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Understanding strength exercise intentions and behavior in hematologic cancer survivors: an analysis of the intention-behavior gap

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Abstract
Background Strength exercise improves many health outcomes in cancer survivors but the prevalence and correlates of strength exercise have not been well-described. Moreover, no study has examined the critical intention-behavior gap for exercise in cancer survivors.
Purpose The aims of this study are to quantify the intention-behavior gap for strength exercise in hematologic cancer survivors (HCS) and examine correlates of both intention formation and translation using the multi-process action control framework (M-PAC).
Methods A random sample of 2100 HCS in Alberta, Canada, were mailed a survey assessing strength exercise behavior, the M-PAC, and demographic/medical variables. Separate logistic regressions were used to analyze the relationships between the correlates and intention formation and translation.
Results Surveys were completed by 606 HCS with 58 % ($n = 353$) intending to do strength exercise. HCS who were not retired (OR = 1.56, $p = 0.001$), were highly educated (OR = 1.32, $p = 0.001$), and had a favorable attitude (OR = 1.56, $p < 0.001$), descriptive norm (OR = 1.38, $p = 0.006$), injunctive norm (OR = 1.45, $p = 0.004$), and perceived control (OR = 1.38, $p < 0.001$), were more likely to form an exercise intention. Of those with an exercise intention, 51 % ($n = 181$) reported regular strength exercise. HCS with a detailed plan (OR = 1.86, $p < 0.001$), favorable attitude (OR = 1.68, $p = 0.001$), sense of obligation (OR = 1.38, $p = 0.010$), and self-regulated their affinity for competing activities (OR = 1.35, $p = 0.012$), were more likely to translate their intention into behavior.
Conclusion Just over half of HCS intended to do strength exercise and only half of intenders translated that intention into behavior.
Implications for Cancer Survivors Interventions targeting both intention formation and translation may provide the best approach for increasing strength exercise in HCS.

Keywords Intention formation · Intention translation · Action control · M-PAC · Physical activity · Resistance training

Introduction

Strength exercise, or resistance training, improves physical functioning [1, 2], quality of life [3], and may even help cancer survivors live longer [4]. Few cancer survivors, however, are meeting the strength exercise guideline of at least 2 days per week of moderate-to-intense strength training of all the major muscle groups [5, 6]. The first study to estimate the prevalence of strength exercise found that only 26 % of colorectal cancer survivors were meeting the guideline [7]. Similar estimates were reported for breast cancer survivors (24 %) [8] and a mixed sample of breast, prostate, and colorectal cancer survivors (23 %) [9]. Moreover, the few studies that have examined the correlates of strength exercise in cancer survivors have reported that survivors who were younger, highly educated, healthier, nonsmokers, and not obese were more likely to do strength exercise [7–9]. Survivors were especially more likely to do strength exercise if they were also more motivated, had

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strong exercise self-efficacy, and developed a detailed plan for their exercise [8, 9].

To date, no study has estimated the prevalence or examined the correlates of strength exercise in hematologic cancer survivors (HCS). HCS are a unique cancer survivor group because their tumors are not solid, their disease is often widely disseminated at diagnosis, and they primarily receive intensive systemic treatments including stem cell transplantation [10]. Moreover, hematologic cancers are often managed as chronic diseases with multiple ongoing treatments over an extended period of time. These disease characteristics and treatment protocols may influence the prevalence and correlates of strength exercise [11].

Of the few population-based studies that have examined exercise in HCS, all have focused on the correlates of an aerobic exercise intention [12–14]. While intention is a critical psychological determinant of exercise behavior [15], it is clear that intention does not always lead to exercise [16]. In fact, only about half of those who intend to do aerobic exercise successfully translate their intention into meeting the exercise guideline [17]. To our knowledge, this gap between exercise intention and behavior (I-B gap) has never been examined for strength exercise and has never been examined in cancer survivors.

The multi-process action control (M-PAC) framework was developed to specifically understand the I-B gap in exercise. Through an explicit focus on the correlates of both intention formation and translation [18], the M-PAC framework consists of motivational processes (i.e., attitude, perceived control) which influence the likelihood for an exercise intention to be formed. These motivational processes coupled with behavioral regulations (i.e., planning, and making financial investments into one's personal exercise), and reflexive processes (i.e., sense of obligation, anticipated regret, and the self-regulation of affinity toward alternative activities), help translate an exercise intention into exercise behavior [19, 20]. Understanding how intentions are formed and translated may facilitate the development of more effective exercise behavior change interventions for HCS.

The purpose of this study was to estimate the prevalence and examine the correlates of intention formation and translation for strength exercise in HCS using the M-PAC framework. We hypothesized that similar to aerobic exercise [13], more than 50 % of survivors would intend to do strength exercise. Based on previous research in other cancer survivor populations, we hypothesized that about 25 % of HCS would meet strength exercise guidelines [7–9]. Moreover, based on results in healthy adults [17], we hypothesized that less than 50 % of HCS who intend to do strength exercise would translate that intention into behavior. We also hypothesized that based on the M-PAC model [18, 21], the motivational processes from the theory of planned behavior (TPB) would be strongly associated with intention formation, and that behavioral regulations and reflexive processes would additionally be strongly associated with intention translation. Finally, we hypothesized that any cancer and demographic variables associated with intention formation and translation would be mediated by the M-PAC model.

