Bone Marrow Transplantation (2004) 33, 553–558

www.nature.com/bmt

Quality of life

Quality of life changes following peripheral blood stem cell transplantation and participation in a mixed-type, moderate-intensity, exercise program

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Summary:

The purpose of this investigation was to evaluate the impact of undertaking peripheral blood stem cell transplantation (PBST) on quality of life (QoL), and to determine the effect of participating in a mixed-type, moderate-intensity exercise program on QoL. It was also an objective to determine the relationship between peak aerobic capacity and QoL in PBST patients. QoL was assessed via the CARES questionnaire and peak aerobic capacity by a maximal graded treadmill test, pretransplant (PI), post transplant (PII) and following a 12-week intervention period (PIII). At PII, 12 patients were divided equally into a control or exercise intervention group. Undergoing a PBST was associated with a statistically but not clinically significant decline in QoL ($P<0.05$). Following the intervention, exercising patients demonstrated an improved QoL when compared with pretransplant ratings ($P<0.01$) and nonexercising transplant patients ($P<0.05$). Moreover, peak aerobic capacity and QoL were correlated ($P<0.05$). The findings demonstrated that exercise participation following oncology treatment is associated with a reduction in the number and severity of endorsed problems, which in turn leads to improvements in global, physical and psychosocial QoL. Furthermore, a relationship between fitness and QoL exists, with those experiencing higher levels of fitness also demonstrating higher QoL.
Bone Marrow Transplantation (2004) **33,** 553–558. doi:10.1038/sj.bmt.1704378
Published online 12 January 2004
Keywords: quality of life; fitness; aerobic exercise; resistance training

As a consequence of continuous progress in medical science, numerous previously fatal diseases are now curable and the severity of others has been effectively reduced.[1] Currently, 59% of patients diagnosed with cancer are expected to live longer than 5 years.[2] Unfortunately, cancer diagnosis and oncology treatments are associated with physical and psychological consequences, which adversely influence quality of life (QoL).[3] Diminished cardiovascular function, reduced strength and deterioration of lean body tissue, body composition changes, fatigue, pain, weakness, insomnia, gastrointestinal problems, shortness of breath, sweating and anorexia constitute some of the known physical side effects.[4] Depression, anxiety, stress, reduced self-esteem, loss of sense of control and diminished psychological and emotional well-being comprise the potential psychological consequences.[4] Many of these side effects have been reported by patients following high-dose chemotherapy and bone marrow transplantation (BMT), and it is therefore not surprising that these patients also report reduced QoL following treatment.[5]

The need for intervention strategies to assist in mitigating the adverse effects on QoL of cancer and its treatment is evident. 'Physical exercise is a fundamental aspect of the QoL'[6] and has been associated with physiological and psychological health benefits within the healthy population. A review of 24 studies published between 1980 and 1997 regarding exercise, QoL and cancer also showed that physical exercise has been consistently associated with a positive effect on QoL following cancer diagnosis.[4] Importantly, exercise was found to induce a beneficial effect on both global QoL as well as components of QoL including physical, functional, psychological, emotional and social well-being. A decrease in the total mood disturbance,[7] sleep disturbance, depression, anxiety, fatigue and nausea,[8] and an enhanced perceived internal locus of control,[9] self-esteem, self-confidence,[10] life satisfaction[11] and overall QoL,[12] have been reported among exercising cancer patients. Further, patients perceive exercise as a stress-controlling mechanism that assists them in coping with the disease, while at the same time allowing them to maintain a sense of control over their lives.[13]

Although the majority of this research has focused on aerobic exercise and breast cancer patients, exercise participation during hospitalisation for BMT has also been associated with improvements in physical well-being, depression, anxiety and psychological well-being.[14]

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Received 12 June 2003; accepted 03 September 2003
Published online 12 January 2004

Additionally, significantly fewer medical complications, including duration of neutropenia and thrombocytopenia and severity of diarrhoea and pain, have been found in exercising BMT patients.[15]

