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The Role of Physical Activity in Improving Quality of Life Among Colorectal Cancer Patients

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Abstract

The third most common cancer in the world is colorectal cancer (CRC), and while survival rates have increased, many survivors still have long-term health issues. Severe fatigue, persistent pain, bowel issues like urgency or incontinence, and emotional difficulties like anxiety, depression, and fear of the cancer coming back are frequently among these problems. A survivor's quality of life can be significantly impacted by these challenges. According to research informed by the biopsychosocial model, survivors' recovery is influenced by social, psychological, and biological factors. One crucial component is physical activity (PA), which can enhance emotional well-being, lessen fatigue, and improve health. Studies support the benefits of regular aerobic exercise and strength training, which are recommended by health organizations for cancer survivors. However, there is still a dearth of research that focuses specifically on CRC survivors, and it frequently uses self-reported activity and inconsistent measures. The studies selected for this review explore how physical activity influences the quality of life of CRC survivors. These consist of systematic reviews, long-term studies, and studies on gender differences, bowel function, and fitness levels. When taken as a whole, these studies demonstrate that physical activity is a beneficial and modifiable factor that can direct improved clinical care and assist CRC survivors in leading healthier lives.

Introduction

Colorectal cancer continues to be one of the most common forms of cancer worldwide, its treatment and control have actually improved so much that one of the reasons for the trend change in CRC is the capital in the form of the medical profession's commitment to the early diagnosis and various treatment options, which have together raised the survival rates and also underlined the requirement for the long-term survivorship care of the patients [1]. The primary concern of this situation is the health-related quality of life, which includes the physical, psychological, and social dimensions of a person's life. Most cancer patients experience several side effects such as extreme tiredness, pain, gastrointestinal problems, fear, and difficulty in moving around, etc. All these factors have a very negative impact on the person's health and the daily life activities for quite a long time [2]. The availability of post-treatment care will largely depend on the timely medical solutions applied to these problems.[3]

There is a growing consensus that non-pharmacological methods can be effective and, in some cases, even more efficient than pharmacological ones for side effects management and recovery support.[4] PA has been acknowledged as the main point of supportive cancer care. Current recommendations, such as those of the American College of Sports Medicine, support that being active is not just safe even in case of ongoing treatment but also leads to significant gains in cardio fitness, muscle strength, and mental wellness [5]. There is an increasing body of evidence that suggests these benefits might be through PA's direct impact on the inflammatory system and stress-related hormones, thus reducing common symptoms and improving the quality of life [6].This paper primarily intends to combine the current evidence from major longitudinal, cross-sectional and review studies to critique the involvement of PA in the amelioration of QOL in case of CRC patients. To assess the degree to which regular physical activity (PA) is associated with various elements of quality of life (QOL) in individuals who have survived colorectal cancer (CRC)to determine the psychological and physiological processes via which PA enhances the prognosis of CRC survivors and to investigate how the link between PA and QOL is influenced (moderated) by variables such patient sex, operation type, and cancer stage and to compile current, high-quality research to inform lifestyle modifications and therapeutic management for CRC survivors.

MATERIALS AND METHODS

Study Designs

The findings of four varied research methods serve as mutual support. The totality of evidence was strengthened by each study presenting different, but solid, methodological weaknesses. [6] employed a prospective longitudinal cohort study design and gathered data at 6, 12, and 24 months after diagnosis to indicate the temporal relations among PA and QOL. [7] did a systematic review, combining the outcomes of 35 studies published between 2000 and 2019, to give a complete and integrative view. The examination of physical fitness was guided by the cross-sectional nature of [8] which measured subjective fitness and QOL at one time, approximately six months post-operation. [9] employed a cross-sectional survey design to trace the lives of the long-term survivors, thereby concentrating on the participants at least five years after the diagnosis, which is very important in the understanding of the chronic functional losses and already mentioned QOL outcomes [10].