Methods

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. A population-based, stratified random sample of 2100 HCS (700 each of leukemia, Hodgkin lymphoma, and non-Hodgkin lymphoma) were contacted by the Alberta cancer registry to participate in this cross-sectional study. Participants aged between 18 and 80 years, and diagnosed with hematologic cancer, were eligible. Three attempts to contact survivors were made [22]. Informed consent was obtained from all individual participants included in the study. Participants were asked to complete a self-report questionnaire and return it to the cancer registry via the provided prepaid postage envelope. HCS were instructed that if they were uninterested in participating in the study, they could call the cancer registry personally or through a family member, return the questionnaire blank, or ignore our mailed requests.

Measures

Demographic and cancer-specific variables All measures were assessed using self-report. Demographic variables included age (continuous), gender (male/female), marital status (never married/married/common law/separated/widowed/divorced), education level (some high school/completed high school/some university or college/completed university or college/some graduate school/completed graduate school), employment status (disability/retired/part time/homemaker/full time/temporarily unemployed), ethnicity (white/black/Hispanic/Asian/aboriginal/other), height (continuous), and weight (continuous). Cancer-specific variables included date of diagnosis (month, year), type of hematologic cancer (leukemia, Hodgkin lymphoma, non-Hodgkin lymphoma), disease stage (I/II/III/IV), previous treatments (surgery yes/no; radiation yes/no; chemotherapy yes/no; stem cell or marrow transplant yes/no), current treatment status (completed treatments for now/still receiving treatment), cancer recurrence (yes/no), and current cancer status (existing disease/disease-free). Cancer symptom burden was measured using 19 items from the MD Anderson Symptom Inventory [23], covering a range of symptoms such as nausea, lack of appetite, insomnia, pain, fatigue, and digestive function, and was rated on an 11-point scale (0–10).

Strength exercise Strength exercise was measured using a modified Leisure Score Index from the Leisure Time Exercise Questionnaire [24]. While retaining the structure and template of the original Leisure Time Exercise Questionnaire, the modification entailed adding a separate section focused on strength exercise that asked participants to indicate the average frequency (days/week) and duration (minutes/session) of any moderate-to-intense strength exercise (i.e., "exercise that improves muscular strength such as weight lifting, resistance bands, sit-ups, push-ups") that they performed in a typical week over the past month [7, 9, 25]. To be consistent with prior research, strength exercise was dichotomized into meeting versus not meeting the strength exercise guideline for cancer survivors based on a frequency of at least 2 days per week [26], and the duration of weekly moderate-to-intense strength exercise was reported descriptively.

Motivational processes All survey items were referenced to reflect meeting the strength exercise guideline of moderate-to-intense strength exercise at least 2 days per week. Fifteen standard TPB measures were used to assess survivors' exercise motivation using a seven-point bipolar scale [27]. Three items captured participants' instrumental attitude (e.g., useful-useless) and three for affective attitude (e.g., enjoyable-unenjoyable). Three items assessed injunctive norm (e.g., "… people who are important to me will be…" encouraging-discouraging), and three for descriptive norm (e.g., "… people who are important to me will perform…" regular strength exercise-no strength exercise). Perceived control was measured using three items (e.g., "… regular strength exercise over the next month would be completely up to me…" strongly agree-disagree). In line with the theory proposed by M-PAC, the decision to form an exercise intention was measured using a single dichotomous item (i.e., "Do you intend to do regular strength exercise over the next month? (please circle): Yes/No") [28].

Regulatory behaviors Exercise plans were assessed through five items using a seven-point bipolar scale (i.e., no plans–detailed plans) [29, 30]. Financial investments were measured using a ten-point scale (completely true for me–not at all true for me) on the following single item: "I have invested a lot of my own money into doing regular strength exercise…" [20, 31].

Reflexive processes Anticipated regret was measured using two items (e.g., "If I do not engage in regular strength exercise over the next month, I will feel regret.") on an 11-point scale (i.e., definitely no–definitely yes) [32, 33]. Seven items on a ten-point scale (i.e., completely true for me – not at all true for me) measured participants' exercise obligation and regulation over alternative activities [20, 31]. Exercise obligation was measured using three items (e.g., "I feel obligated to do regular strength exercise over the next month…") and four items captured self-regulation over alternative competing activities (e.g., "Compared to doing regular strength exercise over the next month, there are other things I could do which would be more fun…").

