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Physical Activity Levels and Health Quality of Life in Spanish Young Adults with Cancer Prior to and after Cancer Diagnosis

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1. Abstract

1.1. Purpose: To understand how healthy lifestyle behaviors patterns change across key phases of the disease in young adults. The main purposes were to evaluate change in minutes of physical activity in young adults with cancer across two timepoints: prior to and after cancer diagnosis, and to assess physical activity habits and HrQOL across the two timepoints.

1.2. Methods: A multi-center, retrospective, observational study on young adults with cancer (18-45 years) who were recruited from two hospitals from the Castilla La-Mancha region and three community hospitals of Madrid. Data were collected through online survey.

1.3. Results: A total of 171 were recruited. 31-33,9% of participants reported engaging in at least 150 minutes of physical activity per week across the two timepoints. There were no significant differences in minutes of physical activity across the two timepoints. "Helps me to feel better and have a better mood", "improves my functionality and physical fitness", and "decreases side effects of my cancer treatments" were the main reasons participants performed physical activity across the two timepoints. HrQOL was higher prior to cancer diagnosis.

1.4. Conclusions: Around 70% of Spanish young adults in this study were inactive or insufficiently active before cancer diagnosis, and despite the benefits of physical activity in the management of side effects and prevention of NCDs, they did not increase their physical activity levels after diagnosis.

Implications for Cancer Survivors: The present study helps professionals learn about physical activity levels in young adults with

cancer, HQOL after diagnosis, as well as barriers and facilitators to physical activity.

2. Introduction

The World Health Organization (WHO) estimates >2 million young adults aged 18 to 45 years will be diagnosed with cancer in 2040. [1] Young adult cancer survivors are at greater risk of dying due to non-communicable diseases (NCDs). [2] Additionally, young adults typically have more aggressive treatments, [3] which often cause adverse effects and health complications across the lifespan. Cardiotoxicity, [4] cardiovascular diseases (CVD; i.e., heart failure, stroke, or peripheral vascular events), [2] infertility, sexual dysfunction, [5] and increased cancer recurrence [6] are common and can cause a cascade of poor health outcomes. Moreover, young adults who survive cancer may have difficulties forming healthy and stable relationships [7] and struggle with depression and anxiety throughout their life. [8] These and other effects can diminish young adults' health-related quality of life (HrQOL), [9] limit their vocational opportunities and earning potential, [10] and increase healthcare expenditures. [11] Identifying factors associated with adverse effects and health complications is important to inform the provision of adequate healthcare resources and minimize the burden of disease.

Evidence indicates healthy lifestyle behaviours (e.g., regular physical activity, abstention from smoking or avoiding overweight) can reduce the risk of NCDs, [12] which is noteworthy because cancer survivors are at increased risk of dying from a NCD. [13] Regular physical activity and abstention from smoking can also significantly reduce the risk of adverse effects and health complications reported by cancer survivors. [14] Finally, significant associations have been observed between physical activity, abstention from smoking, and improved cardiorespiratory fitness, fatigue, HrQOL, body composition, and overall survival rates. [15,16]

Yet, data show the proportion of young adults meeting current physical activity guidelines is low worldwide. [17] In Spain, as in other countries, only 30-35% of young adults aged 18 to 45 years engage in regular physical activity during their leisure time, [18] and rates have been shown to be lower during and after the cancer treatment. [19] As well, data show smoking is often initiated during adolescence and continues into young adulthood, [20] with smoking rates ranging between 27-33% in young adults diagnosed with cancer. [21] This evidence calls for increased efforts to understand how healthy lifestyle behaviors patterns change across key phases of the disease in young adults, describe the nature of their behaviour at different timepoints, and assess whether behaviors are related to key outcomes like weight status and HrQOL. Furthermore, identifying young adults' barriers to physical activity would help inform intervention efforts. To address these knowledge gaps, the "Physical activity and health questionnaire in young adults with cancer" (YOUNGmove) project was developed. The primary objective of this study was to use YOUNGmove data to evaluate

change in minutes of physical activity in young adults with cancer across two timepoints: prior to and after cancer diagnosis. Secondary objectives were to: (a) describe physical activity habits across the two timepoints, along with reasons underlying behaviour, (b) evaluate change in HrQOL and anthropometric measures (i.e., weight, body mass index [BMI]) across the two timepoints, (c) describe smoking prior to cancer diagnosis, quit rates, and whether cancer influenced quit decision. Finally, differences in physical activity, HrQOL, anthropometrics, and smoking according to age (18-30, 31-40 vs 40-45 years), type of tumor (breast cancer vs other tumors), and treatment status (on vs off treatment) were explored.

3. Methods

3.1. Study Design and Setting

Data from the YOUNG move project were utilized for this study. The YOUNGmove project is a multi-center, retrospective, observational study on young adults who were recruited from two hospitals from the Castilla La-Mancha region and three community hospitals of Madrid. Data were collected from June 2020 to March 2022, after the protocol was approved by the ethics committees at each participating hospital. This study was performed in compliance with the Declaration of Helsinki and all participants provided informed consent digitally.

3.2. Participants and Procedures

Inclusion criteria for the YOUNGmove project were: (1) Spanish-speaking; (2) currently 18 to 45 years of age; (3) diagnosed with cancer in the past 5 years whilst between the 18 and 45 years of age; and (4) any cancer stage (including advanced and metastatic disease) at any point on the cancer trajectory. Exclusion criteria were: (1) cognitive impairment that could affect responses to survey questions; and (2) physical impairment or condition that contraindicated or limited physical activity. Participants were recruited through healthcare provider referral at participating hospitals, wherein eligible young adults were approached by healthcare personnel (e.g., oncologists, nurses) within the Oncology Department who explained the project and invited them to participate in it. Young adults who expressed an interest in the project were given a card with QR code to scan to access the consent form and anonymized online survey created with the Google Forms platform (detailed below). Of note, participants could elect to receive an email with a link to the consent form and anonymized online survey. All data were self-reported by participants patients in this survey.