Participants

The compilation of proof comes from a very large population that is also very different. The total analytical sample of the four studies together is more than 2,700 CRC survivors. The criteria for inclusion were similar and targeted largely the group of people that had been diagnosed with colonic cancer, but there were differences in timing: [11] took patients right from the time of diagnosis, [12]six months post-surgery, and [13] from a long-term survivorship cohort (≥5 years post-diagnosis). There was a common ground in exclusion of treatment for Stage IV metastatic disease, or people with cognitive impairment, or hereditary cancer syndromes. Many of the participants were elderly, having an average age of 60 to 75 years, and there were more males than females, which is consistent with the overall epidemiology of CRC. The treatment options included surgery, adjuvant chemotherapy, and radiotherapy, and one of the factors that influenced some of the analyses [14] was the patients' ostomy status, which was used to stratify the subjects.

Survey

The research works that were the focus of this analysis each employed different reliable methods for the measurements of health-related leisure. In the case of self-reports, the assessment of people's activity levels was done through the Active Australia Survey[15] and the Godin Leisure-Time Exercise Questionnaire[16] while also the objective measurement of accelerometrywas used for the assessment. We used several performance tests to measure physical fitness: the 6-minute walk test to assess aerobic capacity; the 30-second chair stand test to assess lower body strength; and handgrip dynamometry to measure upper body strength. We employed a variety of instruments to assess health-related quality of life: the Cancer-Specific FACT-C; the European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire, Core 30 (EORTC QLQ-C30) plus its module, QLQ-CR29; the COH-QOL-CRC survey; and the generic SF-12. The bowel function was assessed using the Memorial Sloan Kettering BFI only. All analyses considered the following primary covariates: age, sex, stage of cancer, BMI, comorbidities, and type of treatment analogy, to maintain the integrity of the findings [17].

Statistical Analysis

Rigorous statistical techniques used in research examining the connection between colorectal cancer patients' quality of life (QoL) and physical activity (PA). A Generalized Linear Mixed Model (GLMM) was used to evaluate longitudinal data in order to take into consideration several time points. Multiple linear regression was used in cross-sectional research to account for confounding variables. Lastly, a qualitative synthesis of the literature was carried out using systematic reviews, which comprised studies that employed regression models adjusted for factors such as age and treatment strategy. The main analytical technique for the is qualitative synthesis, which is a systematic review approach rather than a statistical test.

RESULTS

The first table shows a continuous and advantageous connection among the amounts of physical activity and the quality of life of colorectal cancer patients over the course of two years. The patients that adhered to the physical activity recommendations (≥150 minutes/week) at the follow-up sessions (6-, 12-, and 24-months post-diagnosis) were given FACT-C scores that were significantly higher than those of the non-active patients, the difference widening from +9.9 to +11.2 points. These variations are greater than the minimal clinically important difference of 5-8 points, which not only leads to statistical significance but also to the active survivor’s huge, substantial, real-

world improvements in physical, functional, and emotional well-being. The study backs the upsurge, continuous, and dose-dependent benefits of routine exercise for long-term survival outcomes.

Table 1: Mean FACT-C Scores by Physical Activity Level Across a 24-Month Follow-Up Period

Physical Activity Category	6 Months			12 Months			24 Months		No.
	No.	Mean	SD	No.	Mean	SD	No.	Mean	SD
Sedentary (0 minutes)	742	106.4	19.1	588	110.8	17.3	492	111.2	18.0
Moderately Active (1–149 minutes)	503	112.9	16.2	447	117.3	15.6	412	118.1	15.9
Highly Active (≥150 minutes)	685	116.3	14.8	604	121.5	13.9	571	122.4	14.1
FACT-C Score Difference (Active vs. Sedentary)		+9.9			+10.7			+11.2	

Abbreviations: FACT-C = Functional Assessment of Cancer Therapy–Colorectal; SD = standard deviation

The 2 table shows a generalized linear mixed model; this, first, the analysis reveals the obvious connection between more active lifestyle and quality of life among colorectal cancer survivors. The presented association was further reinforced by showing through several other approaches adopted by the researchers. Adherence to the physical activity guidelines (≥150 minutes/week) was associated with an increase in the QOL score by 18.3% as compared to the inactive participants (β = -0.168, $p < 0.001$; 95% CI: 13.5–23.4%), whereas moderate activity was credited with an increase of 8.9% (β = -0.085, $p < 0.001$; 95% CI: 4.2–13.8%). The connection was still determined to be of statistical significance even when corrected for factors such as age, cancer stage, treatment type, and symptoms including fatigue (β = 0.483, OR = 0.617, -38.3%) and bowel dysfunction (β = 0.222, OR = 0.801, -19.9%), thus suggesting that physical activity by itself may be an important tool for cancer survivors to gain health and quality of life apart from symptom relief.