Statistical analyses

To create an intention translation variable, intenders were divided as successful (meeting guidelines) or unsuccessful (not meeting guidelines). Descriptive frequency and percentage data are reported for intention formation, strength exercise behavior, and intention translation. An exploratory factor analysis (EFA) with Varimax rotation ensured that constructs were distinct from one another [34]. Factor loading criteria for item aggregation was a primary loading of ≥ 0.40, and a Cronbach's alpha of ≥ 0.70. Multivariate analyses of variances (MANOVAs) and chi-squared analyses were used to examine differences in motive, behavioral, reflexive, demographic, and cancer variables (dependent variables), between intenders and nonintenders (fixed factor). This procedure was replicated to examine differences for intention translation (successful/unsuccessful intenders).

To determine the independent correlates of intention formation and translation, variables that approached significance in the MANOVAs/chi-squares ($p < 0.10$) were included in hierarchical forward stepwise logistic regressions. Separate regressions were conducted for intention formation and translation. The stepwise variable entry threshold was $p = 0.05$, and $p = 0.10$ for removal [34]. Standardized Bartlett factor scores for each of the motive, behavioral, and reflexive variables were used to help guard against violations of multicollinearity [35]. The intention formation regression consisted of three hierarchical blocks. Block 1 included demographic variables, block 2 comprised the cancer-specific variables, and block 3 included motivational variables [36]. Behavioral and reflexive variables were not entered because theoretically, they are postintention constructs [18]. Four hierarchical blocks were entered for the intention translation regression. The first three blocks mirrored the sequencing of the intention formation regression (demographics, cancer, and motivational variables), and the fourth block consisted of behavioral/reflexive variables.

Results

Participant flow through the study is presented in Fig. 1. The survey resulted in a 29 % completion rate ($n = 606/2100$) and a 32 % response rate ($n = 606/1921$) after excluding deceased persons and return-to-senders. Based on limited medical and demographic data available in the registry, we found no significant differences between responders and nonresponders on

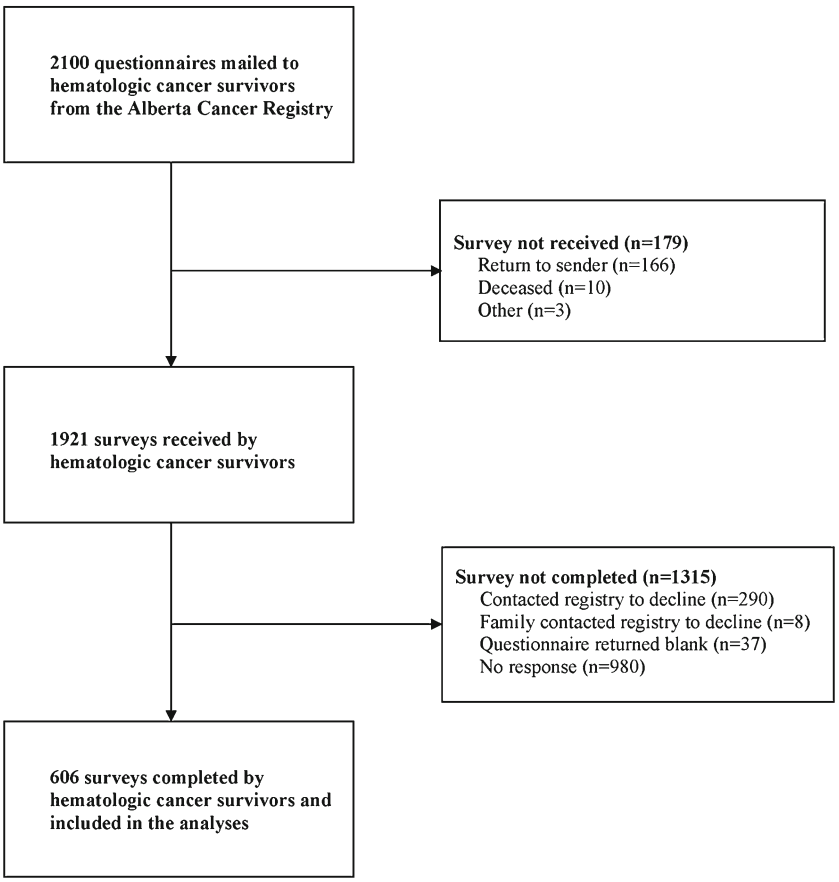

Fig. 1 Flow of participants through the study

age, sex, disease stage, and time since diagnosis. Responders were more likely to have been diagnosed with non-Hodgkin lymphoma ($p < 0.001$) and to have received chemotherapy ($p = 0.017$). Participant demographic and medical information is presented in Table 1.

Overall, 58 % ($n = 353/606$) of HCS intended to do strength exercise and 32 % ($n = 192/606$) met the strength exercise guideline. Considering those who met the strength exercise guideline, 91 % ($n = 174/192$) reported doing 30 min or more of weekly strength exercise. Furthermore, survivors meeting the guideline averaged 118 weekly minutes of strength exercise, versus 3 min for those not meeting the guideline ($p < 0.001$, $d = 1.52$). Of those who intended to do strength exercise, 51 % ($n = 181/353$) actually did strength exercise. Of those without an intention to do strength exercise, 4 % ($n = 11/253$) did strength exercise. Conversely, for those meeting guidelines, 94 % had an exercise intention ($n = 181/192$) and 6 % did not ($n = 11/192$).

