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Nutrition, anthropometric and bioimpedance (BIS) status improve with intradialytic exercise training using stationary cycling in patients with end-stage renal disease(ESRD) treated on hemodialysis (HD)

Patients with end-stage renal disease (ESRD) undergoing hemodialysis and peritioneal dialysis are functionally limited as a consequence of their physical, emotional, and social problems (3, 11, 12). Psychological and physical complications in patients with ESRD treated on dialysis included: depression, poor compliance, apathy, limitations in daily activities including walking, bending, kneeling, carrying heavy objects and even grasping, and other simple manipulative movements. Exercise programme in humans have been shown to significantly increase the exercise tolerance in dialysis patients from 21 to 42% following aerobic training program me which lasted for 3–12 months (4, 7).

Exercise during haemodialysis has many potential benefits, including increased peak oxygen uptake, improved self-reported physical functioning and enhanced urea clearances (5, 6). It has been suggested that the cardiovascular response to exercise during haemodialysis is superimposed onto that of the dialysis process.

The present study describe the effect of cycling exercises during dialysis in 10 HD patients over 12 months' period (including each dialysis session) on nutrition, inflammation, dialysis adequacy, and water hydration parameters as measured by biochemical, and bioimpedance parameters.

MATERIAL AND METHODS

Patients and exercise setup. In 10 patients with end-stage renal failure (ESRD) receiving hemodialysis were performed exercises for about 30 minutes during the first hour of each hemodialysis treatment during 12 months' period. Standard bicarbonate dialysis was delivered by dialysis machines with volumetric control. All treatments were performed using polysulfone capillary dialyzers (F5, F6 Fresenius Medical Care, Germany) with surface area of 1.2 to 1.4 m^2. Medications were not adjusted during these studies. All patients had given informed consent to participate in the study. Anthropometric measurements included: body mass index (BMI) assessment, mid-arm circumference (MAC) and triceps skinfold thickness (TST) measurements. "Kidney Diseases and Quality of Life-Short Form" KDQOL-SF Scores by RAND, Santa Monica CA and Univ. of Arizona, 1995 has been used as a basic quesitonaire for evaluation of physical, emotional, and social condition of hemodialysed patients.

Bioimpedance. Whole body bioimpedance was measured for a spectrum of frequencies ranging from 5 to 500 kHz (Hydra 4200 Analyzer, supplied by Xitron Technologies Inc., San Diego, CA). Electrodes were placed on the wrist and on the ankle on the contra-lateral access side of the patient for whole body bioimpedance measurement as described elsewhere (12). Data were collected at the time pre-dialysis, and at the end of each dialysis session. The software supplied with the device was used to fit the impedance data to an electrical model to obtain the value of total body water (TBW) and extracellular water (ECW) volumes.

Biochemical parameters. Serum biochemical parameters including chronic inflammation markers (c-reactive protein; CRP), cytokines inflammatory mediators indicators (Interleukin-6, Interleukin-12, TNF-alfa) versus factors of nutrition such as: albumin and transferrin and also dialysis adequacy as measured by urea kinetic modelling (UKM; eKt/V and nPCR have been measured before and after 6 months and after 12 months of cycling exercises.

Statistical analysis. Data are presented as mean±standard deviation (SD). Differences between groups were estimated by means of Pearson's product – moment correlations and the probability $(P)<0.05$ were assumed to reject the null hypothesis. Statistical analysis was performed using SPSS/PC for Windows, version 10.0.

RESULTS

The quality of life questionnaire using "Kidney Diseases and Quality of Life-Short Form" KDQOL-SF Scores are summarized in Table 1. The results of biochemical serum parameters in comparison to urea kinetic modelling data, and TBW and ECW as measured by BIS analysis data are presented in Table 2.

