.5 years and we believe it would be beneficial to add foot plantar applications or foot massage applications to routine rehabilitation exercises so that the problems such as balance and falls associated with advanced age can be reduced and the patients have improved quality of life. Our results are in good agreement with the results of many authors mentioned above and unfold the role and importance of the plantar region in rehabilitation treatment once more.

It was reported that complaints decreased or disappeared in 56% of the diabetic neuropathic patients with problems including tingling, pain, itching, and restless leg at the end of 1 month following a massage therapy (Ezzo, Donner, Nickols, and Cox, 2001). In our study, the momentary effect of the massage was considered, so assessments of patients suffering from pain were not repeated after the massage for long-term carryover. However, similar to the results reported in the literature, some of our patients stated that they could reduce foot pain with rest and massage. This also reveals the importance of foot massage applications in diabetic patients in terms of reducing foot pain.

This study has several limitations. One of them is the lack of a control group and that the study was conducted with a single group. In future studies, a comparative analysis could be performed with two different control groups consisting of healthy subjects and those with diabetic neuropathy. Similarly, comparative studies can be conducted with diabetic patients with or without neuropathy.

Another limitation of the study was that posttests were only considered immediately after the application. Repeating measurements at regular intervals after the massage could provide important data in terms of determination of the length of effect achieved by massage. Long-term effects of plantar massage application can be studied in further studies.

Conclusion

This study demonstrated that plantar massage for patients with T2 DM results in significant gains in balance, functional mobility and reach immediately after the intervention. In the case of diseases causing a decrease in plantar sensitivity such as DM, such interventions to the soles of the feet are thought to be important in terms of attaining postural control and balance in patients and improving their quality of life. In these patients, plantar foot massage treatments can be incorporated into routine rehabilitation exercise programs.

Declaration of interest

The authors declared no potential conflicts of interest.

References

Bernard-Demanze L, Burdet C, Berger L, Rougier P 2004 Recalibration of somesthetic plantar information in the control of undisturbed upright stance maintenance. Journal of Integrative Neuroscience 3: 433–451.

Bernard-Demanze L, Dumitrescu M, Jimeno P, Borel L, Lacour M 2009 Age-related changes in posture control are differentially affected by postural and cognitive task complexity. Current Aging Science 2: 139–149.

Boulton AJ 2005 Management of diabetic peripheral neuropathy. Clinical Diabetes 23: 9–15.

Brandt T, Glasauer S, Stephan T, Bense S, Yousry TA, Deutschlander A 2002 Visual-vestibular and visuovisual cortical interaction.Annals of the New York Academy of Sciences 956: 230–241.

Bretan O, Pinheiro RF, Corrento JE 2010 Balance and plantar cutaneous sensitivity functional assessment in community-dwelling elderly. Brazilian Journal of Otorhinolaryngologia 76: 219–224.

Cavanagh PR, Hewitt FG, Perry JE 1992 In shoe plantar pressure measurement: A review. Foot 12: 185–194.

Chudyk A, Petrella RJ 2011 Effects of exercise on cardiovascular risk factors in type 2 diabetes. Diabetes Care 34: 1228–1237.

Cimbiz A, Cakir Ö 2005 Evaluation of balance and physical fitness in diabetic neuropathic patients. Journal of Diabetic Complications 19:160–164.

Collins JJ, DeLuca CJ, Pavlik AE, Roy SH, Emley MS 1995 The effects of spaceflight on open-loop and closed-loop postural control mechanisms: Human neurovestibular studies on SLS-2. Experimental Brain Research 107: 145–220.

Cordeiro RC, Jardim JR, Perracini MR, Ramos LR 2009 Factors associated with functional balance and mobility among elderly diabetic out patients. Endocrinologia and Metabologia 53: 834–843.

Ezzo J, Donner T, Nickols D, Cox M 2001 Is massage useful in the management of diabetes? A systematic review. Diabetes Spectrum 14: 218–224.

Finch P, Baskwill A, Marincola F, Becker P 2007 Changes in pedal plantar pressure variability and contact time following massage therapy: A case study of a client with diabetic neuropathy. Journal of Bodywork and Movement Therapies 11: 295–301.

Horak FB, Shupert CL, Mirka A 1989 Components of postural dyscontrol in the elderly: A review. Neurobiology Aging 10: 727–738.

Kavounoudias A, Gilhodes JC, Roll R, Roll JP 1999 From balance regulation to body orientation: Two goals for muscle proprioceptive information processing? Experimental Brain Research 124: 80–88.

Kavounoudias A, Roll R, Roll JP 1998 The plantar sole is a ‘dynamometric map’ for human balance control. Neuroreport 9: 3247–3252.

Kavounoudias A, Roll R, Roll JP 2001 Foot sole and ankle muscle inputs contribute jointly to human erect posture regulation. The Journal of Physiology 532: 869–878.

Kordi Yoosefinejad A, Shadmehr A, Olyaei G, Talebian S, Bagheri H, Mohajeri-Tehrani MR 2015 Short-term effects of the whole-body vibration on the balance and muscle strength of type 2 diabetic patients with peripheral neuropathy: A quasi-randomized-controlled trial study. Journal of Diabetes and Metabolic Disorders 14: 45.

