Regular low-intensity aquatic exercise improves cardio-respiratory functional capacity and reduces proteinuria in chronic renal failure patients

Sir,

Results from several studies indicate that patients with chronic renal failure (CRF) can benefit from regular exercise training by improving their cardio-respiratory capacity and quality of life [1,2]. However, there have been no studies examining the effect of exercise on renal function in patients with moderate renal failure. Although experiments have shown that swimming significantly lowers proteinuria and reduces glomerulosclerosis in rats [3–5], human non-swimming exercise studies were not able to confirm these findings [6]. Interestingly, studies with uraemic animals have shown that land-based exercise did not positively affect the renal function [7,8], whereas water-based training effectively reduced proteinuria and glomerulosclerosis, even though these pathologies were less prominent [3,4]. Previous work has shown that aquatic immersion favourably affects renal function by lowering plasma renin activity, decreasing renal sympathetic nerve activity and by immediately altering cathecholamine and prostaglandin levels [5], thereby decreasing renal vascular pressure and elevating sodium excretion [9,10]. Several studies have validated the use of the aquatic environment in exercise therapy [11], and have shown that water immersion *per se* significantly affects blood circulation, and especially stimulates increases in renal blood flow. The orthostatic and renal vasoconstrictive effects of land-based exercise can be avoided by exercising in water. We therefore hypothesized that individually dosed and well-supervised aquatic exercise training may provide an effective therapeutic rehabilitation method for CRF patients by improving physical capacity and retarding the progression of renal failure. The aim of the study was to determine the efficacy of low-intensity 12-week regular aquatic exercise training on cardio-respiratory endurance and renal functional parameters in patients with CRF.

We designed a prospective study including patients ($n=20$) having moderate proteinuria, with no anaemia, and with two or more cardiovascular risk factors with one of the factors being physical inactivity. There were 12 patients with chronic glomerulonephritis, five patients with hypertension and three with diabetes. Eleven patients out of the 20 had mild cardiovascular problems (NYHA I-II), and all were on antihypertensive therapy, which was not changed during the programme. There were no dietary alterations and patients were instructed to maintain usual diet habits. The patients were divided into two groups that were matched by age, blood pressure, body mass index (BMI), maximal oxygen uptake and renal function: an exercising group ($n=11$: six males, five females, age range 31–65 years, mean age 49.5 ± 3.5 years) and a control group ($n=9$, six males, three females, age range 35–65 years, mean age 47.9 ± 3.8 years) that remained sedentary during the study period. We measured cardio-respiratory functional capacity, urinary protein excretion (UprotV, g/24 h), serum creatinine (μmol/l), cystatin C (CysC, mg/l), total cholesterol (mmol/l), HDL/LDL cholesterol (mmol/l) and triglycerides (mmol/l) at baseline and at follow-up. Glomerular filtration rate (GFR) was calculated using the Cockcroft–Gault formula. Cardio-respiratory functional capacity was determined using cardiopulmonary exercise testing (on ergometric bicycle) that included measurement of peak oxygen uptake (VO_2max, ml/min/kg), oxygen pulse (ml/heartbeat/min) and peak load (W) at the ventilatory anaerobic threshold. Intensity of training was determined individually after testing and was 40–50% of VO_2max (low-intensity). The training group exercised vertically in the pool (water temperature +24–26°C) two times per week for 30 min/session. The exercise involved the joints and body and was under supervision of a trained physical therapy specialist and rehabilitation physician. Differences between initial and final values within groups were evaluated using two-sample paired *t*-test for means. $P<0.05$ was accepted as statistically significant (NS, not significant). Informed consent was obtained from all patients and the Ethics Review Committee on Human Research at the University of Tartu approved the study protocol.

At study completion, blood pressure levels were significantly lower in the exercise group contrasting with no change in the control group (Table 1). Although all of the physical capacity parameters significantly improved in the exercising group, they remained the same in the controls. Lipid parameters were slightly improved in exercising patients, although the differences were not significant. In the controls, lipid levels remained practically unchanged. BMI did not change in either group and at the end of the study was 28.8 ± 0.7 in the exercise group and 28.1 ± 1.3 in controls. Renal functional parameters of exercising patients improved during the study (Table 1). In this group, 24 h proteinuria (g/24 h) diminished significantly from 1.0 ± 0.3 to 0.5 ± 0.3, mean cystatin C levels decreased from 1.7 ± 0.2 to 1.3 ± 0.1 and serum creatinine decreased from 161.7 ± 13.7 to 154.8 ± 12.4. An improvement in GFR was also detected (60.0 ± 7.4 to 67.3 ± 10.1).

In summary, all of the aquatic-exercising patients benefited from improved physical functioning and showed significant decreases in proteinuria. The decreases in cystatin C confirmed the amelioration of renal function. In contrast, renal functional parameters worsened in sedentary controls during the study period. The decrease in proteinuria in exercising patients was due partly to the normalizing of systemic blood pressure but was also probably related to other well described mechanisms associated with water-based exercise, including alterations in plasma angiotensin II and renal prostaglandin levels as well as reductions in and renal sympathetic activity in response to immersion [11].

Table 1.

	VO_2max	SBP	DBP	UProtV	CysC	GFR
Exercise group baseline	19.7 ± 1.2	144.2 ± 5.6	87.8 ± 3.4	1.0 ± 0.3	1.7 ± 0.2	60.0 ± 7.4
Exercise group follow-up	20.8 ± 1.3	138.0 ± 5.4	84.1 ± 3.1	0.5 ± 0.3	1.3 ± 0.1	67.3 ± 10.1
P value	0.04	0.007	0.03	0.005	0.05	NS
Control group baseline	21.0 ± 2.9	147.8 ± 5.7	90.2 ± 3.0	1.4 ± 0.3	1.7 ± 0.3	69.8 ± 12.3
Control group follow-up	21.3 ± 3.2	146.7 ± 8.7	89.2 ± 4.9	1.5 ± 0.3	2.0 ± 0.5	66.3 ± 13.2
P value	NS	NS	NS	NS	NS	NS

[1]Departments of Sports Medicine and Rehabilitation
[2]Internal Medicine
University of Tartu
Estonia
Email: mai.ots@kliinikum.ee

Ülle Pechter[1]
Jaak Maaroos[1]
Siiri Mesikepp[2]
Alar Veraksits[1]
Mai Ots[2]

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