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Feasibility, physical capacity, and health benefits of a multidimensional exercise program for cancer patients undergoing chemotherapy

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Abstract Cancer patients frequently experience considerable loss of physical capacity and general well-being when diagnosed and treated for their disease. The aim of this study was to evaluate the feasibility, physical capacity, and health benefits of a multidimensional exercise program for cancer patients during advanced stages of disease who are undergoing adjuvant or high-dose chemotherapy. The supervised program included high- and low-intensity activities (physical exercise, relaxation, massage, and body-awareness training). A total of 23 patients between 18 and 65 years of age (median 40 years) participated in groups of seven to nine patients for 9 h weekly for 6 weeks. Physical capacity in terms of repetition maximum (RM) and maximal oxygen uptake (VO_2max), physical activity level and psychosocial wellbeing (EORTC QLQ-C30, SF-36, HAD) were compared prior to and after completion of the program. The program was safe and well tolerated. The completion rate was 85.2%. Highly significant increases in physical capacity (1RM, VO_2max) and an improved level of physical activity were achieved. Quality of life and general wellbeing assessments indicated improvements in several measures, but without reaching significance. It is concluded that an exercise program, which combines high- and low-intensity physical activities, may be used to prevent and/or minimize physical inactivity, fatigue, muscle wasting and energy loss in cancer patients undergoing chemotherapy.

Keywords Exercise · Chemotherapy · Muscle strength · Physical capacity · Health benefits

Introduction

It is well known that patients undergoing cancer chemotherapy experience symptoms and side effects, e.g. nausea, vomiting, infections, reduced appetite, etc. [27, 37, 52, 67]. Recent surveys have shown that fatigue is the most frequent and burdensome side effect of chemotherapy and results in impaired or diminished physical activity [23, 39, 60, 64]. In addition, psychosocial problems often follow the diagnosis of cancer and subsequent treatment with chemotherapy [8]. For some cancer patients, diagnosis and treatment are synonymous with an inactive daily life [54], resulting in significant loss of muscle mass, and strength [21]. A series of studies have shown that rehabilitation may improve a cancer patient's oxygen uptake, physical fitness and quality of life (QOL). However, these studies were generally small, non-randomized and home-based, with little control of the amount of physical activity undertaken [7]. It is thus difficult to specifically determine which patient group

Table 1 Weekly schedule

Monday	Tuesday	Wednesday	Thursday	Friday
Physical exercise (1.5 h) Relaxation (0.5 h) Massage (0.5 h)	Body awareness (1.5 h) Relaxation (0.5 h)	Physical exercise (1.5 h) Relaxation (0.5 h)		Physical exercise (1.5 h) Relaxation (0.5 h) Massage (0.5 h)

(stage of illness, diagnosis and treatment) may benefit from physical activity in general, at what intensity rate and with what forms of activity.

Most patients in the previous studies have been women with breast cancer to whom a physical exercise program was offered in connection with adjuvant treatment [47, 48, 49, 70, 71, 73] and/or following cytostatic treatment [13, 51, 61]. In a small number of intervention studies, attempts have been made to use physical training programs for cancer patients with diagnoses other than breast cancer, e.g. patients with hematological malignancies [20, 22, 24, 62], or oncological and hematological patients have been included [25, 26, 28]. Seven studies were identified in which patients undergoing chemotherapy were included. Six of these were clinically controlled [26, 48, 49, 61, 71, 73]. With one exception [26], the patients in these studies were women with breast cancer who were undergoing adjuvant treatment [48, 49, 61, 71, 73], and the main form of training was aerobic interval training on a stationary bicycle equipped with an ergometer (10 to 26 weeks). Collectively, the results of these studies point to the fact that exercise can reduce physical inactivity, fatigue and nausea.

Clinically controlled trials have demonstrated that intervention with relaxation training and massage can have a positive impact on the symptoms and side effects of cancer patients undergoing chemotherapy. These interventions have focused on muscle relaxation as well as on breathing exercise [31, 33, 55, 69] with the belief that relaxation can prevent side effects and treatment-related anxiety [6, 17, 43, 45, 65]. Furthermore, relaxation can be seen as a means of achieving psychological and psychosocial goals (coping, counteracting stress, depression and anxiety) [6, 14, 17, 55, 63, 65]. Similarly, sports science and psychology have shown that training in body awareness can be used by athletes to release tension and to control anxiety [53, 66].