3.3. Online Survey

3.3.1. Descriptive variables: Participants were asked to report demographic (gender, current age, where they lived and were admitted for cancer care) and medical characteristics (type of cancer, treatment status and history). Of note, gender in this study is dichotomous (men and women) as the survey did not include catego-

ries for other gender identities. Last, participants were asked about their alcohol use prior to diagnosis.

3.3.2. Primary outcome: Physical activity: Participants were asked about their physical activity participation prior to and after their cancer diagnosis. Specifically, they were asked if they engaged in at least 150 minutes of physical activity per week, and if not, how many minutes. They were also asked whether they engaged in aerobic exercise, strength training, and other activities, as well as to select which specific activities they did for aerobic exercise and strength training. They could list other activities in an open-ended response question. Additionally, they were asked which reason(s) underlined their participation in physical activity or lack thereof prior to and after diagnosis. Finally, they were asked to select the side effect that most limited them from doing physical activity and the side effect that most improved with physical activity (Supplemental File 2).

3.3.3. Additional Outcomes of Interest: Body mass index (BMI). Participants reported their weight (kg) and height (m). BMI was calculated using weight and height (kg/m2).

HrQOL was assessed using the Euro-Quality of Life-5 Dimension (EQ-5D) questionnaire – a widely used instrument with adults diagnosed with cancer. [22] The EQ-5D evaluates five dimensions of HrQOL: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. It also asks participants to report their health perception using a visual analog scale.

Smoking. Participants were asked about their smoking habits prior to their cancer diagnosis. Specifically, they were asked to report if they smoked before cancer and how many cigarettes they smoked. Participants were also asked if they had stopped smoking and to what extent cancer was a reason for quitting smoking (Supplemental File 2).

3.4. Statistical Analysis

SPSS V. 21.0 for Windows 7 (SPSS Inc., Chicago, IL) was used for data analysis. Prior to analysis, data were visually inspected for normality using Q-Q plots. Descriptive statistics were computed to describe the sample, report on study variables, and address specific research objectives; continuous data are reported as means ± standard deviations (SD) and categorical data are reported as frequencies and percentages. Paired sample t-tests were used to assess for statistical differences in physical activity, weight, BMI, and HrQOL across the two timepoints: prior to and after cancer diagnosis. The percent difference between timepoints were computed for each variable.

At each timepoints (i.e., prior to and after cancer diagnosis), exploratory subgroup analyses were conducted to investigate possible differences in physical activity, weight, BMI, and HrQOL among subgroups for age (18-30, 31-40 vs 40-45 years), type of tumor (breast cancer vs other tumors) and treatment status (on vs off treatment) using independent samples t-tests (for type of tumor

and treatment status) and ANOVA (for age).

4. Results

4.1. Sample Characteristics

231 eligible young adults received information about the YOUNG-move project; 171 provided informed consent and completed the online survey, accessed via the QR code (87.1%) or email (12.9%). Due to the settings of the survey software, there were no missing data. The sample had a mean age of 39±5.9 years (range=20-45) and 86% were women. Breast cancer (66.7%) was the most common type of cancer, 60% had surgery, 53.2% had completed chemotherapy (with an additional 40.4% currently receiving chemotherapy). Additional characteristics of the sample are provided in Table 1 (for the total sample) and Supplemental File 1 (by subgroup).

Table 1: Baseline characteristics of the sample (N=171) (Spain, 2020-2022).

	Total sample
Age in years, M (SD)	39 (5.9)
18-30 years, n (%)	18 (10.5)
31-40 years, n (%)	63 (36.8)
>41 years, n (%)	90 (52.7)
Height in meters, M (SD)	165.76 (7.41)
Gender, n (%) female	147 (86)
Type of tumor, n (%)	
Breast	114 (66.7)
Leukemia	10 (5.8)
Hodgkin Lymphoma	2 (1.2)
Non-Hodgkin's Lymphoma	6 (3.5)
Prostate	1 (0.6)
Colorectal	5 (2.9)
Lung	3 (1.8)
Ovary and cervical	5 (2.9)
Central Nervous System	2 (1.2)
Stomach	3 (1.8)
Pancreas	2 (1.2)
Bladder	1 (0.6)
Esophagus	3 (1.8)
Other	14 (8.2)
Treatments, n (%)	
Chemotherapy	
Completed	91 (53.2)
Undergoing	69 (40.4)
Hormonal therapy	
Completed	18 (10.5)
Undergoing	52 (30.4)
Radiotherapy	
Completed	78 (45.6)
Undergoing	12 (7)
Immunotherapy	
Completed	25 (14.6)
Undergoing	24 (14)
Surgery	
Completed	103 (60.2)
Alcohol consumption	
Drank alcohol prior to diagnosis, n (%)	131 (76.6)
Type, n (%)	
Wine	45 (26.3)
Beer	70 (40.9)
Cocktails	19 (11.1)
Weekly frequency, n (%)	
<1 glass	78 (45.6)
3-5 Glass	48 (28.1)
3-6 *>5 glass*	8 (4.7)

Notes: M=mean; SD=Standard Deviation; N=number of participants, %=percentage.

Supplemental File 1: Baseline characteristics by subgroup (Spain, 2020-2022).