Mounting evidence indicates that participation in a physical exercise program pre-, during and post treatment could address a broad range of physical and psychological issues associated with cancer diagnosis and treatment. However, research to date has been regarded as ‘positive but preliminary’.[11] It is therefore necessary to not only replicate but also extend the current work within the domain of cancer, exercise and QoL. This includes testing the current boundaries of exercise prescription for this patient group. The purpose of this study was to investigate changes in QoL following high-dose chemotherapy and peripheral blood stem cell transplant (PBST), and to investigate the impact of participating in a 3-month duration, moderate-intensity, mixed-type exercise program on QoL, post PBST. Impairment in physical fitness is a substantial contributor to reduced QoL in patients with cancer.[16] It was therefore also an objective to investigate the relationship between peak aerobic capacity (fitness) and QoL among PBST patients.

Methodology

Subjects

Mean changes of 10% or greater from baseline (PI) in QoL and of $5\,\text{ml}\,\text{kg}\,\text{min}^{-1}$ or greater in peak aerobic capacity, between or within groups, were considered to be of clinical interest. At the time of sample size calculations, no data were available with regard to QoL scores derived from the use of the CARES in this patient group. Consequently, sample size calculations were based on aerobic capacity data of patients following BMT (16.45 + 4.2 ml kg min).[17] Approximately 10 subjects per group were required to detect a 2 standard deviation difference with power and significance set at 80 and 5% (two-tailed), respectively. In all, 12 patients undertaking high-dose chemotherapy followed by autologous PBST at a private hospital in Brisbane, Australia, provided written informed consent to participate in this investigation. Patients ranged in age from 16 to 64 years, and included seven men and five women. Original cancer diagnoses included acute myeloid leukaemia, lymphoblastic lymphoma, breast carcinoma T_2 N_1 M_0 (two patients), breast carcinoma T_2 N_0 M_1, multiple myeloma (two patients), non-Hodgkin’s lymphoma (four patients) and rhabdomyosarcoma. Nine patients underwent one PBST, while the remaining three patients underwent a three-transplant protocol.

Following transplant, patients were divided into experimental and control groups. Initially, patients were to be randomly divided into two groups, with age stratification, as they presented to the study. Unfortunately, a slow recruitment rate and hence low subject numbers meant that randomising subjects could pose more problems during the statistical analysis relative to investigator allocation of patients. Therefore, the two groups were matched as closely as possible, taking into account both medical and nonmedical factors that might influence the level of change in an intervention project. These included age, gender, post-treatment weight, previous exercise history, living distance from the research centre, cancer diagnosis, number of transplants undertaken and type of high-dose chemotherapy regimen. The two groups were therefore generally comparable on these characteristics.[18]

Testing phases

This investigation consisted of three primary testing phases, pretreatment (phase I – PI), immediately post treatment (phase II – PII) and 3 months following PII (phase III – PIII). Due to variations in the time of recruitment, only seven patients were assessed during PI. Phase I occurred between 7 and 10 days before admission into hospital for the start of the high-dose chemotherapy regime. All 12 subjects were assessed during PII, which occurred 14–21 days following treatment. Treatment cessation was classified as the day of stem cell infusion. For those undertaking a three-transplant treatment regimen, this reflects the day of stem cell infusion of the last transplant. One patient, diagnosed with non-Hodgkin’s lymphoma and in the control group, relapsed prior to PIII, and therefore only 11 patients were assessed at PIII.

Exercise intervention

During PI and PII, the effect of the transplant was being assessed and all patients were considered to be in the same group (SG). Immediately after PII, patients were allocated to either the control/stretching group (CG) or the exercise intervention group (EG). Subjects within the CG participated in a 3-month stretching program, three times per week. Stretches were performed for all major muscle groups, with each stretch being taken to the point of discomfort, but not pain. To ensure that the same contact time was spent with the CG compared with the EG, the number of stretches performed across the 3 months progressed from 20 to 30, and the duration each stretch was held increased from 15 to 30 s. While participation in the stretching programme could potentially lead to mobility improvements, it was unlikely that the programme would lead to improvements in the outcomes of physical QoL and functional capacity. However, the tester/patient contact time could lead to improvements in psychosocial and global QoL.

