Nephrol Dial Transplant (2005) 20: 141–146
doi:10.1093/ndt/gfh560
Advance Access publication 2 November 2004

Nephrology Dialysis Transplantation

Original Article

The effects of a low-to-moderate intensity pre-conditioning exercise programme linked with exercise counselling for sedentary haemodialysis patients in The Netherlands: results of a randomized clinical trial

Marieke C. B. A. van Vilsteren[1], Mathieu H. G. de Greef[2] and Roel M. Huisman[3]

[1]UC ProMotion, [2]Institute of Human Movement Sciences, University of Groningen and [3]Groningen Dialysis Center, Groningen University Hospital, The Netherlands

Abstract

Objectives. The purpose of this study is to determine whether a low-to-moderate intensity pre-conditioning exercise programme linked with exercise counselling could improve behavioural change, physical fitness, physiological condition and health-related quality of life of sedentary haemodialysis patients in The Netherlands.

Methods. Ninety-six haemodialysis patients of the Groningen Dialysis Center were randomized into an exercise group ($n = 53$) and a control group ($n = 43$). The exercise programme consists of cycling during dialysis together with a pre-dialysis strength training programme lasting 12 weeks. The intensity of the exercise programme is condition level 12–16 according to the rate of perceived exertion (RPE). Motivational interviewing techniques were used for exercise counselling. Before and after the intervention, both groups were tested on behavioural change and physical fitness components such as reaction time, manual dexterity, lower extremity muscle strength and VO_2 peak. Physiological conditions such as weight, blood pressure, haemoglobin and haematocrit values, cholesterol and Kt/V were obtained from the medical records. Health-related quality of life assessment included RAND-36 scores, symptoms and depression.

Results. A group $\times$ time analysis with MANOVA (repeated measures) demonstrates that participation in a low-to-moderate intensity exercise programme linked with exercise counselling yields a significant increase in behavioural change, reaction time, lower extremity muscle strength, Kt/V and three components of quality of life, and no significant effects in the control group.

Conclusion. Participating in a low-to-moderate intensity pre-conditioning exercise programme showed beneficial effects on behavioural change, physical fitness, physiological conditions and health-related quality of life.

Keywords: exercise; haemodialysis; health-related quality of life; physical fitness

Introduction

Exercise capacity in haemodialysis patients is low compared with age-matched healthy persons. These patients experience not only significantly low physical fitness but also psychosocial problems and poor quality of life [1–3]. Studies in the field of renal rehabilitation support the fact that exercise training in haemodialysis patients can ameliorate many of the morphological and functional disorders that accompany end-stage renal disease, as well as enhance physical activity, physical fitness and health-related quality of life [4–8]. These programmes are aimed primarily at improving endurance but, in order to decrease muscle weakness, haemodialysis patients should also be involved in strength training activities. This also complies with the recommendations of the American College of Sports Medicine (ACSM) exercise guidelines, that exercise programmes should be tailored to combine endurance and muscle strength exercise [9].

There are no renal rehabilitation exercise programmes for haemodialysis patients in The Netherlands. To improve the physical condition of haemodialysis patients, the Groningen Dialysis Center has taken the initiative to develop a pre-conditioning programme

Correspondence and offprint requests to: Dr M. H. G. de Greef, Institute of Human Movement Sciences, University of Groningen, PO Box 196, 9700 AD Groningen, The Netherlands.
E-mail: M.de.Greef@ppsw.rug.nl

for such patients. The graded and low-to-moderate intensity exercise programme aims to improve physical fitness, physiological condition and health-related quality of life with an endurance and strength training exercise programme. Exercise counselling is added to improve exercise adherence [10]. The purpose of the present study is to analyse and compare the effects of this pre-conditioning exercise programme, consisting of cycling, strength training and exercise counselling, on behavioural change, physical fitness, physiological condition and health-related quality of life in sedentary haemodialysis patients.

Subjects and methods

This section and the results are ordered following the criteria of the consort statement for reporting randomized trials [11].

Patients

All haemodialysis patients ($n = 128$) at the Groningen Dialysis Center in The Netherlands were asked to participate in this study.