	Breast vs Other tumor N=114/57	On vs Off treatment N=75//96	Age category 18-30 N=18	Age category 31-40 N=63	Age category 41-45 N=90
Age M(SD)	39.9 (4.8)/37.1 (7.3)	38.8 (5.9)/39.2 (5.9)	25.78 (3.2)	36.7 (2.8)	43.3 (1.4)
18-30 years					
31-40 years					
>41 years					
Height M(SD)	164.4 (6)/168.8 (8.8)	165.9 (6.4)/166.2 (8)	164.7 (9)	166.3 (6.9)	165.9 (7.3)
Gender N(%)					
Female	113 (66.1)/34 (19.9)	65 (38) / 82 (48)	14 (8.2)	55 (32.2)	78 (45.6)
Type of tumor					
Breast	114 (66.7) / 0 (0)	55 (32.2) / 59 (34.5)	6 (3.5)	43 (25.1)	65 (38)
Leukemia	0 (0) / 10 (5.8)	2 (1.2) / 8 (4.7)	2 (1.2)	4 (2.3)	4 (2.3)
Hodgkin Lymphoma	0 (0) / 2 (1.2)	0 (0) / 2 (1.2)	0 (0)	2 (1.2)	0 (0)
Non-Hodgkin's Lymphoma	0 (0) / 6 (3.5)	2 (1.2) / 4 (2.3)	3 (1.8)	2 (1.2)	1 (0.6)
Prostate	0 (0) / 1 (0.6)	0 (0) / 1 (0.6)	1 (0.6)	0 (0)	0 (0)
Colorectal	0 (0) / 5 (2.9)	1 (0.6) / 4 (2,3)	1 (0.6)	0 (0)	4 (2,3)
Lung	0 (0) / 3 (1.8)	3 (1.8) / 0 (0)	0 (0)	0 (0)	3 (1,8)
Ovary and cervical	0 (0) / 5 (2.9)	2 (1.2) / 3 (1.8)	0 (0)	3 (1,8)	2 (1,2)
Central Nervous System	0 (0) / 2 (1.2)	2 (1.2) / 0 (0)	0 (0)	2 (1,2)	0 (0)
Stomach	0 (0) / 3 (1.8)	2 (1.2) / 1 (0.6)	0 (0)	2 (1,2)	1 (0,6)
Pancreas	0 (0) / 2 (1.2)	1 (0.6) / 1 (0.6)	0 (0)	0 (0)	2, (1,2)
Bladder	0 (0) / 1 (0.6)	1 (0.6) / 0 (0)	1 (0.6)	0 (0)	0 (0)
Esophagus	0 (0) / 3 (1.8)	2 (1.2) / 1 (0.6)	2 (1.2)	1 (0,6)	0 (0)
Others	0 (0) / 14 (8.2)	2 (1.2) / 12 (7)	2 (1.2)	4 (2,3)	8 (4,7)
Treatments, n (%)					
Chemotherapy					
Completed	56 (32.7)/ 35 (20.5)	10 (5.8)/ 81 (47.4)	13 (7.6)	35 (20.5)	43 (25.1)
Undergoing	50 (29.2)/ 19 (11.1)	69 (40.4)/ 0 (0)	7 (4.1)	27 (15.8)	35 (50.7)
Hormonal therapy					
Completed	8 (4.7)/ 10 (5.8)	4 (2.3) /14 (8.2)	2 (1.2)	2 (1.2)	14 (8.2)
Undergoing	47 (27.5)/ 5 (2.9)	5 (2.9)/ 47 (27.5)	2 (1.2)	17 (9.9)	33 (19.3)
Radiotherapy					
Completed	54 (31.6)/ 24 (14)	16 (9.4) / 62 (36.3)	8 (4.7)	27 (15.8)	43 (25.1)
Undergoing	9 (5.3)/ 3 (1.8)	12 (7)/ 0 (0)	1 (0.6)	5 (2.9)	6 (3.5)
Immunotherapy					
Completed	16 (9.4)/ 9 (5.3)	4 (2.3)/ 21 (12.3)	3 (1.8)	6 (3.5)	16 (9.4)
Undergoing	18 (10.5)/ 6 (3.5)	10 (5.8)/ 14 (8.2)	4 (2.3)	14 (8.2)	6 (3.5)
Surgery					
Completed	65 (38)/ 38 (22.2)	33 (19.3)/ 70 (40.9)	11 (6.4)	36 (21.1)	56 (32.7)
Alcohol consumption					
Drank alcohol prior to diagnosis, n (%)	83 (48.5)/48 (28.1)	56 (32.7)/ 75 (43.9)	16 (9.4)	44 (25.7)	71 (41.5)
Type, n (%)					
Wine	34 (19.9)/11 (6.4)	20 (11.7)/25 (14.6)	2 (1.2)	15 (8.8)	28 (16.4)
Beer	39 (22.8)/ 31 (18.1)	32 (18.7)/38 (22.2)	12 (7)	23 (13.5)	35 (20,5)
Cocktails	11 (6.4)/8 (4.7)	6 (3.5)/13 (7.6)	2 (1.2)	8 (4.7)	9 (5.3)
Weekly frequency, n (%)					
<1 glass	48 (28.1)/30 (17.5)	37 (21.6)/41 (24)	10 (5.8)	27 (15.8)	41 (24)
a. Glass	32 (18.7)/16 (9.4)	18 (10.5)/30 (17.5)	6 (3.5)	15 (8.8)	27 (15.8)
b. >5 glass	5 (2.9)/ 3 (1.8)	3 (1.8)/5 (2.9)	0 (0)	4 (2.3)	4 (2.3)

Notes: M=mean; SD=Standard Deviation; N=number of participants, %= percentage.

Supplemental File 2: Online survey (outcomes).

Question	Answer
PHYSICAL ACTIVITY (Prior to and after cancer diagnosis)	
Did/do you perform at least 150 minutes of physical activity at week?	Yes or no
If no, how many minutes of physical activity did/do you perform at week?	120 minutes
	90 minutes
	60 minutes
	30 minutes
	I do not do any physical activity
Did/do you engage aerobic exercise?	Yes or no
Did/do you engage resistance exercise?	Yes or no
Did/do you engage other exercise?	Yes or no
What type of aerobic activities did/do you do?	Walking
	Running
	Swimming
	Cycling
	Directed activities
	Circuit training
	Other (open-ended response question)
What type of aerobic activities did/do you do?	Machines
	Free weight
	Exercise with body weight
	Directed activities
	Other (open-ended response question)
Why did/do you engage in physical activity?	Helps me to feel better and have a better mood
	Reduce stress for me
	Improves my functionality and physical fitness
	Decreases side effects of my cancer treatments
	Other reasons
	I do not do physical activity
Why did/do you not engage in physical activity?	Lack of time
	I find it hard to keep the habit
	Not knowing what activities to do
	Due to the side effects of cancer treatments
	Other reasons
	I do physical activity
What is the side effects most limited from doing physical activity?	Numbness in hands and feet
	Joint pain
	Fatigue
	I have no side effects
What is the side effects most limited from doing physical activity?	Numbness in hands and feet
	Joint pain
	Fatigue
	I have no side effects
SMOKING (Prior to cancer diagnosis)	
Did you smoke prior a cancer diagnosis?	Yes or no
How many cigarettes did you smoke?	open-ended response question
Have you stop smoking?	Yes
	No
	I have never smoked
Was cancer the main reason for quitting smoking?	Not at all
	Somewhat
	I have never smoked