Table 1. "Kidney Diseases and Quality of Life-Short Form" KDQOL-SF Scores (by RAND, Santa Monica CA and Univ. of Arizona, 1995) performed in patients before and after 12 months of the regular cycling exercise. The mean value ± SD and P value

Symptoms	Pre-exercise period	After 12 months of exercise	P
Burden of kidney disease	41.3±7.7	47.4±6.9	NS
Cognitive function	41.3±7.7	47.4±6.9	0.042
Dialysis staff encouragement	69.3±14.3	78.6±10.5	NS
Effects of kidney disease	79±24.5	78.6±23.2	NS
Patients satisfaction	69.7±14.1	71±13.5	NS
Quality of social interaction	64±6.7	65.1±3.9	NS
Sleep	70.4±4.7	72.1±5.2	0.035
Social support	65.1±6.1	68.7±4.4	NS
Symptom	66.5±16.6	66.7±16.5	NS
Work status	20.1±6.3	23.7±4.9	NS

Serum biochemical parameters including chronic inflammation markers (c-reactive protein; CRP), cytokines inflammatory mediators indicators (Interleukin-6, Interleukin-12, TNF-alfa) versus factors of nutrition such as: albumin and transferrin and also dialysis adequacy as measured by urea kinetic modeling (UKM; eKt/V and nPCR have been measured before and after 6 months and after 12 months of cycling exercises.

We observed a significant increase of serum albumin concentration, serum transferrin, higher Kt/V, and nPCR after 12 months of regular stationary cycling during hemodialysis. It is very interesting that serum level of C-reactive protein and IL-6 decreased after 12 months of study and this correlation has been also noted as statistically significant (Table 2).

Anthropometric measurements including: body mass index (BMI) assessment, mid-arm circumference (MAC) and triceps skinfold thickness (TST) measurements did not significantly change during 12 months of observation. Relative changes (pre-post HD) of extracellular water compartment and ECW/TBW ratio as measured before study significantly increased in comparison to values after 12 months of the observation period.

Table 2. Serum biochemical parameters including chronic inflammation markers, cytokines inflammatory mediators indicators versus factors of nutrition, also dialysis as measured before, after 6 and 12 months of cycling exercises. The mean value ± SD and P value; *P<0.05 pre-exercise versus after 6 months of exercise,$^{\Delta}$P<0.05 pre-exercise versus after 12 months of exercise

Unit	Pre-exercise period	After 6 months of exercise	After 12 months of exercise
Treatment time (hr)	4.05±0.2		4.1±0.3
Duration on HD (months)	85±56		
Height (cm)	162±11		
pre HD Hemoglobin (g/dL)	11.2±1.09	12.4±1.13	11.2±0.93
pre HD Albumin (g/dL)	3.90±0.29	4.06±0.30	4.1 ±0.33$^{\Delta}$
preHD Transferrin (mg/dL)	263 ±63	265 ±75	319 ±53$^{\Delta}$
pre HD CRP (mg/dL)	4.37±1.04	3.05±1.08*	1.28 ±0.60$^{\Delta}$
pre HD IL-6 (pg/mL)	15.9±3.9		7.9±4.9$^{\Delta}$
pre HD IL-12 (pg/mL)	21.7±11.2		28.1±42.9
pre HD TNF-alfa (pg/mL)	6.9±5.7		4.5±4.8
nPCR (g/kg/day)	0.98±0.16	1.03±0.16*	1.08±0.13$^{\Delta}$
eKt/V	0.87±0.15	1.01±0.28*	1.03±0.11$^{\Delta}$

Table 3. Anthropometric measurements included: body mass index (BMI) assessment, mid-arm circumference (MAC) and triceps skinfold thickness (TST) measurements and whole body bioimpedance measurements (total body water (TBW) and extracellular water (ECW) volumes. The mean value ± SD and P value; *P<0.05 pre-exercise versus after 6 months of exercise, ΔP<0.05 pre-exercise versus after 12 months of exercise

Parameters	Pre-exercise period	After 6 months	After 12 months
BMI	23.90±4.41	23.57±4.26	24.07±3.27
MAC (pre HD) (cm)	26.4±3.7	24.3±6.4	25.3±6.4
TST (pre HD) (cm)	18.4±6.0	16.5±6.1	17.3±8.4
TBW (pre HD) (L)	33.7±9.5	32.2±8.7	34.3±6.4
ECV (pre HD) (L)	14.99±3.5	15.39±3.9	15.13±6.4
ECV/TBW (preHD) (%)	0.45±0.06	0.42±0.05	0.41±0.08 $^{\Delta}$