Exclusion criteria for exercise were severe cardiovascular disease, use of β-blockers, unstable angina pectoris and orthopaedic complaints. The inclusion criterion are sedentary physical activity status (according to ACSM criteria). To assess the physical activity status, the self-reported Stage of Change Questionnaire was used [10]. Based on inclusion and exclusion criteria, 103 haemodialysis patients were randomized. Extra patients were randomized into the exercise group to compensate for the effects of drop-out. A flow diagram shows the progress of the patients through the phases of the trial (see Figure 1). Participation was voluntary, contingent on the approval of the patients' supervising physician. Written informed consent was obtained from all patients who agreed to participate. Table 1 shows the demographic and clinical characteristics of patients recruited into the exercise and control groups. The exercise group consisted of 38 men and 22 women aged 20–77 years (mean age 52), and the control group consisted of 30 men and 13 women aged 22–83 years (mean age 58).

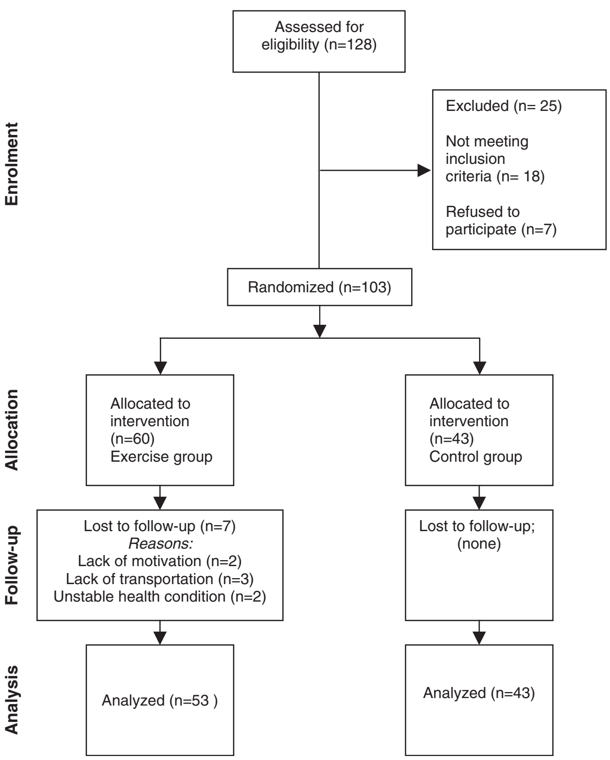

Fig. 1. Flow diagram of the progress through the phases of a randomized trial.

Exercise programme

The exercise programme consisted of a pre-dialysis strength training programme and a cycling (during dialysis) programme. The pre-dialysis strength training programme was held at a gym in the dialysis centre. The training programme consisted of a 5–10 min warm up, a 20 min exercise programme including calisthenics, steps, flexibility and low weight resistance exercises, and a 5–10 min cool down period. The cycling programme was first done on a prototype made by the Technical Support team of the University of Groningen; 2 months later the programme was done on an adjusted 'exercise trainer' (Thera-Joy, Medizintechnik GMBH, Germany), which was modified to fit the dialysis chair. The training sessions were performed 2–3 times per week, for ~20–30 min within the first 2 h of dialysis. The intensity of exercise was prescribed on an individual basis, using the rate of perceived exertion (RPE) of the Borg scale [12], so that intensity involved ~60% of an individual's maximal capacity, a level at which cardiovascular health benefits can be obtained.

Exercise counselling

The exercise counselling techniques used were based on the transtheoretical model, motivational interviewing and health

Table 1. Baseline characteristics of haemodialysis patients

Characteristics	Exercise group ($n = 53$)	Control group ($n = 43$)	*P*
Age (years)	52 (15)	58 (16)	0.055
Men (%)	63.3	69.8	0.565
Years on dialysis	3.22 (4.08)	3.90 (4.41)	0.443
Dialysis adequacy (Kt/V)	1.19 (0.22)	1.23 (0.22)	0.381
Haematocrit (l/l)	0.36 (0.04)	0.36 (0.04)	0.841
Haemoglobin (mmol/l)	7.52 (0.85)	7.44 (0.83)	0.666
Systolic blood pressure (mmHg)	144 (23)	151 (23)	0.171
Diastolic blood pressure (mmHg)	81 (14)	82 (16)	0.545
Co-morbidity (%)[a]			0.139
None (0)	52.5	22.2	
Intermediate (1–2)	35.0	63.0	
Severe (>3)	12.5	14.8	

Values are given as mean (SD).
[a]Co-morbidity is expressed as a score where each of the following conditions contributed one point: malignancy, ischaemic heart disease, left ventricular dysfunction, diabetes mellitus, systemic collagen vascular disease and other significant pathology.

counselling [12]. The central idea behind this is that behavioural change is a long-term process during which patients can be counselled, depending on their stage of change [10]. During the intervention, the exercise counsellors met with the haemodialysis patients four times. Conversation topics were the motivation of patients to enhance their physical activity and physical fitness, the stage of change, perceived barriers, exercise targets of haemodialysis patients and coping with exercise adherence. The exercise counsellor served as motivational support to stimulate patients to become and stay more active.