4.2. Physical Activity Levels, Patterns, and Motives (Table 2)

Physical activity levels. Fewer than 31% of participants reported engaging in at least 150 minutes of physical activity per week prior to their cancer diagnosis; a similar percentage was observed after diagnosis (33.9%). The remainder engaged in 30 to 120 minutes of physical activity per week (prior to: 77.5%; after diagnosis: 81.5%) or zero minutes (prior to: 22.5%; after diagnosis: 18.5%), and were thus considered insufficiently active and inactive, respectively. There were no statistically significant differences in minutes of physical activity across the two timepoints (ΔM=4.2; p=1.00; CI: -15.7 to 7.63).

Physical activity patterns. Most participants performed aerobic exercises prior to (77.8%) and after cancer diagnosis (83.6%). Walking was the most popular activity prior to (32.2%) and after cancer diagnosis (61%). Nearly 41% of participants performed strength training, with body weight training and weight training as the most frequently performed at both timepoints. Between 30-40% of participants reported doing "other activities" such as Pilates or yoga at each timepoint.

Physical activity motives. "Helps me to feel better and have a better mood" (73.7%) and "improves my functionality and physical fitness" (73.7%) were the main reasons participants performed physical activity prior to cancer diagnosis. After cancer diagnosis, "helps me to feel better and better mood" (82.5%) and "improves my functionality and physical fitness" (82%) remained the main reasons, but "decreases side effects of my cancer treatments" (73.7%) was also a key reason. The main reasons participants did not perform physical activity prior to cancer diagnosis was "lack of time" (39.2%) and "I find it hard to keep the habit" (33.3%). After cancer diagnosis, "I find it hard to keep the habit" (34%) remained a key reason, but "due to the side effects of cancer treatments" (26%) was also a key reason. After cancer diagnosis, fatigue and joint pain were the main side effects that most limited participants' physical activity (53% and 18%, respectively), but 47% and 28% of participants reported that these side effects improved with physical activity, respectively.

Anthropometrics measures and HrQOL. Mean BMI values fell within the 'normal' range prior to (23.9kg/m2±4.3) and after cancer diagnosis (23.9 kg/m2±4.4), and mean weight was 66.11kg±13.7 prior to diagnosis and 65.9kg±13.8 after cancer diagnosis. No significant differences were found between weight (ΔM=-0.2; P=0.74; CI: -0.75 to 1.05) and BMI prior to and after cancer diagnosis (ΔM=-0.05; p=0.75; CI: -0.27 to 0.28). HrQOL was higher prior to cancer diagnosis (0.90 ± 0.165) compared to after diagnosis (0.75 ± 0.173); the difference was notable (17%) and statistically significant (ΔM=-0.15; p=0.001; CI: 0.1 to 0.2). Mean EQ-5D visual analogue scale values for health perceptions were also higher prior to diagnosis (86.1 ± 13.2) compared to after diagnosis (61.7 ± 21.6); the difference was notable (28%) and statistically significant (ΔM=-24.38; p=0.001; CI: 19.6 to 29.2) (Table 3).

Smoking. 28.7% of participants smoked prior to cancer diagnosis, with most (71.9%) smoking more than 10 cigarettes daily. Among those who smoked prior to diagnosis, 41% stopped smoking after diagnosis, but only 7.6% reported that cancer was the main reason for them quitting (Table 4 and Figure 1).
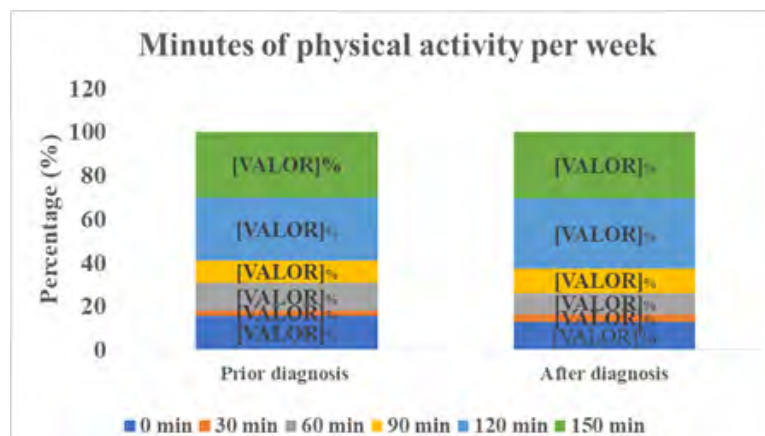

Figure 1: Minutes of physical activity per week for the total sample (N=171) prior to and after cancer diagnosis (Spain, 2020-2022).

Table 2: Physical activity results for the total sample (N=171) and subgroups (Spain, 2020-2022).

