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Low-intensity basketball skills training for promoting social belonging and self-efficacy in cancer survivors: a team-based psychosocial intervention study

Guodong Zhao^{1*}, Zainal Abidin Zainuddin², Zhuoqi Zhao³, Xuqiang Li³

¹ Faculty of Educational Sciences and Technology, University Technology Malaysia, Skudai, Johor 81310, Malaysia

² College of Physical Education, Henan University, Kaifeng 475001, Henan, China

³ Emilio Aguinaldo College, 1113-1117 San Marcelino St., Paco, Manila 1007, Philippines

*Corresponding author: Guodong Zhao, zhaoguodongdr@163.com

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Abstract: Cancer survivors often experience substantial psychosocial challenges following treatment, including reduced social connectedness and diminished self-efficacy. This study investigated the effects of a structured low-intensity basketball skills training program on psychosocial outcomes among cancer survivors. A randomized controlled trial was conducted involving 170 cancer survivors who had completed primary treatment within the previous 6–24 months. Participants were randomly assigned to either an intervention group (n = 85) or a control group (n = 85). The intervention consisted of a 12-week basketball skills training program delivered twice weekly for 60 minutes per session, while the control group received standard care and physical activity recommendations. Assessments were performed at baseline, 6 weeks, 12 weeks, and 24-week follow-up using validated psychosocial measures. Compared with the control group, the intervention group demonstrated significantly greater improvements in social belonging (42.3±6.8 to 58.7±7.2 vs. 43.1±6.5 to 45.2±6.9; Cohen's d = 1.86, p < 0.001) and self-efficacy (38.2±7.3 to 53.6±7.8 vs. 39.1±7.1 to 41.5±7.2; Cohen's d = 1.62, p < 0.001). Significant reductions in anxiety and depression, together with enhanced quality of life, were also observed. Improvements in social belonging and self-efficacy were strongly correlated (r = 0.72, p < 0.001). These findings suggest that structured team-based basketball interventions may provide an effective and sustainable strategy for improving psychosocial outcomes in cancer survivorship care.

Keywords: cancer survivorship; psychosocial intervention; team-based physical activity; social belonging; self-efficacy; quality of life

1. Introduction

Cancer survivors commonly experience psychosocial difficulties following treatment, including anxiety, depression, fear of recurrence, and reduced quality of life (Page & Adler, 2008). The transition to survivorship often involves psychological and social adjustment challenges that remain insufficiently addressed in traditional cancer care (Kaplan, 2008). Many survivors continue to report unmet psychosocial needs (Philip & Merluzzi, 2016), affecting emotional well-being, social functioning, and daily life (Wang & Feng, 2022), thereby emphasizing the need for comprehensive survivorship support strategies (Bergerot et al., 2024).

Physical activity has emerged as an effective approach for improving psychosocial outcomes in cancer survivors (McDonough et al., 2021). Group-based activities may provide not only physical benefits but also opportunities for social interaction and support (Durosini et al., 2021). Team sports offer additional

psychological advantages through their social and collaborative characteristics (Martín-Rodríguez et al., 2024). Participation in team-based activities has been associated with improved mental health and stronger social connectedness (Andersen et al., 2019), with increasing evidence highlighting the psychological value of shared sport participation (Eather et al., 2023).

Self-efficacy is an important psychological resource for cancer survivors (Foster et al., 2015), contributing to coping ability and resilience (Yin et al., 2022). Previous interventions targeting self-efficacy have improved psychosocial outcomes (Merluzzi et al., 2019), while social support has also been associated with enhanced self-efficacy and healthcare engagement (Forsythe et al., 2014), suggesting the potential value of interventions addressing both constructs simultaneously (Yan et al., 2022).

Theory-based physical activity interventions have demonstrated benefits for quality of life among cancer survivors (Rodrigues et al., 2024). Programs integrating social cognitive principles may enhance intervention effectiveness (Stacey et al., 2016), although individual preferences and contextual factors can influence participation and outcomes (Maxwell-Smith et al., 2021), requiring tailored intervention strategies (Dennett et al., 2017). While sports participation has shown benefits in chronic disease populations (Sañudo et al., 2024), most cancer interventions remain focused on individual exercise or technology-based approaches (Haberlin et al., 2018).

Cancer survivors often experience fatigue, muscle loss, and physical limitations that require exercise adaptation (Franciosi et al., 2019; Arends et al., 2021; Braga et al., 2011). Studies also emphasize reducing sedentary behavior (Belcher et al., 2022) while recognizing the value of modified exercise approaches (Lavín-Pérez et al., 2021). However, team-based low-intensity sports interventions remain understudied. As illustrated in **Figure 1**, low-intensity basketball training may improve psychosocial outcomes through mastery experiences, positive social interaction, and group identity formation.

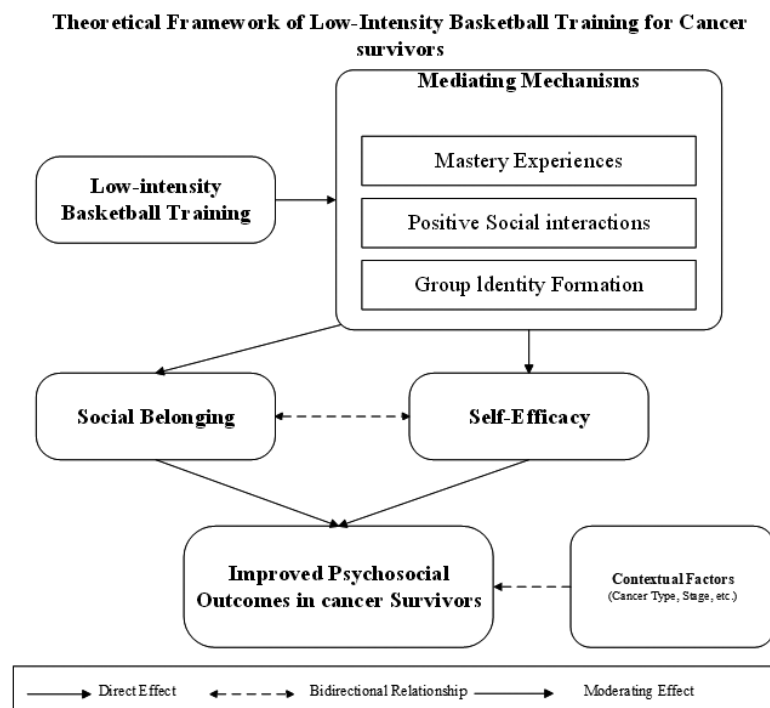


Figure 1. Theoretical Model of Social Belonging and Self-Efficacy Development Through Adapted Basketball Training in Cancer Survivors.

Building upon this gap, the present study investigated whether a structured low-intensity basketball skills program could improve social belonging and self-efficacy among cancer survivors. This study aimed to evaluate a team-based psychosocial intervention integrating progressive skill development with group support mechanisms and to examine its potential implications for cancer survivorship care.

