Is there a relationship between plantar foot sensation and static balance, physical performance, fear of falling, and quality of life in hemodialysis patients?

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Abstract

Introduction: This study was conducted to investigate the relationship between plantar foot sensation and static balance, physical performance, fear of falling, and quality of life in hemodialysis patients.

Materials and Methods: The study involved 24 hemodialysis patients and 20 healthy volunteers. Light touch-pressure sensation (Semmes Weinstein Monofilament test kit), two-point discrimination sensation (esthesiometer) and vibration sensation (128 Hz diapason) were used to evaluate plantar foot sensation. Static balance was assessed by the one-leg standing balance test, physical performance by the Timed Up and Go test, fear of falling with the Fall Efficacy Scale, and quality of life with the Ferrans and Powers Quality of Life Index Dialysis Version.

Findings: There was a significant difference in plantar foot sensation, static balance, and physical performance of the patients compared to the healthy controls (P < 0.05). There was a strong correlation between static balance and physical performance with foot sensation in the hemodialysis patients (P < 0.05). There was also a strong correlation between static balance, physical performance, and fear of falling in hemodialysis patients (P < 0.05). The correlation between static balance, physical performance, and quality of life in the hemodialysis patients was strong (P < 0.05).

Discussion: The most important result of this study is that light touch-pressure sensation, vibration sensation, two-point discrimination sensation, static balance, and physical performance, all of which involve the activity of cutaneous sensory receptors on the sole of the foot, are reduced in individuals who undergo hemodialysis. The findings of this study suggest potential rehabilitation strategies that could be applied to this patient group.

Keywords: Foot base pressure, hemodialysis, physical, physical performance, balance

INTRODUCTION

Individuals receiving hemodialysis may have sensory problems in the form of uremic neuropathy. It is typically symmetric, with both motor and sensory impairments. In particular, in the lower extremities, there is a loss of the sense of touch and sense of position, distal sensory loss of being able to feel vibrations, and a loss of
METHODS

Design: Prospective-controlled study.

Participants

Twenty-four hemodialysis patients (9 women, 15 men) who had received hemodialysis treatment for at least 6 months and 20 healthy control volunteers (12 women, 8 men) were included in the study. Individuals with hypertension, acute chronic infection, pregnancy, Parkinson’s disease, neuropathies, mental retardation, unstable cardiovascular diseases, diabetes mellitus, diagnosed with depression, drug abuse, a body mass index of 18.5 kg/sqm > BMI > 30 kg/sqm, or a myocardial infarction and angina history within the past 1 month were excluded from the study.11 Assessments were done bilaterally by the same physiotherapist.

For this study, approval was obtained from the Non-Interventional Ethics Committee of Uskudar University B.08.6.YOK.2.US.0.05.0.06/2018/411 as per decision no. 2 dated February 22, 2018, as well as a voluntary confirmation form, from all of the individuals who participated in the study.

Methods

Light touch-pressure sensation was assessed using a full Semmes Weinstein Monofilament test kit (North Coast Medical, San Jose, CA, USA) on three regions of the foot (1st metatarsal tip, 5th metatarsal tip, and heel mid-point). First, monofilament no. 2.83 was used. The monofilaments contacted the test sites for 1.0–1.5 seconds, and they were tested using monofilament numbers between 2.83 and 6.65, with three repetitions in sequence. The monofilament number when the individual felt two stimuli correctly within the three trials was recorded. The next monofilament was used when there was no sensation during the three trials.13

Vibration sensation was measured from two zones in the foot (1st metatarsal tip and medial malleol) with a diapason (Elcon Medical Instruments, Tuttlingen, Germany) at 128 Hz frequency. Individuals’ vibration times were recorded with a chronometer. The time started as the diapason contacted the measured site, and it ended when the individuals expressed that the vibration was over. After three trials, the average time was recorded in seconds.14

Two-point discrimination sensation of the foot sole was measured using an aesthesiometer (Baseline, White Plains, NY, USA) at two points on the baseline (trans-metatarsal region and heel regions). Assessment was initiated from the maximum distance, and the distance between the two extremes was gradually reduced based on the distance from the two ends. Three trials were performed at each point, and two out of three trials were recorded in millimeter once the correct response was obtained.15