	PRIOR to diagnosis	AFTER diagnosis	Breast vs Other tumor PRIOR to diagnosis	On vs Off treatment PRIOR to diagnosis	Age categories 18-30/ 31-40/ 41-45 PRIOR to diagnosis	Breast vs Other tumor AFTER diagnosis	On vs Off treatment AFTER diagnosis	Age categories 18-30/ 31-40/ 41-45 AFTER diagnosis
Physical activity levels, n (yes %)								
150 minutes/ week	52 (30.4)	58 (33.9)	34(19.9)/18(10.5)*	28(16.4)/24(14)	9(5.3)/28(16.4)/15(8.8)	42(24.6)/16(9.4)	28(16.4)/30(17.5)	6(3.5)/19(11.1)/33(19.3)*
Categories [a]								
Active	51 (29.8)	52 (30.4)	33(19.3)/18(10.5)	27(15.8)/24(14)	9(5.3)/27(15.8)/15(8.8)	39(22.8)/13(7.6)	25(14.6)/27(15.8)	6(3.5)/18(10.5)/28(16.4)
Insufficiently active	93 (54.3)	97 (56.7)	62(36.2)/31(18.1)	43(25.1)/50(29.2)	7(4.1)/32(18.8)/54(31.6)	64(37.5)/33(19.4)	44(25.7)/53(31)	8(4.8)/38(22.3)/51(29.8)
Inactive	27 (15.8)	22 (12.9)	19(11.1)/8(4.7)	5(2.9)/22(12.9)	2(1.2)/4(2.3)/21(12.3)	11(6.4)/11(6.4)	6(3.5)/16(9.4)	4(2.3)/7(4.1)/11(6.4)
Type, n (yes %)								
Aerobic exercise	133 (77.8)	143 (83.6)	88(51.5)/45(26.3)	63(36.8)/70(40.9)	15(8.8)/53(31)/65(38)	99(57.9)/44(25.7)	64(37.4)/79(46.2)	15(8.8)/57(33.3)/71(41.5)
Strength training	69 (40.4)	70 (40.9)	43(25.1)/26(15.2)	33(19.3)/36(21.1)	10(5.8)/29(17)/30(17.5)	49(28.7)/21(12.3)	31(18.1)/39(22.8)	7(4.1)/29(17)/34(19.9)
Other	62 (36.3)	50 (29.2)	41(24)/21(12.3)	31(18.19)/31(18.1)	6(3.5)/25(14.6)/31(18.19)	37(21.6)/13(7.6)	23(13.5)/27(15.8)	3(1.8)/17(9.9)/30(17.5)
Type of aerobic exercise, n (%)								
Walking	55 (32.2)	105 (61.4)	42(24.6)/13(7.6)	29(17)/26(15.2)	3(1.8)/24(14)/28(16.4)	68(39.8)/37(21.6)	53(31)/52(30.5)	11(6.4)/41(24)/53(31)
Running	23 (13.5)	10 (5.8)	15(8.8)/8(14)	11(6.4)/12(7)	2(1.2)/7(4.1)/14(8.2)	7(4.1)/3(1.8)	3(1.8)/7(4.1)	1(0.6)/4(2.3)/5(2.9)
Swimming	7 (4.2)	6 (3.5)	4(2.3)/3(1.8)	3(1.8)/4(2.3)	1(0.6)/0/6(3.5)	6(3.5)/0	3(1.8)/7(4.1)	0/1(0.6)/5(2.9)
Cycling	10 (5.8)	8 (4.7)	4(3.5)/6(3.5)	6(8)/4(2.3)	1(0.6)/6(3.5)/3(1.8)	3(1.8)/5(2.9)	3(1.8)/3(1.8)	1(0.6)/4(2.3)/3(1.8)
Directed activities	26 (15.2)	12 (7)	15(13.2)/11(6.4)	11(6.4)/15(8.8)	6(3.5)/10(5.8)/10(5.8)	12(7)/0	4(2.39)/8(4.7)	1(0.6)/4(2.3)/7(4.1)
Endurance exercise circuit	13 (7.6)	7 (4.1)	10(5.8)/3(1.8)	7(4.1)/6(3.5)	1(0.6)/9(5.3)/3(1.8)	7(4.1)/0	3(1.8)/4(2.3)	0 (0)/3(1.8)/4(2.3)
Other	12 (7)	8 (4.7)	8(4.7)/4(2.3)	5(2.9)/7(4.1)	1(0.6)/2(1.2)/9(5.3)	4(2.3)/4(2.3)	1(0.6)/7(4.1)	0 (0)/2(1.2)/6(3.5)
No endurance exercises	25 (14.6)	15 (8.8)	16(9.4)/9(5.3)	3(1.8)/22(12.9)	3(1.8)/5(2.9)/17(9.9)	7(4.1)/8(4.7)	5(2.9)/10(5.8)	4(2.3)/4(2.3)74.1)
Type of strength exercise, n (%)								
Upper/lower body machine	10 (5.8)	4 (2.3)	5(2.9)/5(2.9)	3(1.8)/7(4.1)	1(0.6)/5(2.9)/4(2.3)	3(1.8)/1(0.6)	2(1.2)/1(1.2)	0/2(1.2)/2(1.2)
Weight training	13 (7.6)	22 (12.9)	4(2.4/9(5.3)	7(4.1)/6(3.5)	1(0.6)/8(4.7)/4(2.3)	12(7)/10(5.8)	7(4.1)/15(8.8)	3(1.8)/9(5.3)/10(5.8)
Body weight training	35 (20.5)	39 (22.8)	30(17.5)/5(2.9)	20(11.7)/15(8.8)	5(2.9)/12(7)/18(10.5)	32(18.7)/7(4.1)	21(12.3)/18(10.5)	3(1.8)/16(9.4)/20(11.7)
Directed activities	15 (8.8)	1 (0.6)	8(4.7)/7(4.1)	6(3.5)/9(5.3)	3(1.8)/8(4.7)/4(2.3)	1(0.6)/0	1(0.6)/0	0/0/1(0.6)
Other	15 (8.8)	12 (7)	9(5.3)/6(3.5)	9(5.3)/6(3.5)	0/4(2.3)/11(6.4)	7(4.1)/5(2.9)	4(2.3)/8(4.7)	1(0.6)/3(1.8)/8(4.7)
No strength training	83 (48.5)	93 (54.4)	58(33.9)/25(14.6)	30(17.5)/53(31)	8(4.7)/26(15.2)/49(28.7)	59(34.5)/34(19.9)	40(23.4)/53(31)	11(6.4)/33(19.3)/49(28.7)
Reason for *doing* physical activity, n (%)								
Helps me to feel better and have a better mood	126 (73.7)	141 (82.5)	83(48.5)/43(25.1)	59(34.5)/67(39.2)	14(8.2)/52(30.4)/60(35.1)	99(57.9)/42(24.6)	63(36.8)/78(45.6)	14(8.2)/53(31)/74(43.3)
Reduces stress for me	126 (73.7)		85(49.7)/41(24)	65(38)/61(35.7)	14(8.2)/48(28.1)/64(37.4)			
Improves my functionality and physical fitness	120 (70.2)	133 (77.8)	76(44.4)/44(25.7)	57(33.3)/63(36.8)	12(7)/49(28.7)/59(34.5)	91(53.2)/35(20.5)	57(33.3)/69(40.4)	12(7)/46(26.9)/68(39.8)
Decreases side effects of my cancer treatments	-	126 (73.7)	-	-		91(53.2)/42(24.6)	56(32.7)/77(45)	11(6.4)/51(29.8)/71(41.5)
Other	50 (29.2)	46 (26.9)	32(18.7)/18(10.5)	24(14)/26(15.2)	6(3.5)/20(11.7)/24(14)	114(66.7)/57(33.3)	21(12.3)/25(14.6)	3(1.8)/16(9.4)/27(15.8)
No reason, I do not do physical activity)	31 (18.1)	15 (8.8)	20(11.7)/11(6.4)	5(2.9)/26(15.2)	2(1.2)/8(4.7)/21(12.3)	12(7)/12(7)	9(5.39)/15(8.8)	4(2.3)/8(4.7)/12(7)
Reason for *not doing* physical activity, n (%)								
Lack of time	67 (39.2)	31 (18.1)	47(27.5)/11.7)	25(14.6)/42(24.6)	5(2.9)/22(12.9)/40(23.4)	22(12.9)/9(5.3)	12(7)/19(11.1)	7(4.1)/10(5.8)/14(8.2)
I find it hard to keep the habit	57 (33.3)	58 (33.9)	45(26.3)/12(7)	20(11.7)/37(21.6)	3(1.8)/17(9.9)/37(21.6))	38(22.2)/20(11.7)	24(14)/34(19.9)	9(5.3)/21(12.3)/28(16.4)
Not knowing what activities to do	18 (10.5)	36 (21.1)	13(7.6)/5(2.9)	8(10.7)/10(5.8)	1(0.6)/6(3.5)/11(6.4)	19(11.1)/17(9.9)	15(8.8)/21(12.3)	6(3.5)/11(6.4)/19(11.1)
Due to the side effects of cancer treatments	-	44 (25.7)	-	-		25(14.6)/19(11.1)	23(13.5)/21(12.3)	7(6.4)/17(9.9)/20(11.7)
Other	12 (7)	15 (8.8)	11(6.4)/1(0.6)	3(1.8)/9(5.3)	3(1.8)/4(2.3)/5(2.9)	9(5.3)/6(3.6)	5(2.9)/10(5.8)	3(1.8)/4(2.3)/8(4.7)
No reason why I do physical activity	75 (43.9)	84 (49.1)	52(30.4)/23(13.5)	34(19.9)/41(24)	8(4.7)/35(20.5)/32(18.7)	63(36.8)/21(12.3)	35(20.5)/49(28.7)	8(4.7)/31(18.1)/45(26.3)

