Upper extremities function in patients undergoing hemodialysis treatment

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ABSTRACT

Objective: To determine the effects of hemodialysis treatment on upper extremities functional ability.

Methods: This study was carried out from June 2003 to March 2004 at Pamukkale University School of Physical Therapy, Denizli, Turkey. One hundred patients with chronic renal failure (CRF) undergoing hemodialysis treatment for at least 2 months participated in the study, and were compared with a control group (N=40 healthy subjects). The 100 patients were divided into 4 groups according to the length of hemodialysis duration: 19 patients dialyzing for less than one year (Group 1); 42 patients dialyzing for 1-4 years (Group 2); 21 patients dialyzing for 4.1-8 years (Group 3); 18 patients dialyzing for 8.1 or more years (Group 4). All participants were evaluated for range of motion by goniometry, muscle strength by manual muscle testing, sensation disturbances by Semmes-Weinstein monofilaments, static grip strength by hand dynamometer, and functional status of upper limbs by the Disabilities Arm Shoulder Hand Questionnaire (DASH-T).

Results: The results showed that the patients with CRF had significantly more functional problems associated with CRF and hemodialysis treatment than the healthy controls. In addition to these results, the scores of the DASH-T also showed that the most independent group was the control group with a mean score of 0.72±0.86, whereas, the most dependent group was the 3rd group of the hemodialysis groups (mean score of 2.70±1.77).

Conclusion: Musculoskeletal or functional problems decreasing functional ability of the upper limbs are a common complaint in hemodialysis patients.

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Chronic renal failure (CRF) is defined as a chronic and advanced disorder in the fluid-electrolyte balance system and metabolic-endocrine function because of decreased glomerular filtration rate. Uremia is a term that includes all of the clinical and biochemical abnormalities that chronic renal insufficiency causes, and is used in the place of chronic renal insufficiency in many references. In chronic renal insufficiency, there are disorders of the function of many organs other than just the kidneys.[1,2] Some of the chief causes of these are: 1) the accumulation of excessive fluid and waste products in the body, 2) failure of the body to eliminate the byproducts of protein metabolism, 3) nutritional disorders, and 4) hormonal disorders.[3] In patients with CRF, the quality and length of life can be improved with hemodialysis treatment that uses vascular access. There are varieties of problems that result in the upper extremities of patients because of the vascular access, due to the uremia caused by renal disease. The main problems are weakening in muscle and grip strength, massive edema in the arm, polyneuropathy, and loss of sensation. It is important for a physiotherapist to evaluate these problems, and to plan a treatment program based on that evaluation.[4] In these patients the problems in the upper extremity are generally a combination of compression neuropathy,

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edema, and peripheral neuropathy. Clinically, uremia-caused peripheral neuropathy is a late finding in renal disease. The combination of symptoms such as arthritic joint changes, nerve compression syndrome, neuropathy and edema lead to hand dysfunction.[5] The risks for development of loss of hand function in hemodialysis patients and the symptoms that need to be monitored are: 1) edema in the hand, 2) itching or burning sensation in the fingers, 3) difficulty picking up small objects or holding them in the hand, 4) decrease in hand grip strength, 5) difficulty in making a tight fist because of stiffness in the fingers, 6) loss of active movements in the fingers, particularly the pinch and opposition movements. Hemodialysis patients may show a decrease in grip strength on the side of the fistula because it is used less to protect the fistula, and because of other symptoms that occur clinically in the patients.[5] Today it is possible to obtain early diagnosis of problems that can create difficulty in performing activities of daily living (ADLs) with the upper extremities by using objective test materials located in dialysis centers to determine the patient's upper extremity functional capacity, and then to ensure treatment using a physiotherapy program. This can improve the quality of life of hemodialysis patients with CRF.[5] The aim of the present study was to determine the functional capacity of the upper extremities in CRF patients undergoing hemodialysis, and to show how the problems affect ADLs in comparison with normal healthy subjects.