In contrast, the exercising subjects participated in a 3-month, moderate-intensity, mixed-type exercise program. The program consisted of aerobic and resistance exercise. The aerobic component involved a combination of treadmill walking and stationary cycling, three times/week, for 20–40 min, at an intensity of 70–90% heart rate maximum. Each participant’s training heart rate range was calculated following a maximal graded exercise treadmill test. Progression in the aerobic component of the intervention was ensured throughout the 3-month programme by gradually increasing the exercise intensity and duration. The initial resistance-training program consisted of three exercises (seated bench press, latissimus pulldown and leg press) using machine weights. Within the fifth to sixth week of the programme, an upright row was introduced. By the

final week of the program, patients were performing two additional exercises (seated shoulder press and lunges) using free weights. All exercises were performed until the participant was unable to successfully complete one more repetition (ie, to failure). The weight was set to induce failure between 15 and 20 repetitions during weeks 1–6, followed by 8–12 repetitions during weeks 7–12. All participants kept physical activity logbooks, which were then checked to identify any additional physical activity performed, over and above the planned intervention.

Quality of life

The Cancer Rehabilitation Evaluation System (CARES) was used to assess QoL. The CARES is a standardised, comprehensive, rehabilitation and QoL questionnaire designed specifically for use with cancer patients.[19] The theoretical background, item and scale development of the instrument, and its reliability and validity, have been previously described.[20,21] The tool provides a global QoL score and global scores for five QoL domains, which are referred to as higher-order factors (HOF). The five HOF are physical, psychosocial (which covers psychological, emotional and social issues), medical interaction, marital and sexual. For each of these categories, further information is provided regarding the number of problems and the average severity rating of the identified problems.

The CARES consists of 139 items, 88 of which are completed by all patients. The remaining 51 items are only completed by patients when relevant. In total, a minimum of 93 items and a maximum of 132 items may apply to any one patient. Patients completing the questionnaire were required to read each item statement and rate how much the statement applied to them. The CARES utilises a five-point rating scale, ranging from 0 (the statement does not apply at all during the past month) to 4 (the statement applies very much during the past month). Due to the nature of the scoring system, a lower score corresponds with a higher QoL rating.

Three preliminary scores including the severity rating of a problem, the number of ‘endorsed’ problems and the number of potential problems were calculated for each summary scale. The average severity rating and the global score were then calculated. Following the computation of the raw scores, the data were converted to T scores using the tables provided in the CARES manual.[22] In summary, a global score, the number of endorsed problem (EP) score and average severity (AS) score were calculated for total QoL, and physical and psychosocial QoL.

Peak aerobic capacity

Patients participated in a patient-specific, maximal graded treadmill exercise test (GXT) to assess peak oxygen consumption (VO_{2peak}) using a Quinton treadmill (Q65 Series 90), electrocardiogram (ECG-Q4500) and gas-analysis machine (Q-Plex 1). Medical supervision was present at all testing sessions, and electrocardiography was continually monitored throughout the testing protocol. The treadmill speed began at a slower than ‘normal’ or ‘comfortable’ pace for each subject, with the initial workload set at a speed ranging between 1 and 4 km/h and a grade of 0. Depending on the heart rate, workload was increased every 1–2 min through the use of speed and/or grade. Standard criteria [23] were used to determine the test cessation, at which time VO_{2peak} was recorded (ml kg min^{-1}) and treadmill speed was reduced to a comfortable speed, as judged by the patient, at a 0% grade. Continual recordings of heart rate, blood pressure and electrocardiography occurred until HR was below 100 bpm.