Data collection

Physical fitness. The physical fitness components assessed in the present study are exercise capacity, lower extremity muscle strength, manual dexterity and reaction time. Exercise capacity (VO_2 peak) was assessed with the submaximal Åstrand cycling test [13]. This test predicts the maximal aerobic capacity from submaximal heart rates. The cycling test was held before the dialysis session, before and after the intervention, using a cycle ergometer (Corival, ProCare BV, The Netherlands) and a Polar S210^{TM} to measure heart rate. Lower extremity muscle strength was assessed with the time to complete 10 repetitions of the sit-to-stand-to-sit test. [14]. The other two components were assessed with the Groningen Fitness Test for the Elderly (GFE). The GFE is reliable, validated and sensitive to changes in performance-based fitness of sedentary older adults (aged 55–65 years) [15], and is used in this study because of the expected low performance-based fitness of haemodialysis patients.

Health-related quality of life. The Dutch version of the MOS Short-Form General Health Survey (RAND-36) was used to measure the patients' generic health-related quality of life. This questionnaire was used because of its comprehensiveness, conciseness and high standards of reliability and validity [16]. Symptom frequency was measured using a scale based on the most common symptoms experienced by haemodialysis patients, such as tiredness, cramps, itching, shortness of breath, etc. [17]. The 20-item Self-rating Depression Scale (SDS) was used to assess depression. The SDS is reliable and valid for use as a screening instrument to identify depressive symptoms [18].

Physiological condition. Information about the physiological condition was assessed from patients' medical status before and after the intervention, including weight, blood pressure, cholesterol levels, heart rate, haematocrit levels, haemoglobin levels and Kt/V.

Behavioural change. In this study, behavioural change was studied through self-efficacy, stage of change and perceived fitness. Self-efficacy was measured with the LIVAS questionnaire and brings out the capacity of one's physical competences [19]. According to the transtheoretical model, individuals pass through five common stages of change as they move toward the adoption of a regular exercise programme [10]. We measure the stage of change for each patient before and after the pre-conditioning exercise programme. For perceived fitness, patients were asked to give a grade between 1 and 10.

Statistical analysis

Data on physical fitness, health-related quality of life, physiological condition and behavioural change were analysed (SPSS Base 10.0) using MANOVA (repeated measures) to look for significant interaction (group × time) effects. Statistical significance was achieved at $P < 0.05$. Effect sizes were calculated according to Cohen. Effect sizes (d scores) <0.20 indicated a low effect, between 0.50 and 0.80 a moderate effect, and >0.80 a large effect [20].

Results

As many as 88% of the participants completed the exercise programme. Reasons for not participating were unstable health ($n = 2$), lack of transport ($n = 3$) and lack of motivation ($n = 2$). The mean frequency of cycling during dialysis was 2.73 times per week (SD = 0.693) and the mean duration per session was 49.86 min (SD = 42.22). The mean frequency of the strength training programme before dialysis was 1.86 times per week (SD = 0.86) and the mean duration 16.78 min (SD = 3.60).

Physical fitness

Table 2 shows the physical fitness pre- and post-training results for the exercise and control groups. The MANOVA analysis shows a significant multivariate group × time interaction effect for reaction time [$F(1,94) = 11.8$, $P = 0.002$] and lower extremity muscle strength [$F(1,94) = 3.92$, $P = 0.05$]. No significant effects were shown within the control group. For the significant effects, large effect sizes were calculated for reaction time ($d = 1.31$) and lower extremity muscle strength ($d = 1.48$).

