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# Effects of different measurements of foot angle on vital activities of hemodialysis patients

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## Abstract

**Aim:** Individuals who receive hemodialysis treatment due to chronic renal failure have limitations in their daily lives and a decrease in physical activity and walking speed. In this study, we have investigated the effectiveness of various measurements of ankle angles of hemodialysis performed on patients on balance, falling risk, and daily life activities.

**Materials and Methods:** 114 volunteer hemodialysis patients with a mean age of 30-94 have measured at the position of plantar flexion, inversion, and eversion by a 1-degree sensitivity manual goniometer. The Time Up and Go test (TUG), Lawton and Brody Instrumental Activities of Daily Living (IADL) Scale and Barthel Index (BI) were applied to the patients. Statistical analyses were made with the SPSS 25 program.

**Results:** 55 male and 59 female participants were accompanied in the study. The average age was 62.8 ± 15.29, the average hemodialysis duration was 5.59 ± 3.92, the average body mass index was 5.08 ± 5.1 and he average number of falls was 5.59 ± 3.92. A low positive significant correlation was observed between plantar flexion and inversion foot angle measurements with The Lawton and Brody IADL scale ($p<0,05$). A low-level significant positive correlation was observed between the BI score and the plantar flexion angle measurements ($p<0.05$). A highly significant positive correlation was observed between plantar flexion angle measurement and inversion angle measurement. In contrast, a moderately significant positive correlation was observed between plantar flexion angle measurement and eversion angle measurement ($p<0.05$).

**Conclusion:** We observed a decrease in daily life activities and a walking speed increase in falling risk in the diagnosis of chronic renal failure in hemodialysis patients.



## Introduction

Chronic renal failure (CRF) is a health problem that affects 8-16% of the world's population and causes high levels of morbidity and mortality by affecting the quality of life of individuals [1].

CRF is typically diagnosed with a glomerular filtration rate of less than 60 mL/min per 1.73 $m^2$ or images of renal damage detected at least 3 months ago [2].The decrease in glomerular filtration rate impairs the fluid-electrolyte balance, metabolic and endocrine functions of the kidney. Renal replacement therapy is performed if the glomerular filtration rate of patients is 20-25 mL/min for below [3].

Hemodialysis (HD) is the most commonly used treatment for patients with CRF. Hemodialysis is the process of depurating the blood received from the same patient by depurating it from liquid, electrolytes and waste materials with an outside machine. CRF patients need hemodialysis on average three times a week and for 3-5 hours [4].

Adherence to the HD machine during hemodialysis can cause hypotension, nausea-vomiting, a tendency to infection, impaired physical functionality, decreased physical activity, and restrictions in the daily lives of patients [5,6]. The patients indicate muscle failure and weakness during receiving hemodialysis [7]. It has been reported that stiffness may occur in some joints in patients receiving long-term hemodialysis due to these conditions [8].

The ankle joint's range of motion (ROM) is essential to maintaining the center of gravity while standing and walking and to moving it forward in a controlled manner. The restriction of ROM causes increased plantar pressure while

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walking. The increased plantar pressure is one of the majör causes of ankle ulcers, and these problems alter the ankle joint movement patterns [9-11]. In addition, hip and trunk movements performed to balance the restriction lead to impaired postural control [12]. Impairment of postural control can lead to injuries by increasing the risk of falling.

In our study, we aimed to reduce the risk of falling and increase the patient's quality of life by investigating the relationship between ankle ROM measurements and balance, fall risk, and activities of daily living in hemodialysis patients.

## Materials and Methods

The study was carried out at the Training and Research Hospital Hemodialysis Unit. Ethical approval was accepted by the Malatya Turgut Özal Üniversitesi Non-Invasive Clinical Research Ethics Committee, numbered 2022/87. One hundred fourteen volunteer hemodialysis patients were included with a mean age of 30-94 years were included and received informed consent forms.

### *Data collection measurements*

Data collection was initially performed for the treatment with a face-to-face method. Individual Introduction Form, The Time Up and Go Test, The Lawton and Brody Instrumental Activities of Daily Living Scale, and the Barthel Index were applied to the participants. The ankle angle measurements have been taken with a manual goniometer.

