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ORIGINAL ARTICLE

Predictors of Adherence to Supervised Exercise in Lymphoma Patients Participating in a Randomized Controlled Trial

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Abstract Exercise improves health in lymphoma patients but the determinants of adherence in this population are unknown. The purpose of this study is to examine predictors of exercise adherence in lymphoma patients. In a randomized trial, 60 lymphoma patients were assigned to the exercise group and asked to attend three supervised exercise sessions per week for 12 weeks. Baseline data were collected on demographic, medical, fitness, psychosocial, and motivational variables. Adherence was assessed by objective attendance. Adherence was 77.8% and was significantly predicted by age (β=0.29; p=0.016) and past exercise (β=0.27; p=0.024); and borderline significantly predicted by previous treatments (β=0.22; p=0.053), body mass index (β=−0.21; p=0.076), and smoking (β=−0.19; p=0.092). Poorer exercise adherence was experienced by lymphoma patients under age 40, insufficiently active at baseline, previously treated with radiation therapy, overweight or obese, and smokers. Findings may facilitate the development of targeted interventions to improve exercise adherence in this understudied patient population.

Keywords Cancer · Cancer survivors · Determinants · Physical activity · Theory of planned behavior

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Introduction

Lymphoma is the fifth most common cancer in the United States and Canada with a five year relative survival rate of 63% for non-Hodgkin lymphoma and 85% for Hodgkin lymphoma [1, 2]. To achieve these survival rates, lymphoma patients are often treated with successive courses of chemotherapy, radiation therapy, and/or biologic therapy that can produce side effects resulting in physical deconditioning and diminished quality of life [3–6]. We previously reported the Healthy Exercise for Lymphoma Patients (HELP) trial [7] that showed aerobic exercise training improved patient-reported outcomes and health-related fitness compared to usual care in 122 lymphoma patients receiving chemotherapy or off treatments (not receiving any treatments). Moreover, improvements were most pronounced in patients that were unmarried, with more advanced disease, and in poorer health [8].

Unfortunately, the long and difficult medical treatments that serve to potentiate the benefits of exercise for lymphoma patients may also undermine adherence. In the HELP trial, we reported a mean adherence rate of 77.8% with significant variability (SD=30%). In the present study, we examined potential predictors of exercise adherence from the intervention arm of the HELP trial that might be

useful in developing targeted behavioral interventions to achieve better adherence rates and improved outcomes. To the best of our knowledge, no previous study has examined the predictors of exercise adherence in lymphoma patients. It is possible that the unique disease and treatment factors in lymphoma patients may be novel determinants of exercise and/or they may amplify or attenuate the predictive utility of other previously established determinants.

We used the theory of planned behavior to guide our investigation [9] within a broader ecological model that included demographic and health-related fitness variables along with the unique medical and PRO variables. The theory of planned behavior is a social cognitive model of human behavior that proposes that intention (i.e., motivation) is the key determinant of behavior. Intention, in turn, is influenced by perceived control (controllability over the behavior), self-efficacy (confidence in performing the behavior), instrumental attitude (expected benefits of performing the behavior), affective attitude (expected enjoyment in performing the behavior), injunctive norm (anticipated support from important others for performing the behavior), and descriptive norm (the extent to which important others perform the behavior themselves).

Our hypotheses were based on the results of our Supervised Trial of Aerobic versus Resistance Training (START) in breast cancer patients receiving chemotherapy [10]. In that trial, we did not find that the theory of planned behavior variables predicted exercise adherence, rather, we found that higher cardiovascular fitness, lower body fat, more advanced disease stage, higher education, less depression, and being a nonsmoker predicted better exercise adherence. Consequently, in the present paper, we did not expect theory of planned behavior variables to predict exercise adherence but we did hypothesize that cardiovascular fitness, body fat, more advanced disease stage, higher education, less depression, and being a nonsmoker would predict exercise adherence. In addition, because we included patients receiving chemotherapy or off treatments in the HELP trial, we were able to examine the effects of treatment on adherence. Based on previous survey research [11, 12], we hypothesized that patients off treatments would achieve higher adherence than patients receiving chemotherapy.