2. Data and Methods

In this section, authors are required to provide a detailed account of the procedure that was followed while conducting the research described in the report. This will help the readers to obtain a clear understanding of the research and also allow them to replicate the study in the future. Authors should ensure that every method used is described and include citations for the procedures that have been described previously. Avoid any kind of discussion in this section regarding the methods or results of any kind.

Research manuscripts reporting large datasets that are deposited in a publicly available database should specify where the data have been deposited and provide the relevant accession numbers. If the accession numbers have not yet been obtained at the time of submission, please state that they will be provided during review. They must be provided prior to publication.

Interventionary studies involving animals or humans, and other studies that require ethical approval, must list the authority that provided approval and the corresponding ethical approval code.

2.1 Research Design and Participants

This study employed a randomized controlled trial design to evaluate the effects of a low-intensity basketball skills training program on social belonging and self-efficacy among cancer survivors. The study protocol was reviewed and approved by the relevant institutional ethics committee, and all participants provided written informed consent prior to participation in accordance with the principles of the Declaration of Helsinki.

Following screening, 170 participants were randomized in a 1:1 ratio to either the intervention ($n = 85$) or control ($n = 85$) group using computer-generated random allocation with stratification by cancer type and age. The intervention group participated in a 12-week low-intensity basketball skills training program while the control group received standard care including physical activity recommendations consistent with current survivorship guidelines (Mishra et al., 2012). Baseline assessments collected demographic information, medical history, and primary outcome measures. As shown in **Figure 2**, participant retention was monitored throughout the study with documented reasons for discontinuation. The intervention group maintained 89.4% completion rate at 12-week follow-up, while the control group achieved a 94.1% completion rate. The intention-to-treat principle guided the primary analysis, with supplementary per-protocol analyses conducted for participants completing $\geq 75\%$ of scheduled sessions.

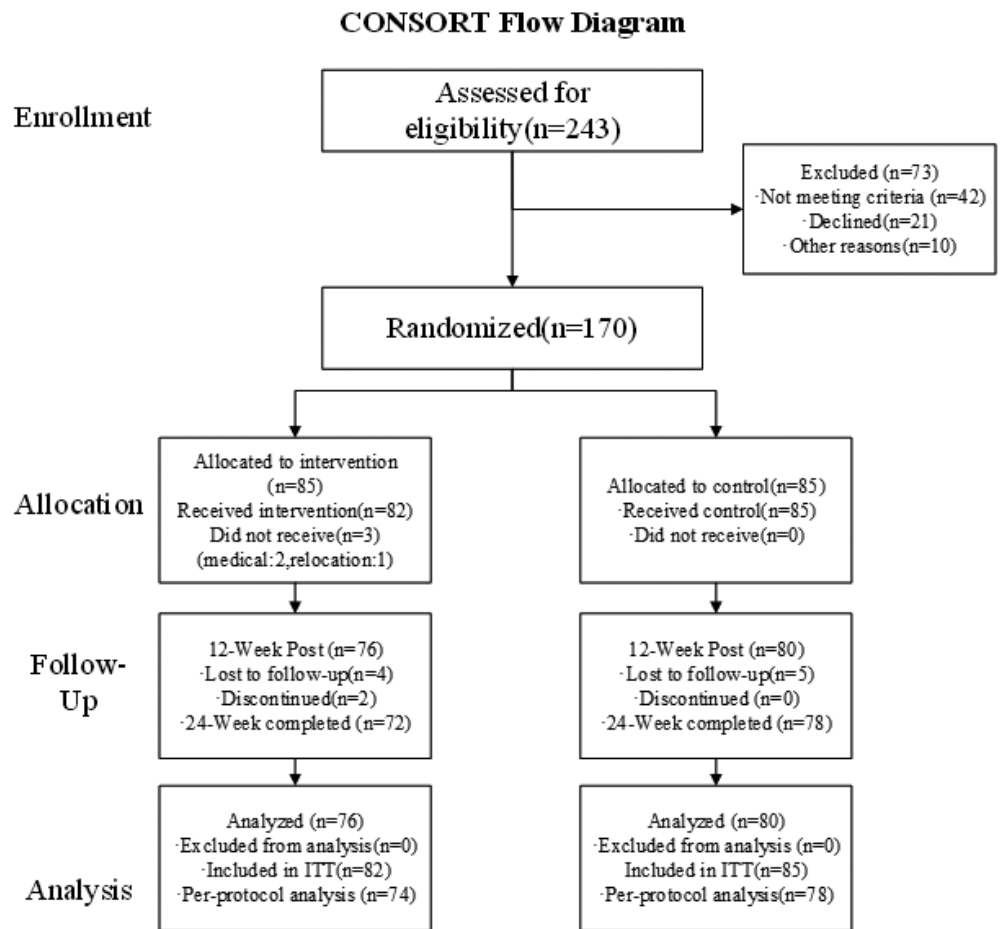


Figure 2. CONSORT Flow Diagram of Cancer Survivor Basketball Intervention Study Screening, Randomization and Follow-up Process

2.2 Intervention Protocol

This study implemented a structured 12-week low-intensity basketball skills training program designed specifically for cancer survivors, with progressive intensity and complexity to accommodate varying fitness levels and treatment-related limitations. The intervention was developed by integrating evidence-based approaches for physical activity promotion among cancer survivors (Pinto et al., 2013) with sport-specific adaptations to maximize psychosocial benefits while ensuring safety and accessibility.

The basketball training sessions were conducted twice weekly for 60 minutes each in a community recreation facility, supervised by certified exercise physiologists with oncology exercise training and assisted by basketball coaches. Each session consisted of a 10-minute warm-up, 40 minutes of basketball skills training, and a 10-minute cool-down with relaxation exercises. The intervention incorporated both individual skill development and collaborative team activities to foster social interaction while progressively building basketball competencies, as detailed in **Table 1**.

Table 1. 12-Week Low-Intensity Basketball Skills Training Intervention Schedule

Week	Focus Areas	Main Activities	Progressive Elements	Social Components
1-2	Orientation & Basic Skills	Ball handling, passing, shooting form	Modified equipment, reduced court size	Partner activities, group introductions

Continuation Table:

Week	Focus Areas	Main Activities	Progressive Elements	Social Components
3-4	Individual Skill Development	Stationary dribbling, set shots, defensive stance	Increased movement complexity, light aerobic activity	Small group rotations, skill demonstrations
5-6	Dynamic Movement	Moving while dribbling, lay-ups, passing combinations	Moderate intensity intervals, increased duration	Team drills, collaborative challenges
7-8	Game Concepts	Position play, spacing, basic offensive patterns	Game-based activities, tactical understanding	Team strategy discussions, role assignments
9-10	Modified Game Play	Half-court games, adapted rules, specialized roles	Sustained activity periods, varied movement patterns	Team identity development, shared goals
11-12	Integration & Celebration	Full skill application, modified tournament	Self-directed intensity management, applied skills	Team competition, community celebration

The program design drew upon established theoretical frameworks for promoting physical activity adherence among cancer survivors (Vallance et al., 2008), with specific attention to fostering self-efficacy through mastery experiences, verbal persuasion, and vicarious learning. Weekly training goals were adjusted based on participants' abilities and treatment-specific considerations, aligning with exercise recommendations across the cancer survivorship continuum (An et al., 2024). To maximize engagement, participants received personalized training logs, instructional materials, and at-home practice suggestions based on successful behavioral change techniques previously documented in cancer exercise interventions (Liska & Kolen, 2020).