### *Individual introduction form*

This form contains ten questions and evaluates patients' socio-demographic properties, including, age, gender, marital status, body mass index (BMI), duration of hemodialysis, and the number of falls.

### *The Time Up and Go Test (TUG)*

This test evaluates walking speed, postural control, functional mobility, and balance. The patient stands up with the 'start' command and, after 3 meters of walking, sits on the chair again. Above the 15-second duration, the outcome is determined as a falling risk [13].

### *The Lawton and Brody Instrumental Activities of Daily Living (IADL) Scale*

This scale consists of 8 questions and includes information about using the mobile telephone, preparing food, shopping, daily household work, washing clothes, getting on a vehicle, using medicines, and managing money. The evaluation was made by giving 3 points if the individual did the activities independently, 2 points if the individual did it them assistance, and 1 point if the individual could not do it them all [14]. The spelling form was converted by Yardımcı AE [15]. Altın M. determined the Cronbach alpha reliability coefficient of the Lawton and Brody IADL scale to be 0.84 [16].

### *Barthel Index (BI)*

The index was developed by Mahoney and Barthel in 1965, and Shah et al. modified it in 1992 [17]. The BI test is a detailed, unbiased, easily applicable and understandable scale that investigates the cause-effect relationship and evaluates all steps of daily living activities. It consists of 10 questions. In our study, The aim of the BI test was to determine the independence levels of individual activities. The range of index scores is between 0-100. 0-20 points; completely addicted, 21-61 points; severe addiction, 62-90 points; moderate addiction, 91-99 points; mild addiction, 100 points; demonstrates independence. In studies using the BI, a score of 60 was taken as the limit, and scores above 60 explain the ability to function independently [18]. Its validity and reliability for Turkey were determined by Küçükdeveci et al. Accordingly, the internal consistency of the BI was 0.93, the Kapa proficiency level was above 0.5, the intraclass correlation coefficient was 0.99, and the Cronbach's alpha value was 0.93 [19].

### *The ROM of ankle measurements*

The patient has layed on the inspection table for the ROM of the plantar flexion movement. The ankle stabilized at a 90-degree angle, and this position was accepted as the initial position. The goniometer was placed for the measurement of the first metatarsal as a pivot point. The inversion and eversion ROM measurements were taken at the side lay position, and in this position, both hips were placed in extension, and the measured side of the knee was placed in extension. The other knee was placed in flexion for stabilization of the joint. During the measurement, the instrument was zeroed by placing the probe of the goniometer perpendicular to the first metatarsal in the medial arch of the foot. First, inversion and then eversion ROM were measured and recorded [11].

### *Power analyzes*

According to the calculation made using the G*power 3.1 program, The sample size was determined to be at least 111 with an effect size of 0.30, a margin of error of 0.05, a confidence level of 0.95, and a population representation of 0.95 [20]. The patients were selected for the study using the simple random sampling method.

### *Statistical analysis*

The analysis of the data included in the research was performed with the SPSS (Statistical Program in Social Sciences) 25 program. The significance level (p) was taken as 0.05 for the comparison tests. The suitability of the data included in the study for the normal distribution was determined by the Kolmogorov-Smirnow Test. Since the variables did not have a normal distribution ($p>0.05$), the analysis was continued with non-parametric test methods. Comparisons in independent paired groups were made with the Mann-Whitney U test, and in multiple independent groups, comparisons were made with the Kruskal Wallis test analysis. Since the p-value would increase depending on the increase in the number of comparisons in the variables with the difference in multiple groups, the Bonferroni corrected p-value was used and calculated with

"(0.05/pairwise comparison)". The Spearman Rank Correlation coefficient was used to examine the relationship between variables. The Cronbach's $\alpha$ coefficient was used to determine the reliability analysis of the scales.

## Results

*Demographic information*

The demographic information of the participants included in the study is given in Table 1. The individuals participated in the study were between the ages of 30-94, and the mean age was 62.8 ± 15.29 years. The duration of hemodialysis for the patients ranged from 1 year to 17 years, with a mean of 5.59 ± 3.92 years. 55 (48.2%) of the patients were male, and 59 (51.8%) were female. 98 (86%) of the patients were married, 7 (6.1%) were single, and 9 (7.9%) were widowed. The mean body mass index of the patients was between 25.08 ± 5.17. The mean number of falls among the patients was between 5.59 ± 3.92 (Table 1).