Table 2. MANOVA results of physical fitness before and after the exercise intervention

	Exercise group		Control group		*n*	*F*	*P*	*d*
	Pre-training	Post-training	Pre-training	Post-training				
Manual dexterity (s)	53.09 (12.7)	50.06 (13.2)	57.51 (18.8)	56.81 (18.2)	96	0.51	0.48	0.47
Reaction time (ms)	234.67 (43.9)	208.51 (36.0)	249.17 (73.6)	255.42 (97.4)	96	11.90	0.002*	1.31
Muscle strength (s)	26.30 (14.6)	20.42 (7.5)	31.64 (19.7)	31.56 (19.8)	96	2.92	0.05*	1.48
VO_2 peak (ml/kg/min)	25.44 (6.3)	28.02 (8.8)	26.13 (10.9)	26.25 (10.8)	57	2.31	0.14	0.20

Values are given as mean (SD).
*Significant interaction effect $P < 0.05$.

Health-related quality of life

Table 3 shows the health-related quality of life pre- and post-training results for the exercise and control groups. Compared with the general population, haemodialysis patients had lower RAND-36 scores, therefore were experiencing a poorer quality of life. The MANOVA analysis shows a significant multivariate group × time interaction effect for the RAND-36 components of vitality [$F(1,94)=17.37$, $P=0.001$], general health perception [$F(1,94)=9.64$, $P=0.001$] and health change [$F(1,94)=6.66$, $P=0.02$]. For the significant effects, moderate effect sizes were calculated for vitality ($d=0.65$), general health perception ($d=0.45$) and health change ($d=0.45$).

Physiological condition

Table 4 shows the physiological condition pre- and post-training results for the exercise and control groups. The MANOVA analysis showed one significant multivariate group × time interaction effect for Kt/V [$F(1,94)=3.29$, $p=0.05$].

Behavioural change

Table 5 shows the behavioural change pre- and post-training results for the exercise and control groups. The MANOVA analysis shows a significant multivariate group × time interaction effect for stage of change [$F(1,94)=10.48$, $P=0.002$]. For the significant effect

Table 3. MANOVA results of health-related quality of life before and after the exercise intervention

RAND 36 subscales	Exercise group		Control group		*n*	*F*	*P*	*d*
	Pre-training	Post-training	Pre-training	Post-training				
Physical functioning	56.5 (28.0)	62.5 (28.0)	59.6 (31.8)	60.2 (34.5)	96	1.50	0.22	0.08
Social functioning	70.4 (19.9)	71.6 (19.0)	68.8 (28.8)	74.1 (25.0)	96	0.68	0.42	0.13
Role of physical limitations	35.2 (42.7)	50.0 (43.0)	48.2 (46.1)	54.5 (45.7)	96	0.60	0.44	0.10
Role of emotional limitations	65.1 (44.2)	78.8 (35.0)	69.1 (41.5)	70.2 (41.9)	96	1.08	0.30	0.25
Mental health	72.1 (17.4)	76.2 (18.9)	80.6 (14.3)	79.4 (15.0)	96	2.81	0.20	0.17
Pain	78.9 (27.3)	76.9 (21.0)	77.3 (29.6)	76.1 (25.5)	96	0.01	0.90	0.04
Vitality	53.6 (16.8)	66.1 (15.3)	57.9 (19.6)	56.1 (17.4)	96	17.37	0.001*	0.65
General health perception	41.3 (19.2)	51.8 (15.9)	46.1 (18.9)	45.2 (18.1)	96	9.64	0.001*	0.42
Health change	50.0 (24.4)	67.1 (26.0)	56.3 (28.6)	55.4 (25.8)	96	6.66	0.021*	0.45
Symptoms	22.5 (8.6)	23.5 (9.1)	24.5 (9.8)	23.9 (9.5)	96	3.69	0.06	0.04
Depression	36.2 (7.8)	37.2 (8.3)	39.0 (8.7)	41.4 (9.6)	96	0.70	0.40	0.51

Values are given as mean (SD).
*Significant interaction effect $P<0.05$.