Static balance was assessed for both the dominant and nondominant lower limb according to the one-leg standing balance test. The test was described and demonstrated, and then three repetitive one-leg standing balance tests were performed on a flat floor with each test period measured by a timekeeper. Three measurements were averaged. The test was considered complete when individuals were able to stand on one foot for 30 seconds.16

Physical performance was assessed with the Timed Up and Go test. Individuals were asked to return and sit back in the chair after getting up and walking 3 m away. The test was repeated three times, and the average of the duration was taken and recorded accordingly.17

Fear of Falling was assessed by the Fall Efficacy Scale. This test is a test battery with high reliability and validity in Turkish.18 The test consists of 10 questions. The test battery was explained to the individuals, who were asked to mark the answers appropriate for their case. Individuals with a score of >70 in total were rated as having a fear of falling.

Quality of Life was assessed using the Ferrans Powers Quality of Life Index Dialysis Version Scale. This is an index-based scale tailored for dialysis patients and...
validated in Turkish. Patients were asked to read 34 questions on the scale and mark their answers accordingly. The total score of the test was evaluated from 0 to 30 points.

**Statistical analysis**

All data were analyzed using the IBM SPSS (22.0) program. Data normality were tested using the Kolmogorov-Smirnov test. The descriptive means in the study were expressed as the mean (±SD) and standard deviation (SD). Dominant and nondominant side effects of the subjects who received hemodialysis treatment (light touch-pressure sensation, vibration sensation, two-point discrimination sensation) were evaluated using the paired sample t-test. The plantar foot sensation static balance, physical performance, fear of falling, and quality of life of the subjects who received hemodialysis were compared with the healthy subjects using the independent samples t-test. Pearson correlations were calculated to assess plantar and static balance, physical performance, fear of falling, and quality of life in the hemodialysis patients. Statistical significance was determined to be P < 0.05.

**RESULTS**

The demographic characteristics of the healthy controls and hemodialysis patients in this study are shown in Table 1.

The plantar foot light touch-pressure sensation (1st metatarsus tip, 5th metatarsus tip, and heel midpoint), vibration sensation (1st metatarsus tip and leg medial malleol), two-point discrimination sensation (trans-metatarsal region and heel regions), static balance and physical performances were compared between the hemodialysis patients and healthy controls, and all were found to be significantly different (P < 0.05; Table 2).

Between the dominant and nondominant limbs in hemodialysis patients, the plantar foot light touch-pressure sensation (1st metatarsus tip, 5th metatarsus tip, and heel midpoint), vibration sensation (1st metatarsus tip and medial malleol), two-point discrimination sensation (trans-metatarsal region and heel regions) and static balance were found to not be significantly different (P > 0.05; Table 2).

There was a strong correlation between static balance and physical performance for all parameters of plantar foot sensation in hemodialysis patients (P < 0.05; Table 3).

There was also a strong correlation between static balance, physical performance, and fear of falling in hemodialysis patients (P < 0.05). Static balance and physical performance were strongly associated with quality of life (Table 3).

There was no significant relationship between the sense of plantar foot light touch pressure sensation and fear of falling, or between the vibration sensation and fear of falling, or between the two-point discrimination sensation and fear of falling with all parameters of the plantar foot sensation and quality of life in hemodialysis patients (P > 0.05; Table 3).

**DISCUSSION**

In the literature, no prior evaluation of plantar foot pressure sensation has been performed on renal patients, including chronic kidney disease patients. However, neurotransmission, peripheral nerve function evaluation, and motor and sensory nerve sensitivity evaluations have been performed, particularly among chronic kidney disease patients. These evaluations have shown significant changes in plantar foot pressure sensation, vibration sensation, and two-point discrimination sensation in hemodialysis patients compared to healthy controls. The changes in plantar foot sensation in hemodialysis patients may be due to the effects of chronic kidney disease and the dialysis treatment itself, which can result in peripheral neuropathy and decreased nerve function. The results of this study provide valuable insights into the plantar foot sensation and its implications for quality of life in hemodialysis patients.
patients, and it was found that these patients were significantly affected by neurotransmission.\textsuperscript{20–22} These patients are observed to have remained inactive for a long time due to decreased oxygenation, reduced energy levels, muscle weakness, hypotension, vitamin D deficiency, atherosclerotic diseases, and balance problems due to frequent circulatory problems.\textsuperscript{6} Postural control after being inactive is also impaired.