**Table 1.** Demographic information of the participants.

| Variable | Group | Number of patients | Percent (%) |
|---|---|---|---|
| Year | 1-24 Months | 22 | 19.3 |
| | 25-48 Months | 39 | 34.2 |
| | 49-84 Months | 27 | 23.7 |
| | 85 Months and over | 26 | 22.8 |
| Gender | Male | 55 | 48.2 |
| | Female | 59 | 51.8 |
| Marital status | Married | 98 | 86 |
| | Single | 7 | 6.1 |
| | Widow | 9 | 7.9 |
| Variable | | Mean ± SD | Min – Max |
| Age | | 62.8 ± 15.29 | 30 – 94 |
| BMI | | 25.08 ± 5.17 | 15..52 – 45 |
| Number of falls | | 0.97 ± 1.04 | 0 – 4 |
| Hemodialysis year | | 5.59 ± 3.92 | 1 – 17 |

SD: standard deviation, Min: Minimum value, Max: Maximum value, BMI: Body Mass Index.

**Table 2.** Descriptive statistics of scale scores.

| Variable | Mean ± SD | Min - Max | Cronbach $\alpha$ |
|---|---|---|---|
| TUG | 18.67 ± 8.53 | 0 - 53 | 0.754 |
| Lawton and Brody's IADL scale | 3.89 ± 2.45 | 0 - 8 | 0.819 |
| BI | 77.5 ± 21.08 | 0 - 100 | 0.723 |

SD: standard deviation, Min: Minimum value, Max: Maximum value, TUG: The Time Up and Go Test, Lawton and Brody IADL Scale: Lawton and Brody Instrumental Activities of Daily Living Scale, BI: Barthel Index.

**Table 3.** Descriptive statistics of measurement values.

| Variable | Mean ± SD | Min - Max |
|---|---|---|
| Plantar flexion | 21.4 ± 4.64 | 9.3 – 32 |
| Inversion | 20.99 ± 5.03 | 6.7 – 33 |
| Eversion | 22.02 ± 9.1 | 6.5 – 100 |

SD: standard deviation, Min: Minimum value, Max: Maximum value.

*Descriptive statistics of scale scores*

The mean scores of the scale scores, the standard deviation values, the intervals of change of the scale scores, and the Cronbach's $\alpha$ coefficients (reliability coefficients) were calculated for the participants (Table 2).

The TUG ranged from 0-53 points, and the average points were between 18.67 ± 8.53. The Cronbach's alpha total correlation coefficient of the scale was 0.754. The Lawton and Brody IADL scale values ranged from 0-8 points. The average values were between 3.89 ± 2.45. The Cronbach's alpha total correlation coefficient of the scale was 0.819. 51 (44.7%) of 114 patients had low scores, and 34 (29.8%) had high scores. BI values ranged from 0-100, the average values were 77.5 ± 21.08, and the Cronbach's alpha total correlation coefficient of the scale was 0.723.

*Descriptive statistics of measurement values*

The mean scores, standard deviation values, and change intervals of scale scores of plantar flexion ROM, inversion ROM, and eversion ROM were calculated from the participants (Table 3).

*Comparison of variables according to years of hemodialysis*

TUG, Lawton, and Brody IADL scales, BI scale scores, and plantar flexion ROM, inversion ROM and eversion ROM. Measurements were applied to the participants. The data were evaluated to determine whether there was a difference according to the years of hemodialysis (Table 4).

There was no statistically significant difference between the groups on the TUG scale ($p>0.05$). The mean walking speed of the patients in the duration of HD treatment between 1 and 24 months was recorded as 16.75 ± 7.14 seconds in the TUG test; on the other hand, the average walking speed of patients in the duration of HD treatment applied 85 months and over was 20.12 ± 10.21 seconds. This data indicates that as the time to enter HD increases, the walking speed slows down.