DISCUSSION

Patients with end-stage renal failure disease (ESRD) usually manifest symptoms of exercise intolerance. This study has demonstrated that long-term exercises such as stationary cycling during hemodialysis make potential improvement for nutrition and dialysis adequacy in hemodialyzed patients population. Exercise during dialysis enhanced dialysate urea removal as it has been previously reported (1, 10). It is also recommended in several studies that exercise during dialysis be performed during the first 2 hours of dialysis. The exercise programme had no effect on KDQOL-SF scores and this was most likely due to the short duration of the exercise programme and high-functioning level of the population studied as compared to normative data for this patient population. Many previous studies showed that exercise training improves exercise capacity, blood pressure, and mood for some patients with end-stage renal disease (2, 3, 6). The exercise training employed had beneficial effect on muscles of ESRD patients correcting atrophy and inducing changes in capillarization. Skeletal muscles of uraemic patients responded to exercise stimulus in the same way as a normal population, however, further research needs to examine the degree of improvement. Moore et el. investigated cardiovascular response to submaximal stationary cycling during hemodialysis. They concluded that the cardiovascular exercise response is superimposed on hemodynamic effects of dialysis and is adequately stable during the first 2 hours of treatment (8). We noted based on bioimpedance analysis of body water compartment such as changes in extracellular compartment and in total body water compartment that patients after 12 months of regular cycling exercise on stationary ergometer are less overhydrated.

In conclusion, we support the recommendation of regular exercise training using stationary cycling during regular hemodialysis session.

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SUMMARY

Patients with end-stage renal disease (ESRD) undergoing hemodialysis and peritoneal dialysis are functionally limited as a consequence of their physical, emotional, and social problems. Patients with end-stage renal failure disease (ESRD) usually manifest symptoms of exercise intolerance. The purpose of the present study was to evaluate the effect of cycling exercises in 10 HD patients during 12 months' period (including each of dialysis sessions) on nutrition, inflammation, dialysis adequacy, and fluid parameters as measured by biochemical, and bioimpedance parameters. Significant increase of serum albumin concentration, Kt/V, and nPCR, and decrease of serum CRP and serum IL-6 have been observed after 12 months of regular stationary cycling during hemodialysis. The exercise programme had no effect on KDQOL-SF scores. Relative changes (pre-post HD) of extracellular water compartment and ECW/TBW ratio measured before the study significantly increased in comparison to values after 12 months' observation period. We support the recommendation of regular exercise training using stationary cycling during regular hemodialysis sessions.

Wpływ ćwiczeń z użyciem ergometru rowerowego w czasie dializy na stan odżywienia, parametry antropometryczne oraz pomiary bioimpedancyjne u pacjentów z rozpoznaniem schyłkowej niewydolności nerek, leczonych hemodializami

Pacjenci z rozpoznaną schyłkową niewydolnością nerek leczeni terapią nerkozastępczą (hemodializy oraz dializy otrzewnowej) wykazują istotną dysfunkcję z aktywnością fizyczną, a także w sferze emocjonalnej oraz socjalnej. Ograniczenie tolerancji wysiłku jest istotnym problemem w tej grupie pacjentów. Celem naszego badania było określenie wpływu 12-miesięcznego cyklu regularnych ćwiczeń na ergometrze rowerowym w czasie dializy na parametry stanu odżywienia, stanu zapalnego, adekwatności dializy oraz wielkości przestrzeni wodnych mierzonych przy użyciu wskaźników biochemicznych oraz techniki bioimpedancji elektrycznej. Stwierdzono istotny statystycznie wzrost poziomu albumin w osoczu, wskaźników adekwatności dializy Kt/V oraz nPCR, natomiast obniżenie stężenia w osoczu CRP oraz IL-6 po 12 miesiącach regularnych ćwiczeń na ergometrze rowerowym. Mierzone za pomocą bioimpedancji elektrycznej zmiany wielkości przestrzeni pozakomórkowej (ECW) oraz wskaźnika ECW/TBW istotnie wzrosły po 12 miesiącach regularnych ćwiczeń. Postulujemy wprowadzenie regularnych ćwiczeń z użyciem ergometru rowerowego w czasie dializy w grupie pacjentów dializowanych.