Methods

Ethical approval was obtained from the Alberta Cancer Board and the University of Alberta, and written informed consent was obtained from all participants. Detailed methods for the overall HELP trial have been reported elsewhere [7]. Here, we describe the intervention arm of the HELP trial and the measures used to predict adherence in the present study.

Participants and Procedures

Participants were recruited from the Cross Cancer Institute in Edmonton, Canada. Eligibility criteria were English speaking, ≥18 years old, histologically confirmed Hodgkin lymphoma or non-Hodgkin lymphoma, and receiving chemotherapy or off treatments (patients receiving radiation therapy at the time of the intervention were not eligible). Eligible patients were identified in clinic by oncologists and through a mailed invitation using the Alberta Cancer Registry. Participants were stratified by major disease type (Hodgkin lymphoma, indolent non-Hodgkin lymphoma, aggressive non-Hodgkin lymphoma) and current treatment status (chemotherapy, off treatments) before being randomized to aerobic exercise training or usual care using a computer-generated program with concealed allocation sequence.

Exercise Training Intervention

Participants randomized to aerobic exercise training received a supervised exercise program consisting of cycling on an upright or recumbent exercise bike three times per week for 12 weeks at a well-equipped, university-based fitness center used exclusively for exercise and cancer trials. Duration and intensity were progressed over time. Adherence was facilitated with behavioral techniques including booked exercise sessions, telephone follow-up after missed sessions, positive reinforcement from staff, and paid parking. Exercise adherence was recorded by the fitness trainers and included attendance, duration, and intensity. Given that over 90% of the sessions attended were completed at the prescribed duration and intensity [7], adherence was simply calculated as the number of sessions attended divided by the number of sessions expected (i.e., 36).

Assessment of Predictors

Demographic data were collected by self-report and consisted of age, sex, marital status, education, annual family income, and employment status. Medical data were abstracted from medical records and consisted of major cancer type, specific disease type, disease stage, time since diagnosis, previous treatments, current treatment, current chemotherapy protocol (for those currently receiving chemotherapy), and percent of maximum planned chemotherapy cycles completed (for those currently receiving chemotherapy). Health-related fitness data consisted of self-reports of smoking, exercise [13], and general health assessed by the single item from the Medical Outcomes Survey Short Form 12 [14] as well as objective fitness testing consisting of peak oxygen consumption (VO_{2peak}), body weight and height to calculate body mass index, and a dual X-ray absorptiometry for the assessment of whole body fat and lean tissue. Patient-reported outcomes

consisted of physical functioning, quality of life, and fatigue assessed by the Functional Assessment of Cancer Therapy-Anemia scale [15], the Happiness Scale [16]; the short form Center for Epidemiological Studies-Depression Scale [17], the short form Spielberger State Anxiety Inventory [18]; and the lymphoma symptoms subscale [19].

Theory of planned behavior constructs were assessed prior to randomization by all participants based on a standard format recommended by Ajzen [20]. Prior to answering the theory of planned behavior questions, participants received the following written instructions: "As you know, based on random draw, we will ask you to either follow our exercise program over the next 12 weeks or not to change your exercise for 12 weeks. The following questions ask you about your feelings on exercising over the next 12 weeks. Please remember that if you are asked to do the exercise program, it will consist of three endurance exercise sessions per week for 20–45 min each time at a moderate to vigorous intensity (some sweating, increased heart rate, fairly fast breathing)". Each theory of planned behavior variable was assessed by three items except for the descriptive norm variable which was assessed by one item.

Examples of each of the theory of planned behavior variables are as follows. Motivation: "How motivated are you to exercise over the next 12 weeks?" with response options ranging from 1 (extremely unmotivated) through 4 (neutral) to 7 (extremely motivated). Self-efficacy: "How confident are you that you can exercise over the next 12 weeks?" with response options ranging from 1 (extremely unconfident) through 4 (neutral) to 7 (extremely confident). Perceived control: "How controllable would it be for you to exercise over the next 12 weeks?" with response options ranging from 1 (extremely uncontrollable) through 4 (neutral) to 7 (extremely controllable). Instrumental attitude: "I think that exercising over the next 12 weeks would be…" with response options ranging from 1 (extremely harmful) through 4 (neutral) to 7 (extremely beneficial). Affective attitude: "I think that exercising over the next 12 weeks would be…" with response options ranging from 1 (extremely unenjoyable) through 4 (neutral) to 7 (extremely enjoyable). Injunctive norm: "I think that if I exercised over the next 12 weeks, most people who are important to me would be…" with response options ranging from 1 (extremely unsupportive) through 4 (neutral) to 7 (extremely supportive). The descriptive norm item was: "I think that over the next 12 weeks, most people who are important to me will themselves be…" with response options ranging from 1 (extremely inactive) through 4 (neutral) to 7 (extremely active).