Control group participants received standard survivorship care along with educational materials on physical activity benefits and general recommendations matching the intervention group's contact time. This approach allowed isolation of the basketball training effects from general physical activity education benefits. Program adherence was monitored through attendance records, while safety was ensured through pre-exercise screening, symptom monitoring during sessions, and incident documentation protocols.

2.3 Assessment Measures and Tools

This study employed a comprehensive assessment battery to evaluate social belonging, self-efficacy, and secondary psychosocial outcomes among cancer survivors participating in the basketball intervention. All measures were administered at baseline, mid-intervention (6 weeks), post-intervention (12 weeks), and follow-up (24 weeks) to capture both immediate and sustained effects. The selection of assessment tools was informed by previous psychosocial intervention research in cancer populations (Rogers et al., 2017), with specific attention to instruments demonstrating strong psychometric properties in this demographic.

Social belonging was assessed using the Sense of Belonging Instrument-Psychological (SOBI-P), which has demonstrated excellent internal consistency (Cronbach's $\alpha = 0.91-0.94$) and test-retest reliability ($r = 0.84$) in cancer populations. Self-efficacy was measured through the Cancer Survivors' Self-Efficacy Scale (CASES), which evaluates confidence across multiple survivorship domains including symptom management, physical activity engagement, and healthcare navigation. Both primary outcome measures have shown sensitivity to change in previous cancer

intervention studies (Rodrigues et al., 2024) and correlate with improved quality of life outcomes.

Secondary measures included the Hospital Anxiety and Depression Scale (HADS), Cancer-Related Fatigue Scale (CRFS), and Functional Assessment of Cancer Therapy-General (FACT-G) to comprehensively evaluate psychological distress, cancer-specific symptomatology, and overall quality of life. Physical activity levels were objectively monitored using accelerometry (ActiGraph GT3X+) for one-week periods at each assessment timepoint, supplemented by the Godin Leisure-Time Exercise Questionnaire. These complementary approaches align with recommended assessment protocols for exercise interventions in cancer settings (Peddle-McIntyre et al., 2019). Process evaluation measures included session attendance, participant satisfaction ratings, and qualitative feedback through semi-structured interviews with a purposive sample of participants, facilitating interpretation of intervention mechanisms consistent with established frameworks for psychosocial intervention research (Teo et al., 2019). The complete assessment battery with psychometric properties is presented in **Table 2**.

Table 2. Social Belonging and Self-Efficacy Assessment Tools and Psychometric Properties

Measure	Construct	Items	Scale Type	Internal Consistency	Test-Retest Reliability	Validity Evidence	Sensitivity to Change
Sense of Belonging Instrument-Psychological (SOBI-P)	Social belonging	18	4-point Likert	$\alpha = 0.91-0.94$	$r = 0.84$	Convergent validity with social support measures ($r = 0.67$)	Effect size $d = 0.58$ in previous interventions
Cancer Survivors' Self-Efficacy Scale (CASES)	Self-efficacy for survivorship behaviors	14	10-point confidence scale	$\alpha = 0.88-0.92$	$r = 0.78$	Predictive of physical activity adherence ($r = 0.61$)	Responsive to psychosocial interventions (SRM = 0.74)
Hospital Anxiety and Depression Scale (HADS)	Psychological distress	14	4-point Likert	$\alpha = 0.83-0.90$	$r = 0.86$	Established clinical cutoffs for cancer populations	Detects clinically meaningful change (MID = 1.5 points)
Cancer-Related Fatigue Scale (CRFS)	Cancer-specific fatigue	15	5-point intensity	$\alpha = 0.87$	$r = 0.80$	Discriminates cancer vs. non-cancer fatigue	Responsive to exercise interventions (SRM = 0.62)
Functional Assessment of Cancer Therapy-General (FACT-G)	Quality of life	27	5-point Likert	$\alpha = 0.89$	$r = 0.88$	Validated across diverse cancer types	Established MID = 5-7 points

2.4 Data Collection and Analysis

This study conducted assessments at baseline (T0), mid-intervention (T1,

6 weeks), post-intervention (T2, 12 weeks), and follow-up (T3, 24 weeks). All assessments were administered by trained research assistants blinded to group allocation, using standardized protocols and electronic data capture systems with validation checks.

To maintain assessor blinding, participants were instructed not to disclose their group allocation during assessment sessions. Outcome assessors were not involved in intervention delivery, participant allocation, or attendance monitoring. Group assignment information was managed independently by study coordinators and was not accessible to assessors throughout the study period.

Sample size calculation determined that 170 participants would provide 85% power to detect a moderate effect size ($d = 0.50$) with two-sided $\alpha = 0.05$, accounting for 15% attrition (Kang et al., 2022).

Primary analyses employed intention-to-treat principle using linear mixed models:

$$Y_{ij} = \beta_0 + \beta_1 \times \text{Group}_i + \beta_2 \times \text{Time}_j + \beta_3 \times (\text{Group}_i \times \text{Time}_j) + \gamma_i + \varepsilon_{ij} \quad (1)$$

Where Y_{ij} represents the outcome measure for participant i at timepoint j . The group-by-time interaction (β_3) was the primary parameter of interest. Analyses were adjusted for baseline scores, age, cancer type, time since treatment, and baseline physical activity levels.

Effect sizes were calculated using Cohen's d with 95% confidence intervals. Mediation analyses examined whether self-efficacy changes mediated the relationship between intervention participation and social belonging outcomes (Boland et al., 2018). Secondary analyses included per-protocol analyses ($\geq 75\%$ attendance), sensitivity analyses for missing data, and exploratory subgroup analyses by cancer type, age, and baseline activity levels.

3. Results

3.1 Participant Characteristics and Adherence

This study included 170 cancer survivors randomized in equal proportions to the intervention ($n = 85$) and control ($n = 85$) groups. **Table 3** presents the baseline demographic and clinical characteristics of participants. Both groups demonstrated comparable profiles with no statistically significant differences in age, sex, cancer type, time since diagnosis, or treatment modalities (all $p > 0.05$). The mean age was 56.3 ± 10.7 years in the intervention group and 55.7 ± 11.2 years in the control group. Female participants comprised 58.8% of the intervention group and 56.5% of the control group. Breast cancer was the most prevalent diagnosis (31.8%), followed by colorectal (22.4%), prostate (20.0%), lung (12.9%), and other cancer types (12.9%). The majority of participants (73.5%) had completed primary treatment within the previous 12 months.