Methods. Patients with CRF, recruited from 4 hemodialysis centers in the Denizli region between June 2003 and March 2004 participated in the study. One hundred volunteer patients with CRF who fulfilled the inclusion criteria were studied. The criteria for inclusion were: 1) patients with diagnosis of CRF, 2) patients who have received hemodialysis treatment via an arterio-venous fistula (AVF) for at least 2 months. The criteria for exclusion were: other diseases that negatively affect the functional capacity and ability of the upper extremities including neurologic or infectious diseases, severe somatic or psychiatric disorders, musculoskeletal problems, rheumatic or cardiovascular diseases, inability to communicate, and inability to seat independently. One hundred patients with CRF undergoing hemodialysis treatment were compared with 40 healthy subjects who fulfilled the inclusion criteria. The inclusion criteria for healthy subjects were: 1) Subjects without a history of health problem affecting the functional capacity and ability in ADLs negatively. 2) Subjects with the same age range as the hemodialysis patients. The exclusion criteria for healthy subjects were: 1) Subjects with a diagnosis of CRF, rheumatic diseases, infectious disorders, neurologic or musculoskeletal problems, cardiovascular diseases, severe somatic or psychiatric disorders and so on. The subjects' examination was carried out by 2 physical therapists with at least 5 years experience in physical therapy. All subjects were asked to complete an information sheet before testing. The patients were evaluated before beginning hemodialysis treatment in the hemodialysis center to avoid the development of the complication of tiredness and were informed of the test procedure. All participants who were examined in the study gave their informed consent for participation. The 100 patients were divided into 4 groups according to the length of hemodialysis duration: Group 1 - patients who had been dialyzing for less one year (N=19); Group 2 - patients who had been dialyzing for 1-4 years (N=42); Group 3 - patients who had been dialyzing for 4.1-8 years (N=21); Group 4 - patients who had been dialyzing for 8.1 or more years (N=18). Demographic and physical data belonging to the sample that completed the study (100 patients and 40 healthy subjects) are shown in **Table 1**.

Outcome measures. The total score of Disabilities of the Arm, Shoulder and Hand Test (DASH-T) was chosen as the primary outcome measure.[6] Measuring the range of motion of the upper extremities joints using a standardized goniometry,[7,8] examining of the upper extremities muscles' strength using manual muscle testing, which was described by Dr. Lovett,[9] evaluating of loss of sensation by Semmes Weinstein Monofilaments,[10] and grip strength of the hands by hand dynamometer were chosen as the secondary outcome measurements.[11,12]

The DASH-T. The questionnaire was developed by the American Academy of Orthopedic Surgeons as a region specific instrument for measuring upper-extremity disability and symptoms.[6,13] The DASH is a questionnaire that has been shown to have validity and reliability to evaluate upper extremity function, and is widely used by physical therapists and occupational therapists. The DASH, a brief 30-item questionnaire, consists of 2 sections, of which both sections were applied in the present study. The first section (20 items) assesses physical ability and the second section (10 items) assesses pair, functional, and environmental limitations caused by pain. The DASH was completed with the subjects' answering the questions in a face-to-face interview. For the results of the questionnaire, a score close to zero means a high level of function, as the score increases as the level of function decreases. The DASH score was calculated as a raw score – 30/12.

Measuring of range of motion by a goniometry. Shoulder range of motion (flexion, extension,

Table 1 - Demographic and physical data of the study groups.

Variables	Hemodialysis Groups (N=100)				Healthy Control Group (N=40)
	Group 1 (N=19) Mean±SD	Group 2 (N=43) Mean±SD	Group 3 (N=21) Mean±SD	Group 4 (N=17) Mean±SD	Mean±SD
Age (years)	49.63 ± 15.63	46.86 ± 15.29	44.7 ± 12.99	42.23 ± 11.12	37.05 ± 5.57
Height (cm)	167.57 ± 5.96	164.44 ± 9.07	162.71 ± 8.05	163.23 ± 7.93	168.00 ± 8.39
Mass (kg)	63.65 ± 10.35	60.48 ± 10.76	62.85 ± 15.05	55.70 ± 0.82	70.67 ± 12.72
Body Mass Index (kg/m2)	22.66 ± 3.51	22.38 ± 3.72	23.57 ± 4.49	20.98 ± 2.89	24.91 ± 3.15
Hemodialysis duration (years)	<1	1-4	4.1-8	>8.1	---
Grip Strength Score (kgf)					
Right Hand	24.68 ± 7.35	24.18 ± 10.99	18.61 ± 6. 55	21.37 ± 9.34	32.70 ± 11.30
Left Hand	21.46 ± 6.95	21.71 ± 9.56	16.88 ± 6.89	17.95 ± 8.16	30.30 ± 10.75
AVF in Right hand	23.68 ± 7.35	22.18 ± 10.39	15.61 ± 6.55	17.37 ± 9.34	---
AVF in Left hand	20.46 ± 6.95	19.71 ± 9.56	13.88 ± 6.89	13.95 ± 8.16	---
Gender	**N (%)**	**N (%)**	**N (%)**	**N (%)**	**N (%)**
Female	3 (15.7)	13 (30.2)	9 (42.8)	9 (52.9)	23 (57.5)
Male	16 (84.2)	30 (69.7)	12 (57.1)	8 (47.0)	17 (42.5)
AVF side					
Right	6 (31.5)	12 (27.9)	9 (42.8)	8 (47.1)	---
Left	13 (68.4)	31 (72.1)	12 (57.1)	9 (52.9)	---
Hand Dominance					
Right	17 (89.4)	41 (95.3)	17 (80.9)	17 (100)	---
Left	2 (10.5)	2 (4.6)	4 (19.1)	0 (0)	---