Statistical analysis

As a consequence of the data set being incomplete (that is, $n = 7$, 12 and 11 at PI, PII and PIII, respectively), a random-effects mixed model (REMM) was applied to determine the group by phase interaction (exercise by time). Unlike the standard approach of a two-way repeated measures analysis of variance (RM-ANOVA), the REMM was able to accommodate the partially incomplete records and relatively small sample size, while maximising the power.[24] As a factor of the model specification, subjects were treated as random effects. Furthermore, simple contrasts were derived via the use of the REMM. The standard two-way ANOVA, with repeated measures on one factor (phase), was also applied to the data, and as such restricted the analysis to cases with data available at all testing phases. Consequently, power decreased and no statistical differences were detected in the analysis. However, the trend of change between measures was similar to that observed via the use of the REMM, lending support for the use of the latter model. Additionally, aerobic capacity and QoL measures at PII and PIII, as well as changes between PII and PIII, were assessed using Pearson correlation to determine the relationship between functional capacity and QoL. Statistical procedures were performed using the statistical package SPSS 10.0 for Windows. Outcome measures were approximately normal in distribution, and hence were summarised as means and standard deviations.

Results

While the adverse change in total QoL observed for the pooled group of participants between PI (54.2 ± 3.2) and PII (57.8 ± 1.7) reached statistical significance ($P = 0.02$), it was not clinically significant. The increases observed in the psychosocial and physical QoL scores from 51.5 ± 3.7 and 56.4 ± 5.6 at PI, respectively, to 54.5 ± 2.2 and 61.2 ± 3.2 at PII following high-dose chemotherapy and autologous PBST were neither clinically nor statistically significant ($P = 0.09$ and 0.07, respectively).

As shown in Table 1, regardless of whether patients participated in the exercise program following treatment, a 3-month recovery period was related to an improvement in global QoL ($P = 0.009$). However, in contrast to the improvement in mean scores of 12.7 for the EG, the improvement in mean global QoL scores for the control group was 1.5, which is not considered clinically important. Those who participated in the exercise program also reported significantly fewer and less severe problems ($P < 0.01$) at PIII, when compared with pre- and immediately

Table 1 Global, physical and psychosocial quality of life, endorsed problems and average severity scores for the control and exercise group at phase I, II and III (mean ± s.d.)

	Phase I		*Phase II*		*Phase III*		*Comparisons between phases (P-value)*		
	Mean	*s.d.*	*Mean*	*s.d.*	*Mean*	*s.d.*	*PI–PII*	*PI–PIII*	*PII–PIII*
Control group	n = 3		n = 6		n = 5				
QoL[a]	55.3	3.8	58.3	2.7	53.8	2.7	NS	NS	0.009
QoL EP[a]	60.3	4.3	59.7	2.9	58.3	3.1	NS	NS	NS
QoL AS[a]	50.4	9.5	54.3	6.4	48.7	6.7	NS	NS	NS
Physical QoL	59.8	6.4	64.5	4.4	58.7	4.7	NS	NS	NS
Physical QoL EP	63.0	6.8	66.2	4.7	62.1	4.9	NS	NS	NS
Physical QoL AS	56.3	5.9	60.3	3.9	54.1	4.2	NS	NS	NS
Psychosocial QoL	49.3	4.5	54.0	2.9	52.7	3.1	0.04	NS	NS
Psychosocial QoL EP	56.6	5.5	57.2	3.9	55.2	4.0	NS	NS	NS
Psychosocial QoL AS	42.8	5.4	49.7	3.7	48.2	3.8	NS	NS	NS
Exercise group	n = 4		n = 6		n = 6				
QoL	53.0	2.2	57.2	2.7	40.3	2.7	0.03	<0.001	<0.001
QoL EP	53.0	2.4	56.2	2.9	42.0	2.9	NS	<0.001	<0.001
QoL AS	52.2	5.2	55.5	6.4	37.7	6.4	NS	0.007	0.002
Physical QoL	53.0	3.6	57.8	4.4	42.8	4.4	NS	0.001	<0.001
Physical QoL EP	53.5	3.8	57.0	4.7	43.7	4.7	NS	0.004	<0.001
Physical QoL AS	52.0	3.2	56.7	3.9	43.8	3.9	NS	0.003	<0.001
Psychosocial QoL	53.7	2.4	55.0	2.9	42.0	2.9	NS	<0.001	<0.001
Psychosocial QoL EP	52.5	3.2	54.2	3.9	43.5	3.9	NS	0.005	0.002
Psychosocial QoL AS	53.7	3.0	53.5	3.7	45.2	3.7	NS	0.005	0.005