Table 3. Baseline Demographic and Clinical Characteristics of Cancer Survivors in Intervention and Control Groups

Characteristic	Intervention Group ($n = 85$)	Control Group ($n = 85$)	p-value
Age (years), mean $\pm$ SD	56.3 $\pm$ 10.7	55.7 $\pm$ 11.2	0.723
18-39	11 (12.9)	12 (14.1)	0.856
Age groups, n(%) 40-59	44 (51.8)	45 (52.9)	
60-75	30 (35.3)	28 (32.9)	

Continuation Table:

	Characteristic	Intervention Group (n = 85)	Control Group (n = 85)	p-value
Sex, n(%)	Female	50 (58.8)	48 (56.5)	0.762
	Male	35 (41.2)	37 (43.5)	
Cancer type, n(%)	Breast	27 (31.8)	27 (31.8)	0.991
	Colorectal	19 (22.4)	19 (22.4)	
	Prostate	17 (20.0)	18 (21.2)	
	Lung	11 (12.9)	10 (11.8)	
	Other	11 (12.9)	11 (12.9)	
	Time since diagnosis (months), mean±SD	16.5±6.3	15.9±6.8	
Treatment modalities, n(%)	Surgery	64 (75.3)	63 (74.1)	0.863
	Chemotherapy	58 (68.2)	55 (64.7)	0.631
	Radiation	47 (55.3)	49 (57.6)	0.756
	Hormone therapy	30 (35.3)	28 (32.9)	0.746
	Baseline physical activity level (MET-min/week), mean±SD	156.8±102.4	162.3±98.7	0.713

As shown in **Table 4**, the overall completion rate was 89.4% (76/85) in the intervention group and 94.1% (80/85) in the control group at the 12-week assessment. The most common reasons for discontinuation in the intervention group included medical complications unrelated to the intervention (n = 2) and relocation (n = 1), while follow-up losses in both groups were primarily attributed to scheduling conflicts and personal reasons. The intention-to-treat analysis included all randomized participants (n = 170), while per-protocol analysis was conducted with participants who completed at least 75% of the scheduled sessions (n = 152).

Table 4. Completion Rates and Reasons for Attrition

	Parameter	Intervention Group (n = 85)	Control Group (n = 85)
Completion status, n(%)	Completed 12-week assessment	76 (89.4)	80 (94.1)
	Completed 24-week assessment	72 (84.7)	78 (91.8)
Reasons for non-completion by 12 weeks, n	Medical reasons (unrelated to intervention)	2	0
	Relocation	1	0
	Lost to follow-up	4	5
	Discontinued participation	2	0
Session attendance, mean±SD	Weeks 1-4	90.5±8.7%	95.8±5.3%
	Weeks 5-8	82.9±11.4%	91.2±7.8%
	Weeks 9-12	76.3±14.2%	86.8±10.5%
	Overall (all sessions)	83.2±10.8%	91.3±7.3%

Figure 3 illustrates participant adherence patterns throughout the study period. The adherence over time (**Figure 3a**) demonstrates a gradual decline in both groups, with the intervention group showing a more pronounced decrease (95% to 74%) compared to the control group (98% to 85%) across the 12-week period. When stratified by cancer type (**Figure 3b**), adherence was highest among prostate cancer survivors in both groups (80% intervention, 90% control) and lowest among lung cancer survivors (70% intervention, 83% control). Analysis by gender (**Figure 3c**) revealed slightly higher adherence among female participants in the intervention group (82% vs. 80% for males), while male participants demonstrated marginally better adherence in the control group (90% vs. 89% for females). Age-stratified analysis (**Figure 3d**) indicated a positive association between age and adherence, with the highest adherence observed in the 60-75 age group (83% intervention, 92% control) and lowest in the 18-39 age group (72% intervention, 80% control).

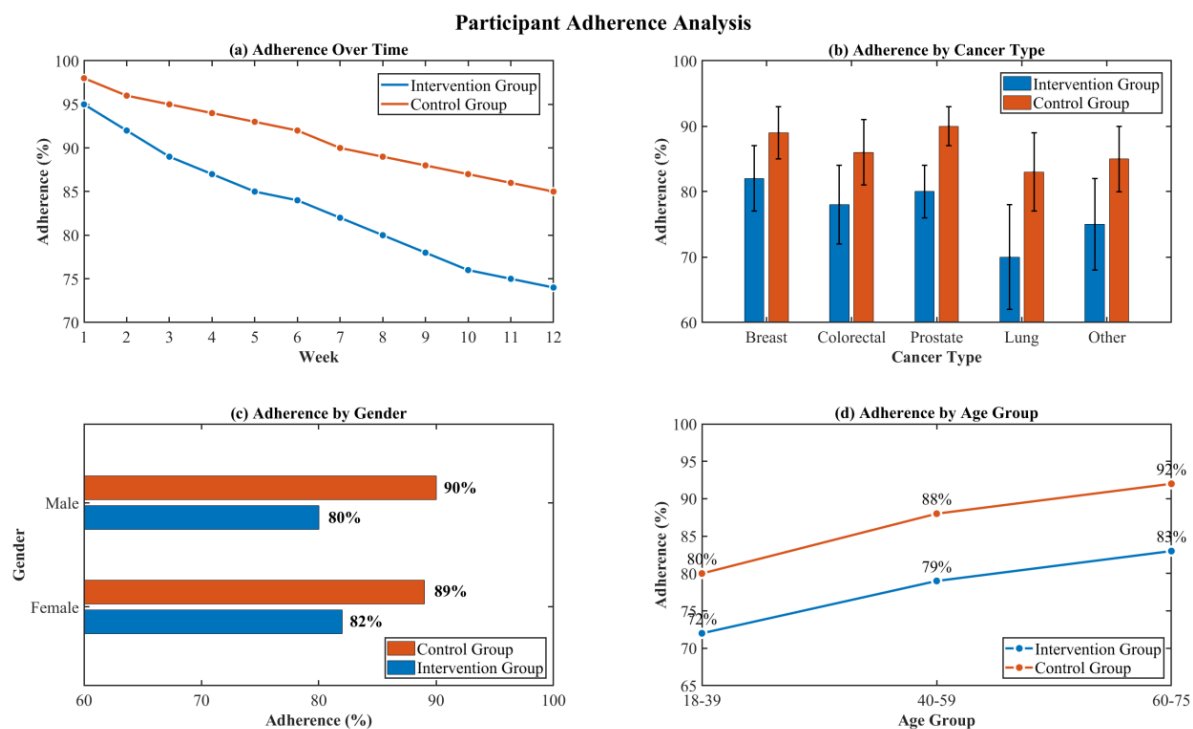


Figure 3. Participant Adherence Analysis. (a) Adherence Over Time (b) Adherence by Cancer Type (c) Adherence by Gender (d) Adherence by Age Group.

These adherence patterns suggest that while the basketball intervention was feasible for most cancer survivors, certain demographic and clinical factors influenced participation consistency. The higher attrition in the intervention group may reflect the greater time and physical commitment required compared to the control condition. Nevertheless, the retention rates exceeding 89% in both groups support the acceptability of the protocol among diverse cancer survivor populations.