AVF - arterio-venous fistula

abduction, adduction, internal and external rotation), elbow range of motion (flexion, extension, supination, pronation) and wrist range of motion (flexion, extension, ulnar and radial deviation) were measured using a standardized manual goniometry, and the scores of active and passive range of motion were recorded for both sides separately. All measurements were applied while the patients were in the lying down position on a treatment table.

Muscle strength of the upper extremities. Manual muscle testing, which was developed by Dr. Lovett, gives a score between 0-5 points as follows: O - There is no evidence of contractility. 1 - Trace: there is slight evidence of contractility and no joint motion. 2 - Poor: There is complete range of motion with gravity eliminated. 3 - Fair: There is complete range of motion against gravity. 4 – Good: There is complete range of motion against gravity with some resistance. 5 - Normal: There is complete range of motion against gravity with full resistance

Assessing loss of sensation. Semmes–Weinstein monofilaments were used to examine whether the subjects had any kind of loss of sensation or not. The test was performed on both upper extremities for both groups.

Hand grip measuring static grip strength was measured using a hand grip dynamometer, while the subjects were in the seated position, the arm was next to the body, except for the evaluation of elbow flexion, when the forearm was in the midline position to prevent it from receiving support from the body. The test was repeated 3 times by the patient, and the patient was allowed to rest for 10 seconds between every trial. The average of the 3 trials was recorded for each patient. The primary and secondary outcome measures were also applied to the healthy control subjects.

The data obtained from the present study were analyzed using SPSS (version 10.0) statistical package. Descriptive statistics were computed on all

variables in the study. One-Way Analysis of Variance (ANOVA) and *t* test for dependent groups were used to analyze the results of both patients and healthy subjects. In addition, post hoc test results were used in order to find the difference of the DASH scores among the groups. Multiple regression analysis was also used to determine the effect of age and gender on functional status in patients with CRF. The significance level was set at 0.05.

Results. In this study, the upper extremity functional capacity of 100 CRF patients undergoing hemodialysis treatment was compared with 40 healthy individuals. There were 34 females and 64 males in the hemodialysis group. Ninety-two of the total of 100 were right-handed and 8 were left-handed; there were 23 females and 17 males' in the healthy group. Thirty-seven of the total of 40 were right-handed and 3 were left-handed (**Table 1**). No limitations were found in the subjects' unaffected side, but on the side of the fistula, there was a statistically significant decreasing in their strength moving from proximal to distal. However, no statistically significant loss of sensation was found in both groups. The results of the comparison of the grip strength test between the hemodialysis and control groups are shown in **Table 2**. As can be seen in the previous tables in the comparison of the right and left hand grip strength of the subjects in the control group and hemodialysis group, both the right and the left hand grip strength was significantly stronger in the control group relative to the matched hemodialysis patients. In the self-comparison of the subject's right and left hand grip strength, the right side was significantly stronger in all groups except for the 4th group. The changes in grip strength according to side of AVF are shown in **Table 3**. In patients with the AVF on the right side, there was no significant difference in the right and left hand grip strength, however, in patients with left sided AVF, the difference between the right and left did reach statistical significance, with the right being stronger. The fact that more than 90% of the patients were right-handed, and the AVF being placed on the left side in 65% of the patients caused the nondominant side to become even weaker. For this reason, the difference reached a significant level. The status of

Table 2 - Comparison of subjects' grip strength scores.

Grip Strength (kgf)	Hemodialysis patients				Healthy control group	F	*p**
	Group 1 Mean±SD	Group 2 Mean±SD	Group 3 Mean±SD	Group 4 Mean±SD	Mean±SD		
Right hand	24.68±7.35	24.18±10.99	18.61±6.55	21.37±9.34	32.70±11.30	8.756	0.000
Left hand	21.46±6.95	21.71± 9.56	16.88±6.89	17.95±8.16	30.30±10.75	10.40	0.000
*One-Way Anova, significant difference (p<0.05)							

Table 3 - Comparison of grip strength according to side of arterio-venous fistula (AVF).