Side effects profile, n (%)								
Most limiting side effect								
Peripherical neuropathies		6 (3.5)				4(2.3)/2(1.2)	2(1.2)/6(3.5)	1(0.6)/3(1.8)/2(1.2)
Joint pain	-	30 (17.5)	-	-	-	23(13.5)/7(4.1)	19(11.1)/30(17.5)	2(1.2)/12(7)/16(9.4)
Fatigue		90 (52.6)				57(33.3)/33(19.3)	35(20.5)/46(26.9)	11(6.4)/35(20.5)/44(25.7)
No side effects		45 (26.3)				30(17.5)/15(8.8)	19(11.1)/14(8.2)	4(2.3)/13(7.6)/28(16.4)
Side effects that improved with exercise								
Peripherical neuropathies		8 (4.7)				5(2,9)/3(1,8)	2(1,2)/4(2,3)	1(0,6)/5(2,9)/2(1,2)
Joint pain	-	49 (28)	-	-	-	40(23,4)/9(5,3)	7(4,1)/23(13,5)	3(1,8)/16(9,4)/30(17,5)
Fatigue		81 (47.4)				48(28,1)/33(19,3)	44(25,7)/46(26,9)	11(6,4)/33(19,3)/37(21,6)
No side effects		33 (19.3)				21(12,3)/12(7)	22(12,9)/23(13,5)	3(1,8)/9(5,3)/21(12,3)

Notes: N=number of participants, %=percentage; Categories: active=participants who reported doing at least 150 minutes of physical activity per week; Insufficiently active = participants who reported between 30 and 120 minutes of physical activity per week; Inactive = participants who reported 'I do not do physical activity'; *= significant different observed (p<0.05)

Table 3: Comparison of scores across timepoints for the total sample (N=171) and subgroups (Spain, 2020-2022).

	Total sample		Breast cancer vs other tumors		With Treatment vs Without treatment		Age categories	
	Mean±SD		Mean±SD		Mean±SD		Mean±SD	
							<30 / 31-40 / >41	
	Prior	**After**	**Prior**	**After**	**Prior**	**After**	**Prior**	**After**
Physical Activity Levels								
Physical activity at week (min)	97.2±52.72	101.22±50.30	94.7±53.12/102.1±50.9	108.2±46.7/87.4±54.8	94.7±53.12/102.1±50.9	108.2±46.7/ 87.4±54.8	118.3±47.1/111.4±45.9/83±54.5	88.3±58.6/101,4±48.6/ 103.7±49.9
Secondary outcomes								
Weight (kg)	66.11±13.7	65.96±13.8	63.65±12.1 / 71.1±15.3	64.13±12.9 / 69.6±14.9	63.65±12.1/71.1±15.3	64.13±12.9/69.6±14.9	62±10.8/66.2±13.1/66.9±14.6	62.5±11.5/65.5±13.7/ 66.9±14.3
BMI (kg/m²)	23.9±4.3	23.9±4.4	23.5±4/24.8±4,8	23.7±4.3/24.3±4.6	23.5±4/24.8±4.8	23.7±4.3/24.3±4.6	22.8±3.3/23.8±3,8/24.2±4.8	22.9±3.5/23.6±4.2/ 24.3±4.4
EQ5D index value	0.90±0.165	0.75±0.173*	0.95±0,07/0.85±0.22*	0.77±0.16/0.71±0.18	0.95±0.07/0.85±0.22	0.77±0.16/0.71±0.18	0.94±0.1/0.9±0.2/0.9±0.2	0.74±0.18/0.75±0.2/ 0.73±0.2
EQ5D percentage of health (%)	86.1±13.2	61.7±21.6*	89.5±8.8/82.2±16.1*	64.6±21.4/58.45±21.7	89.5±8.8/82.2±16.1	64.6±21.4/58.45±21.7	92.3±11.7/84.4±14.4/85.8±12.4	62.7±22.3/60.3±23.2/ 62.6±20.6

Notes: M=mean; SD=Standard Deviation; BMI= [weight (kg)/Height (m2)]; *= significant different observed (p<0.05)

Table 4: Smoking results for the total sample (N=171) and subgroups (Spain, 2020-2022).