Our EFA resulted in an initial six factor model based on eigenvalue criteria of >1.0. After visual inspection of the scree plot, we accepted a seven factor model (all eigenvalues >0.95, Cronbach's alpha > 0.90), which significantly improved the fit versus the initial six-factor model (nested comparison: $x^2 = 852.24$, $df = 24$, $p < 0.001$) [34, 37]. The resulting factors were as follows: planning, obligation/regret, attitude, self-regulation over competing activities, descriptive norm, injunctive norm, and perceived control (interested readers are referred to the supplemental Online Resource).

Univariate correlates of intention formation and translation

The univariate correlates of intention formation and translation are reported in Tables 2 and 3. Participants who were younger, not retired, had completed university, had fewer than two comorbidities, currently disease free, and diagnosed with Hodgkin lymphoma were more likely to intend to do strength exercise (all $ps < 0.01$; see Table 2). Participants who were younger, had completed university, and reported no comorbidities were more likely to translate their intention into strength exercise (all $ps < 0.05$; see Table 2). All motivational processes were significant univariate correlates of intention formation (all $ps < 0.001$; see Table 3). Attitude ($p < 0.001$), perceived control ($p = 0.002$), and all behavioral and reflexive processes were significant correlates of intention translation (all $ps \leq 0.001$; see Table 3).

Table 1 Demographic and medical characteristics of hematologic cancer survivors participating in this study

Variable	Overall ($n = 606$)	Leukemia ($n = 186$)	Hodgkin lymphoma ($n = 187$)	Non-Hodgkin lymphoma ($n = 233$)	p value
Age [M (SD)]	58.1 (16.4)	61.7 (14.2)	48.5 (17.7)	62.8 (13.4)	<0.001
<60 years	303 (50 %)	76 (25 %)	135 (45 %)	92 (30 %)	<0.001
≥60 years	303 (50 %)	110 (36 %)	52 (17 %)	141 (47 %)	
Gender					0.089
Female	341 (56 %)	112 (34 %)	93 (27 %)	136 (40 %)	
Male	265 (44 %)	74 (28 %)	94 (35 %)	97 (37 %)	
Body mass index [M (SD)]	27.7 (7.4)	27.1 (5.6)	28.0 (8.0)	27.9 (8.3)	0.449
Normal weight	221 (37 %)	67 (30 %)	70 (32 %)	84 (38 %)	0.813
Overweight	245 (40 %)	81 (33 %)	72 (29 %)	92 (38 %)	
Obese	140 (23 %)	38 (27 %)	45 (32 %)	57 (41 %)	
Marital status					0.096
Not married	179 (29 %)	53 (30 %)	66 (37 %)	60 (33 %)	
Married	427 (71 %)	133 (31 %)	121 (28 %)	173 (41 %)	
Children living at home					0.003
None	450 (74 %)	148 (33 %)	122 (27 %)	180 (40 %)	
One or more	156 (26 %)	38 (24 %)	65 (42 %)	53 (34 %)	
Education					0.441
Did not complete university	295 (49 %)	92 (31 %)	84 (29 %)	119 (40 %)	
Completed university or more	311 (51 %)	94 (30 %)	103 (33 %)	114 (37 %)	
Employment status					<0.001
Not retired	375 (62 %)	106 (28 %)	144 (38 %)	125 (33 %)	
Retired	231 (38 %)	80 (35 %)	43 (19 %)	108 (47 %)	
Ethnicity					0.163
White	562 (93 %)	178 (32 %)	170 (30 %)	214 (38 %)	
Other	44 (7 %)	8 (18 %)	17 (39 %)	19 (43 %)	
Time since diagnosis					0.991
<2 years	116 (19 %)	37 (32 %)	36 (31 %)	43 (37 %)	
2–5 years	304 (50 %)	93 (41 %)	95 (31 %)	116 (38 %)	
>5 years	186 (31 %)	56 (30 %)	56 (30 %)	74 (40 %)	
Radiotherapy					<0.001
No	399 (66 %)	152 (38 %)	104 (26 %)	143 (36 %)	
Yes	207 (34 %)	34 (16 %)	83 (40 %)	90 (44 %)	
Chemotherapy					<0.001
No	173 (28 %)	95 (55 %)	23 (13 %)	55 (32 %)	
Yes	433 (72 %)	91 (21 %)	164 (38 %)	178 (41 %)	
Stem cell/marrow transplant					0.015
No	541 (89 %)	156 (29 %)	170 (31 %)	215 (40 %)	
Yes	65 (11 %)	30 (46 %)	17 (26 %)	18 (28 %)	
Treatment status					<0.001
Receiving treatments	193 (32 %)	113 (59 %)	17 (9 %)	63 (33 %)	
Completed treatments	413 (68 %)	73 (18 %)	170 (41 %)	170 (41 %)	
Recurrence					0.036
No	524 (87 %)	165 (31 %)	168 (32 %)	191 (37 %)	
Yes	82 (13 %)	21 (26 %)	19 (23 %)	42 (51 %)	
Current disease status					<0.001
Disease free	372 (61 %)	61 (16 %)	164 (44 %)	147 (40 %)	
Existing disease	234 (39 %)	125 (53 %)	23 (10 %)	86 (37 %)	
Comorbidities					<0.001
None	221 (36 %)	49 (22 %)	108 (49 %)	64 (29 %)	
One	151 (25 %)	52 (34 %)	41 (27 %)	58 (38 %)	
Two or more	234 (39 %)	85 (36 %)	38 (16 %)	111 (47 %)	
Symptom burden [M (SD)]	1.2 (1.5)	1.3 (1.5)	1.1 (1.5)	1.3 (1.4)	0.295