This body of research provides evidence that physical activity, relaxation, massage, and body-awareness training can each positively impact on physical capacity and psychosocial wellbeing of cancer patients. We chose to test an intervention which combines the above-mentioned different elements to maximize its effect. Our hypothesis was that the intervention would increase physical capacity and general wellbeing of the cancer patients as well as reduce their level of anxiety and the side effects of chemotherapy.

The aim of this study was to determine the feasibility, safety and possible benefits of a supervised, structured physical exercise and group intervention program for cancer patients undergoing chemotherapy.

Patients and methods

Intervention program

The intervention program included a so-called "body package" comprising four components: physical exercise, relaxation, massage, and body-awareness training. Patients undertook activities that were classified as either high or low intensity. High-intensity activities were those that considerably raised the heart rate and included heavy resistance training and cycling on a stationary bicycle. Low-intensity activities required lower energy expenditure by patients and took the forms of relaxation, massage and body-awareness training. The program took place in specially designed workout rooms located at the hospital and was carried out over a 6-week period, 9 h per week in the mornings (see Table 1). The patients trained in mixed groups (men and women) of seven to nine patients each. During the program, time was set aside for patients to exchange experiences (work, family, illness and treatment). The program was supervised by trained physiotherapists and a specially trained nurse who participated in the physical training component.

High-intensity physical training

The patients trained in groups for 1.5 h per session three times weekly. Physical training was divided into three components: warm-up exercise, heavy resistance training and fitness. Warm-up exercise comprised dynamic actions with the large muscle groups, balance and coordination training (running, ball games and weight-lifting). Three machines were used for heavy resistance training including a leg press, a chest press and a lat machine (Technogym, Gambettola, Italy). The practical goal in the training component was to accomplish three continuous series of five to eight repetitions at 85–95% of one repetition maximum (1RM). This selection of heavy resistance training activities was made in an attempt to involve as many muscle groups in as few exercises as possible, allowing a noticeable effect to be accomplished in a short time span (10 min, two to three times weekly) [34]. Fitness training took the form of aerobic activities which involved large muscle groups over longer periods of time and which aimed to positively affect circulation and overall energy levels [30, 57, 59]. The exercise involved 10 min interval training on a stationary bicycle with an intensity of 150–250 W equivalent to 60–100% of each patient's maximum pulse rate.

Low-intensity physical training

Relaxation. The patients trained in groups for 0.5 h four times weekly. Groups of patients were instructed in the use of relaxation mechanisms, using principles of progressive relaxation [40]. This involves switching from muscle tensing to muscle relaxation motions in each of the muscle groups. The relaxation training took

place in the workout room, where the patients lay on mats with pillows and rugs. The patients used audio tapes with recorded instructions and relaxing background music.

Massage. The patients received individual treatment for 0.5 h twice weekly. Massage could be relaxing, facilitative or therapeutic. Classic, scar tissue and venous pump massages were administered as well as ultrasound and exercise therapy [16].

Body awareness training. The patients trained in groups for 1.5 h once weekly. Special emphasis was placed on physical movement and the purpose of exercise in increasing body acceptance, awareness and knowledge, and focused on balance/coordination and grounding and integration of the senses [9, 29, 32, 38].

Procedure

Cancer patients were initially attracted to the project by posters and pamphlets at the outpatient clinic or in the ward. Recruitment was carried out through efforts made by nurses and doctors in informing patients about the project, after which the patients contacted the project team directly.

Patients aged 18–65 years of either gender with a diagnosis of cancer (given at least 1 month previously) who were admitted to hospital for outpatient chemotherapy either as treatment for advanced disease or as part of an adjuvant treatment at the oncological or hematological clinic were included. The patients had received at least one series of chemotherapy treatment and had a WHO performance status of 0–1. The exclusion criteria included: documented brain or bone metastases; anticoagulation treatment; a previously diagnosed symptomatic cardiac disease, including clinical congestive heart disease; treatment for arrhythmia or myocardial infarction within the last 3 months; dementia or psychotic condition; terminal care; and unable to write or read Danish.