[a]Quality of life (QoL); endorsed problems (EP); average severity of problems (AS).

post transplant. Additionally, exercising patients reported a higher QoL (40.3 ± 2.7) and fewer problems (42.0 ± 2.9) associated with QoL at PIII, when compared with the control group (53.8 ± 2.7, $P = 0.03$ and 58.3 ± 3.1, $P = 0.04$, respectively).

Statistically significant improvements ($P < 0.01$) in overall QoL as well as the endorsed problems and average severity of problems in both the physical and psychosocial domains were observed for the EG but not the CG, following the 3-month recovery period (Table 1). The magnitude of the differences experienced by the EG between PI and PIII for overall QoL as well as the endorsed problems and average severity of problems in both the physical and psychosocial domains ranged between 8.2 and 14.5, which exceeded the criteria for clinical significance. In contrast, the CG demonstrated changes between 0.8 and 2.2 for physical QoL measures between PI and PIII, while the overall scores for psychosocial QoL and the average severity of psychosocial QoL items worsened during this same period.

The negative correlation coefficients in Table 2 indicate that those who were experiencing a higher level of fitness were more likely to experience higher QoL ($P < 0.05$) and higher physical QoL ($P < 0.001$) at PII and PIII. Higher fitness levels also were moderately related to improved psychosocial QoL at PIII; however, this relationship was not statistically significant. Although not statistically significant at the 0.05 level, the change in peak aerobic capacity was moderately correlated with the level of change experienced in QoL ($r = -0.56$, $P = 0.09$).

Table 2 Relationship between peak aerobic capacity (ml kg min^{-1}) and global, physical and psychosocial quality of life measures of the study group at PII and PIII

Outcome	*Phase II (n = 12)*		*Phase II (n = 12)*	
	Pearson correlation	*P-value*	*Pearson correlation*	*P-value*
Global QoL[a]	−0.64	0.03	−0.68	0.02
QoL EP[a]	−0.40	0.19	−0.63	0.04
QoL AS[a]	−0.71	0.01	−0.27	0.42
Physical QoL	−0.75	0.005	−0.75	0.008
Physical QoL EP	−0.63	0.03	−0.73	0.01
Physical QoL AS	−0.79	0.002	−0.66	0.03
Psychosocial QoL	−0.20	0.53	−0.49	0.12

[a]Quality of life (QoL); endorsed problems (EP); average severity of problems (AS).

Discussion

The adverse physical and psychosocial side effects of undertaking oncology treatment are well reported, and the presence of these symptoms has been related to reduced QoL.[3] Moreover, the intensive oncology treatment undertaken by the patient group in this study has been previously associated with declines in functional capacity, adverse changes in body composition and fatigue,[16,25] as well as social, psychological and emotional impairments.[25–27] It was therefore hypothesised that QoL would decline following treatment. Although statistically significant, the

decline observed in QoL following high-dose chemotherapy and autologous PBST did not meet our criterion for clinical significance (ie, 10% or greater decline in mean score). More importantly, we were able to demonstrate statistically and clinically significant improvements in all measures of QoL following a 3-month, mixed-type, moderate-intensity exercise programme.