Multivariate correlates of intention formation and translation

The independent correlates of intention formation and translation are reported in Table 4. The independent correlates of intention formation were not being retired (OR = 1.56, $p = 0.001$), having graduated from university (OR = 1.32, $p = 0.001$), and a favorable attitude (OR = 1.56, $p < 0.001$), descriptive norm (OR = 1.38, $p = 0.006$), injunctive norm (OR = 1.45, $p = 0.004$), and perceived control (OR = 1.38, $p < 0.001$). The independent correlates of intention translation were having a

Table 2 Associations of demographic and cancer-specific variables with strength exercise intention formation and translation in hematologic cancer survivors

Variable	Non-intenders ($n = 253$)	Intenders ($n = 353$)	p value	Unsuccessful intenders ($n = 172$)	Successful intenders ($n = 181$)	p value
Age			<0.001			0.010
<60 years	100 (33 %)	203 (67 %)		87 (43 %)	116 (57 %)	
≥60 years	153 (51 %)	150 (49 %)		85 (57 %)	65 (43 %)	
Gender			0.27			0.16
Female	149 (44 %)	192 (56 %)		87 (45 %)	105 (55 %)	
Male	104 (39 %)	161 (61 %)		85 (53 %)	76 (47 %)	
Body mass index			0.47			0.54
Normal weight	88 (40 %)	133 (60 %)		62 (47 %)	71 (53 %)	
Overweight/Obese	165 (43 %)	220 (57 %)		110 (50 %)	110 (53 %)	
Marital status			0.08			0.42
Not married	65 (36 %)	114 (64 %)		52 (46 %)	62 (54 %)	
Married	188 (44 %)	239 (56 %)		120 (50 %)	119 (50 %)	
Children living at home			0.33			0.21
None	193 (43 %)	257 (57 %)		120 (47 %)	137 (53 %)	
One or more	60 (38 %)	96 (62 %)		52 (54 %)	44 (46 %)	
Education			0.006			0.025
Not completed university	140 (47 %)	155 (53 %)		86 (56 %)	69 (44 %)	
Completed university	113 (36 %)	198 (64 %)		86 (43 %)	112 (57 %)	
Employment status			<0.001			0.016
Not retired	130 (35 %)	245 (65 %)		109 (44 %)	136 (56 %)	
Retired	123 (53 %)	108 (47 %)		63 (58 %)	45 (42 %)	
Ethnicity			0.12			0.34
White	241 (43 %)	321 (57 %)		159 (49 %)	162 (51 %)	
Other	12 (27 %)	32 (73 %)		13 (41 %)	19 (59 %)	
Cancer type			0.006			0.42
Leukemia	85 (46 %)	101 (54 %)		51 (51 %)	50 (49 %)	
Hodgkin lymphoma	60 (32 %)	127 (68 %)		56 (44 %)	71 (56 %)	
Non-Hodgkin lymphoma	108 (46 %)	125 (54 %)		65 (52 %)	60 (48 %)	
Time since diagnosis			0.217			0.235
<2 years	42 (36 %)	74 (64 %)		34 (46 %)	40 (54 %)	
2–5 years	125 (41 %)	179 (59 %)		95 (53 %)	84 (47 %)	
>5 years	86 (46 %)	100 (54 %)		43 (43 %)	57 (57 %)	
Radiation			0.44			0.28
No	171 (43 %)	228 (57 %)		116 (51 %)	112 (49 %)	
Yes	82 (40 %)	125 (60 %)		56 (45 %)	69 (55 %)	
Chemotherapy			0.49			0.86
No	76 (44 %)	97 (56 %)		48 (49 %)	49 (51 %)	
Yes	177 (40 %)	256 (59 %)		124 (48 %)	132 (52 %)	
Stem cell/marrow transplant			0.17			0.11
No	231 (43 %)	310 (57 %)		156 (50 %)	154 (50 %)	
Yes	22 (34 %)	43 (66 %)		16 (37 %)	27 (63 %)	
Treatment status			0.66			0.37
Receiving treatments	86 (45 %)	107 (55 %)		56 (52 %)	51 (48 %)	
Completed treatments	167 (40 %)	246 (60 %)		116 (47 %)	130 (53 %)	
Recurrence			0.34			0.76
No	151 (29 %)	373 (71 %)		152 (49 %)	158 (51 %)	
Yes	27 (33 %)	55 (67 %)		20 (46 %)	23 (54 %)	
Current disease status			0.024			0.26
Disease free	142 (38 %)	230 (62 %)		107 (46 %)	123 (54 %)	
Existing disease	111 (47 %)	123 (53 %)		65 (53 %)	58 (47 %)	
Comorbidities			<0.001			0.001
None	72 (33 %)	149 (67 %)		57 (38 %)	92 (62 %)	
One or more	181 (47 %)	204 (53 %)		115 (56 %)	89 (44 %)	
Symptom burden [M (SD)]	1.3 (1.4)	1.2 (1.5)	0.29	1.2 (1.3)	1.2 (1.6)	0.77