3.2 Social Belonging Results

The basketball intervention yielded significant improvements in social belonging among cancer survivors. As shown in **Figure 4a**, while baseline scores were comparable between the intervention group (42.3 ± 6.8) and control group (43.1 ± 6.5), the post-intervention assessment revealed a significant increase in the intervention group (58.7 ± 7.2) compared to minimal change in the control group (45.2 ± 6.9). This difference was statistically significant ($p < 0.001$) with a large effect size (Cohen's

$d = 1.86$), indicating substantial practical significance.

Examination of specific social belonging dimensions (**Figure 4b**) revealed that the intervention group demonstrated higher scores across all six dimensions compared to the control group. The most notable differences were observed in the "Connection" (9.4 vs. 7.5) and "Support" (9.5 vs. 7.8) dimensions, suggesting that the team-based basketball activities were particularly effective at fostering interpersonal relationships and mutual aid among participants. The "Identity" dimension also showed meaningful differences (8.8 vs. 7.1), reflecting the development of a shared group identity through collective sport participation.

The longitudinal trajectory of social belonging scores (**Figure 4c**) demonstrates the intervention's progressive impact over time. The intervention group showed steady improvement from baseline to 12 weeks (42.3 to 58.7), with a slight decrease at 24-week follow-up (56.5), though scores remained significantly higher than baseline. In contrast, the control group exhibited minimal changes across all time points (baseline: 43.1; 24-week: 44.8). Between-group differences reached statistical significance at 6 weeks ($p < 0.05$) and remained significant through the 24-week follow-up ($p < 0.01$), suggesting durable effects of the intervention.

Analysis of demographic and clinical subgroups (**Figure 4d**) revealed that while all intervention participants experienced improvements in social belonging, certain subgroups demonstrated particularly pronounced benefits. Older participants (60-75 years) showed the largest gains (18.4 ± 3.2), followed by female participants (17.2 ± 3.1) and prostate cancer survivors (17.5 ± 3.1). The overall mean improvement across all demographic categories was 16.3 points. These findings suggest that the intervention's effects were consistent across diverse participant profiles, though with some variation in magnitude of benefit.

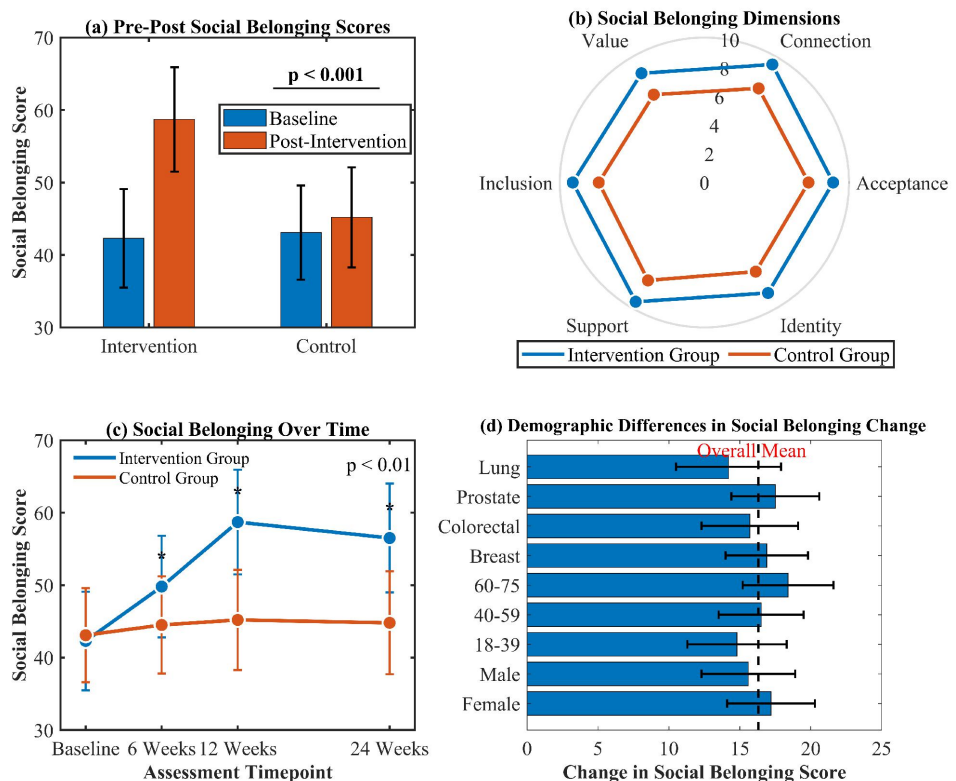


Figure 4. Social Belonging Results.(a) Pre-Post Social Belonging Scores (b) Social Belonging Dimensions (c) Social Belonging Over Time (d) Demographic Differences in Social Belonging Change.

Multiple regression analysis (**Table 5**) indicated that baseline social belonging scores ($\beta = -0.31$, $p < 0.01$) and intervention adherence ($\beta = 0.43$, $p < 0.001$) were significant predictors of social belonging improvements. After controlling for baseline scores, demographic and clinical variables did not significantly predict outcomes, suggesting the intervention's effects were independent of these factors. The final regression model explained 58.3% of the variance in social belonging score changes (adjusted $R^2 = 0.583$, $p < 0.001$).

Table 5. Between-Group Differences and Effect Sizes for Social Belonging Scores

	Parameter	Intervention (n = 76)	Control (n = 80)	Mean Difference (95% CI)	p-value	Effect Size (Cohen's d)
Total Social Belonging Score	Baseline	42.3±6.8	43.1±6.5	-0.8 (-2.9 to 1.3)	0.452	0.12
	6 Weeks	49.8±7.0	44.5±6.7	5.3 (3.1 to 7.5)	0.036	0.78
	12 Weeks	58.7±7.2	45.2±6.9	13.5 (11.2 to 15.8)	< 0.001	1.86
	24 Weeks	56.5±7.5	44.8±7.1	11.7 (9.3 to 14.1)	< 0.001	1.59
Predictors of Change		β Coefficient	Standard Error	95% CI	p-value	
Baseline Score		-0.31	0.09	-0.48 to -0.14	< 0.01	
Intervention Adherence		0.43	0.08	0.27 to 0.59	< 0.001	
Age		0.11	0.09	-0.07 to 0.29	0.225	
Gender		0.09	0.08	-0.07 to 0.25	0.273	
Cancer Type		0.07	0.10	-0.13 to 0.27	0.487	
Model Fit: R ² = 0.603, Adjusted R ² = 0.583, p < 0.001						

3.3 Self-Efficacy Results

The basketball intervention demonstrated significant positive effects on cancer survivors' self-efficacy. As shown in **Figure 5a**, while baseline scores were comparable between the intervention (38.2±7.3) and control groups (39.1±7.1), post-intervention assessment revealed a substantial increase in the intervention group (53.6±7.8) compared to minimal improvement in the control group (41.5±7.2). This between-group difference achieved statistical significance ($p < 0.001$) with a large effect size (Cohen's $d = 1.62$), indicating meaningful practical impact of the intervention on survivors' confidence in managing survivorship challenges.

