RESEARCH ARTICLE

Editorial Process: Submission:03/31/2023 Acceptance:09/16/2023

Physical Activity among Colorectal Cancer Patients and Survivors in Egypt

Salma M. Aly[1]*, Doaa Genena[2], Lori Brand Bateman[3], James M. Shikany[3], Mona N. Fouad[3,4], Waleed O. Arafat[5], Salah-Eldin Abdelmoniam[5], Sejong Bae[3], Isabel C. Scarinci[6], Marwa Hussien[7], Mariam Alaa[1], Barbara Hansen[3], Yassmin Hegazy[3], Laura Q. Rogers[3,8]

Abstract

Introduction: Understanding physical activity (PA) levels is important when developing tertiary cancer prevention interventions, especially in Egypt where colorectal cancer (CRC) is more often diagnosed at later stages and at a younger age of onset (≤40 years). **Methods:** We assessed PA levels among CRC patients and survivors in Alexandria, Egypt. All participants completed two self-reported PA assessments: Global Physical Activity Questionnaire (GPAQ) and Godin Leisure-Time Exercise Questionnaire (GLTEQ). Participants could opt to wear an accelerometer for seven days. Results were compared against WHO recommendations of ≥150 minutes or ≥600 metabolic equivalents of tasks (METs) of moderate-to-vigorous PA weekly. **Results:** Of 86 participants enrolled, all completed the surveys and 29 agreed to accelerometer use. Prevalence of meeting PA recommendations was 62.8% based on the GPAQ, 14.0% based on GLTEQ, and 41% based on accelerometer. Based on the GPAQ, very few respondents reported vigorous occupational, vigorous recreational, or moderate recreational activity (median = 0 with interquartile range [IQR] of 0 – 0 weekly minutes for all three) while most activity resulted from moderate occupational and transportation (median [IQR] of 60 [0-840] and 60 [0-187.5] weekly minutes, respectively). Participants meeting PA recommendations were less likely to be married (p = 0.043) according to GPAQ and more likely to be female (p=0.047) and early cancer stage (p=0.007) by GLTEQ. **Conclusion:** Non-leisure free-living PA is a major contributor to meeting PA recommendations while leisure-time PA is a potential target for future interventions that increase PA in this population.

Keywords: Physical activity- colorectal cancer- physical activity assessment- lower-middle-income country

Asian Pac J Cancer Prev, **24 (9)**, 3117-3123

Introduction

A healthy lifestyle plays a crucial role in reducing the risk of colorectal cancer (CRC), which is associated with lower than recommended levels of physical activity (PA), lower fruit and vegetable consumption, greater alcohol consumption, and being overweight or obese (Dartois et al., 2014; Katzke et al., 2015). Although CRC incidence and mortality have decreased dramatically over the past decades, it remains the third most diagnosed cancer and the second most common cause of cancer deaths worldwide (Sung et al., 2021). Despite lower middle-income countries (LMICs), such as Egypt, reporting lower CRC incidence, their long-term survival rates paint a grim picture. In the U.S., 65% of persons diagnosed with CRC survive five years or more and survival time varies widely by stage at diagnosis (Surveillance Research Program, 2021). For instance, 91% of persons diagnosed at the localized stage (Stage I) survive past five years compared with only 15% of their distant-stage (Stage IV) counterparts. In comparison, CRC in Egypt is typically diagnosed at later stages (Stage III and IV), with an average 2-year life expectancy post-diagnosis (Metwally et al., 2018). Further, there is evidence of a younger age of onset in Egypt, with 35% of Egyptian patients diagnosed with CRC under 40 years of age (El Haddad et al., 2014) compared with 12% of their U.S. counterparts under age 50 (American Cancer Society, 2020).