Statistical Analyses

Our study was originally powered for its primary purpose of examining the effects of exercise on patient-reported physical functioning in lymphoma patients [7]. For the present analyses, the 60 patients randomized to the exercise group provided 80% power (two-tailed alpha <0.05) to detect medium-sized correlations of approximately r=0.30. To conserve power, we created a priori dichotomous categories based on standard groupings for most demographic and medical variables. Dichotomization increases power by reducing the degrees of freedom and by increasing cell size [21]. For ease of interpretation, we transformed the continuous variables into trichotomous ordinal predictors based on statistically determined tertiles (i.e., health-related fitness variables, patient-reported outcomes, and theory of planned behavior variables) with the exception of past exercise and body mass index, which were based on previously established clinical cut-points. Past exercise was categorized as completely sedentary (no moderate or vigorous exercise minutes), insufficiently active (1–149 moderate or vigorous exercise minutes), or meeting guidelines (150+ moderate or vigorous exercise minutes) based on the Physical Activity Guidelines for Americans [22]. Body mass index was categorized as healthy weight (<25.0 kg/m^2), overweight (25.0–29.9 kg/m^2), or obese (≥30.0 kg/m^2) based on guidelines [23]. We analyzed all predictor variables using Pearson r correlations. Where there was an obvious non-linear association between the predictor variable and exercise adherence, we created a dummy-coded dichotomous variable that reflected the main group differences to allow for inclusion in a multivariate regression analyses. Variables that had statistically significant or borderline significant (p<0.10) univariate associations with exercise adherence were included in a forced entry multivariate regression analyses with a prespecified limit of having a subject-to-variable ratio of at least 5:1 (i.e., no more than 12 predictor variables) [24].

Results

Flow of participants through the trial has been reported elsewhere [7]. Briefly, we recruited 122 lymphoma patients and randomized 60 to aerobic exercise training. The mean age of the sample was 53 years, 59% were men, 77% were married, 82% had non-Hodgkins lymphoma, and 44% were currently receiving chemotherapy. The aerobic exercise training group attended a mean of 77.8% (SD=30.1%) of their supervised sessions and 65% attended≥80% of their sessions. Baseline theory of planned behavior variables are presented in Table 1. There were no differences between the randomized groups. Overall, our sample of lymphoma patients felt that exercising during the next 12 weeks would be quite-to-extremely beneficial, slightly-to-quite enjoyable, quite controllable, and they were quite confident in their ability to do the exercise program. They also felt that most people

Table 1 Theory of planned behavior beliefs about aerobic exercise training in lymphoma patients

Variables[a]	Overall (N=122) M (SD)	Usual care (n=62) M (SD)	AET (n=60) M (SD)	p value
Motivation/intention	6.4 (0.6)	6.4 (0.6)	6.4 (0.6)	0.507
Perceived control	6.0 (0.9)	5.9 (0.9)	6.1 (0.9)	0.418
Self-efficacy	5.8 (0.8)	5.8 (0.9)	5.9 (0.8)	0.416
Instrumental attitude	6.3 (0.6)	6.3 (0.7)	6.4 (0.6)	0.321
Affective attitude	5.3 (0.9)	5.3 (0.8)	5.3 (0.9)	0.723
Injunctive norm	6.4 (0.7)	6.3 (0.8)	6.5 (0.6)	0.097
Descriptive norm	5.2 (1.2)	5.3 (1.2)	5.2 (1.2)	0.910

AET aerobic exercise training, *SD* standard deviation

[a] All variables range from 1–7

important to them would be quite-to-extremely supportive and would be slightly active themselves. Finally, they were quite-to-extremely motivated to exercise over the next 12 weeks.