Greater insight regarding the role of exercise on QoL can be obtained by analysing changes to the specific QoL domains during the recovery period. Exercising patients demonstrated significant improvements in physical QoL, and reported fewer and less severe physical problems, by 3 months post transplant. These results indicate that the exercising patients maintained the ability to return to higher than pretransplant physical QoL within a period as short as 3 months. Similar physical benefits have also been shown in exercising patients with breast cancer,[12,28] exercising adolescents with cancer[29] and exercising BMT patients.[30]

Little variation occurred in psychosocial QoL of nonexercising patients following a transplant. In comparison, those who exercised regularly demonstrated significant improvements in psychosocial QoL, and by PIII had achieved higher psychosocial QoL when compared with their pretransplant values and with the nonexercising patients. Contributing to this enhanced psychosocial QoL were reductions in psychological distress, worry, anxiety, body image concerns, work concerns, cognitive problems and difficulty in communicating and interacting with friends and relatives. Others investigating exercising patients with breast cancer have also reported a reduction in depression,[7,8] anxiety[7] and total mood disturbance,[7] and enhanced self esteem and confidence.[8,10,31] Exercising adolescents with cancer[29] have demonstrated improvements in self-concept and relationships with family and friends, while exercising BMT patients[15] and exercising autologous PBST patients[16] have shown beneficial changes in self-confidence, mood states and mental status.

Impairment in physical fitness is a substantial contributor to reduced QoL in cancer patients.[16] Correlations performed on QoL data with peak aerobic capacity data indicated that those experiencing a higher level of fitness were also more likely to experience higher QoL and fewer and less severe QoL problems ($P<0.05$). Not surprisingly, those demonstrating higher fitness levels also reported more favourable physical QoL ($P<0.01$) and fewer and less severe physical problems ($P<0.05$). Although the relationship between the level of change experienced in aerobic capacity and QoL between PII and PIII was not significant, the results suggest that those displaying the greatest improvement in aerobic fitness following treatment also showed the greatest improvement in QoL. Moreover, participation in a regular exercise intervention program may simultaneously influence many dimensions of QoL, or alternatively it may directly influence one dimension, which in turn has a 'domino effect among other wellness domains'.[12] The results of this investigation support this statement, as physical fitness was also found to be moderately correlated with psychosocial QoL, although not significantly.

While peak aerobic capacity was associated with global and physical QoL here, others have demonstrated that functional QoL is also associated with post-BMT survival.[32] Those who demonstrated higher functional QoL evidenced a trend toward longer survival. Taken together, these results suggest that physical fitness has the potential to influence both the quantity and quality of life. In turn, the importance of functional well-being is highlighted, as is the potential inadequacy of QoL interventions that fail to address the physical concerns of the patient with cancer.[4]

In addition to these findings, the unique aspects of this study must also be highlighted. The exercise intervention involved a combination of aerobic and resistance training, for a duration of 12 weeks, and was of higher intensity than that previously studied. All patients within the exercise group adhered to the program, working at or above the minimum intensity and duration of each exercise session. Additionally, two participants completed one extra session of aerobic-only exercise most weeks throughout the intervention study. Only two patients failed to attend 1 week of the 12-week program, due to illness. Additionally, in contrast to previous work that has used submaximal exercise tests or field tests to assess the peak aerobic capacity in oncology patients, the more accurate method, a maximal graded exercise treadmill test, was implemented in this study. Consequently, this work demonstrates that patients undergoing PBST can safely participate in a regular, mixed-type, moderate-intensity exercise program, as well as a maximal exercise test, without adverse consequences. These results have significant ramifications for the type of advice given to PBST patients regarding exercise, and the type of methods used in assessing aerobic capacity in future studies with this oncology group. Although this work shows that the patients in this study were capable of tolerating the level of overload and progression in both the aerobic and strength-training components outlined in the Methods section of this paper, it is equally important to point out that participation in the exercise program was under the supervision of an Exercise Physiologist, who was well informed of each participant's health condition, including current blood counts. Until the boundaries of exercise prescription are further tested, it remains important to ensure that the prescription and monitoring of exercise for oncology patients occurs by qualified health professionals knowledgeable in the exercise considerations for patients with cancer.