There was no statistically significant difference between the groups on the Lawton and Brody IADL scale ($p>0.05$). The Lawton and Brody IADL scale of patients who applied HD treatment between 1 and 24 months average value was found to be between 4.77 ± 2.43, while the mean of patients who applied HD treatment for 85 months and over was found to be between 4.12 ± 2.53. There was no significant difference between the duration of HD treatment and the Lawton and Brody IADL scale values ($p>0.05$).

There was no statistical difference between the groups on the BI scale ($p>0.05$). The patients for whom HD treatment was performed between 1 and 24 months had an average BI scale of 83.18 ± 16.73 and 85 months, and over HD treatment, the average value was 75.38 ± 22.13.

In the comparison of HD duration and ankle ROM, the average plantar flexion ROM in 1-24 months was 21.47 ± 4.23, and the average value in 85 months and over was

**Table 4.** Comparison of values according to hemodialysis years.

| Measurements | Groups | Mean ± SD | M (Min-Max) | test | p* value |
|---|---|---|---|---|---|
| TUG | 1-24 months | 16.75 ± 7.14 | 16.56(0-30.93) | 0.832 | 0.841 |
| | 25-48 months | 19 ± 9.51 | 17.7(0-53.13) | | |
| | 49-84 months | 18.36 ± 6.09 | 18.7(10.58-32.3) | | |
| | 85 months and over | 20.12 ± 10.21 | 16.49(8.11-47.51) | | |
| Lawton and Brody's IADL scale | 1-24 months | 4.77 ± 2.43 | 5(1-8) | 7.374 | 0.062 |
| | 25-48 months | 3.1 ± 2.33 | 2(0-8) | | |
| | 49-84 months | 4.11 ± 2.38 | 4(0-8) | | |
| | 85 months and over | 4.12 ± 2.53 | 3.5(1-8) | | |
| BI | 1-24 months | 83.18 ± 16.73 | 87.5(45-100) | 2.123 | 0.553 |
| | 25-48 months | 74.49 ± 23.36 | 80(0-100) | | |
| | 49-84 months | 79.26 ± 19.69 | 80(15-100) | | |
| | 85 months and over | 75.38 ± 22.13 | 77.5(15-100) | | |
| Plantar flexion | 1-24 months | 21.47 ± 4.23 | 21.15(10.2-27.2) | 0.772 | 0.859 |
| | 25-48 months | 21.04 ± 5.11 | 22(9.3-29.3) | | |
| | 49-84 months | 22.2 ± 4.95 | 22.7(14.2-31.5) | | |
| | 85 months and over | 21.05 ± 4.01 | 20.35(9.6-29.6) | | |
| Inversion | 1-24 months | 19.79 ± 4.08 | 18.75(9.7-28.2) | 3.231 | 0.361 |
| | 25-48 months | 20.67 ± 5.98 | 19.8(8.5-32.5) | | |
| | 49-84 months | 21.83 ± 4.7 | 21.8(14.7-31.4) | | |
| | 85 months and over | 21.63 ± 4.53 | 21.1(6.7-28.2) | | |
| Eversion | 1-24 months | 20.43 ± 4.14 | 20.5(11.3-28.6) | 1.681 | 0.642 |
| | 25-48 months | 23.64 ± 13.97 | 23.2(10.2-99.7) | | |
| | 49-84 months | 21.39 ± 5.18 | 21.4(13.1-30.7) | | |
| | 85 months and over | 21.61 ± 5.35 | 20.95(6.5-35.8) | | |

SD: standard deviation, Min: Minimum value, Max: Maximum value, TUG: The Time Up and Go Test, Lawton and Brody IADL Scale: Lawton and Brody Instrumental Activities of Daily Living Scale, BI: Barthel Index, *Kruskal Wallis Test.