Predictors of Adherence to Supervised Exercise

Univariate associations between the predictors and exercise adherence are presented in Tables 2 (demographic), 3 (medical), 4 (health-related fitness), 5 (patient-reported outcomes), and 6 (theory of planned behavior variables). The associations with disease stage (Table 3) and past exercise (Table 4) were not linear, consequently, these variables were dummy-coded to reflect the main group differences for the multivariate analyses. We found statistically significant or borderline significant univariate associations between exercise adherence and the percent of maximum planned cycles completed (r=0.42; p=0.026), age (r=0.38; p=0.003), past exercise (r=−0.32; p=0.014), disease stage (r=0.29; p=0.026), body mass index (r=−0.27; p=0.039), previous treatments (r=0.24; p=0.060), depression (r=−0.23; p=0.072), and smoking (r=−0.22; p=0.085). Higher exercise adherence was achieved by lymphoma patients that had completed over 85% of their planned chemotherapy cycles, were over age 40, were previously regular exercisers or completely sedentary, had no disease or disease stage IV, were healthy weight, had not received previous radiation therapy, had lower depression scores, or were nonsmokers.

The seven significant or borderline significant predictors obtained on the entire sample of 60 patients (excluding percent of planned chemotherapy cycles completed because it only applied to patients on chemotherapy) were included in a forced entry multivariate regression analysis and explained 39.6% (p<0.001) of the variance in exercise adherence. In the multivariate model, age (β=0.29; p=0.016) and past exercise (β=−0.27; p=0.024) were significant predictors of exercise adherence while previous treatments (β=0.22; p=0.053), body mass index (β=

Table 2 Associations between demographic variables and supervised exercise adherence in lymphoma patients

Variable	M (SD)	r value	p value
Age		0.38[a]	0.003[a]
<40 years (n=10)	52.8% (36.9%)		
40-59 years (n=26)	82.7% (29.8%)		
≥60 years (n=24)	83.0% (22.3%)		
Sex		0.00	0.988
Male (n=37)	77.8% (31.0%)		
Female (n=23)	77.9% (29.3%)		
Marital status		−0.06	0.642
Unmarried (n=12)	81.5% (31.9%)		
Married (n=48)	76.9% (29.9%)		
Education		0.11	0.416
Did not complete university (n=29)	74.5% (34.5%)		
Completed university (n=31)	80.9% (25.5%)		
Annual Family Income		0.04	0.778
< $60,000 ($n$=20)	75.3% (32.3%)		
≥ $60,000 ($n$=34)	77.8% (30.7%)		
Employment Status		−0.11	0.394
Not full-time employed (n=45)	79.8% (27.3%)		
Full-time employed (n=15)	72.0% (37.8%)		

[a] Based on a dummy-coded variable comparing <40 years versus 40–59 years/≥60 years

Table 3 Associations between medical variables and supervised exercise adherence in lymphoma patients

Variable	M (SD)	*r* value	*p* value
Major cancer type		−0.16	0.231
Non-Hodgkin lymphoma (*n*=49)	80.1% (29.7%)		
Hodgkin lymphoma (*n*=11)	67.9% (31.4%)		
Specific disease type		0.07	0.599
Diffuse large B cell (*n*=21)	75.7% (32.0%)		
Follicular (*n*=14)	76.6% (33.6%)		
Other (*n*=25)	80.3% (27.4%)		
Disease stage at study entry		0.29[a]	0.026[a]
No evidence of disease (*n*=16)	85.8% (22.3%)		
Stages I–III (*n*=29)	69.0% (32.3%)		
Stage IV (*n*=15)	86.5% (29.7%)		
Time since diagnosis		0.16	0.223
< 12 months (*n*=29)	72.9% (32.9%)		
≥ 12 months (*n*=31)	82.4% (26.9%)		
Previous treatments		0.24	0.060
Radiation±chemotherapy (*n*=13)	68.0% (33.6%)		
None (*n*=28)	75.7% (31.2%)		
Chemotherapy alone (*n*=19)	87.7% (23.9%)		
Current treatment status		−0.20	0.119
Off Treatment (*n*=32)	83.5% (26.1%)		
Receiving chemotherapy (*n*=28)	71.3% (33.4%)		
Current chemotherapy protocol[b]		−0.28	0.165
RCHOP/CHOP (*n*=16)	79.0% (31.5%)		
ABVD/RCVP/Other (*n*=12)	61.1% (34.4%)		
% of maximum planned cycles completed[b]		0.42	0.026
< 85% (*n*=6)	44.9% (33.6%)		
> 85% (*n*=22)	78.5% (30.2%)		