Lacour M, Bernard-Demanze L, Dumitrescu M 2008 Posture control, aging, and attention resources: Models and posture-analysis methods. Neurophysiologie Clinique 38: 411–421.

Lacour M, Borel L 1993 Vestibular control of posture and gait. Archives Italiennes de Biologie 131: 81–104.

Lafond D, Corriveau H, Francois P 2004 Postural control mechanisms during quiet standing in patients with diabetic sensory neuropathy. Diabetes Care 27: 173–177.

Lee K, Lee S, Song C 2013 Whole-body vibration training improves balance, muscle strength and glycosylated hemoglobin in elderly patients with diabetic neuropathy. The Tohoku Journal of Experimental Medicine 231: 305–314.

Leonard DR, Farooqui H, Myers F, Myers S 2004 Restoration of sensation, reduced pain, and improved balance in subjects with diabetic peripheral neuropathy. Diabetes Care 27: 168–172.

Lin MR, Hwang HF, Hu MH, Isaac HD, Wang YW, Huang FC 2004 Psychometric comparison of the timed up and go, one-leg stand, functional reach, and tinetti balance measures community Dwelling older people. Journal of American Geriatrics Society 52:1343–1348.

Lin SI, Chen YR, Liao CF, Chou CW 2010 Association between sensorimotor function and forward reach in patients with diabetes. Gait and Posture 32: 581–585.

Lynch EA, Hillier SC, Stiller K, Campanella RR, Fisher PM 2007 Sensory retraining of the lower limb after acute stroke: A randomized controlled pilot trial. Archives of Physical Medicine and Rehabilitation 88: 1101–1107.

Marsh AP, Geel SE 2000 The effect of age on the attentional demands of postural control. Gait and Posture 12: 205–213.

Massion J 1994 Postural control system. Current Opinion in Neurobiology 4: 877–887.

Menz HB, Lord SR, George R, Fitzpatrick RC 2004 Walking stability and sensorimotor function in older people with diabetic peripheral neuropathy. Archives of Physical Medicine and Rehabilitation 85: 245–251.

Mergner T, Rosemeier T 1998 Interaction of vestibular somatosensory and visual recordings for postural control and motion perception under terrestrial and microgravity conditions: A conceptual model. Brain Research Reviews 28: 118–135.

Meyer PF, Oddsson LIE, Luca CJ 2004 The role of plantar cutaneous sensation in unperturbed stance. Experimental Brain Research 156: 505–512.

Perry SD 2006 Evaluation of age-related plantar-surface insensitivity and onset age of advanced insensitivity in older adults using vibratory and touch sensation tests. Neuroscience Letters 392: 62–67.

Perry SD, McIlroy WE, Maki BE 2000 The role of plantar cutaneous mechanoreceptors in the control of compensatory stepping reactions evoked by unpredictable, multi directional perturbation. Brain Research 877: 401–406.

Ribot-Ciscar E, Vedel JP, Roll JP 1989 Vibration sensitivity of slowly and rapidly adapting cutaneous mechanoreceptors in the human foot and leg. Neuroscience Letter 104: 130–135.

Roll R, Gilhodes JC, Roll JP, Popov K, Charade O, Gurnkel V 1998 Proprioceptive information processing in weightlessness. Experimental Brain Research 122: 393–402.

Silva P, FigueredoBorges Botelho PF, De Oliveira Guirro EC, Vaz MM, De Abreu DC 2015 Long-term benefits of somatosensory training to improve balance of elderly with diabetes mellitus. Journal of Bodywork and Movement Therapy 19: 453–457.

Simmons RW, Richardson C, Pozos R 1997 Postural stability of diabetic patients with and without cutaneous sensory deficit in the foot. Diabetes Research and Clinical Practice 36: 153–160.

Taylor AJ, Menz HB, Keenan A-M 2004 Effects of experimentally induced plantar insensitivity on forces and pressures under the foot during normal walking. Gait and Posture 20: 232–237.

Vaillant J, Rouland A, Martigne P, Braujou R, Nissen MJ, Caillat Miousse JL 2009 Massage and mobilization of the feet and ankles in elderly adults: Effect on clinical balance performance. Manuel Therapy 14: 661–664.

Vaillant J, Vuillerme N, Janvey A, Louis F, Braujou R, Juvin R 2008 Effect of manipulation of the feet and ankles on postural control in elderly adults. Brain Research Bulletin 75: 18–22.

Wandel PE, Carlsson AC, Gafvels C, Andersson K, Törnkvist L 2012 Measuring possible effect on health-related quality of life by tactile massage or relaxation in patients with type 2 diabetes. Complementary Therapies in Medicine 20: 8–15.

Williamson A, Hoggart B 2005 Pain: A review of three commonly used pain rating scales. Journal of Clinical Nursing 14: 798–804.

Woollacott M 2000 Systems contributing to balance disorders in older adults. Journal of Gerontology and Medical Science 55A: M424–M428.

Yamamoto R, Kinoshita T, Momoki T, Arai T, Okamura A, Hirao K 2001 Postural sway and diabetic peripheral neuropathy. Diabetes Research and Clinical Practice 52: 213–221.

Zhang P, Zhang X, Brown J, Vistisen D, Sicree R, Shaw J 2010 Global health care expenditure on diabetes for 2010 and 2030. Diabetes Research and Clinical Practice 87: 293–301.