AVF	Grip strength (kgf)		*t*	*p**
	Right hand Mean±SD	Left hand Mean±SD		
Right	18.93±9.06	19.78±9.06	-1.244	0.843
Left	24.62±9.12	20.13±8.47	8.260	0.000
*t-test				

Table 4 - Comparison of grip strength according to side of dominance.

Dominant side	Grip strength (kgf)		*t*	*p**
	Right hand Mean±SD	Left hand Mean±SD		
Right	25.89±10.94	22.91±10.21	7.082	0.000
Left	21.03±10.77	23.46±11.62	-1.598	0.865
*t-test				

Table 5 - Comparison of subjects' DASH scores.

Variable	Hemodialysis patients				Healthy control group	F	*p**
	Group 1 Mean±SD	Group 2 Mean±SD	Group 3 Mean±SD	Group 4 Mean±SD	Mean±SD		
DASH score	17.85±1.05	2.13±1.66	2.70±1.77	2.24±1.65	0.72±0.86	8.857	0.000
*One-Way Anova							

grip strength according to hand dominance is shown in **Table 4**. There was a statistically significant higher level of grip strength in right-handed dominance. There is an important influence in grip strength by the side of dominance. The DASH scores for the hemodialysis and control groups are shown in **Table 5**. The statistical analysis of the mean values of the DASH questionnaire showed a statistically significant difference between the 2 groups in favor of the control group. The results of the questionnaire showed that the most independent group was the healthy control group, with a mean score of 0.72±0.86. The most dependent group was the 3rd group that had the highest mean score of 2.70±1.77. We also examined post hoc test results to describe the difference between the DASH scores belonging to the other dialysis groups compared to the control group. We found that there was a significant difference between the control group and the 2nd and 3rd groups, with the 4th group. When the groups were compared to each other, there was a difference in level of function but the difference was not statistically significant. In the examination of the DASH scores with multiple regression analysis, age and gender were shown to have a statistically significant effect. As expected the functional level may be protected at the beginning of hemodialysis treatment, but functional loss occurs over time.

Discussion. Chronic renal failure is a life-threatening disease affecting every age group, especially young adults, is an important cause of loss of work force, and leads to a variety of complications. For these reasons, CRF is one of the important health problems today.[14] The primary musculoskeletal system problems that occur in patients who are hemodialyzed are arthropathies, joint pain, skeletal deformities, and walking disorders.[15] At the same time, CRF leads to medical and musculoskeletal problems that negatively affect the quality of life, and require physical therapy in order to improve.[16] The upper extremity complications in hemodialysis patients are very important from the aspect of physiotherapy. In a study by Limaye et al,[17] it was determined that hemodialysis leads to beta 2 microglobulin deposition in the musculoskeletal system structures, and accumulation of amyloidosis that can lead to a variety of dysfunctions in the hand. In that study, 20 ADLs and 8 types of grip were used to evaluate handgrip function with the Sollerman test, hand grip strength with hand dynamometer, pain and function with a visual pain scale and general level of health with the Health Assessment Questionnaire. The results showed that the majority of long-term hemodialysis patients share the problems of loss of hand function. Duruöz et al[18] developed the Duruöz Hand Index (DHI) for the purpose of evaluating the hand function of patients who had been hemodialyzed for more than 2 months and, examining the correlation between the DHI and Perdue Pegboard Test, which is used to evaluate function, grip strength, pinch strength, and Health Assessment Questionnaire. The authors found a positive correlation between DHI and the other functional evaluation tools. This index has been found to be a practical and reliable method of evaluating hand function in patients who are continuing with hemodialysis. In the present study, we did not use to the DHI as it is described so as to evaluate only hand function, whereas the DASH Questionnaire, which we did use, evaluates all functions of the upper extremities. In a study conducted by Wilson,[5] a program was developed for the evaluation of hemodialysis patients' hand function. According to this study, it is recommended that hand edema was measured with hand volume or finger circumferential measurement, grip and pinch strength with dynamometer and pinch dynamometer, sensation with monofilaments and 2-point discrimination, hand dexterity with Pick-Up test, Jebsen Hand Function Test and O'Connor Finger Skill Test, which is similar to the Pegboard test.[16] In a study by Chazot et al,[19] hand function was evaluated in 66 patients with a mean age of 59.2 years and mean length of continuing dialysis of 16.7 years. The abnormal symptoms found in this group were synovial hypertrophy, nonfunctional finger tendons, muscle atrophy, trigger finger and compression neuropathy. The major finding of that study was that they had difficulty performing fine motor hand skills that are necessary for self-care activities. The researchers found that in the development of dysfunctions in the hand there was a positive correlation with length of time dialyzing, however, no correlation was found with the side of the fistula and hand dysfunction as they reported abnormal findings on both sides. In the current study, we also found a correlation between side of fistula and length of dialyzing time and a decrease in grip strength as the length of time increased in the 3rd and 4th groups. After many years, the clinical effects of the disease and the negative effects of the fistula lead to a decrease in grip strength. In a study by Branz et al,[20] the hand function of 30 patients who dialyze regularly was evaluated comparing the extremity contralateral to the vascular access by evaluating normal joint movements, edema, grip and pinch strength with the ability to perceive objects while gripping. They found that patients who had been dialyzing for a long time (more than 2 years) had lower grip and pinch strength than those who had recently begun dialysis treatment (less than 2 years) ($p<0.05$). In our study,