The findings presented here must be viewed in light of the study's limitations. Firstly, the low subject numbers reflect recruitment difficulties faced when dealing with patients undertaking this type of oncology treatment. Nevertheless, the statistical power was sufficient to detect many of the changes observed as statistically significant (at two-tailed, $\alpha=0.05$). The second limitation was the inability to effectively randomise patients to the control and exercise intervention group, which could potentially introduce bias. It is important to highlight though, that participants were assigned to match on potential confounders between the groups, and allocation was not based on convenience or desire of the participant to be in a particular group. This controlled allocation led to the control and intervention groups exhibiting similar medical and nonmedical

characteristics. However, initial QoL values were not considered during group allocation and, although not statistically significant, the CG seems to exhibit poorer QoL values when compared with the EG at PI, in particular the QoL endorsed problem score. Importantly, this group difference strengthens the findings of the study, as the control subjects had more room for improvement as a result of regression to the mean.

Despite these limitations, the findings of this study warrant attention. The findings demonstrate that exercise participation following oncology treatment is associated with a reduction in the number of endorsed problems and the average severity of these problems, which in turn leads to significant improvements in global, physical and psychosocial QoL. Furthermore, a relationship between fitness and QoL exists, with those experiencing higher levels of fitness also demonstrating higher QoL.

Acknowledgements

This study was carried out in part with the support of the National Breast Cancer Foundation, Australia.