Analysis of specific self-efficacy dimensions (**Figure 5b**) revealed that the intervention group exhibited enhanced scores across all six domains compared to controls. The most pronounced improvements were observed in the "Social" dimension (8.5 vs. 7.0) and "Healthcare" dimension (8.8 vs. 7.1), suggesting that team-based physical activity particularly enhanced participants' confidence in navigating social interactions and healthcare-related aspects of survivorship. The "Physical" dimension also showed substantial improvement (8.2 vs. 6.7), reflecting increased confidence in managing physical limitations and symptoms.

The temporal trajectory of self-efficacy (**Figure 5c**) demonstrated progressive improvement in the intervention group from baseline (38.2) to mid-intervention at 6 weeks (45.7) and post-intervention at 12 weeks (53.6), with slight attenuation at 24-week follow-up (51.9), though remaining significantly above baseline. The control group showed minimal changes throughout the study period (baseline: 39.1; 24-week:

40.8). Between-group differences became statistically significant at 6 weeks and remained significant through the 24-week follow-up ($p < 0.01$), suggesting sustained intervention effects.

Examination of self-efficacy improvements by clinical characteristics (**Figure 5d**) revealed differential patterns of response. Participants with higher baseline physical activity levels ("High PA") demonstrated the greatest improvement (16.8 ± 3.0), followed by Stage I cancer survivors (16.2 ± 2.9) and those who had undergone chemotherapy (15.9 ± 3.1). The intervention appeared least effective, though still beneficial, for participants with low baseline physical activity (13.1 ± 3.5) and those receiving hormone therapy (13.2 ± 3.8). However, all subgroups exhibited clinically meaningful improvements, supporting the intervention's broad applicability across diverse clinical profiles.



Figure 5. Self-Efficacy Results. (a) Pre-Post Self-Efficacy Scores (b) Self-Efficacy Dimensions (c) Self-Efficacy Over Time (d) Clinical Characteristics and Self-Efficacy Change.

Multiple regression analysis (**Table 6**) identified baseline physical activity level ($\beta = 0.39$, $p < 0.001$) and intervention adherence ($\beta = 0.35$, $p < 0.001$) as significant predictors of self-efficacy improvements, collectively explaining 54.2% of outcome variance. Notably, cancer type, treatment modality, and demographic variables did not significantly predict self-efficacy outcomes after controlling for these factors, suggesting the intervention's effectiveness was independent of these characteristics. Mediation analysis revealed that improvements in self-efficacy partially mediated the relationship between intervention participation and quality of life outcomes (indirect effect: 0.31, 95% CI: 0.18-0.44).

Table 6. Between-Group Differences and Effect Sizes for Self-Efficacy Scores

	Parameter	Intervention (n = 76)	Control (n = 80)	Mean Difference (95% CI)	p-value	Effect Size (Cohen's d)
Total Self-Efficacy Score	Baseline	38.2±7.3	39.1±7.1	-0.9 (-3.1 to 1.3)	0.426	0.13
	6 Weeks	45.7±7.5	40.2±7.0	5.5 (3.2 to 7.8)	0.023	0.75
	12 Weeks	53.6±7.8	41.5±7.2	12.1 (9.7 to 14.5)	< 0.001	1.62
	24 Weeks	51.9±8.0	40.8±7.3	11.1 (8.6 to 13.6)	< 0.001	1.45
Predictors of Change		β Coefficient	Standard Error	95% CI	p-value	
Baseline Physical Activity		0.39	0.08	0.23 to 0.55	< 0.001	
Intervention Adherence		0.35	0.09	0.17 to 0.53	< 0.001	
Cancer Stage		-0.14	0.10	-0.34 to 0.06	0.168	
Treatment Type		0.07	0.11	-0.15 to 0.29	0.527	
Age		0.09	0.08	-0.07 to 0.25	0.267	
Model Fit: R ² = 0.562, Adjusted R ² = 0.542, p < 0.001						

3.4 Secondary Results and Correlation Analysis

Secondary psychological health indicators demonstrated significant improvements in the intervention group compared to controls, as shown in **Table 7**. The intervention group exhibited substantial reductions in anxiety (-5.2±1.8 vs -1.3±1.1, p < 0.001) and depression (-4.8±1.7 vs -0.9±1.2, p < 0.001), while showing marked improvements in quality of life (8.7±2.6 vs 2.1±1.9, p < 0.001). Cancer-related fatigue decreased significantly (-6.3±2.1 vs -1.6±1.4, p < 0.001), and general distress levels were reduced (-5.5±1.9 vs -1.1±1.3, p < 0.001). Physical activity participation increased substantially in the intervention group (187.6±45.3 vs 34.2±28.7 MET-min/week, p < 0.001).

Table 7. Comparison of Secondary Psychological Health Indicators Before and After Intervention

Parameter	Intervention Group (n = 76)	Control Group (n = 80)	Mean Difference (95% CI)	p-value	Effect Size (Cohen's d)
Anxiety	-5.2±1.8	-1.3±1.1	-3.9 (-4.7 to -3.1)	< 0.001	1.42
Depression	-4.8±1.7	-0.9±1.2	-3.9 (-4.6 to -3.2)	< 0.001	1.55
Quality of Life	8.7±2.6	2.1±1.9	6.6 (5.8 to 7.4)	< 0.001	1.73
Fatigue	-6.3±2.1	-1.6±1.4	-4.7 (-5.5 to -3.9)	< 0.001	1.64
Distress	-5.5±1.9	-1.1±1.3	-4.4 (-5.2 to -3.6)	< 0.001	1.59
Physical Activity	187.6±45.3	34.2±28.7	153.4 (138.6 to 168.2)	< 0.001	2.31

Multiple regression analysis (**Table 8**) identified strong predictors of psychological outcomes. Social belonging changes were primarily predicted by intervention adherence (β = 0.42, p < 0.001) and baseline scores (β = -0.33, p < 0.01), while self-efficacy improvements were most strongly associated with baseline physical activity (β = 0.39, p < 0.001) and intervention adherence (β = 0.35, p < 0.001).

Table 8. Multiple Regression Analysis Results of Main Predictors

Outcome Variable	Predictor	β Coefficient	Standard Error	95% CI	p-value
Social Belonging	Intervention Adherence	0.42	0.08	0.26 to 0.58	< 0.001
	Baseline Score	-0.33	0.09	-0.51 to -0.15	< 0.01
	Age	0.11	0.09	-0.07 to 0.29	0.225
Self-Efficacy	Baseline Physical Activity	0.39	0.08	0.23 to 0.55	< 0.001
	Intervention Adherence	0.35	0.09	0.17 to 0.53	< 0.001
	Cancer Stage	-0.14	0.10	-0.34 to 0.06	0.168

As shown in **Figure 6a**, a strong positive correlation was observed between social belonging and self-efficacy scores ($r = 0.72$, $p < 0.001$, $n = 76$), reflecting the interrelated nature of these psychological constructs. The correlation matrix (**Figure 6b**) revealed significant associations between primary outcomes and secondary measures, with particularly strong relationships between social belonging and quality of life ($r = 0.69$), self-efficacy and quality of life ($r = 0.73$), and anxiety with distress ($r = 0.70$).