Table 4. MANOVA results of physiological condition before and after the exercise intervention

	Exercise group		Control group		*n*	*F*	*P*	*d*
	Pre-training	Post-training	Pre-training	Post-training				
Weight (kg)	76.6 (16.1)	75.6 (16.2)	77.8 (15.3)	77.6 (15.6)	96	0.65	0.42	0.12
Systolic blood pressure (mmHg)	145 (23.2)	140 (26.4)	150 (23)	146 (25)	96	0.02	0.90	0.23
Diastolic blood pressure (mmHg)	81 (14.2)	80 (14.9)	83 (15)	79 (12)	96	0.94	0.34	0.07
Cholesterol (mmol/l)	4.6 (1.1)	4.6 (1.0)	4.7 (1.1)	4.6 (1.2)	96	0.01	0.86	0.00
Haematocrit (l/l)	0.36 (0.04)	0.36 (0.04)	0.36 (0.04)	0.37 (0.04)	96	0.64	0.42	0.25
Haemoglobin (mmol/l)	7.52 (0.9)	7.52 (0.8)	7.46 (0.8)	7.57 (0.8)	96	0.42	0.52	0.08
Kt/V	1.20 (0.2)	1.26 (0.2)	1.23 (0.2)	1.23 (0.2)	96	3.30	0.05*	0.15

Values are given as mean (SD).
*Significant interaction effect $P<0.05$.

Table 5. MANOVA results of behavioural change before and after the exercise intervention

	Exercise group		Control group		*n*	*F*	*P*	*d*
	Pre-training	Post-training	Pre-training	Post-training				
Stage of change	2.6 (0.9)	3.3 (0.5)	2.0 (1.3)	1.9 (1.1)	96	10.50	0.002*	2.64
LIVAS	33.6 (6.9)	34.8 (6.6)	32.8 (9.7)	32.1 (10.0)	96	3.24	0.08	0.41
Perceived fitness	5.7 (1.9)	6.3 (1.2)	5.9 (1.9)	6.4 (2.1)	96	0.14	0.74	0.08

Values are given as mean (SD).
*Significant interaction effect $P<0.05$.

in the stage of change, a large effect size ($d = 2.64$) was found.

Discussion

The current study, 12 weeks of low-to-moderate intensity pre-conditioning exercise linked with exercise counselling, showed beneficial effects on stage of change, reaction time, lower extremity muscle strength, Kt/V and three components of quality of life. The results showed that sedentary haemodialysis patients are able to participate safely in a low-to-moderate intensity pre-conditioning exercise programme. Of the patients in the exercise group, no one was forced to terminate the study because of injury sustained while exercising.

Except for the absence of effects on VO_2 peak, the results of the exercise intervention on physical fitness and health-related quality of life in the exercise group are in agreement with those of other studies [2,5,6]. To our knowledge, the effects of an exercise programme on behavioural change and reaction time of haemodialysis patients has not been assessed before in other studies.

The physical fitness component of endurance was assessed with the submaximal Åstrand cycling test. In this study, the maximal aerobic capacity (VO_2 peak) of 57 patients could be predicted, with 96 patients having taken the Åstrand cycling test. One important reason for this drop-out figure is muscular fatigue of haemodialysis patients. As a result, haemodialysis patients could not cycle at a constant workload for 6 min and therefore the VO_2 peak could not be assessed. The fact that no effect on VO_2 peak was found when assessing aerobic capacity may be due to the drop-out rate.

Furthermore, the duration of the low-to-moderate intensity exercise programme may be too short for a beneficial effect on all the haemodialysis patients who participated. Older participants in particular may take several weeks to adapt to the initial rigours of training and may therefore need a longer adjustment period to benefit optimally from an exercise programme.

Nevertheless, it appears from our study that, besides the known positive effects of exercise on physical fitness and health-related quality of life, there are additional benefits for those haemodialysis patients who exercise. The behavioural change that we found indicates that exercising patients developed a greater belief in their capacity to bring about a change of behaviour in themselves (self-efficacy). This helps to improve the self-image of these patients, who before the exercise programme often felt they were in decline.

The improved reaction time in the exercise group is an unexpected finding but will probably help patients in their activities of daily living. Together with the increased lower extremity muscle strength and the improved manual dexterity, patients in the exercise group could function better in everyday life, for example thanks to improvement in neuropsychological functions, maintaining agility, coordination, balance, decreasing chances of falling and less fear of movement as a result of better motor control.

The results of this study show that exercise increased Kt/V. This increase is interesting from a mechanistic point of view. Since the dialysis prescription had not changed, the exercise programme appears to be responsible for this improvement in dialysis efficiency. The most likely factor involved is cycling during dialysis. We speculate that improved muscle circulation leads to better wash-out of urea from this compartment, so that less urea rebound occurs directly after dialysis, which results in a higher equilibrated Kt/V value.