Table 2: Equal-warning, economic involvement plays a somewhat different role between males and females, but leisure-time physical involvement has an independent impact..

				Difference	
Factor	Regression Coefficient	Standard Error	Antilog of Coefficient	%	95% CI
Site					
Colon					

Rectum	-0.024	0.028	0.976	-2.4	-7.8 to 2.9
Stage					
A					
B	-0.058	0.030	0.944	-5.6	-11.6 to 0.5
C	-0.012	0.039	0.988	-1.2 4	-8.9 to 6.7
D	0.047	0.066	0.954	—4.6	—16.1 to 8.5
Presence of stoma					
Permanent					
Temporary	-0.041	0.065	0.960	-4.0	-16.8 to 9.2
None	-0.231	0.062	1.260	26.0	13.8 to 39.4
Treatment Surgery					
Only					
Surgery and adjuvant	-0.028	0.034	0.972	-2.8	-9.5 to 4.0
Sex					
Male					
Female	0.015	0.027	1.015	1.5	-5.2 to 8.3
Age category, years					
20-49					
50-59	-0.143	0.049	0.867	-13.3%	-23.9 to -1.8
60-69	-0.128	0.047	0.880	-12.0%	-22.0 to -1.2
70+	-0.175	0.050	0.839	-16.1%	-27.3 to -3.4
BMI category					
Healthy weight					
Underweight	0.091	0.093	0.913	—8.7	—23.9 to 9.6
Overweight	—0.030	0.032	1.030	3.0	—3.2 to 9.6
Obese	0.046	0.038	0.955	—4.5	—11.4 to 3.0
Fatigue					
No					
Yes	0.483	0.020	0.617	—38.3	—35.9 to —40.6
Nausea					
No					
Yes	0.328	0.027	0.720	—28.0	—24.0 to —31.7
Problems with fecal control					

No					
Yes	0.222	0.021	0.801	—19.9	—16.5 to —23.2
Smoking status					
Never smoked					
Current smoker	0.082	0.046	1.085	+8.5%	-2.1 to 20.3
Former smoker	0.048	0.025	1.049	+4.9%	-0.5 to 10.5
Time (t)	-0.082	0.008	0.921	-7.9%	-9.8 to -5.9
Physical activity					
Inactive Insufficiently active Sufficiently	-0.085	0.020	1.089	+8.9%	4.2 to 13.8
Active	-0.168	0.022	1.183	+18.3%	13.5 to 23.4

NOTE. The method of analysis utilized was generalized linear mixed modelling which reflected both interindividual and intraindividual differences in the data. The model adjustments included diverse demographic, clinical, and treatment-related factors to assess the independent influence of each variable on quality of life. Odds Ratios (OR) greater than 1 indicate a positive association with quality of life, whereas OR less than 1 indicate a negative association.

Table 3 displays the demographic and clinical characteristics of the 71 colorectal cancer patients who made up the study cohort and were assessed six months after surgery. The sample was mainly older (mean age 67), male (63%), and married or cohabiting (80%). The low educational attainment was very common (79% with mandatory schooling or less) as well as being overweight or obese (78%). In terms of the clinical features, most of the patients had early or intermediate disease stages (74% in Stages I and II), nearly one-third were given adjuvant therapy, and 13% had a stoma. This profile gives a picture of a study population typical of colorectal cancer epidemiology—older adults with co-morbidities—and thus the generalization of the physical fitness and quality of life results to clinical settings is enhanced.
Table 3: Main characteristics of the study participants

	Total (N = 71)
Age (years)	67 ± 10
	n (%)
Sex (% of male)	45 (63 %)
Marital status	
Married/Cohabitate	57 (80 %)
Divorced	3 (4 %)
Widowed	11 (16 %)
Education level	
Mandatory or less	56 (79 %)
Secondary	6 (9 %)
College/university	9 (13 %)
Smoking status	
Non-smoker	32 (45 %)
Ex-smoker	30 (42 %)

Current-smoker	9 (13 %)
Weight status	
Normal weight	16 (23 %)
Overweight	34 (48 %)
Obese	21 (30 %)
Cancer stage	
I	25 (35 %)
II	28 (39 %)
III	18 (25 %)
Adjuvant treatment	22 (31 %)
Stoma	9 (13 %)