\textbf{β2} Microglobulin (β2M) stimulates osteoarticular formation due to dialysis-driven amyloidosis in hemodialysis patients. Due to osteoarticular tissue injury, destructive arthropathy findings accompanied by carpal tunnel syndrome and cystic and lytic bone lesions are frequently observed in clinics. In addition to the effects of β2M on the skeletal system, it also forms deposits in the gastrointestinal system and organs such as the heart.

### Table 2
Comparison of light-touch pressure, vibration, and two-point discrimination sensation of hemodialysis patients and healthy controls

<table>
<thead>
<tr>
<th>Evaluation criteria</th>
<th>Hemodialysis patients (n = 24)</th>
<th>Healthy (n = 20) controls</th>
<th>P</th>
<th>α</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Median (25–75 IQR)</td>
<td>Dominant</td>
<td>Nondominant</td>
<td></td>
</tr>
<tr>
<td>Foot base light touch sensation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st metatars head</td>
<td>4.93 (3.61–6.45)</td>
<td>4.93 (3.61–6.45)</td>
<td>3.22 (2.83–5.88)</td>
<td>0.01*</td>
</tr>
<tr>
<td>5th metatars head</td>
<td>5.65 (3.83–6.65)</td>
<td>4.93 (3.83–6.65)</td>
<td>3.22 (2.83–5.88)</td>
<td>0.01*</td>
</tr>
<tr>
<td>Heel midpoint</td>
<td>5.88 (4.08–6.65)</td>
<td>5.88 (4.08–6.65)</td>
<td>3.22 (2.83–5.88)</td>
<td>0.01*</td>
</tr>
<tr>
<td>Vibration (s)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st metatars head</td>
<td>3.85 (0.43–9.5)</td>
<td>3.50 (0.77–5.5)</td>
<td>9.55 (2.5–10.45)</td>
<td>0.03*</td>
</tr>
<tr>
<td>Medial malleol</td>
<td>3.50 (0.7–6)</td>
<td>2.05 (1–4.5)</td>
<td>8.00 (1.5–9)</td>
<td>0.02*</td>
</tr>
<tr>
<td>Two-point discrimination (cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trans-metatarsal</td>
<td>6.05 (2.5–15.0)</td>
<td>5.00 (2.5–15.0)</td>
<td>1.15 (0.5–5.5)</td>
<td>0.01*</td>
</tr>
<tr>
<td>Heel midpoint</td>
<td>5.00 (3–15)</td>
<td>6.25 (2.7–16)</td>
<td>1.35 (0.5–2.9)</td>
<td>0.01*</td>
</tr>
</tbody>
</table>

\textsuperscript{P < 0.05, IQR = interquartile range; p = paired sample T test; *P < 0.05 α = independent samples test.}

### Table 3
Correlations between plantar foot sensation and static balance, fear of falling, physical performance, and quality of life in hemodialysis patients

<table>
<thead>
<tr>
<th>Fear of falling (FES)</th>
<th>Quality of life (Ferrans and powers quality of life index)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foot base light touch sensation</td>
<td>r = 0.458, P = 0.100</td>
</tr>
<tr>
<td>Vibration</td>
<td>r = −0.524, P = 0.09</td>
</tr>
<tr>
<td>Two-point discrimination</td>
<td>r = 0.678, P = 0.100</td>
</tr>
<tr>
<td>Static balance</td>
<td>r = 0.300, P = 0.001*</td>
</tr>
<tr>
<td>Physical performance</td>
<td>r = 0.700, P = 0.001*</td>
</tr>
</tbody>
</table>

Pearson correlation analysis, \textsuperscript{*P < 0.05}
and skin, causing symptoms over time such as intestinal obstruction, cardiac arrhythmia, and coronary failure. These symptoms further reduce patients’ physical activity and contribute to balance and postural control disorders. Consequently, this study was conducting, considering that the reasons listed above may reduce plantar foot sensory input.