(R)CHOP (rituximab), cyclophosphamide, doxorubicin, vincristine, prednisone; *ABVD* doxorubicin, bleomycin, vinblastine, dacarbazine; *RCVP* rituximab, cyclophosphamide, vincristine, prednisone

[a] Based on a dummy-coded variable comparing no disease/stage IV disease versus stages I–III disease

[b] Only applies to patients currently receiving chemotherapy (*n*=28)

−0.21; p=0.076), and smoking (β=−0.19; p=0.092) were borderline significant predictors. Disease stage (β=0.17; p=0.160) and depression (β=−0.01; p=0.969) became nonsignificant.

Discussion

Adherence to supervised exercise in the HELP trial was 78%. In our START trial involving breast cancer patients receiving chemotherapy, the adherence rate was 70%. One important difference between the trials is that all the breast cancer patients in the START trial were receiving chemotherapy whereas only 44% of the lymphoma patients in the HELP trial were receiving chemotherapy. Consequently, we were able to directly test the effects of chemotherapy treatment on exercise adherence in the HELP trial. Although not statistically different, we did find that the adherence rate was 71% for HELP patients on chemotherapy—almost identical to the START trial—whereas it was 83% for patients off treatment. These data are consistent with cross-sectional data showing that cancer survivors report higher rates of exercise during the postadjuvant survivorship phase than the active treatment phase [11, 12]. These differences in adherence may partly explain the generally better outcomes for exercise interventions in the postadjuvant versus adjuvant setting [25] although we did not find such a difference in the HELP trial [7].

Consistent with our START trial, motivational variables did not predict exercise adherence. Conversely, however, in a previous trial of prostate cancer patients receiving androgen deprivation therapy, intention (motivation), perceived behavioral control, and injunctive norm did predict supervised exercise adherence [26]. Moreover, in previous trials of mixed cancer survivors attending group psychotherapy sessions [27] and colorectal cancer survivors mostly on treatments [28], perceived behavioral control was an independent predictor of self-reported exercise adherence. Although not statistically significant in the HELP trial, motivation did appear to be meaningfully associated with exercise adherence. Lymphoma patients that scored 7 (extremely motivated) on the motivation scale achieved an 85% adherence rate compared to 77% for patients that scored between 6.0 and 6.9 (quite motivated)

Table 4 Associations between health-related fitness variables and supervised exercise adherence in lymphoma patients

Variable	M (SD)	*r* value	*p* value
Past exercise		−0.32[a]	0.014[a]
Completely sedentary (*n*=27)	82.8% (26.5%)		
Insufficiently active (*n*=20)	64.4% (37.5%)		
Meeting guidelines (*n*=13)	88.0% (15.5%)		
Current smoking		−0.22	0.085
Smoker (*n*=4)	52.8% (39.8%)		
Nonsmoker (*n*=56)	79.6% (28.9%)		
VO_{2peak}, ml/kg/min		0.05	0.730
< 20.0 (*n*=17)	77.5% (30.0%)		
20.0–26.9 (*n*=23)	75.6% (31.5%)		
≥ 27 (*n*=20)	80.7% (29.9%)		
Body fat,%		−0.08	0.563
< 28.0 (*n*=20)	79.3% (32.3%)		
28.0–37.9 (*n*=20)	84.0% (22.2%)		
≥38 (*n*=19)	73.8% (30.8%)		
Lean body mass, kg		−0.08	0.570
< 45.0 (*n*=17)	79.9% (27.3%)		
45.1–56.9 (*n*=18)	83.5% (23.1%)		
≥ 57.0 (*n*=24)	75.4% (33.3%)		
Body mass index		−0.27	0.039
Healthy weight (*n*=15)	88.7% (23.9%)		
Overweight (*n*=26)	79.1% (25.4%)		
Obese (*n*=19)	67.5% (37.6%)		
General health		0.06	0.675
Poor/fair (*n*=12)	80.6% (31.5%)		
Good (*n*=27)	72.7% (34.2%)		
Very good/excellent (*n*=21)	82.8% (23.2%)		

[a] Based on a dummy-coded variable comparing completely sedentary/meeting guidelines versus insufficiently active

and 66% for patients that scored below 6.0 (slightly motivated).