Ethical considerations

The project was approved by the Scientific Committees of the Copenhagen and Frederiksberg Municipalities (J.no. 01-273/00) and by the Danish Data Protection Agency (J.no. 2000-41-0-149). A total of 27 cancer patients gave informed consent to enter the study. Two patients withdraw, one due to progressive acute illness, and the other due to lack of sense of belonging to the group. Thus, 25 cancer patients completed the 6-week intervention. Two patients were excluded from the dataset because their chemotherapy treatments terminated prior to completion of the program. The remaining patients (n=23) received chemotherapy as determined by their oncologist/hematologist. Two patients completed the program but failed to give post-testing data.

Screening and monitoring

In accordance with the guidelines and safety precautions determined by Winnningham et al. [72] and Dimeo et al. [26], daily pre-exercise screening was performed. If one of the following criteria was met, the patient was excluded from the physical training component of the program on that specific day: diastolic blood pressure <45 or >95 mmHg; pulse at rest >100/min, temperature >38°C, respiration frequency at rest >20/min, infection requiring treatment with antibiotics, ongoing bleeding, fresh petechiae, bruises, thrombocytes $<50\times10^9$/l, or leukocytes $<1.0\times10^9$/l. Monitoring was carried out by means of a sphygmomanometer (Polar Xtrainer Plus) worn by the patients during physical training as well as by observations made by the nurse.

Table 2 Demographic characteristics of patients (n=23)

Age (years)	
Median	40
Range	18–63
Gender	
Women	14
Men	9
Body mass index (kg/m^2)	
Median	26.1
Range	20.1–34.8
Cohabiting	
Yes	14
No	9
Education	
Lower level	7
Secondary school/university graduate	16
Employed (during treatment)	
Yes	4
No	19
Level of physical activity before onset of disease	
I (sedentary)	1
II (walking or cycling for pleasure)	10
III (regular physical exercise—at least 3 h/week)	8
IV (athletic—more than 4 h/week)	4

Subjects

The demographic characteristics of the patients and their diagnosis and treatment are detailed in Tables 2 and 3, respectively.

Assessment instruments

Demographic data were collected at baseline. Disease variables and treatments were obtained through review of medical records [74]. Assessments were made at baseline (test 1) and repeated after 6 weeks (test 2). The battery of tests included: (1) two physiological tests measuring one repetition maximum (1RM) and maximal oxygen uptake (VO_2max), (2) three questionnaires (EORTC QLQ-C30, SF-36, HAD), (3) a body and physical training record, (4) a patient diary, (5) interviews, and (6) patient observation. We present here the results from the first three of these.

Physical capacity

Muscular strength. Estimated 1RM tests were used to evaluate upper and lower body strength potential [15, 56]. The tests involved performance on Technogym variable resistance equipment and targeted the large muscle groups as follows: (1) chest press (focusing on the pectoral muscles, the foremost part of the deltoids, the triceps and secondary muscles of the serratus anterior and the coracobrachialis); (2) leg press (knee extensors, hip extensors, hip adductors and ankle joint flexors); and (3) pull-down/lat machine (targeting the latissimus dorsi, teres major, posterior deltoids, biceps, brachialis, brachioradialis, erector spinae, rhomboideus, trapezius). 1RM is stated in kilograms.

Aerobic capacity. Aerobic capacity of the participants was indirectly estimated using stepwise work capacity on an exercise bicy-

Table 3 Patient characteristics: diagnosis and treatment (*n*=23) (*ABVD* doxorubicin, bleomycin, vinblastine, dacarbazine; *B* bleomycin; *CARBO* carboplatin; *CEP* cyclophosphamide, epirubicin, fluorouracil; *CHOP* cyclophosphamide, doxorubicin, vincristine, prednisone; *CMF* cyclophosphamide, methotrexate, 5-fluorouracil; *COP* cyclophosphamide, vincristine, prednisone; *E* epirubicin; *ET* etoposide; *5-FU* 5-fluorouracil; *G* gemcitabine; *I* ifosfamide; *LV* leucovorin; *NC* residual disease, no change; *NED* no evidence of disease; *P* cisplatin; *PR* partial remission; *T* taxanes; *TOPO* topotecan; *V* vincristine; *VAD* vincristine, doxorubicin, dexamethasone)