In summary, even short-term activity of low-to-moderate intensity improves a number of physiological and psychological parameters in haemodialysis patients. In view of the high cardiovascular mortality of this patient group, stimulation of physical activity should receive more emphasis in dialysis centres. A structured programme such as ours can help in this respect.

Acknowledgements. We would like to thank the patients and medical staff at the Groningen Dialysis Center for their support and assistance.

Conflict of interest statement. None declared.

References

1. Kouidi E, Lacovides A, Lordanidis P *et al.* Exercise renal rehabilitation program (ERRP): psychosocial effects. *Nephron* 1997; 77: 152–158
2. Painter PL, Carlson L, Carey MS, Paul SM, Myll J. Physical functioning and health-related quality-of-life changes with exercise training in hemodialysis patients. *Am J Kidney Dis* 2000; 35: 482–492
3. Suh MR, Jung HH, Kim SB, Park JS, Yang WS. Effects of regular exercise on anxiety, depression, and quality of life in maintenance hemodialysis patients. *Renal Fail* 2002; 24: 337–345
4. Tawney KW, Tawney PJW, Hladik G *et al.* The life readiness program: a physical rehabilitation program for patients on hemodialysis. *Am J Kidney Dis* 2000; 36: 581–591
5. Kouidi E, Albani M, Natsis K *et al.* The effects of exercise training on muscle atrophy in haemodialysis patients. *Nephrol Dial Transplant* 1998; 13: 685–699
6. Park MO, Fast A, Gopal S *et al.* Exercise for the dialysed: aerobic and strength training during hemodialysis. *Am J Phys Med Rehabil* 2002; 81: 814–821
7. Konstantinidou E, Koukouvou G, Kouidi E, Deligiannis A, Tourkantonis A. Exercise training in patients with end-stage renal disease on hemodialysis: comparison of three rehabilitation programs. *J Rehabil Med* 2002; 34: 40–45
8. Painter P, Moore G, Carlson L *et al.* Effects of exercise training plus normalization of hematocrit on exercise capacity and health-related quality of life. *Am J Kidney Dis* 2002; 39: 257–65
9. American College of Sports Medicine. *Position Stand: The Recommended Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory and Muscular Fitness and Flexibility in Healthy Adults*. 1998
10. Marcus BH, Banspach SW, Léfebre RC, Rossi JS, Carleton RC, Abrams DB. Using the stage of change model to increase the adoption of physical activity amnong community participants. *Am J Health Prom* 1992; 6: 424–429

11. Moher D, Schulz KF, Altman DG. The CONSORT statement: revised recommendations for improving the quality of reports of parallel-group randomised trials. *Lancet* 2001; 357: 1191–1194
12. Miller WR and Rollnick S. *Motivational Interviewing. Preparing People to Change Addictive Behavior*. Guilford Press, New York; 1991
13. Åstrand PO, Rodahl KA. *Textbook of Work Physiology: Physiological Bases of Exercise*, 3rd edn. McGraw-Hill, New York; 1986
14. Csuka M and McCarthy DJ. Simple method for measurement of lower extremity muscle strength. *Am J Med* 1985; 78: 77–81
15. Van Heuvelen MJG, Kempen GIJM, Ormel J, Rispens P. Physical fitness related to age and physical activity in older persons. *Med Sci Sports Exerc* 1998; 30: 434–441
16. Zee KI van der, Sanderman R. *Measuring General Health: RAND-36: A Manual (Dutch Version)*. Noordelijk Centrum voor Gezondheidsvraagstukken reeks meetinstrumenten 3, Groningen, The Netherlands; 1993
17. Parfey PS, Vavasour HM, Henry S, Bullock M, Gault MH. Clinical features and severity of nonspecific symptoms in dialysis patients. *Nephron* 1988; 50: 121–128
18. Dugan, W, McDonald MV, Passik SD, Rosenfeld BD, Theobald D, Edgerton S. Use of the Zung Self-Rating Depression Scale in cancer patients: feasibility as a screening tool. *Psycho-oncology* 1998; 7: 483–493
19. Bosscher RJ, Laurijssen L, de Boer, E. Measuring physical self-efficacy in old age. *Percept Mot Skills* 1993; 77: 470
20. Cohen, *Statistical Power Analysis for the Behavioral Sciences*. Academic Press, New York; 1969

Received for publication: 25.11.03
Accepted in revised form: 22.9.04