References

1 Irvine EJ. Measuring quality of life: a review. *Scand J Gastroenterol* 1996; **31**: S5–S7.
2 Greenlee RT, Murray T, Bolden S, Wingo PA. Cancer Statistics, 2000. *CA Cancer J Clin* 2000; **50**: 7–33.
3 Norum J, Wist E. Psychological distress in survivors of Hodgkin's disease. *Support Care Cancer* 1996; **4**: 191–195.
4 Courneya KS, Friedenreich CM. Physical exercise and quality of life following cancer diagnosis: a literature review. *Ann Behav Med* 1999; **21**: 171–179.
5 Andrykowski MA, Breiner CB, Altmaier EM. Quality of life following bone marrow transplantation: findings from a multicentric study. *Br J Cancer* 1995; **71**: 1322–1329.
6 Black P, Gutjahr P, Stopfkuchen H. Physical performance in long-term survivors of acute leukaemia in childhood. *Eur J Pediatr* 1998; **157**: 464–467.
7 MacVicar MG, Winningham ML. Promoting the functional capacity of cancer patients. *Cancer Bull* 1986; **38**: 235–239.
8 Mock V, Burke MB, Sheehan P *et al*. A nursing rehabilitation program for women with breast cancer receiving adjuvant chemotherapy. *Oncol Nurs Forum* 1994; **21**: 899–907.
9 Friedenreich CM, Courneya KS. Exercise as rehabilitation for cancer patients. *Clin J Sport Med* 1996; **6**: 237–244.
10 Nelson JP. Perceived health, self-esteem, health habits, and perceived benefits and barriers to exercise in women who have and who have not experienced stage I breast cancer. *Oncol Nurs Forum* 1991; **18**: 1191–1197.
11 Courneya KS, Friedenreich CM. Relationship between exercise pattern across the cancer experience and current quality of life in colorectal survivors. *J Alternat Complement Med* 1997; **3**: 215–226.
12 Young-McCaughan S, Sexton DL. A retrospective investigation of the relationship between aerobic exercise and quality of life in women with breast cancer. *Oncol Nurs Forum* 1991; **18**: 751–757.
13 Winningham ML. Walking program for people with cancer. *Cancer Nurs* 1991; **14**: 270–276.
14 Courneya KS, Keats MR, Turner RA. Physical exercise and quality of life in cancer patients following high dose chemotherapy and autologous bone marrow transplantation. *Psycho-Oncology* 2000; **9**: 127–136.
15 Dimeo F, Fetscher S, Lange W *et al*. Effects of aerobic exercise on the physical performance and incidence of treatment-related complications after high-dose chemotherapy. *Blood* 1997; **18**: 1157–1160.
16 Dimeo FC, Stieglitz R-D, Novelli-Fischer U *et al*. Effects of physical activity on the fatigue and psychologic status of cancer patients during chemotherapy. *Cancer* 1999; **15**: 2273–2277.
17 Dimeo F, Bertz H, Finke J *et al*. An aerobic exercise program for patients with haematological malignancies after bone marrow transplantation. *Bone Marrow Transplant* 1996; **18**: 1157–1160.
18 Hayes SC, Davies PSW, Parker AW, Bashford J. Total energy expenditure and body composition changes following peripheral blood stem cell transplantation and participation in an exercise program. *Bone Marrow Transplant* 2003; **31**: 331–338.
19 Ganz PA, Hirji K, Sim M-S *et al*. Predicting psychosocial risk in patients with breast cancer. *Med Care* 1993; **31**: 419–431.
20 Schag CAC, Heinrich RL. Development of a comprehensive quality of life measurements tool: CARES. *Oncology* 1990; **4**: 135–147.
21 Schag CAC, Heinrich RL, Ganz PA. The cancer inventory of problem situations: an instrument for assessing cancer patients' rehabilitation needs. *J Psychosoc Oncol* 1983; **1**: 11–24.
22 Coscarelli A, Heinich RL. *Cancer Rehabilitation Evaluation System – CARES – Manual*. Santa Monica: California, 1988.
23 American College of Sports Medicine. *Guidelines for exercise testing and prescription*, 4th edn. Lea & Febiger: Philadelphia, 1991.
24 Jones RH. *Longitudinal data with serial correlation: a state-space approach*. Chapman & Hall: Bury St Edmonds, Suffolk, 1993.
25 Andrykowski MA, Altmaier EM, Barnett RL *et al*. The quality of life in adult survivors of allogeneic bone marrow transplantation. *Transplantation* 1990; **50**: 399–406.
26 Larsen J, Bardulf A, Nordstrom G *et al*. Health-related quality of life in women with breast cancer undergoing autologous stem-cell transplantation. *Cancer Nurs* 1996; **19**: 368–375.
27 Wingard JR, Curbow B, Baker F, Piantadosi L. Health, functional status and employment of adult survivors of bone marrow transplantation. *Ann Intern Med* 1991; **114**: 113–118.
28 Mock V, HasseyDow K, Meares CJ *et al*. Effects of exercise on fatigue, physical functioning and emotional distress during radiation therapy for breast cancer. *Oncol Nurs Forum* 1997; **24**: 991–1000.
29 Keats MR, Courneya KS, Danielsen S, Whitsett SF. Leisure-time physical activity and psychosocial well-being in adolescents after cancer diagnosis. *J Pediatr Oncol Nurs* 1999; **16**: 180–188.
30 Dimeo F, Tilmann MHM, Bertz H *et al*. Aerobic exercise in the rehabilitation of cancer patients after high dose chemotherapy and autologous peripheral stem cell transplantation. *Cancer* 1997; **79**: 1717–1722.
31 Smith SL. Physical exercise as an oncology nursing intervention to enhance quality of life. *Oncol Nurs Forum* 1996; **23**: 771–778.
32 Andrykowski MA, Brady MJ, Henslee-Downey PJ. Psychosocial factors predictive of survival after allogeneic bone marrow transplantation for leukemia. *Psychosom Med* 1994; **56**: 342–439.