**Table 5.** Examining the relationship between the Variables

| Scales | | BMI | Number of falls | Year of HD | TUG | Lawton and Brody IADL scale | BI | Plantar flexion | Inversion | Eversion |
|---|---|---|---|---|---|---|---|---|---|---|
| Age | r | 0.030 | 0.604 | -0.060 | 0.327 | -0.345 | -0.277 | -0.336 | -0.265 | -0.035 |
| | p | 0.750 | <0.001* | 0.528 | <0.001* | <0.001* | 0.003* | <0.001* | 0.004* | 0.708 |
| BMI | r | | -0.119 | 0.040 | 0.165 | 0.031 | 0.073 | 0.005 | 0.021 | -0.068 |
| | p | | 0.209 | 0.672 | 0.080 | 0.742 | 0.442 | 0.962 | 0.821 | 0.473 |
| Number of falls | r | | | 0.057 | 0.168 | -0.357 | -0.393 | -0.287 | -0.140 | 0.039 |
| | p | | | 0.549 | 0.074 | <0.001* | <0.001* | 0.046* | 0.138 | 0.677 |
| Year of HD | r | | | | 0.031 | 0.058 | -0.028 | -0.023 | 0.109 | -0.039 |
| | p | | | | 0.743 | 0.542 | 0.768 | 0.808 | 0.248 | 0.677 |
| TUG | r | | | | | -0.480 | -0.385 | -0.102 | -0.132 | -0.122 |
| | p | | | | | <0.001* | <0.001* | 0.280 | 0.163 | 0.197 |
| Lawton and Brody IADL scale | r | | | | | | 0.735 | 0.221 | 0.291 | 0.178 |
| | p | | | | | | <0.001* | 0.018* | 0.042* | 0.059 |
| BI | r | | | | | | | 0.270 | 0.178 | 0.164 |
| | p | | | | | | | 0.004 | 0.058 | 0.081 |
| Plantar Flexion | r | | | | | | | | 0.804 | 0.539 |
| | p | | | | | | | | <0.001* | <0.001* |
| Inversion | r | | | | | | | | | 0.484* |
| | p | | | | | | | | | <0.001* |

r: spearman rank correlation coefficient, p: statistically significance, TUG: The Time Up and Go Test, Lawton and Brody IADL Scale: Lawton and Brody Instrumental Activities of Daily Living Scale, BI: Barthel Index,* p<0.05.

21.05 ± 4.01. The average inversion ROM in 1-24 months was 19.79 ± 4.08, and the average value in 85 months and over was 21.63 ± 4.53. Average eversion ROM in 1-24 months was 20.43 ± 4.14, average value in 85 months and over was 21.61 ± 5.35. There was no statistical difference between ankle ROM measurements (plantar flexion, inversion, and eversion) and HD duration ($p>0.05$).

*Examining the relationship between the variables*

The correlation between the TUG, Lawton, and Brody IADL scales, BI scale scores, plantar flexion, inversion, eversion measurements, age, dialysis year, number of falls, and BMI value was measured and demonstrated in Table 5.

There was no statistical correlation between the number of falls and HD duration and the TUG scale of the patients ($p>0.05$). A moderately significant negative correlation was found between the Lawton and Brody IADL scales, BI scales, and the number of falls ($p<0.05$). There was a statistically significant low negative correlation between plantar flexion ROM and the number of falls ($p<0.05$). There was no statistical correlation between inversion and eversion ROM with the number of falls ($p>0.05$). There was a moderately significant negative correlation between the TUG scale, Lawton and Brody IADL scale, and BI scales ($p<0.05$). There was a highly significant positive correlation between the Lawton and Brody IADL scale and BI scores ($p<0.05$).

There was a low-level positive correlation between the Lawton and Brody IADL scale and plantar flexion and inversion foot angle measurements ($p<0.05$). There was a low positive statistically correlation BI scale score and the plantar flexion ROM ($p<0.05$). There was a high positive statistical correlation between plantar flexion ROM and inversion ROM and a moderately significant positive correlation between plantar flexion ROM and eversion ROM.

## Discussion

The quality of life is adversely affected due to complications after falling. Falls are a significant cause of morbidity and mortality in patients receiving HD treatment for CRF. Muscle and bone pains related to CRF also negatively affect the patients' walking speed, physical activities, and locomotor functions [21,22].

In our study, the HD performed on patients' different ankle ROM measurements affected falling risk and daily activities. The average age of patients was over 60 years old. The HD duration was altered between 1 and 17 years, the average year was over 5 years. Fifty-five of the patients (48.2%) were male, and 59 of the patients (51.8%) were female. Ninety-eight of the patients (86%) were married, 7 (%6.1) of the patients were single, and 9(%7,.9) of the patients were widowed. The average BMI value of the patients ranged from 15 to 45. The number of falls among the patients ranged from 0 to 4.