*[1]Community Medicine department, Faculty of Medicine, Alexandria University, Alexandria, Egypt. [2]Medical Research Institute, Alexandria University, Alexandria, Egypt. [3]Department of Preventive Medicine, The University of Alabama at Birmingham Heersink School of Medicine, Birmingham, AL, United States. [4]Preventive Medicine, The University of Alabama at Birmingham School of Medicine, Birmingham, AL, United States. [5]Department of Clinical Oncology, Faculty of Medicine, Alexandria University, Alexandria, Egypt. [6]Global and Rural Health, University of Alabama at Birmingham Heersink School of Medicine, Birmingham, AL, U.S. [7]Department of Obstetrics and Gynecology, Faculty of Medicine, Alexandria University, Alexandria, Egypt. [8]Department of Medicine, the University of Alabama at Birmingham, Birmingham, Alabama*For Correspondence: s_aly14@alexmed.edu.eg*

Implementing PA programs can improve CRC outcomes and quality of life among survivors (Kenkhuis et al., 2021). CRC treatment can cause symptoms which adversely affect patients' quality of life, including depression, sleep disturbance, and lower extremity neuropathy (Mols et al., 2013; Tofthagen et al., 2013). Further, over one-third of CRC patients have comorbidities, most frequently diabetes and/or cardiovascular disease, which can result in a greater risk of death independent of CRC (Cuthbert et al., 2018). Participating in PA during and after colorectal cancer (CRC) treatment can alleviate fatigue, leading to an enhanced quality of life (Brandenbarg et al., 2018) and lower the chances of CRC-related morbidity (Van Blarigan and Meyerhardt, 2015). Previous studies indicated that engaging in regular moderate-to-vigorous PA is linked to improved health-related quality of life (QOL) and decreased symptoms (e.g., fatigue and anxiety) among colorectal cancer survivors (Lynch et al., 2008; Peddle et al., 2008; Buffart et al., 2012; Campbell et al., 2019; Kim et al., 2019). Higher levels of PA are also associated with improved survival among colorectal cancer patients (Haydon et al., 2006; Choy et al., 2022). Unfortunately, less than one-quarter of CRC survivors adhere to PA guidelines in international non-Egyptian populations, and little is known about PA prevalence in Egypt, a LMIC whose residents suffer poorer survival rates after a CRC diagnosis (Chung et al., 2013). A better understanding of CRC patients and survivors' PA behaviors is needed to develop interventions that can improve cancer outcomes and quality of life short and long-term. Hence, this study aimed to assess PA prevalence among individuals with a diagnosis of CRC in Egypt using self-report and accelerometer PA measures in order to inform future PA interventions for CRC patients and survivors.

Materials and Methods

Participants were recruited from patients attending appointments at the Alexandria University Oncology Clinic and Alexandria Comprehensive Cancer Center in Alexandria, Egypt. Eligibility criteria included 18 years of age and older with a current or past diagnosis of CRC. The study consisted of surveys and an option to wear an accelerometer activity monitor. Participants providing complete data (survey and accelerometer) received 100 LE (Egyptian Pounds) as an incentive. The institutional review boards from Alexandria University and University of Alabama at Birmingham approved the study and written informed consent was given by all participants. Consent forms were in Arabic.

Assessments

Study personnel met with participants either one or three times, depending on participants' willingness to wear an activity monitor. During the first meeting, a demographic survey and two PA questionnaires were administered to all participants. For those agreeing to wear an accelerometer, the device was distributed during a second contact and collected during a third meeting. Meetings were held over three consecutive weeks.

Demographic characteristics of participants were collected using a self-administered survey, including gender, age, educational attainment, marital status, employment status, urban or rural residence, current self-reported weight and height, stage at which CRC was diagnosed, and if a participant was currently being treated for cancer or was a post-treatment cancer survivor. Educational attainment and employment were dichotomized to "Yes" for anyone ever attending school and for anyone employed full time. Body mass index (BMI) was calculated using survey data.

Thresholds for meeting recommended PA were determined, based on the recommendations from the World Health Organization (WHO) of at least 150 minutes of moderate-to-vigorous-intensity PA (MVPA) per week or achieving an intensity of at least 600 metabolic equivalents of tasks (METs) of MVPA per week (World Health Organization, 2011; World Health Organization, 2020). METs are used to describe the energy expenditure during PA using the ratio of working metabolic rate relative to the resting metabolic rate (Ainsworth et al., 2000). According to WHO (2011), when calculating METs, it is appropriate to use thresholds of 1 MET for sedentary, 2-3 for light, 4-7 for moderate, and ≥8 for vigorous activities. Values from the moderate and vigorous categories are used to calculate METs that meet WHO PA recommendations of ≥600 METs of MVPA weekly.