	Total sample N=171	Breast vs Other tumor N=114/57	On vs Off treatment N=75/96	Age category 18-30 N=18	Age category 31-40 N=63	Age category 41-45 N=90
Smoke before cancer diagnosis, n (%) yes	49 (28.7)	32 (18.3)/17 (9.9)	21 (12.3)/28 (16.4)	3 (1.8)	16 (9.4)	30 (17.5)
No. of cigarettes smoked, n (%)	14 (8.3)	82 (48)/41 (24)	6 (3.6)/8 (4.8)	2 (1.2)	30 (4.4)	8 (6.8)
<5 cigarettes	21 (12.3)	10 (5.9)/4 (2.4)	3 (1.8)/5 (3)	0 (0)	2 (1.2)	6 (3.5)
5-10 cigarettes	13 (7.6)	7 (4.1)/1 (0.6)	12 (7)/14 (8.1)	1 (0.6)	9 (5.3)	16 (9.4)
>10 cigarettes	123(71.9)	15 (8.8)/11 (6.5)	54 (31.6)/69 (40.4)	15 (8.8)	48(28.1)	60(35.1)
Quit smoking after diagnosis, n (%) yes	70 (40.9)	49 (28.7)/21 (12.3)	34 (19.9)/36 (21.1)	2 (1.2)	3 (1.8)	12 (7)
Cancer was a reason to stop smoking, n (%)						
Not at all	50 (29.2)	37 (21.6)/13 (7.6)	25 (14.6)/25 (14.6)	3 (1.8)	17 (9.9)	30(17.5)
Somewhat	25 (14.6)	15 (8.8)/10 (5.8)	12 (7)/13 (7.6)	0 (0)	10 (5.8)	15 (8.8)
Totally	13 (7.6)	10 (5.8)/3 (1.8)	5 (2.9)/8 (4.7)	1 (0.6)	3 (1.8)	9 (5.3)
Did you drink alcohol before cancer? N (yes %)	131 (76.6)	83 (48.5)/48 (28.1)	56 (32.7)/ 75 (43.9)	16 (9.4)	44(25.7)	71(41.5)
What type of alcohol? N (%)						
Wine	45 (26.3)	34 (19.9)/11 (6.4)	20 (11.7)/25 (14.6)	2 (1.2)	15 (8.8)	28(16.4)
Beer	70 (40.9)	39 (22.8)/ 31 (18.1)	32 (18.7)/38 (22.2)	12 (7)	23(13.5)	35(20,5)
Cocktails	19 (11.1)	11 (6.4)/8 (4.7)	6 (3.5)/13 (7.6)	2 (1.2)	8 (4.7)	9 (5.3)
Did no drink any alcohol	37 (21.6)	30 (17.5)/7 (4.1)	17 (9.9)/20 (11.7)	2 (1.2)	17 (9.9)	18(10.5)
How often did you drink alcohol? N (%)						
<1 glass	78 (45.6)	48 (28.1)/30 (17.5)	37 (21.6)/41 (24)	10 (5.8)	27(15.8)	41 (24)
3-5 glass	48 (28.1)	32 (18.7)/16 (9.4)	18 (10.5)/30 (17.5)	6 (3.5)	15 (8.8)	27(15.8)
>5 glass	8 (4.7)	30 (2.9)/ 3 (1.8)	3 (1.8)/5 (2.9)	0 (0)	30 (2.3)	30 (2.3)
Did no drink any alcohol	37 (21.6)	29 (17)/8 (4.7)	17 (9.9)/20 (11.7)	2 (1.2)	17 (9.9)	18(10.5)

Notes: N=number of participants, %=percentage.

4.3. Subgroups Analysis

Physical activity levels. Prior to cancer diagnosis, there were significant differences in minutes of physical activity by age, with those 31-40 years reporting more than those >41 years (ΔM=-35.3; p=0.02; CI: -67.05 to -3.6). There were no other differences in minutes of physical activity by age, or by cancer type and treatment status at this timepoint. After cancer diagnosis, there were significant differences in minutes of physical activity by cancer type, with those diagnosed with breast cancer reporting more than those with other types of tumors (ΔM=20.78, p=0.001, CI: 4.9 to 36.6). There were no differences in minutes of physical activity by age and treatment status at this timepoint.

Anthropometrics measurements and HrQOL. There were no significant differences in weight and BMI by age, tumor type, or treatment status prior cancer diagnosis and after cancer diagnosis. HrQOL and health perceptions (i.e., EQ-5D visual analogue scale) differed by tumor type prior to cancer diagnosis, with those diagnosed with breast cancer reporting significantly greater values compared to those with other types of tumors (ΔM=0.9, p=0.006,

CI: 0.03 to 0.2; ΔM=7.3, p=0.008, CI: 1.9 to 12.7). No other differences were observed at this timepoint or after cancer diagnosis.

Smoking. There were no significant differences by age, tumor type, or treatment status in smoking status prior cancer diagnosis. Smoking quit rates did not differ by age, tumor type, or treatments status.