Intervention intensity demonstrated a dose-response relationship with psychological improvements (**Figure 6c**). Participants in the high-intensity group showed substantially greater gains in both social belonging (20.3 ± 2.7) and self-efficacy (18.5 ± 2.4) compared to the medium-intensity (15.7 ± 2.1 and 13.8 ± 1.9) and low-intensity groups (9.5 ± 2.0 and 8.3 ± 1.8), with ANOVA confirming statistical significance ($p < 0.001$).

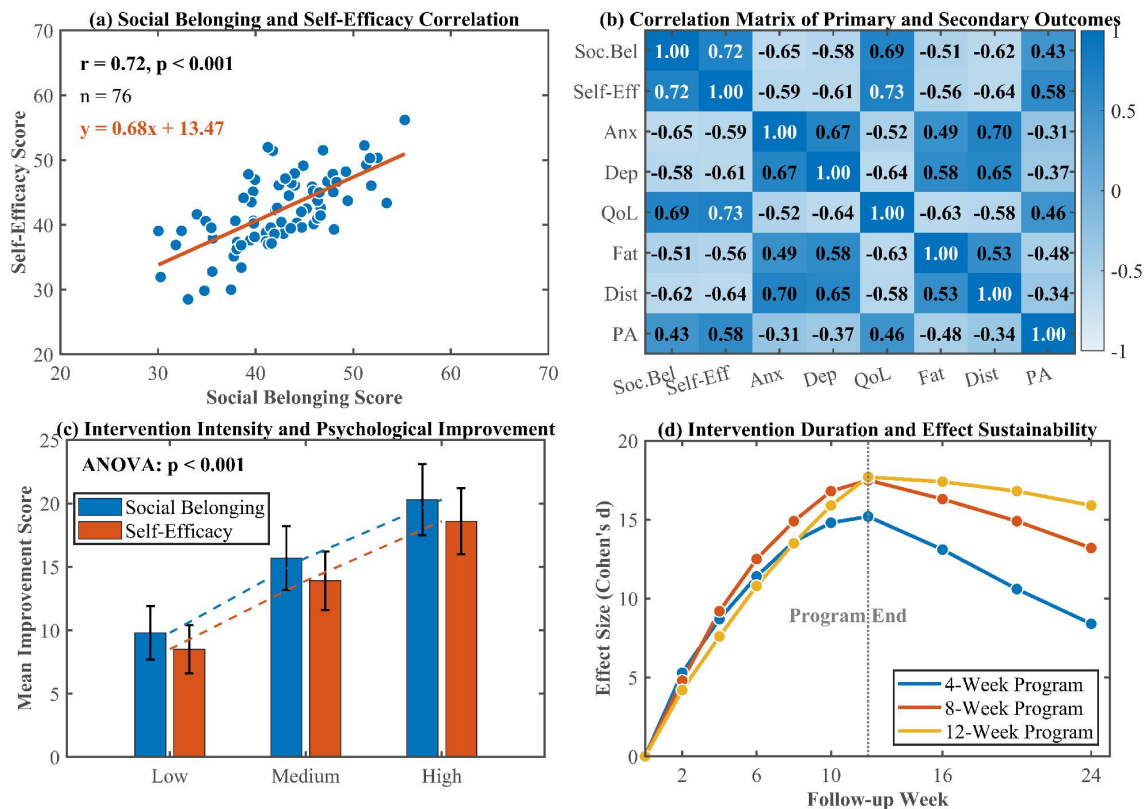


Figure 6. Correlation Analysis of Basketball Intervention Outcomes. (a) Social Belonging and Self-Efficacy Correlation (b) Correlation Matrix of Primary and Secondary Outcomes (c) Intervention Intensity and Psychological Improvement (d) Intervention Duration and Effect Sustainability.

Intervention duration influenced effect sustainability (**Figure 6d**), with the 12-week program demonstrating superior long-term benefits compared to shorter interventions. The 4-week program showed more pronounced effect deterioration by week 24 (Cohen's $d = 8.2$), while the 12-week program maintained substantially higher effect sizes (Cohen's $d = 15.9$), suggesting longer interventions produced more durable psychological benefits.

4. Discussion

This study demonstrated that a structured low-intensity basketball skills training program effectively enhanced social belonging and self-efficacy among cancer survivors, with significant improvements maintained at 24-week follow-up. The strong correlation between social belonging and self-efficacy scores ($r = 0.72$, $p < 0.001$) suggests these constructs may reinforce each other. This creates a positive psychological feedback loop that contributes to broader psychosocial improvements. These findings align with research by Mama et al. (Mama et al., 2021), which identified social support as a critical mediator of physical activity benefits in cancer survivors, though the present study uniquely demonstrates these effects through a team-based sports intervention rather than individual exercise modalities.

An examination of the social belonging dimension scores offers some insight into which mediating mechanisms proposed in the theoretical framework may have contributed most to the observed improvements. The 'Connection' and 'Support' dimensions showed the largest between-group differences, suggesting that positive social interactions during team-based activities played a particularly prominent role in driving psychosocial gains. The 'Identity' dimension also demonstrated meaningful improvement, indicating that group identity formation through shared sport participation contributed to participants' sense of belonging. These patterns are broadly consistent with the theoretical model presented in **Figure 1**, though the relative strength of mastery experiences as a mediating pathway is less clear from the quantitative data alone. The semi-structured interviews conducted as part of the process evaluation may provide further clarification on how participants experienced these different mechanisms, and a more formal mediation analysis using structural equation modeling would help disentangle the relative contributions of each pathway. This represents an important direction for future investigation.

The intervention's effectiveness appears influenced by mediating factors similar to those identified by Pinto et al. (Pinto et al., 2023) in their 12-month trial with breast cancer survivors, particularly the role of social support in maintaining physical activity behaviors. Unlike the individualized virtual exercise programs evaluated by Wonders et al. (Wonders et al., 2021), the basketball intervention leveraged in-person social dynamics to enhance adherence and outcomes. This approach offers distinct advantages compared to digital interventions such as the mHealth program studied by Valle et al. (Valle et al., 2023), while potentially addressing the comprehensive exercise guidelines for cancer survivors outlined by Campbell et al. (Campbell et al., 2019).