	n	Diagnosis	Stage	Treatment	Status
Oncological	6	Colon	Four adjuvant, two advanced	5-FU+LV	NED, NC
	5	Breast	Three adjuvant, two advanced	CEF, CMF, T, E	NED, NC
	2	Ovary	One adjuvant, one advanced	TOPO, CARBO, T	NED, NC
	2	Testis	Two advanced	P, ET, B	One PR, one NC
	1	Sarcoma	Advanced	I	NC
	1	SCLC	Advanced	T, P, E, ET	NC
	1	Unknown primary	Advanced	G, P, T	NC
	1	Cervix	Adjuvant	CARBO, V, ET	NED
Hematological	1	Hodgkin's disease	Advanced	ABVD	NC
	1	Non-Hodgkin's lymphoma	Advanced	CHOP	NC
	1	Myelomatosis	Advanced	VAD	NC
	1	Acute lymphoblastic leukemia	Maintenance	Mercaptopurine, Methotrexate, COP	NED

cle (Monark Ergomedic 839E) [5]. The first part of the test was a "steady rate" test of 8-min duration while the second part comprised a "watt max" test. The steady rate test was started with a work load of 67 W over 8 min with the participant's pulse rate being recorded during the final minute of the test. The watt max test was started with a work load of 67 W, which was increased by 20 W every minute. The test was terminated when the participant could not or did not wish to continue cycling. The heart rate, the workload, and total time were then recorded. VO_2max was estimated using the formula VO_2max=0.16+(0.0117×MPO), where MPO is maximal power output in Watts, as previously described by Andersen [5].

Questionnaires

Quality of life. The European Organization for Research and Treatment of Cancer Quality of Life Questionnaire C30 (EORTC QLQ-C30) comprising 30 items was administered [1]. The EORTC QLQ-C30 assesses health-related QOL in cancer patients and consists of six functional scales (physical, role, cognitive, emotional, and social functioning, and global QOL), three symptom scales (fatigue, nausea, vomiting, and pain) and six individual items assessing sleep disturbance, constipation, diarrhea, appetite loss, dyspnea, and the financial impact of the disease and treatment [36]. Internal reliability coefficients range from 0.52 to 0.89 [1].

General wellbeing. The MOS 36-item Short-Form Health Survey (SF-36) comprising 36 items was administered [68]. The SF-36 contains eight scales measuring general health concepts. Each scale comprises a total of all of the raw scores and is later converted to a 0–100 scale. It is furthermore possible to calculate two global measures specifically related to the physical and psychological functioning levels. This instrument displays substantial reliability, reflected by Cronbach's alpha values ranging from 0.62 to 0.93 [12, 46].

Psychological wellbein. The Hospital Anxiety and Depression Scale (HAD) comprising 14 items was administered [18, 41, 75]. The HAD was designed to measure general anxiety and depression and was developed in 1983 by Zigmond and Snaith [44, 75] for use in investigations concerning patients with physical illness. Moorey et al. reported Cronbach's alpha values of 0.93 and 0.90, respectively, for the anxiety and depression scale [50].

The body and physical training record

Information on diagnosis and the form of chemotherapy administered (e.g. oral, subcutaneous, intravenous) as well as its duration was obtained. Furthermore, the patient's leisure time physical activity level was recorded and included estimates from before the start of the illness, at baseline, and following the 6-week period of training. These were classified as (I) sedentary (completely inactive), (II) walking or cycling for pleasure, (III) regular physical exercise at least 3 h per week, or (IV) intense regular physical training at least 4 h per week [35, 58].

Data analysis

Data were entered into Excel using Microsoft Office 2000 Professional for Windows 2000. Data were entered by two researchers who cross-checked each other's actions in order to control for typing errors. Descriptive statistics and paired sample *t*-tests were computed using SPSS 11.0 for Windows. Paired sample *t*-tests compared baseline measurements with end-of-program measurements for all dependent variables. *P* values of 0.05 were taken as indicating statistical significance. Data are presented as means±SD.