5. Discussion

Data from the YOUNGmove project – a multi-center, retrospective, observational study, was used to: evaluate change in minutes of physical activity in young adults prior to and after cancer diagnosis, describe physical activity habits across the two timepoints, along with reasons underlying behaviour, evaluate change in HrQOL and anthropometric measures, describe smoking prior to cancer diagnosis, quit rates, and whether cancer influenced quit decision, and explore differences in physical activity, HrQOL, anthropometrics, and smoking according to age, type of tumor, and treatment status. Although no significant differences were observed in minutes of physical activity per week prior to and after diagnosis and approximately 70% of young adults did not meet recommendation of 150

minutes per week at either timepoints because of various barriers (e.g., "lack of time" (39.2%), "hard to keep the habit" (33.3%), "side effects of cancer treatments" (26%)), it is worth noting that 80% of those not meeting recommendations engaged in some (i.e., 30 to 120 minutes per week) physical activity, which is important given performing some amount of physical activity is preferable to being inactive. In addition, whilst weight and BMI remained stable, results provide evidence HrQOL was affected by diagnosis with lower levels being reported after diagnosis. Also, nearly 30% of participants smoked prior to cancer diagnosis, though 41% of them stopped smoking after cancer diagnosis. Last, while results remained more or less the same across subgroups, differences in physical activity by age favoring younger participants were observed, and HRQOL appeared to be worse in those diagnosed with non-breast cancer.

Results provide evidence that few young adults diagnosed with cancer are sufficiently active prior to and after diagnosis via mostly aerobic exercise, and that levels were affected by age such that young adults 41-45 years reported fewer minutes of physical activity. Previous cross-sectional studies show only 42% young adults without a history of cancer meet physical activity guidelines [23] and that age is inversely associated with physical activity. [24] Studies also show that few young adults meet recommended levels of physical activity after diagnosis. [25] Moreover, whilst some have suggested that patients may become more physically active after having been diagnosed with cancer because it serves as a 'teachable moment' or 'wake-up call' for adopting a more healthy lifestyle, [26] the current study and previous studies in which change in physical activity in newly diagnosed patients were examined show levels of physical activity decrease after diagnosis. [27,28] Results suggest there are various reasons for this, including lack of time and difficulties maintain behaviour. This is not surprising based on past research with healthy young adults. [29,30] However, low participation in physical activity was also associated with side effects of cancer treatment. Indeed, in line with findings of other studies, [31] a notable finding was that fatigue and joint pain were the most limiting side effects to performing physical activity after diagnosis but were also those that most improved with physical activity. As physical activity is important to reduce the risk of certain cancers [32] and after diagnosis to reduce the likelihood of recurrence, decrease disease progression, and increase HrQOL, [33] it is necessary to consider young adults functional limitations and tailor any physical activity programs accordingly. On the basis of prior research, it is also relevant to address personal (e.g., lack of confidence, lack of motivation) and social factors (e.g., lack of social support from family and friends) because they may be effective for increasing physical activity levels. [34]

In line with past studies, HrQOL levels were lower after diagnosis, possibly as a result of the physical and psychological side effect of their disease and treatments.[35] Additionally, levels were lower in

those diagnosed with non-breast cancer. These findings illustrate deficiencies in current efforts to promote quality survivorship, especially among those diagnosed with non-breast cancer. Although several factors affect HrQOL, [36,37] healthcare providers should promote physical activity around the time of diagnosis based on evidence that it is effective in increasing HrQOL in cancer patients. [38]

As weight gain and overweight/obesity status can increase the progression or complications of cancer, [39] maintaining a healthy weight is important for young adults. Previous studies show young women diagnosed with breast cancer or Hodgkin lymphoma gain weight after cancer diagnosis, [40,41] and that approximately 36% young adults are considered overweight or obese after cancer diagnosis. [42] In this sample of young adults, a cancer diagnosis did not result in weight cancer or change in BMI. It is possible that the retrospective nature of this study or the use of self-report explains changes have not been detected. Alternatively, it is possible that changes in weight and BMI following diagnosis may vary between different types of tumors because some may require treatments associated with weight gain. Therefore, more research should focus on the most prevalent types of tumors for young adults and examine whether diagnosis affects measured (as opposed to self-reported) weight and BMI prospectively.

Finally, smoking rate exceeds 2 billion smokers globally [43] despite the well-known health risks. [44] The current study showed that 28.7% of participants smoked prior to cancer diagnosis, with most (71.9%) smoking >10 cigarettes daily. Whilst 41% quit, greater efforts are needed to further reduce rates. Past research has showed the combination of medication and behavioral counseling may help reduce smoking rates [45].

6. Limitations and Future Directions

When interpreting the results of the current study, strengths and limitations should be considered. Strengths include the relatively large sample and the examination of changes across two timepoints, namely prior to and after diagnosis. Furthermore, the current study examined minutes of physical activity instead of only 'meeting' and 'not meeting' guidelines. However, it should be noted that data were based on self-report, which may have resulted in under or overestimations. As well, the questionnaires might not have been sensitive enough to capture all changes in physical activity, anthropometrics, and HrQOL. Moreover, participants were asked questions 'prior to cancer diagnosis' and 'after cancer diagnosis'; they could have difficulties accurately recalling the information. Also, participants could have been diagnosed between 1 day and 5 years prior to survey completion. In cases where they survey was completed a long time after diagnosis, any potential acute effects of diagnosis may have reverted back to pre-diagnosis levels. Alternatively, in cases where the survey was completed a very short time after diagnosis, there may not have been enough time for a change in some variables (e.g., weight, BMI). Finally,

as the sample comprised mostly women, the results may not be widely applicable to men.

7. Conclusion

Approximately 70% of young adults in this study were inactive or insufficiently active before cancer diagnosis, and despite the important role of physical activity in the management of side effects and prevention of NCDs, they did not increase their physical activity levels after diagnosis. This highlights a critical need for targeted and tailored interventions to enhance physical activity in this population, and in turn examine how it affects other lifestyle behaviors (e.g., smoking habits) and health outcomes (e.g., weight, BMI, HrQOL). This can and should be achieved by promoting aerobic exercise, strength training, and flexibility activities to align with current recommendations. Furthermore, whilst the current study provides insight into why young adults limit their participation prior to and after cancer diagnosis, more research is necessary to fully understand determinants of physical activity to inform behavior change intervention efforts.

8. Acknowledgements

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