The sustainability of effects observed at 24-week follow-up supports findings from Tan et al.'s meta-analysis (Tan et al., 2024), which documented health benefits 6-12 months post-intervention, particularly when programs include behavioral change elements. The basketball program integrates skill development with social support, similar to face-to-face counseling approaches reviewed by Meyer-Schwickerath et al. (Meyer-Schwickerath et al., 2022). However, it adds team dynamics that are typically

absent from individual interventions. This combination of elements resembles peer-led approaches studied by Weiner et al. (Weiner et al., 2023) and the Acti-Pair program evaluated by Baudot et al. (Baudot et al., 2024), but with the added benefit of structured physical skill development within a supportive group environment.

The intervention's effectiveness across diverse cancer types represents a strength, potentially supporting broader implementation approaches such as those described in Heinze et al.'s effectiveness-implementation trial (Heinze et al., 2024). However, rural or remote populations might benefit from adaptations incorporating telehealth delivery methods similar to those evaluated by Batalik et al. (Batalik et al., 2024), potentially expanding accessibility while preserving key social components. The observed improvements in self-efficacy align with Jones et al.'s findings (Jones et al., 2023) regarding psychological correlates of exercise among cancer survivors, suggesting the basketball intervention successfully targeted important mediating factors.

From a practical implementation perspective, the resource requirements of this intervention deserve consideration. The program relied on certified exercise physiologists with oncology training, basketball coaching staff, and access to community recreation facilities, all of which carry associated costs that may vary across healthcare settings. While a formal cost-effectiveness analysis was beyond the scope of this study, the observed reductions in anxiety and depression scores suggest that such interventions could potentially offset downstream mental health service utilization among cancer survivors. The group-based format also offers inherent efficiency advantages over individual counseling or one-on-one exercise programs, as a single session can serve multiple participants simultaneously. Future research incorporating health economic evaluation alongside clinical outcomes would be valuable for informing decisions about integrating team sport-based interventions into standard survivorship care pathways.

Several limitations warrant consideration. The study may have insufficiently measured the full spectrum of social support benefits described in Pasek et al.'s review (Pasek et al., 2023) of cancer patient-caregiver dynamics. The self-selection of participants may have introduced bias toward individuals with pre-existing interest in physical activity, as suggested by Cooper et al. (Cooper et al., 2023) in their review of digital interventions. Additionally, the mechanisms underlying observed psychological improvements require more detailed analysis to determine the relative contributions of physical activity, social interaction, and skill mastery. The sample composition also warrants attention when considering the generalizability of findings. Participants were predominantly survivors of breast, colorectal, prostate, and lung cancers, while survivors of less common cancer types were underrepresented in the 'Other' category (12.9%). The applicability of this basketball-based intervention to individuals with rare cancers or those experiencing more severe functional limitations—such as head and neck cancer survivors who may face mobility or swallowing difficulties—remains uncertain. The exclusion criteria in the present study precluded participation by individuals with severe physical limitations, and the intervention protocol would likely require substantial adaptation for such populations, potentially including seated passing drills, wheelchair-accessible formats, or reduced movement demands. Future studies should specifically evaluate the feasibility and effectiveness of modified protocols for cancer survivors with greater functional impairment.

Future research should investigate potential biological mechanisms alongside psychosocial outcomes, similar to those explored by Friedenreich et al. (Friedenreich

et al., 2022) regarding physical activity and cancer survival. Longitudinal studies extending beyond 24 weeks could evaluate maintenance of benefits and potential impacts on cancer recurrence and mortality. Implementation science approaches could identify optimal strategies for integrating basketball-based interventions into standard cancer survivorship care across diverse healthcare settings, potentially contributing to the Physical Activity and Cancer Control framework described by Yang et al. (Qian, 2026), by demonstrating how structured team sports can address multiple survivorship domains simultaneously. The basketball intervention's positive impact on both psychological well-being and physical activity participation suggests it may serve as a comprehensive approach to cancer survivorship care, potentially reducing healthcare utilization costs while improving quality of life outcomes.

5. Conclusion

This study demonstrated that low-intensity basketball skills training effectively enhances social belonging and self-efficacy among cancer survivors, with significant improvements maintained at 24-week follow-up. The intervention group exhibited substantial increases in social belonging (42.3 ± 6.8 to 58.7 ± 7.2) compared to minimal changes in the control group (43.1 ± 6.5 to 45.2 ± 6.9), yielding a large effect size (Cohen's $d = 1.86$, $p < 0.001$). Similarly, self-efficacy scores improved markedly in the intervention group (38.2 ± 7.3 to 53.6 ± 7.8) versus modest changes in controls (39.1 ± 7.1 to 41.5 ± 7.2 ; Cohen's $d = 1.62$, $p < 0.001$). The strong correlation between these constructs ($r = 0.72$, $p < 0.001$) suggests they may reinforce each other, creating a positive psychological feedback loop that contributes to broader psychosocial benefits.

Secondary outcomes demonstrated consistent improvements across multiple domains, with the intervention group showing significant reductions in anxiety (-5.2 ± 1.8 vs -1.3 ± 1.1 , $p < 0.001$) and depression (-4.8 ± 1.7 vs -0.9 ± 1.2 , $p < 0.001$), while experiencing enhanced quality of life (8.7 ± 2.6 vs 2.1 ± 1.9 , $p < 0.001$). The intervention's effectiveness across diverse participant profiles supports its broad applicability, though adherence patterns revealed higher engagement among older participants (60-75 age group: 83% intervention, 92% control) compared to younger cohorts (18-39 age group: 72% intervention, 80% control). Multiple regression analysis identified intervention adherence ($\beta = 0.42$, $p < 0.001$) and baseline scores ($\beta = -0.33$, $p < 0.01$) as significant predictors of social belonging improvements, while baseline physical activity ($\beta = 0.39$, $p < 0.001$) and intervention adherence ($\beta = 0.35$, $p < 0.001$) most strongly predicted self-efficacy gains.

The basketball intervention offers distinct advantages by integrating physical skill development with social support mechanisms, addressing multiple survivorship domains simultaneously. This integrated approach contrasts with traditional exercise interventions focused primarily on individual physical outcomes rather than team-based psychosocial benefits. The dose-response relationship observed between intervention intensity and psychological improvements (high-intensity: 20.3 ± 2.7 social belonging, 18.5 ± 2.4 self-efficacy; low-intensity: 9.5 ± 2.0 social belonging, 8.3 ± 1.8 self-efficacy; $p < 0.001$) suggests that appropriately structured team sports may represent a comprehensive approach to cancer survivorship care. Future research should examine longer-term outcomes, potential biological mechanisms, and implementation strategies for integrating basketball-based interventions into standard oncological care across diverse healthcare settings.

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Informed consent statement: Not applicable.

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Clinical trial registration: Not applicable. This study evaluated a behavioral and psychosocial sports intervention designed to promote social belonging and self-efficacy among cancer survivors rather than assess the efficacy or safety of a clinical treatment, medical procedure, or therapeutic product. The intervention consisted of structured low-intensity basketball skill activities delivered in a community-based setting and represented a non-pharmacological lifestyle and psychosocial program. Therefore, the study was conducted as a behavioral intervention study rather than a clinical therapeutic trial and was not prospectively registered.

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