Results

Feasibility

As more patients signed up to the study than could be accommodated, a waiting list was established. The pilot study included 23 patients, thus reflecting an 85.2% completion rate.

Safety and tolerability

During daily screening procedures, three patients were excluded from the physical training component three times during the entire program due to fever, infection

Table 4 Muscular strength and aerobic fitness

Measure	Improved	Worsened	Unchanged	Missing	t^a	P^a	Baseline		Week 6	
							Mean	SD	Mean	SD
VO_2max (l/min)	15	3	2	3	−4.05	0.001	2.25	0.53	2.61	0.64
RM chest press (kg)	16	1	4	2	−5.40	0.000	47.14	18.6	56.19	22.3
RM leg press (kg)	21	0	0	2	−9.83	0.000	110.48	27.5	159.10	39.5
RM pull down (kg)	20	0	1	2	−8.08	0.000	51.19	17.2	61.43	17.2
RM total (kg)	21	0	0	2	−10.52	0.000	208.81	51.7	276.71	63.4

[a] Paired one-sampled *t*-test

requiring treatment, and/or risk of bleeding. In accordance with daily exclusion criteria, no patient who participated in the physical training component suffered from marrow toxicity with thrombocytes below 50×10^9/l and leukocytes below 1.0×10^9/l. No patient showed signs of any untoward physical reaction (cardiac or respiratory arrest, hypotension, etc.). The daily screening procedures and observation of body signals (e.g. pausing at signs of dizziness, fatigue, etc.) made by the study nurse as well as by the patients themselves acted to optimize patient safety during the program.

Physical capacity

Over the 6 weeks of treatment, highly significant increases in physical capacity measures were observed. Paired sample *t*-tests indicated a significant increases in aerobic capacity ($t(20)=-4.05$, $P<0.001$), chest press ($t(20)=-5.40$, $P<0.001$), leg press ($t(20)=-9.83$, $P<0.001$), pull-down ($t(20)=-8.08$, $P<0.001$) and total strength potential, i.e. total increase across the three strength potential measures, ($t(20)=-10.52$, $P<0.001$). The patients' improvement in chest press was 19.2%, leg press 44% and pull down 20%. Total increase in strength was 32.5% (minimum 3.8%, maximum 79%). The patients' average rate of VO_2Max improvement was 16% (minimum −28.5%, maximum 59.1%). These results are summarized in Table 4.

A majority of the patients showed a decrease in activity level during the period from before their illness (pre-illness) to when the intervention started (baseline) as seen in Table 5: 52.2% ($n=12$) had a level of physical activity of more than 3 h per week (levels III and IV) prior to the start of their illness compared with 4.4% ($n=1$) on entry to the program. An increase in activity level was seen from baseline to end of the 6-week intervention period, and 82.5% of the patients achieved activity levels III and IV as a consequence of their participation in the program.

Table 5 Leisure time physical activity level (I–IV) ($n=23$)

Level	Pre-illness	Baseline	Week 6
I (sedentary)	1 (4.4%)	13 (56.5%)	1 (4.4%)
II (pleasure)	10 (43.4%)	9 (39.1%)	3 (13.1%)
III (>3 h/week)	8 (34.8%)	0	12 (52.1%)
IV (>4 h/week)	4 (17.4%)	1 (4.4%)	7 (30.4%)

Health benefits

None of the single measures assessing health-related QOL (EORTC-OLQ-C30) showed measurable significance. However, the results, shown in Table 6, indicate a trend towards a general improvement in several single measures, including global health status, physical role and emotional functioning and, to a lesser degree, social functioning and fatigue. Conversely, it is important to note the substantial number of patients showing no change or a decrease in QOL measures.

General wellbeing, SF-36

The SF-36 measures general health concepts. Significant improvement was seen only in relation to the role physical scale (RP) ($t(20)=-2.58$, $P<0.05$). As seen in Table 7, there was a trend towards general improvement in most of the subscales. In terms of physical function, bodily pain, general health perceptions, vitality, social function, role emotional and mental health, a majority of patients improved or showed no decline during the 6-week program. However, it is important to note that in six out of eight subscales, a considerable proportion of the patients showed decreased levels of wellbeing.