There are several possible explanations for why motivational variables are inconsistent predictors of adherence in exercise trials. First, there are usually ceiling effects and limited variability in the theory of planned behavior variables because of the highly select samples that volunteer for such trials. For comparison purposes, we previously conducted a cross-sectional survey of 438 non-Hodgkin lymphoma survivors in Alberta using a similar sampling frame and similar theory of planned behavior scales as in our HELP trial [29]. Despite the fact that even the cross-sectional sample would be biased because they were participating in an exercise survey, our HELP trial participants scored substantially higher than our survey participants on all motivational variables: means (and standard deviations) for the non-Hodgkin lymphoma survey participants versus the HELP trial participants, respectively, were 5.6 (1.7) versus 6.4 (0.6) for motivation, 5.3 (1.5) versus 6.0 (0.9) for perceived behavioral control, 5.9 (1.0) versus 6.3 (0.6) for instrumental attitude, 5.1 (1.2) versus 5.3 (0.9) for affective attitude, and 5.9 (1.3) versus 6.4 (0.7) for injunctive norm. These data provide evidence of a strong motivational bias that has been suspected in exercise trials, and this bias likely negates the predictive utility of motivational variables in this context. Moreover, these data also support previous speculation that such motivational variables are likely important predictors of who might volunteer for such an exercise trial [10]. It is also important to note that our START and HELP trials consisted of supervised exercise conducted at a university-based research facility, with well-trained staff, an excellent behavioral support program, and exercise programs ranging from 12 to 24 weeks. These factors may also partially negate the role of individual motivation. Perhaps motivational variables would be important predictors of exercise adherence in unsupervised trials, longer trials focused on exercise maintenance, or trials with a more limited behavioral support program.

Our trial also showed that lymphoma patients under 40 years of age struggled with adherence. This finding is contrary to the general literature showing that age is typically negatively associated with exercise participation [30]. Moreover, in our START trial, we found that younger breast cancer patients were more likely to be exercising at

Table 5 Associations between patient-reported outcomes and supervised exercise adherence in lymphoma patients

Variable	M (SD)	*r* value	*p* value
Physical functioning		−0.02	0.897
39–95 (*n*=23)	77.4% (33.3%)		
96–116 (*n*=20)	80.0% (27.9%)		
≥ 117 (*n*=17)	75.8% (29.7%)		
Quality of life		0.01	0.943
78–133 (*n*=23)	77.4% (33.3%)		
134–159 (*n*=18)	78.1% (29.5%)		
≥ 160 (*n*=19)	78.1% (28.1%)		
Happiness		0.07	0.574
15–54 (*n*=19)	77.5% (33.4%)		
55–74 (*n*=20)	73.1% (34.1%)		
≥75 (*n*=21)	82.7% (22.8%)		
Fatigue		0.03	0.836
12–32 (*n*=22)	74.9% (33.8%)		
33–43 (*n*=21)	82.1% (26.9%)		
≥ 44 (*n*=17)	76.3% (30.0%)		
Anxiety		−0.10	0.453
10–14 (*n*=20)	81.3% (25.3%)		
15–20 (*n*=20)	78.2% (27.0%)		
≥ 21 (*n*=20)	74.0% (37.6%)		
Depression		−0.23	0.072
< 5 (*n*=20)	87.4% (20.3%)		
5–9 (*n*=22)	75.6% (29.2%)		
≥10 (*n*=18)	69.9% (38.1%)		
Lymphoma symptoms		0.02	0.877
20–44 (*n*=18)	78.1% (31.9%)		
45–52 (*n*=18)	75.6% (36.6%)		
≥53 (*n*=24)	79.3% (23.9%)		

6-month follow-up [31] and we also found better adherence in younger patients in our prostate trial [26]. Other observational studies examining age and exercise in cancer survivors have been mixed [32–35]. Age in lymphoma patients is confounded with many important medical factors including disease type, disease stage, and type of treatments that may nullify any standard association that occurs in the general population. In multivariate analyses controlling for many of these factors, however, age was still positively associated with exercise adherence.