Symptom burden = the average on a ten-point scale derived from 19 items of the MD Anderson Symptom Inventory

detailed plan (OR = 1.86, $p < 0.001$), favorable attitude (OR = 1.68, $p = 0.001$), sense of obligation (OR = 1.38, $p = 0.010$), and self-regulated the affinity for competing activities (OR = 1.35, $p = 0.012$).

Discussion

In our sample of over 600 HCS, almost 60 % intended to do strength exercise. Few studies have estimated the prevalence

Table 3 Associations of motive, behavioral, and reflexive variables with strength exercise intention formation and translation in hematologic cancer survivors

Variable	Non-intenders ($n = 253$)	Intenders ($n = 353$)			Unsuccessful intenders ($n = 172$)	Successful intenders ($n = 181$)	p value	d
	M (SD)	M (SD)	p value	d	M (SD)	M (SD)		
TPB variables								
Attitude	3.9 (1.4)	5.7 (0.8)	<0.001	1.58	5.5 (0.9)	5.9 (0.8)	<0.001	0.47
Injunctive norm	4.7 (1.7)	6.1 (0.9)	<0.001	1.03	6.0 (0.8)	6.1 (0.9)	0.74	0.12
Descriptive norm	3.2 (1.8)	4.4 (1.7)	<0.001	0.69	4.4 (1.7)	4.3 (1.7)	0.72	0.06
Perceived control	4.8 (2.0)	6.1 (1.0)	<0.001	0.82	5.9 (1.1)	6.3 (0.9)	0.002	0.40
Regulatory behaviors								
Planning	1.4 (0.9)	5.1 (1.7)	<0.001	2.72	4.7 (1.8)	5.6 (1.6)	<0.001	0.53
Reflexive processes								
Obligation/regret	2.4 (1.8)	7.5 (2.2)	<0.001	2.54	7.0 (2.2)	7.9 (2.2)	<0.001	0.41
Regulation of alternatives	3.6 (2.5)	5.8 (2.2)	<0.001	0.93	5.4 (2.1)	6.1 (2.2)	0.001	0.33

TPB theory of planned behavior, *d* Cohen's effect size

of intentions for strength exercise in cancer survivors so direct comparisons with our sample are not possible. Nevertheless, the fact that the majority of HCS intended to do strength exercise suggests that many are aware of the benefits of strength exercise. Moreover, about one third of HCS report that they are currently meeting strength exercise guidelines which is slightly higher than the approximate 25 % prevalence estimated across studies in breast, prostate, and colorectal survivors [7–9]. Nevertheless, two thirds of HCS are not experiencing the significant benefits of strength exercise and interventions to promote strength exercise in this unique population are needed.

As hypothesized, about half of HCS were unsuccessful in translating their strength exercise intention into behavior. Our study provides the first examination of the I-B gap for strength exercise, and thus, no direct comparison is possible. Nevertheless, this finding indicates a large I-B gap for strength exercise in HCS, which is consistent with the I-B gap for aerobic exercise reported in healthy populations [17]. Thus, the act of simply forming an intention for strength exercise does not always translate into behavior. Still, forming a strength exercise intention does appear to be necessary for behavior, as almost no survivors reported participating in strength exercise unintentionally, thus making intention one of the strongest psychosocial predictors of behavior [38]. Overall, these data suggest that merely examining exercise intentions may not be the optimal way of understanding strength exercise. Rather, focusing on the I-B gap by using theories that examine the correlates of both phases—intention formation and translation—may lead to the most effective exercise behavior change interventions for HCS.

In terms of intention formation for strength exercise, the univariate results revealed that certain subgroups of HCS were less likely to form an intention. Specifically, non-Hodgkin lymphoma and leukemia survivors, and those who were older, retired, did not have a university degree, suffered from at least one comorbidity, or were not cured of their cancer were less likely to form an intention. Furthermore, intention formation was strongly related to motivational processes, with all TPB-based constructs serving as significant independent correlates. When examining the magnitude of odds ratios, attitude was the only motivational variable to exhibit a meaningful effect size [39]. Attitude is the most stable determinant of intention across TPB applications [13], and mean attitude scores were especially discrepant between intenders and nonintenders (see Table 2).