The patients' 3-meter walking distance, duration, and pattern were measured with the TUG test. The TUG test's reliability and repeatability have been determined [23]. Generally, the points of the TUG test increase with age [24]. Oh et al. determined the TUG test points to be 10.96 seconds in individuals 65 years of age and over, 7.89 seconds in those aged 65 and under [25]. In our study, the average TUG test duration was 18,67 ± 8,53 seconds at the age range of 30-94. Completion of the TUG test score in more than 15 seconds causes a significant increase in the risk of falling, and we have determined the statistical significance of TUG test points in patients who have a history of falling.

In our study, similar to the TUG test findings of Sutcliffe B. K. et al. [26], it was observed that walking speed slowed down as the time to enter HD increased. However, in our study, no statistically significant difference was found between the duration of HD and walking speed.

In our study, BI and The Lawton and Brody IADL Scale were used to evaluate the physical and vital activities of the patients. In our study, the scores of the patients according to the BI index were found to be 77.5 ± 21.08. Civi et al. the six-day activities of 302 people were questioned, and their addiction scores were found to be 71.2%. In our study, daily living activity scores were found to be 3.89 ± 2.45, according to Lawton. It was determined that the patients had difficulty performing their daily living activities due to the disease and treatment, and this negatively affected their proficiency status. Similar to our study, Yurtsever and Beduk [27] found that 92.5% of the patients who underwent HD had difficulty performing moderate or severe daily activities.

In our study, no statistically significant difference was found between the time to HD in The Lawton and Brody IADL Scale and BI scales. Tander et al. reported a negative correlation between dialysis time and physical function [28]. In addition, Acaray et al. found that as the dialysis time increased, there was a decrease in the physical component scores [29].

There are many senior investigations about ankle ROM effectiveness and balance. Mecagni et al. investigated the correlation between ankle ROM and balance in females. They suggested that there is a high positive correlation between balance and the inversion, eversion, and plantar flexion ROM [30]. On the other hand, Rillo et al. have suggested that HD treatment does not affect ankle ROM [31]. In this study, we have determined the a low statistically significant negative correlation between plantar flexion and the number of falls. This result demonstrates similarity with Mecagni et al. and contradiction with Rillo et al. We consider the wide range of ankles essential to decreasing the effect of falling risk.

Lindberg et al. in their study in Stockholm, reported 30 degrees of plantar flexion and 30 degrees of dorsal flexion during walking with the Roentgen Stereophotogrammetry technique [32]. Jonson et al. and Burns and Crosbie reported 32° dorsal flexion in their studies [33,34]. Roass and Anderson, on the other hand, found plantar flexion to be 15.3 degrees in their research in Sweden [35]. In the norms of the American Academy of Orthopedic Surgery, eversion was reported as 15 degrees and inversion as 35 degrees [36]. In our study, plantar flexion was found to be 21.4 ± 4.64, inversion 20.99 ± 5.03, and eversion 22.02 ± 9.1.

Loon et al. suggested that the falling rate is common in HD performed CRF patients, and the falling risk increases

in those over 70 years of age [37]. In our study, Lawton and Barthel index points were lower, and there was a significant negative correlation between plantar flexion ROM and falling risk. On the other hand, there is a positive correlation between ankle ROM and daily life activities. These results demonstrate that the balance ability deteriorates, the daily activities and walking ability decelerate and the falling rate increases whit the HD treatment performed in older patients.

The values found in the study will be a source for future studies. With the increase and diversification of the sample number, more generalizable results will be obtained, differences between the groups will be ensured, and the degree of relations between the variables will increase.

*Declarations*

*Ethical approval*

Ethics committee approval was received from Malatya Turgut Özal University Non-invasive Clinical Research Ethics Committee with protocol number 2022/87 and decision number 7.

*Conflict of interests*

The authors declare no conflict of interest, financial or otherwise.This study has no financial resources and no sponsors.

*Informed consent*

Informed consent was obtained from all participants.

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