Psychological wellbeing, HAD

As seen in Table 8, neither the anxiety nor the depression measures (HAD) indicated significant changes. A majority of the patients (54.5%) showed improved (reduced) anxiety levels while a minority (40.9%) reported an increase in depression levels.

Table 6 Health-related quality of life (EORTC-QLQ-C30) (*n*=22)

Measure	Improved	Worsened	Unchanged	*t*[a]	*P*[a]	Baseline		Week 6	
						Mean	SD	Mean	SD
Global health status	12 (54.5%)	6 (27.3%)	4 (18.2%)	–1.53	0.14	53.8	19.0	61.0	22.3
Physical functioning	12 (54.5%)	4 (18.2%)	6 (27.3%)	–1.71	0.10	80.3	12.6	85.5	14.3
Role functioning	12 (54.5%)	4 (18.2%)	6 (27.3%)	–1.65	0.11	53.0	25.0	64.4	33.1
Emotional functioning	12 (54.5%)	4 (18.2%)	6 (27.3%)	–1.57	0.13	75.0	21.7	80.7	19.3
Cognitive functioning	6 (27.3%)	5 (22.7%)	11 (50.0%)	–0.68	0.50	71.2	26.8	73.5	24.5
Social functioning	10 (45.5%)	6 (27.3%)	6 (27.3%)	–1.25	0.23	69.7	26.5	75.8	23.4
Fatigue	11 (50.0%)	6 (27.3%)	5 (22.7%)	0.79	0.44	49.0	23.4	44.4	22.8
Nausea and vomiting	5 (22.7%)	5 (22.7%)	12 (54.5%)	–0.19	0.85	13.6	17.5	14.4	15.7
Pain	9 (40.9%)	6 (27.3%)	7 (31.8%)	0.62	0.54	25.8	19.1	22.7	19.0
Dyspnea	4 (18.2%)	6 (27.3%)	12 (54.5%)	–0.81	0.43	16.7	22.4	22.7	31.5
Insomnia	7 (31.8%)	3 (13.6%)	12 (54.5%)	1.67	0.11	31.8	36.3	21.2	28.3
Appetite loss	5 (22.7%)	4 (18.2%)	13 (59.1%)	–0.55	0.59	21.2	30.1	25.8	37.0
Constipation	6 (27.3%)	2 (9.1%)	14 (63.6%)	1.37	0.19	19.7	30.3	10.6	26.0
Diarrhea	5 (22.7%)	3 (13.6%)	14 (63.6%)	1.00	0.33	24.2	31.2	16.7	22.4
Financial difficulties	3 (13.6%)	4 (18.2%)	15 (68.2%)	–0.62	0.54	21.2	31.8	24.2	36.0

[a] Paired one-sample *t*-test (significance level 0.05)

Table 7 General wellbeing (SF-36) (*n*=22)

Measure	Improved	Worsened	Unchanged	*t*[a]	*P*[a]	Baseline		Week 6	
						Mean	SD	Mean	SD
Physical function	11 (50.0%)	6 (27.3%)	5 (22.7%)	–0.86	0.40	78.4	17.6	81.9	19.0
Role physical	9 (42.9%)	2 (9.5%)	10 (47.6%)	–2.58	0.02	10.7	16.9	31.8	41.7
Bodily pain	13 (61.9%)	6 (28.6%)	2 (9.5%)	–1.99	0.06	57.6	21.3	67.3	18.8
General health perceptions	13 (61.9%)	7 (33.3%)	1 (4.8%)	–1.63	0.12	53.6	23.7	58.6	24.9
Vitality	11 (52.4%)	8 (38.1%)	2 (9.5%)	–0.87	0.39	52.6	14.9	58.0	22.3
Social function	11 (50.0%)	7 (31.8%)	4 (18.2%)	–1.51	0.14	71.6	27.9	77.3	23.4
Role emotional (RE)	9 (42.9%)	3 (14.3%)	9 (42.9%)	–1.98	0.06	46.0	44.1	66.7	39.8
Mental health	13 (59.1%)	8 (36.4%)	1 (4.5%)	–1.50	0.15	71.8	14.7	77.5	14.7

[a] Paired one-sample *t*-test (significance level 0.05)

Table 8 Anxiety and depression (HAD) (*n*=22)