Thus, to help HCS form a strength exercise intention, interventions should be designed with attitude as the primary intervention target. For example, interventionists can encourage HCS to find ways to make strength exercise fun (e.g., with music or a friend) and detail its specific benefits for HCS (e.g., reduce fatigue, improve health and quality of life) [40]. Interventionists are additionally encouraged to target other key constructs outlined within the TPB (i.e., perceived control, descriptive norm, injunctive norm), as they too emerged as significant correlates of intention formation but exhibited smaller effect sizes. Furthermore, not being retired was a significant unmediated correlate of intention formation that exhibited a meaningful effect size. This highlights that retirees are less likely to form an intention to do strength exercise but the reason is not explained by the TPB (i.e., attitude, norms, perceived control). This finding is surprising because conceptually, HCS' perceived control should have accounted for (and thus mediated) the influence of potential physical, environmental, and informational barriers of strength exercise (e.g., training equipment, space, and technique) [41]. Thus, future research is needed to explain why retired HCS are less likely to form a strength exercise intention.

Table 4 Independent correlates of intention formation ($n = 606$) and translation ($n = 428$) from hierarchical forward stepwise logistic regressions

Variable	Model 1			Model 2			Model 3			Model 4		
	OR [95 % CI]	*Wald*	*p* value	OR [95 % CI]	*Wald*	*p* value	OR [95 % CI]	*Wald*	*p* value	OR [95 % CI]	*Wald*	*p* value
Intention formation												
Education	1.42 [1.02–1.98]	4.23	0.040	1.43 [1.02–1.99]	4.35	0.037	1.32 [0.93–1.88]	2.36	0.001			
Employment	2.03 [1.44–2.85]	16.63	<0.001	1.78 [1.24–2.55]	9.68	0.002	1.56 [1.06–2.30]	5.19	0.001			
Comorbidities	–	–	–	1.48 [1.02–2.15]	4.30	.038	1.39 [0.94–2.06]	2.70	0.051			
Attitude	–	–	–	–	–	–	1.56 [1.31–1.86]	24.65	<0.001			
Descriptive norm	–	–	–	–	–	–	1.38 [1.16–1.64]	13.50	0.006			
Injunctive norm	–	–	–	–	–	–	1.45 [1.21–1.74]	15.99	0.004			
Perceived control	–	–	–	–	–	–	1.38 [1.16–1.65]	13.38	<0.001			
	$R^2 = 0.053$, $x^2 = 24.47$, $p < 0.001$			$R^2 = 0.062$, $x^2 = 28.79$, $p < 0.001$			$R^2 = 0.187$, $x^2 = 90.61$, $p < 0.001$					
Intention translation												
Age	1.74 [1.14–2.67]	6.54	.011	1.33 [0.83–2.15]	1.38	.240	2.03 [1.36–3.04]	11.80	0.001	1.31 [0.79–2.16]	1.08	0.299
Comorbidities	–	–	–	1.83 [1.13–2.97]	6.12	.013	1.73 [1.06–2.83]	3.80	0.051	1.54 [0.92–2.55]	2.73	0.099
Attitude	–	–	–	–	–	–	1.43 [1.07–1.92]	5.86	.015	1.68 [1.23–2.31]	10.58	0.001
Perceived control	–	–	–	–	–	–	1.36 [1.00–1.84]	3.95	.047	1.31 [0.96–1.79]	2.89	0.089
Planning	–	–	–	–	–	–	–	–	–	1.86 [1.37–2.53]	15.89	<0.001
Obligation/regret	–	–	–	–	–	–	–	–	–	1.38 [1.08–1.76]	6.60	0.010
Regulation of alternatives	–	–	–	–	–	–	–	–	–	1.35 [1.07–1.71]	6.35	0.012
	$R^2 = 0.025$, $x^2 = 6.60$, $p = 0.010$			$R^2 = 0.047$, $x^2 = 12.77$, $p = 0.002$			$R^2 = .077$, $x^2 = 21.08$, $p < 0.001$			$R^2 = .155$, $x^2 = 43.68$, $p < 0.001$		

Intention formation regression consisted of three blocks. Intention translation regression consisted of four blocks

OR odds ratio, *CI* confidence interval

In terms of intention translation for strength exercise, the univariate results highlighted that certain subgroups of HCS were less likely to translate their intention into regular strength exercise behavior. Specifically, those who were older, had not completed university degree, were retired, or reported one or more comorbidity were less likely to translate their intention into exercise. In multivariate analyses, the influence of comorbidities and age were mediated by attitude, planning, obligation/regret, and self-regulation over competing activities, which were all, as hypothesized, significant correlates of intention translation. Having a detailed plan and favorable attitude, however, were the only variables with relationships to intention translation that exhibited meaningful effect sizes [39]. Forming a detailed exercise plan is thought to be especially important for participant groups who encounter numerous exercise-related barriers [42], such as cancer survivors. Furthermore, strength exercise requires the coordination of numerous participatory resources (e.g., equipment, space, knowledge). As such, it is likely that participation in strength exercise is rarely done spontaneously without prior planning. Thus, interventions focused on planning may be the most effective in helping HCS translate strength exercise intention into behavior. For example, an intervention strategy may be helping HCS form a detailed plan by guiding them to consider when, where, how, what type, and with whom they might exercise [30]. Furthermore, strategies that target planning may be especially effective for intention translation when supplemented by affect-based strategies, as having a favorable attitude was important for both intention formation and translation. Thus, attitude appears to act as a transitional variable [18, 21], where a favorable attitude will help form an exercise intention, but an especially favorable attitude is needed to help bridge the I-B gap (see mean values in Table 2).