Table 4 shows that the physically fit metered by the objective test, with the focus on aerobic capacity and lower-body strength, are significantly and independently associated with higher health-related quality of life in colorectal cancer survivors. The performance on the 6MWT and the 30sCST was regularly corresponded to worldwide health status, and physical and cognitive functioning was increased, while symptoms of fatigue and pain were reduced. Significant associations were found even after controlling for important confounders like age, sex, cancer stage, and objectively measured moderate-to-vigorous physical activity levels. Handgrip strength (upper-body strength) showed a weaker and less stable connection with quality-of-life outcomes. These findings support the recognition of the benefits of physical activity on health. Physical activity increases general health and provides specific improvements to cardiorespiratory fitness and functional leg strength, both of which are critical components of achieving optimal health.

Table 4: The research investigated the connection between physical fitness and health-related quality of life (HRQoL) by utilizing distinct linear regression models for every scale.

	6MWT			**30sCST**			**handgrip strength**		
	N	**B (95 % CI)**	**P**	**R^2**	**N**	**B (95 % CI)**	**P**	**R^2**	**n**	**B (CI 95 %)**	**P**	**R^2**
Model 1												
HRQoL (EORTC QLQ-C30)	*60				66				67			
Global health status		0.07 (0.04, 0.10)	< 0.001	0.227		2.18 (0.89, 3.46)	0.001	0.150		0.51 (0.10, 0.91)	0.016	0.085
Functional scale		0.09 (0.07, 0.11)	< 0.001	0.527		2.64 (1.62, 3.66)	< 0.001	0.292		0.48 (0.12, 0.84)	0.009	0.098
Cognitive function		0.07 (0.02, 0.12)	0.005	0.125		1.04 (−0.25 0.76, 2.84)		0.020		0.46 (−0.10 0.10, 1.01)	0.039	0.060
Symptom scale /items		– 0.04 (−0.06, −0.03)	< 0.001	0.334		– 1.322 (−1.98, −0.66)	< 0.001	0.197		– 0.28 (−0.50, −0.06)	0.013	0.090
Fatigue		– 0.10 (−0.13, −0.07)	< 0.001	0.397		– 2.99 (−4.37, −1.61)	< 0.001	0.224		– 0.49 (−0.96, −0.01)	0.044	0.060
Pain		– 0.07 (−0.005		0.240		– 2.01 (−0.005		0.115		– 0.45 (−0.045		0.060

		0.11, 0.04)	−0.001		3.39, 0.63)	−		0.90, 0.01)	−
Colorectal cancer module (QLQ-CR29)									
Functional scale	57	– 0.02 (−0.05, 0.003)	0.085	263	– 0.01 (−0.98, 0.97)	0.992	0.00064	– 0.35 (−0.63, 0.06)	0.019
Symptom scale	52	– 0.02 (−0.03, 0.0002)	0.048	0.075	58	– 0.89 (−1.52, 0.25)	0.007	0.121	– 0.23 (−0.41, 0.05)	0.099
Model 2									
HRQoL (EORTC60 QLQ-C30)					66			67	
Global health status		0.05 (0.01, 0.09)	0.017	0.320	1.42 (0.11, 2.95)	−0.068	0.234	0.11 (0.46, 0.68)	−0.704	0.182
Functional scale		0.10 (0.07, 0.12)	< 0.001	0.566	2.55 (1.31, 3.79)	< 0.001	0.332	0.22 (0.29, 0.73)	−0.394	0.150
Cognitive function		0.07 (0.01, 0.13)	0.023	0.151	0.37 (1.85, 2.58)	−0.742	0.053	0.32 (0.49, 1.12)	−0.438	0.056
Symptom scale /items		– 0.05 (0.07, 0.03)	−< −0.001	0.377	– 1.33 (2.12, 0.53)	−0.001	0.262	– 0.21 (0.52, 0.10)	−0.174	0.146
Fatigue		– 0.11 (0.15, 0.07)	−< −0.001	0.454	– 3.20 (4.86, 1.54)	−< −0.001	0.281	– 0.24 (0.92, 0.43)	−0.474	0.112
Pain		– 0.07 (0.11, 0.03)	−< −0.001	0.285	– 1.60 (3.29, 0.10)	−0.064	0.151	– 0.16 (0.80, 0.48)	−0.619	0.102
Colorectal cancer module (QLQ-CR29)									
Functional scale	57	– 0.004 (0.04, 0.03)	−0.790	0.146	63	0.98 (0.10, 2.06)	−0.075	0.200	64	– 0.18 (0.58, 0.23)	−0.391	0.174
Symptom scale	52	– 0.004 (0.02, 0.02)	−0.644	0.216	58	– 0.67 (1.43, 0.09)	−0.081	0.179	59	– 0.18 (0.45, 0.08)	−0.173	0.143
Model 3									
HRQoL (EORTC50 QLQ-C30)					56			56	
Global health status		0.04 (0.003, 0.08)	−0.067	0.352	0.99 (0.59, 2.56)	−0.214	0.287	– 0.08 (0.60, 0.43)	−0.745	0.248
Functional scale		0.10 (0.06, 0.13)	< 0.001	0.625	1.65 (0.14, 3.15)	0.032	0.376	0.17 (0.35, 0.68)	−0.517	0.317
Cognitive function		0.08 (0.00, 0.16)	0.051	0.239	– 1.03 (3.77, 1.72)	−0.456	0.157	0.54 (0.36,1.44)	−0.233	0.142
Symptom scale /items		– 0.04 (0.06, 0.01)	−0.004	0.340	– 1.06 (2.02, 0.10)	−0.031	0.274	– 0.22 (0.54, 0.11)	−0.184	0.220
Fatigue		– 0.09 (0.14,	−< −0.001	0.483	– 2.37 (4.24,	−0.014	0.346	– 0.25 (0.89,	−0.433	0.273