Past exercise also predicted adherence and remained significant in the multivariate analysis. It is well-known that past exercise is one of the best predictors of future exercise [30] and it is intuitive that lymphoma patients that exercised prior to the trial would achieve better adherence during the trial. What was unexpected, however, is that participants that reported no exercise (completely sedentary) also had excellent adherence. It was the patients that were insufficiently active (doing some exercise but not regularly) that demonstrated poor adherence. It is unclear why this "U-shaped" association would exist between past exercise and exercise adherence. It is possible that completely sedentary lymphoma patients recognize the need for exercise and benefit more from the supervised program because they have been unable or unwilling to exercise on their own in the past. Nevertheless, given the unexpected nature of this finding, replication is warranted.

Previous treatment was a borderline significant predictor of exercise adherence in both univariate and multivariate analyses. The lowest adherence was for patients that had received radiation therapy in the past. The negative prognostic finding for radiation therapy is complex because it covaries with many other disease and demographic factors. For example, patients that receive radiation therapy are more likely to have Hodgkin lymphoma, which also

Table 6 Associations between motivational variables and supervised exercise adherence in lymphoma patients

Variable	M (SD)	*r* value	*p* value
Motivation/intention		0.21	0.114
<6.0 (*n*=9)	66.1% (36.5%)		
6.0–6.9 (*n*=33)	76.9% (29.8%)		
=7.0 (*n*=18)	85.3% (26.7%)		
Perceived control		−0.13	0.327
<6.0 (*n*=15)	83.8% (25.1%)		
6.0–6.4 (*n*=22)	77.8% (32.8%)		
≥6.5 (*n*=23)	73.9% (31.0%)		
Self-efficacy		0.01	0.915
<6.0 (*n*=18)	76.7% (30.8%)		
=6.0 (*n*=24)	78.7% (31.4%)		
>6.0 (*n*=18)	77.8% (29.3%)		
Instrumental attitude		0.14	0.274
<6.0 (*n*=7)	72.6% (21.4%)		
6.0–6.4 (*n*=22)	73.1% (35.0%)		
≥6.5 (*n*=31)	82.4% (28.1%)		
Affective attitude		0.02	0.856
≤5.0 (*n*=25)	77.0% (31.4%)		
5.1–6.0 (*n*=28)	78.3% (28.4%)		
>6.0 (*n*=7)	79.0% (36.4%)		
Injunctive norm		−0.01	0.916
<7.0 (*n*=32)	78.2% (29.0%)		
=7.0 (*n*=28)	77.4% (31.8%)		
Descriptive norm		−0.00	0.996
< 5.0 (*n*=11)	74.2% (33.0%)		
5.0–5.9 (*n*=21)	81.6% (27.7%)		
≥6.0 (*n*=28)	76.4% (31.9%)		
Patient Preference		0.11	0.421
Preferred AET (*n*=53)	76.7% (30.0%)		
No preference (*n*=7)	86.5% (32.1%)		

AET aerobic exercise training

trended toward lower adherence in our study. Moreover, Hodgkin lymphoma tends to present in earlier stages and strike younger patients, factors that were negatively associated with exercise adherence in our trial. Nevertheless, the association between past treatments (radiation therapy) remained borderline significant even after controlling for some of these other variables. Future studies should continue to examine past and current treatments as key and unique determinants of exercise in cancer patients.

Body mass index was significantly associated with exercise adherence in univariate analysis and borderline significant in the multivariate analysis. In the START trial, body mass index did not predict adherence but % body fat did. It is possible that % body fat did not predict adherence in the present trial because of the mixed-sex sample and wide age range which influence the acceptable levels of a healthy % body fat. Unfortunately, our sample size was too small to conduct subgroup analyses based on age or sex. Several large studies have also reported that higher body mass index is associated with lower exercise in cancer survivors [32, 34, 35]. Given that body mass index is one of the most consistent predictors of exercise adherence in cancer survivors; interventions targeting obese cancer survivors may be warranted.