This is the first study to examine the effect of plantar foot sensation on static balance, physical performance, fear of falling, and quality of life in hemodialysis patients. The most important result of the study is that, in hemodialysis patients, there is a diminished ability to detect plantar foot light touches, vibrations, and two-point discriminations as well as reduced static balance and physical performance. It was concluded that cutaneous receptor sensation in subjects who received hemodialysis is related to static balance and physical performance. Furthermore, as static balance diminishes, reduced physical performance was found to result in a fear of falling and eventually decreased quality of life. In the literature, it has been reported that plantar foot sensation is associated with balance in different patient groups and in healthy individuals. Kars et al.24 showed that mechanoreceptors on the sole play an important role in balance control in a study of healthy individuals. In the same study, decreased sensation of cutaneous receptors disturbed the static balance and increased postural control loss.

In another study by Mckeon et al.25 in a healthy individual, the role of foot baseline pressure sensation in static balance on one foot and two feet was investigated, and it was found that reduced foot baseline pressure sensation negatively affects balance. Citaker et al.26 have shown that reduced foot baseline sensation adversely affects static balance (one-leg standing balance test) when working with multiple sclerosis patients. It has been proven that individuals who have received hemodialysis experience balance problems, fear of falling, and risk of falling. The study by Erken and Ozelsancak7 on the static, dynamic balance, and the risk of falling found that losses in static and dynamic balance control were associated with patients being on hemodialysis. It is also said that the problems found in hemodialysis patients do not correlate with age-related balance losses. The study by Shin et al.27 compared postural control and physical performance in healthy controls to hemodialysis patients and accordingly showed a significant increase in postural oscillations and a statistically significant decline in subjects who received hemodialysis therapy. Kutner et al.8 assessed daily life activities (in terms of balance, physical performance, walking speed, and pain parameters) in a cohort study with individuals who underwent hemodialysis treatment, and it was accordingly found that balance losses were often associated with hemodialysis treatment and were also among their common problems in performing daily life activities. It has also been emphasized that this negatively affects their quality of life. In this study, it was concluded that decreased foot pressure sensation in hemodialysis patients had a negative effect on static balance and that their static balance decreased when compared to healthy subjects.

In the literature, it was found that physical performance is significantly reduced in hemodialysis patients.9 Pajek and Leskosek16 evaluated physical performance in hemodialysis patients and found that these individuals had low physical performance, which, in turn, directly and adversely affected their daily living activities and quality of life. Kim et al.11 showed that the physical performance of hemodialysis patients is significantly reduced and that it adversely affects quality of life compared to healthy individuals. In our study, the effect of plantar foot sensation on physical performance was investigated as static balance is related to plantar foot sensation, which, in turn, is related to the fact that physical performance and daily living activities were affected. It was concluded that reduced plantar foot sensation resulted in reduced physical performance.

In this study, there was a significant relationship between plantar foot light-pressure touch sensation, vibration sensation, two-point discrimination sensation, static balance, and physical performance. There was, however, no significant relationship between plantar foot sensation, quality of life, and fear of falling, but there was a significant relationship between static balance, physical performance, fear of falling, and quality of life. It was also concluded that there is a strong correlation between static balance and physical performance, fear of falling, and quality of life.

Increased sensory loss in plantar foot sensation can cause balance problems and physical performance loss in hemodialysis patients, resulting in fear of falling and reduced quality of life. In later stages, it can lead to disability in performing daily life activities. These patients may need to be put into early rehabilitation programs, and a customized exercise schedule may need to be created to improve their physical fitness level so that static balance control can be achieved. In this way, their fear of falling may be avoided and their reduced quality of life may also be avoided thanks to rehabilitation programs.

Further studies on the effects of factors such as blood pressure, muscle loss, kinesthesia, proprioceptive sensation, depression, and anxiety about balance and physical performance in hemodialysis patients could help to obtain new results for potential rehabilitation programs.
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REFERENCES