The strengths of our study include being the first to examine the I-B gap for exercise in cancer survivors, the first to examine the I-B gap for strength exercise in any population, the first to test the M-PAC model for strength exercise in any population, one of the few to examine the correlates of exercise in HCS, the validated measures of motivation, the large population-based sample, and the comparison of responders and nonresponders on some demographic and medical variables. Limitations of this study include the modest response rate, the lack of a validated measure of strength exercise, the cross-sectional design, the use of self-report data, and the failure to explore additional variables from the M-PAC framework.

The modest response rate likely biased our sample and influenced our ability to provide an accurate estimate of the prevalence of strength exercise intentions and behavior. Nevertheless, the bias in our sample likely overestimates the number of HCS intending and performing strength exercise and the number of HCS able to translate strength exercise intentions into behavior. Consequently, the need for interventions is likely more pronounced than our data suggest. The lack of a validated strength exercise measure is also a limitation; however, no such measures currently exist. Strength exercise will be particularly difficult to capture by self-report because of the necessity to assess the frequency, intensity, number of sets, number of repetitions, and the number of muscle groups exercised. Our assessment included the frequency and intensity components, and we were able to use duration as a surrogate for the number of sets, repetitions, and muscle groups covered. Still, great merit exists for researchers to develop a more detailed and validated self-report measure of strength exercise for use in population-based studies.

The cross-sectional design of this study does not allow for causal interpretations of results nor to assert temporal relationships between variables. Cross-sectional research, however, serves as the foundation of our understanding of motivated exercise behavior and remains as a critical first step towards informing the development of subsequent intervention-based research. Still, longitudinal designs are needed to explore the stability and reliability of relationships between motivation and behavior long-term, as well as to explore one's progression through the M-PAC model (i.e., shifting from motivational and regulation processes, to placing more emphasis on reflective processes for behavioral maintenance over-time). The reliance on self-report data for medical variables is another limitation of this study. Despite our relative confidence in participants' ability to accurately recall their type of cancer, and treatments received, objective measures of medical data would be preferred.

This initial application of the M-PAC was also limited as we did not assess all possible variables that might influence intention and translation within the framework, and some theoretically important correlates, such as perceived control, were surprisingly not significantly related to intention translation. Thus, future research is needed to replicate our findings and additionally explore other motivational, behavioral, or reflexive processes. For example, given the need to coordinate numerous participatory resources and the strong influence of developing detailed plans for exercise, perhaps the habituation of exercise preparation may aid in translating an intention for strength exercise [21]. This investigation also followed a common approach within the exercise motivation literature, and only focused on one type of exercise modality (strength exercise), in one group of cancer survivors [43–45]. Research examining the I-B gap for other exercise modalities (e.g., aerobic exercise and sport participation) and in other cancer survivor groups is also needed.

This study has practical implications for informing future interventions. Specifically, based on the low and likely overestimated number of HCS intending to strength exercise and successfully translating that intention into behavior, interventions are needed that can address both intention formation and translation. Efforts that focus only on intention formation

are less likely to result in successful behavior change. Moreover, interventions that help HCS develop a more favorable attitude, by making exercise fun and highlighting its benefits, and a detailed plan for exercise that focuses on "with whom, what type, where, and when," may be especially effective in aiding HCS to form and translate their intention into strength exercise. Furthermore, additional attention and support might be required in order to help retirees form an intention for strength exercise, as they were significantly less likely to form an intention on their own. This initial discovery of *what* might help HCS translate exercise intentions (attitude and planning) does not however provide information on *how* these targets might be effectively manipulated. Thus, future research should look to assess the effectiveness of different intervention modalities that might help HCS improve their attitude for exercise and create more detailed exercise plans. For example, it is unclear if written materials with an exercise workbook will be sufficient to change their attitude, plan, and behavior, or whether more intensive counseling procedures will be required [30]. Furthermore, additional considerations relating to the amount of intervention time required to elicit a behavior change (e.g., 12-week intervention vs. 6-month intervention) and the optimal method of delivery (i.e., distance-based vs. face-to-face) remain to be determined.

Conclusions

In summary, few HCS are meeting strength exercise guidelines, despite the majority intending to exercise. Of HCS with an exercise intention, only about half were successful in translating their intention into behavior. HCS who were not retired, and had a favorable attitude toward exercise, were more likely to form a strength exercise intention. Furthermore, HCS who developed a detailed exercise plan, and had a favorable attitude, were more likely to have successfully translated their intention into strength exercise behavior. Interventions targeting both intention formation and translation may reduce the I-B gap and optimize strength exercise participation in HCS.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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