Disease stage showed a significant univariate "U-shaped" association with exercise adherence in our study but became nonsignificant in the multivariate analysis. The univariate association showed excellent adherence for patients with no evidence of disease or stage IV disease, and more modest adherence for patients with disease stages I–III. In cross-sectional studies, the role of disease stage has been mixed with Irwin et al. [32] reporting a positive association between disease stage and exercise levels, Hong et al. [34] reporting a small negative association, and Milne et al. [35] reporting no association. In the START trial, we found that patients with more advanced disease achieved better adherence. Lymphoma patients with more advanced disease typically receive milder treatments for their disease and may be more interested in complementary therapies given the more chronic nature of their disease. Conversely, patients with disease stages I–III are more often curable and receive more aggressive treatment for their disease. Patients with no evidence of disease do not usually receive treatments and mostly feel well. The fact that disease stage became nonsignificant in multivariate analyses suggests that its association with exercise adherence may be partially explained by its associations with other factors such as age, previous treatments, or body mass index. This finding underscores a potentially more complex model of exercise adherence that links the various demographic, medical, behavioral, and psychosocial determinants of exercise.

Depression was only borderline significantly associated with exercise adherence in univariate analyses and became nonsignificant in multivariate analyses. The association between poor psychological health and exercise behavior has been well established in other populations [30] and has been reported in breast cancer survivors [34]. Moreover, we found higher depression predicted lower adherence in our START trial [10]. Clearly, depression is problematic for many reasons in cancer patients and it is intuitive that it may also interfere with self-care strategies including lifestyle changes.

Smoking was a borderline significant predictor of exercise adherence in both univariate and multivariate analyses. Smoking is consistently associated with exercise adherence in the general population and has recently been reported as a negative predictor of exercise in a breast [10] and lung trial [36]. There are many good reasons for cancer patients to quit smoking, and improved adherence to other lifestyle interventions may be another one.

Finally, the percentage of maximum planned chemotherapy cycles completed predicted adherence, most likely because it is an indicator of how well a patient is doing. If the planned number of chemotherapy cycles is not completed, there is likely a very good medical reason for stopping treatments such as progression of the disease, serious adverse reactions (e.g., repeated neutropenia), or hospitalization, all of which would impact adherence negatively. Unfortunately, we could not analyze chemotherapy completion rate in multivariate analysis because it only applied to the subgroup of patients receiving chemotherapy. Consequently, it is unknown what role chemotherapy completion may play in a more complex model of exercise determinants in lymphoma patients.

It is important to briefly note the many variables in our study that did not predict exercise adherence in lymphoma patients including sex, marital status, education, income, time since diagnosis, cardiovascular fitness, body composition, quality of life, fatigue, anxiety, and happiness. These data suggest that men and women, married and unmarried, and patients with different education and income levels adhered equally well to the exercise program. Moreover, having lower quality of life, being fatigued, or anxious at baseline did not interfere with exercise adherence during the trial.

The strengths of our study include being the first study to prospectively examine the predictors of exercise adherence in lymphoma patients, the assessment of many different potential predictors, the adoption of a validated theoretical model, and the use of an objective measure of exercise adherence. One limitation of our study is the focus on supervised exercise performed at a well-staffed, university-based fitness facility. Predictors of unsupervised exercise, or supervised exercise at other facilities may be different. Moreover, prediction of long-term maintenance of exercise after a structured exercise program is an important question that was not addressed in our study. In addition, our predictors explained only 40% of the variance in

exercise adherence, suggesting that other important factors may affect adherence. Some likely prospects include treatment toxicities, treatment response, disease progression, and unexpected family events. Other limitations include the heterogeneity of this patient population, our limited power to detect smaller associations and to examine potential interactions among predictors, the short 12-week exercise program, and the 36 predictors tested which would likely result in two false discoveries if all comparisons were null.

In summary, we examined predictors of supervised exercise adherence in lymphoma patients and found that adherence was predicted by a range of variables including demographic, medical, behavioral, and psychosocial. Consideration should be given to these factors when designing exercise support interventions in this patient population. For example, interventions that target patients who are younger, insufficiently active, previously treated with radiation therapy, overweight or obese, or help address depression and smoking may be most effective in improving exercise adherence. Our results also suggest that motivational variables from the theory of planned behavior are not important predictors of adherence in lymphoma patients that volunteer for a supervised exercise trial but this may change in a different clinical context. Additional research on the determinants of exercise in lymphoma patients is warranted.

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