	0.05)			0.50)			0.39)	
Pain	– 0.09 (	−0.001	0.394	– 1.38 (	−0.159	0.194	– 0.34 (	−0.295	0.160
	0.13, −0.4)			3.32,			0.98,		
				0.56)			0.30)		
Colorectal cancer module (QLQ-CR29)									
Functional scale	47– 0.02 (	−0.499	0.128	531.00 (	−0.150	0.175	53– 0.10 (	−0.668	0.149
	0.06, 0.03)			0.38, 2.38)			0.58,		
							0.37)		
Symptom scale	42– 0.01 (	−0.519	0.198	48– 0.98 (	−0.044	0.182	48– 0.19 (	−0.223	0.119
	0.03, 0.02)			1.93,	−		0.49,		
				0.03)			0.12)		

Model 1: Unadjusted model; Model 2: Adjusted for age, sex and cancer stage; Model 3: Model 2 plus moderate-to-vigorous physical activity. 6MWT, 6-min walk test; 30-sCST test, 30-s chair stand test; CI, confidence interval; EORTC QLQ-C30, European Organization for the Research and Treatment of Cancer Quality of Life Questionnaire-Core 30; QLQ-CR29, Quality of Life Questionnaire Colorectal cancer module; PA, physical activity. * Sample size included ~6-7 fewer participants in each analysis due to missing data on the exposure.

Analysis with many stratifications indicated clear-cut relationships between surgical types and gender-based influences on bowel function compared to the involvement of physical activity for each group. Gender and surgical type also affected the strength of the association between physical activity and bowel function. Women's increased activity showed a clear dose-response improvement in all BFI domains, and high activity was significantly positively correlated with total bowel function (mean difference +4.3 points, $p<0.01$) and urgency control (mean difference +2.0 points, $p<0.05$) when compared to inactive women. The faecal output pattern for men with ostomy was just the opposite: the highest activity levels were linked to the worst bowel function outcomes, and the high-activity men scored 6.2 points lower on total bowel function ($p<0.01$) than their inactive peers. The findings suggest that physical activity invariably improves bowel function in female survivors and men with anastomosis but men with ostomy may need to be prescribed modified physical activities to avoid the worsening of bowel dysfunction.