Measure	Improved	Worsened	Unchanged	*t*[a]	*P*[a]	Baseline		Week 6	
						Mean	SD	Mean	SD
Anxiety	12 (54.5%)	9 (40.9%)	1 (4.5%)	1.10	0.22	5.4	2.8	4.5	3.0
Depression	7 (31.8%)	9 (40.9%)	6 (27.3%)	0.32	0.76	4.5	3.0	4.0	3.6

[a] Paired one-sample *t*-test (significance level 0.05)

Discussion

This study provided data on feasibility, safety and tolerability of a four-component, structured, supervised physical exercise program for cancer patients undergoing chemotherapy. The study included a heterogeneous sample of cancer patients with respect to gender, cancer type, stage of disease and medical (cytostatic) treatments. To the best of our knowledge, this is the first study that combined high- and low-intensity activities. Previous studies have mainly examined the effects of unmonitored aerobic activity. These studies typically used a single physical activity (e.g. a stationary bicycle fitted with an ergometer), thus making direct comparisons difficult.

Despite the demanding nature of the program, a completion rate of 85.2% was achieved, which is above average for psychosocial/QOL interventions without exercise (social support programs, psychotherapy, etc.) [19]. The reports of only a few other studies involving physical activity give information on the number of patients com-

pleting the programs. This is possibly due to the fact that most of these programs involved home-based interventions and lacked rigorous monitoring. The results of this investigation are partially comparable with the completion rate of the study conducted by Kolden et al. [42], which involved a supervised, structured group exercise program (1 h, three times per week, duration 16 weeks) with a 78.4% completion rate among 40 sedentary breast cancer patients (stage I, II, III), of whom 65% were receiving chemotherapy. The existing data are also comparable with completion rates for clinical intervention studies of lesser dosage/intensity in cancer patients who had completed chemotherapy and in which physical activity was carried out as part of their rehabilitation program [10, 11, 25]. There are several possible explanations for the high completion rate in our study. First and foremost, the patients experienced a sense of belonging to their respective groups. This confirms findings from our earlier research on the importance of group formation for male and female cancer patients [2, 3, 4]. Second, 19 of the 23 patients took leave of absence from their job during the program.

Regarding safety and tolerability, several authors have highlighted the potential risks connected with offering vigorous exercise to cancer patients undergoing chemotherapy [19, 26, 72]. One of these is the initial investigation in the field, from which guidelines and safety precautions were developed [72]. Despite this, there is no consensus currently in the literature about what advice can be given to cancer patients undergoing chemotherapy regarding the intensity, type and duration of physical activity they should undertake. The inclusion and exclusion criteria, the daily screening procedures, the presence of the nurse during physical training and training with a sphygmomanometer ensured the required level of safety in this study. The patients were strongly advised to evaluate their own physical capacity and to decide on the level of participation with which they felt comfortable. No adverse reactions occurred. Thus, the program proved to be safe for cancer patients undergoing chemotherapy. As such, it also overrode to a certain extent the original guidelines and safety precautions developed by Winningham et al., who warned that cancer patients undergoing chemotherapy or radiotherapy should be encouraged to lower their activity level during therapy (24 h in advance) [72]. In the present study, however, the majority of the patients undertook physical training on the same day or the day prior to receiving high-dosage cytostatic treatment, and no physical discomfort was reported in connection with exercising.

Our program combined high-intensity physical training with low-intensity relaxation and body awareness components. It is our belief that these elements supported each other and would be suitable for patients during periods of active treatment. We therefore consider that a cancer patient often has the potential to reverse physical impairments, fatigue and general lack of energy that is generally associated with cancer chemotherapy. On the basis of patient interviews, whether a multidimensional program has an influence on bodily discomfort or wellbeing has been explored (data presented elsewhere). The positive responses from the patients compared with the objective findings have provided the basis for the program to continue unchanged in phase 2. The experience from this study also shows that a cancer patient needs breaks during heavy resistance training and conditioning exercises.