the comparison of the extremity with the AVF and without, in the 65 subjects who had left sided AVF, there was significantly advanced grip strength in the right compared to the left side. Patients are told to not use the extremity on the side of the AVF to lift heavy objects or to do other similar difficult activities to keep the AVF healthy. Subsequently, patients generally do not want to do very difficult activities with the extremity that has the AVF. The results of this disuse over a long period and the clinical effects of the disease are an important reason for the decrease in grip strength and general muscle weakness that has been seen by us and other researchers. We did not see a statistically significant difference in grip strength on the right and left side of the 35 right-sided AVF patients. Placing an AVF on the patients' nondominant side is generally due to the use of the left side, or because the fistula is not usable there. Our finding of poor grip strength in the patients in the 3rd and 4th groups who had been dialyzed for the longest period of time is consistent with Branz's study. In a study by Incel et al,[21] an objective index of grip and pinch strength was accepted as concordant with upper extremity function. Their study was designed for the purpose of evaluating the grip and pinch strength difference between right-handed and left-handed dominant individuals. There were 128 right-handed, and 11 left-handed dominant individuals from the 149 volunteers in the study. Grip strength was measured with a dynamometer and pinch strength with a pinch meter. They found a statistically significant difference in the evaluation of the group as a whole between the grip and pinch strength of the dominant and nondominant hands. There was a statistically significant difference in those with the right hand being the dominant hand, however, in those with left hand dominance, there was no statistically significant difference between the 2 sides.[21] In our study, in the examination of grip strength between the dominant and nondominant hands, we found a significant difference between the right and left hands of the right-handed dominant 92 hemodialysis and 37 healthy individuals. Our results were consistent with Incel's findings. We did not find a significant difference between right and left hands' grip strength in the left-handed dominant 8 hemodialysis and 3 healthy individuals. These results show us that hand dominance is a very significance factor that affects grip strength. Similarly, it is expected that the extremity function on the dominant side would be at a higher level.

In many studies in the literature, it has been shown that long term renal failure and the location of vascular access are important factors in the cause of hand dysfunction.[19,20] We could not find any other studies in the literature that used the DASH questionnaire to evaluate hemodialysis patients for upper extremity complications. In our results, we found that the control group was the most independent group with the lowest score, and the 3rd group of dialysis patients had the lowest level of function with the highest score. There was a significant difference among the 2nd, 3rd and 4th groups and the control group. On the subject of decreasing upper extremity function as the length of time of hemodialysis increases, the first group, who had been dialyzing for less than a year, had functional levels high enough to catch up to the control group. This result shows us that, with the passing of time, there is a negative outlook for the upper extremity function of these patients in most of the other parameters. We acknowledge there were limitations to this study; it would be better if the patients were examined regarding quality of life and daily living activities. A physiotherapist, by first determining the method for specific evaluation of these patients and creating a treatment program for the problems that can occur, can promote function loss in an individual with appropriate treatment interventions and can improve their quality of life.

In conclusion, to alleviate the functional disabilities that are seen in CRF patients and to improve their independence, there should be a physiotherapist on the treatment team. A physiotherapist can make recommendations to the team for these patients to have improved level of functioning, to be more independent, to have better quality of life, and to prevent the complication, for example, musculoskeletal problems during hemodialysis treatment. Further studies should be carried out to show effects of endurance training for upper extremities in patients undergoing hemodialysis treatment.

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