Table 5: Bowel Function Outcomes Stratified by Physical Activity Level, Gender, and Surgical Status

BFI Scale[a]	Not Active (0 min/week)	Low Activity (1–149 min/week)	Moderate Activity (150–299 min/week)	High Activity (≥300 min/week)
	Adjusted mean (SE)[b]			
Men ostomy (n = 120)	Sample size	N = 48	N = 26	N = 19	N = 27
	Total bowel function[c]	57.8 (1.4)	56.4 (1.8)	54.9 (2.1)^a	51.6 (1.7)^a,c
	Urgency/soilage[c]	17.9 (0.45)	17.3 (0.59)	16.7 (0.68)^b	15.9 (0.55)^b,c
	Dietary[c]	15.9 (0.48)	15.5 (0.65)	14.8 (0.75)^a	13.5 (0.60)^a,c
Men anastomosis (N = 210)	Sample size	N = 55	N = 71	N = 22	N = 62
	Total bowel function	50.8 (1.5)	52.3 (1.3)	53.8 (2.0)	50.7 (1.3)
	Urgency/soilage	14.9 (0.58)	15.5 (0.49)	16.2 (0.82)	15.0 (0.51)

Frequency	21.3 (0.66)	22.4 (0.55)	23.0 (0.89)	21.5 (0.56)
Dietary	14.6 (0.53)	14.5 (0.44)	15.0 (0.75)	14.1 (0.46)
Women combined[g] (N = 230) Sample size	N = 95	N = 50	N = 33	N = 52
Total bowel function[c]	52.1 (1.1)	53.8 (1.5)	55.2 (1.9)^a	56.4 (1.5)^a
Urgency/soilage[c]	15.5 (0.41)	16.3 (0.55)	17.4 (0.71)^b,c	17.5 (0.53)^b,c
Frequency	22.3 (0.57)	22.1 (0.73)	23.3 (0.86)	24.3 (0.75)
Dietary	14.0 (0.40)	15.1 (0.53)	13.9 (0.69)	14.7 (0.51)

DISCUSSION

A patient's health-related quality of life (HRQoL), which is characterized by crippling symptoms like chronic fatigue, pain, and emotional distress, often declines significantly during the course of colorectal cancer (CRC) diagnosis and treatment [19]. Physical activity (PA) is a crucial non-pharmacological intervention that can considerably reduce these negative effects and improve the general well-being of CRC survivors, according to a strong and growing body of research. From being a general health recommendation, PA has developed into a therapeutic tool and is now acknowledged as a key component of survivorship care for people with and after a diagnosis of colorectal cancer.[20] Improving physical function and lowering cancer-related fatigue (CRF) are two of PA's most immediate and clinically significant advantages. CRF is a common, poorly treated symptom that significantly lowers quality of life. Systematic reviews and meta-analyses consistently demonstrate that structured exercise regimens that combine resistance and aerobic training are very effective in improving cardiorespiratory fitness and reducing the severity of CRF[21].

PA counteracts the deconditioning brought on by cancer treatment and promotes a greater sense of physical vitality by improving physical capacity and assisting patients in regaining independence in daily activities. Additionally, the advantages are available in a number of formats, such as home-based and supervised programs.[22] PA is an effective intervention for enhancing the psychological and mental well-being of CRC survivors in addition to its physical advantages. High levels of anxiety, depression, and distress are frequently associated with the experience of cancer. During a time of uncertainty, exercise serves as a constructive coping mechanism by giving patients a concrete sense of control and achievement. Five. Improved mood states, fewer depressive symptoms, and better sleep quality are all reported by survivors who participate in PA, all of which are critical elements of a high HRQoL [23].

Group exercise environments, which provide beneficial social support and connections with peers who have similar experiences, frequently enhance this psychosocial benefit.[24] International consensus standards, such those from the American College of Sports Medicine (ACSM), suggest combining weight training with aerobic exercise to optimize these effects . A minimum of 150 minutes of moderate-intensity exercise (such as brisk walking) or 75 minutes of vigorous-intensity exercise (such as running) per week, or an equal mix, are recommended for aerobic activity. First. An evidence-based goal of 17.5 to 35 MET-hours of physical activity per week is closely linked to better outcomes for CRC patients in particular. [25] It is advised to include muscle-strengthening exercises for all major muscle groups at least twice a week, and resistance training is equally important. This combined approach is vital for combating muscle wasting (cachexia) and bone density loss associated with cancer and its treatments. In addition to improving QoL, PA also improves prognosis and long-term clinical results. Post-diagnosis PA has been linked to improved survival rates for colon cancer patients, including longer disease-free

survival and a decreased risk of all-cause death, according to observational studies [26].