As hypothesized, this group of cancer patients showed a significant improvement in muscular strength and aerobic capacity by the end of the intervention period. The average improvement in dynamic strength was 32.5% and 16% improvement in aerobic capacity (VO_2max). No published results were found which are directly comparable with those of this study. One specific aspect in this regard is the use of different physiological tests to measure physical capacity, which opens the possibility of misinterpretation. Finally, we identified only a few studies in which an attempt was made to measure muscle strength of cancer patients using valid objective methods (e.g. 1RM) [42, 62]. In the study by Kolden et al., patients achieve an average improvement in strength of 37% in leg presses, while the patients' average improvement in this study was 44% measured with the same variable. Regarding bench press, Kolden et al. found an improvement of 34.4% from start to finish, which is in agreement with the result in this study of 32.5% (total strength). Furthermore, we found an increase of 16% in VO_2max while Kolden et al. found an increase of 11.9%—both significant results [42]. In contrast, Segal et al. found no significant improvement in aerobic capacity in their controlled study of women with breast cancer undergoing chemotherapy [61].

In our study the participating patients were physically active *before* the start of the illness. More specifically, the fact that the population was relatively young and physically active (median 40 years of age) could have influenced their engagement in and sense of wellbeing during the program. The majority felt that they missed physical activity and that they felt tired and were insecure about what type and level of intensity of physical activity they could undertake after the onset of their illness and during chemotherapy. This circumstance persisted despite any dramatic fall in activity level in connection with the onset of further illness and/or treatment. Thus 95.7% of the patients were able to increase their level of physical activity substantially by the end of the program.

The EORTC QLQ-C-30 did not reveal any significant change during the program. In the absence of a control group it is difficult, however, to estimate whether there was an effect, as some of the patients actually reported an increase in QOL parameters. Looking at the average and median values, relatively low levels can be seen on

several scales. Against the backcloth of available SF-36 data, it is estimated that the majority of the patients experienced an improvement or at least an unchanged level in several aspects following 6 weeks participation in the intervention program. Most of the patients experienced an increase in global measurements while more specific and defined problem areas (nausea, vomiting, and pain) most often remained unchanged. This may be explained by the fact that the training program had no influence on these problems. Another possible explanation is that the patients had relatively low scores in some specific problem areas at the beginning of the training period.

The results of the HAD test showed that nine patients experienced a decline in their level of depression, while six patients remained unchanged and seven patients showed improvement; thus the differences were marginal. However, the findings are understandable in the light of the patients' generally strained life, i.e. being of relatively young age and confronted with a life-threatening disease.

Although the psychometric tests used here were not the same as used in other comparable studies on physical activity that included cancer patients undergoing chemotherapy, the results of this study are in line with the results of other studies measuring QOL benefits and psychological wellbeing [19, 23, 26, 28, 60].

With regard to limitations of the study, the small number of patients (n=23) and the absence of a control group mean that the study lacked statistical strength, and thus did not allow valid conclusions to be reached on the basis of the results obtained. The three standardized psychosocial questionnaires were selected for their ability to predict changes in one or more classifiable phenomena in the specific population. In pilot studies with small populations, these methods were insufficiently sensitive to detect changes resulting from a specific intervention. We therefore chose to supplement these methods with our own testing methods (both quantitative and qualitative). Our methods were developed to provide knowledge about the uniqueness of and subtle differences between the studied phenomena (the results of which are published elsewhere). Seen in relation to the project's major theses, these preliminary results from 23 oncological and hematological cancer patients at different stages of the disease and undergoing different treatments confirmed that the majority of the patients showed an improvement in their condition. The benefits of the intervention program for different diagnostic groups and its clinical significance can only be defined following the project's second (diagnosis testing) and third (randomizing) phases, during which a larger population and more in-depth analyses should ensure that valid conclusions can be reached.

In conclusion, the results of our study show that cancer patients undergoing chemotherapy showed an improvement in their physical capacity (muscle strength, aerobic capacity), physical activity level and general wellbeing during a 6-week multidimensional exercise program carried out four times weekly in groups. An individual's desire and ability to undertake 9 h of structured physical activity and to participate in a group do not appear to be negatively affected by chemotherapy. Physical programs that combine high- and low-intensity activities may be used as complementary support for cancer patients undergoing chemotherapy. In this way, it may be possible to prevent and minimize physical inactivity, fatigue, muscle wasting, and loss of energy.

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