This predictive value emphasizes that PA is a powerful determinant in the biological course of the disease rather than just a supportive measure. Therefore, in order to guarantee that CRC survivors may attain the best quality of life and long-term health, healthcare practitioners should aggressively prescribe and enable access to customized PA programs.The evidence that has been synthesized from the four separate studies points out loudly and clearly that the roles of PA and physical fitness as independent but significant contributors to QOL improvement in CRC survivors are the same. One of the major discoveries is the very clear dose-response relationship, where the adherence to the guideline of a weekly intake of 150 minutes of moderate-intensity PA is correlated with the improvement of global health, physical and psychological functioning, and the decrease of fatigue and pain, as well as Lifting [27]. The size of this advantage—the surpassing of the already established minimum clinically important difference for the FACT-C scale—validates the view that these connections are not simply statistical but rather reflect significant changes in the everyday lives of the patients[28].

The effects of physical activity on health are viewed through a complicated interrelationship between biological, psychological, and social factors with multiple impacts being connected in different ways. The two main areas of improvement where physical activity has the most considerable effect are "cardiorespiratory fitness" and "muscular strength" which at the same time lead to a better overall respiratory capacity, reduced chronic inflammation, and lowered severity of side effects resulting from treatment [29]. On the psychological side, PA is linked to self-efficacy, provides a sense of autonomy and control, and reduces anxiety and depressive symptoms; the last one being confirmed by higher ratings on psychological wellbeing and cognitive function scales [30]. PA treatments are particularly useful in alleviating the patients' distress, with walking being the most preferred method suggested by survivors for the management of bowel problems especially concerning constipation and unpredictability [31].

The strength of this variety of evidence is attributed to the different study designs prospective longitudinal, cross-sectional and systematic review methods and the use of large population-based samples and validated measurement tools. It is important to consider some limitations. The reliance on self-reported physical activity in some studies can create recall and social desirability bias. The predominance of cross-sectional studies in the research areas of fitness and long-term survivorship creates a limitation for causal inference in terms of the directionality of the relationship between physical activity and quality of life. The cohorts' underrepresentation of patients in advanced stages and of the very elderly may lead to concerns about the applicability of the results to these more vulnerable subgroups [32].

The results of this study agree with and widen the whole exercise oncology literature, which has already recognized PA (physical activity) as a safe and effective measure in the cancer survivorship care of many different types of patients [33]. They deliver a nuance that is specific to CRC (colorectal cancer), especially about the moderating effects of sex and ostomy status on outcomes such as bowel function, which is an area that is particularly relevant to this patient group. In terms of theory, the results give a strong backing to the biopsychosocial model and social cognitive theory by demonstrating that changing a behavioural factor (PA) can have a positive influence not only on biological outcomes (fitness, symptoms) but also on psychological states (mood, self-efficacy) and social functioning. Research into future intervention efforts should focus predominantly on Randomized Controlled Trials using objective measures of both PA and Fitness (i.e., PA-related fitness) to disentangle their specific

effects and subsequently develop personalized Rehabilitation Protocols for CRC survivors by understanding the mechanisms behind their effects.

Conclusion

There is clear and convincing evidence supporting the role of PA as an important non-drug therapy for enhancing the many different aspects of CRC Survivor Quality of Life. To numerous health and functional benefits, there are also broader benefits to physical ability, psychological health, and symptom management. There is a solid need for PA within All Survivorship Care Models. The use of strong recommendations is a critical step in translating this evidence into practice. The health community should actively promote adherence to the following recommendations: a minimum of 150 minutes of moderate-intensity aerobic activity (such as brisk walking); the addition of weekly resistance training is the least amount of physical activity necessary and should occur regularly. In addition, tailoring physical activity programs to the characteristics of the survivor such as their gender, whether they have an ostomy, and their baseline fitness level will improve survivors' adherence and maximise their benefits. As a key component of all standard survivorship care plans, pre-arranged PA counselling should be part of all Standard Survivorship Care Plans. Working in conjunction with an interdisciplinary health care team comprised of professionals, including nutritionists, psychologists, and physiotherapists, will allow for a holistic approach to meeting the lifestyle and psychosocial needs of CRC survivors and provide for the greatest long-term health benefits.

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