Two questionnaires assessed self-report PA, both translated into Arabic (translation was validated prior to study commencement). The Godin Leisure-Time Exercise Questionnaire (GLTEQ) (Godin and Shephard, 1985; Godin et al., 1986) measured minutes and intensity of leisure-time PA with examples listed that were considered strenuous (hearts beats rapidly, e.g., running, jogging, vigorous swimming), moderate exercise (not exhausting, e.g., fast walking, tennis, easy bicycling), or mild/light exercise (minimal effort, e.g., leisurely walking, fishing). Times per week and durations of light, moderate, and vigorous activity were used to calculate weekly activity minutes. The Global Physical Activity Questionnaire (GPAQ) (World Health Organization, 2011), measured all PA throughout one week, including activities at work, frequency and minutes spent pedaling a bicycle or walking to and from destinations, and activities during leisure time and reported as METs. Among participants agreeing to wear an activity monitor, PA data were collected using an ActiGraph™ accelerometer (ActiGraph Ltd, 2011). Accelerometers were worn at the waist during waking hours for seven days with four valid days required for scoring. The setting was 3-axis and epoch length was 30 seconds. Non-wear time was defined as having 60 minutes of consecutive zeroes. A "valid day" was defined as at least 600 minutes of accelerometer wear-time, excluding sleep period. Cut-points were as follows: 0 to 99 counts/minute for sedentary, 100-499 for inactive, 500 to 1,951 for light activity, 1,952 to 5,724 for moderate activity, and 5,725 or higher for vigorous activity (Freedson et al., 1998; Sirard et al., 2000). Daily averages were used to calculate weekly minutes.

Statistical analysis

Categorical data were summarized using frequency

and percentage. The Kolmogorov-Smirnov test was used to verify the normality of distribution. Data were summarized using range (minimum and maximum), mean, standard deviation (SD), median, and interquartile range (IQR). Chi-square and Monte Carlo tests were used to compare those who agreed to wear with those who refused to wear an accelerometer, and the Mann Whitney test was used to compare non-normally distributed quantitative variables to compare between groups. When calculating intensity of PA, we maintained the PA intensity cut-points as categories of PA. Dichotomous variables were constructed to reflect if participants met the WHO recommendations of ≥150 minutes of weekly MVPA or 600 METs MVPA weekly. Meeting recommendations by GLTEQ and GPAQ were then compared by use of accelerometer. Results were also compared by demographic characteristic, cancer stage, BMI, and cancer treatment status (currently in treatment or completed treatment, hereafter called 'survivor'). Statistical significance was assessed at α=0.05. Data were analyzed using IBM SPSS, v. 24 (IBM Corp., 2016).

Results

Eighty-six CRC patients and survivors consented to participate in the study (100% response rate). As seen in Table 1, participants were majority female with an average age of just over 52 years, not employed full time, married, and living in an urban area. The average (± SD) BMI of participants was 27.9 ± 7.8 kg/m2. Nearly two-thirds (62.8%) were currently undergoing CRC treatment and 63.6% of participants had their CRC identified at an early stage (Stages I or II). Of the 86 participants, 14% self-reported meeting PA recommendations by GLTEQ and 62.8% self-reported meeting recommendations by GPAQ. Among the 29 (33.7%) agreeing to wear the accelerometer, 41% met the PA recommendations.

When PA levels were evaluated per GLTEQ (Figure 1), participants primarily reported mild PA with a median (IQR) of 50 (0-140) minutes weekly, while moderate and vigorous activities saw medians (IQRs) of 0 (0-23.3) and 0 (0-0), respectively. Activity levels, as measured using the GPAQ (Figure 2), indicated primarily sedentary time with a median (IQR) of 4200 (2,520-5,880) minutes weekly. Very few participants reported vigorous PA as noted by the median (IQR) reports of 0 (0-0) vigorous work and 0 (0-0) vigorous recreational minutes. With regard to sources of PA, median (IQR) moderate work activities were 60 (0-840) minutes and 60 (0-187.5) were spent walking or bicycling to and from destinations. Among the 29 participants wearing the accelerometer (Figure 3), sedentary median (IQR) time was high at 4,138 (3,423-4,830) minutes while approximately 24 hours weekly were spent in light intensity PA with a median (IQR) of 1,450 (1,151-1,630) minutes and approximately two hours or 124.7 (68-185) minutes were spent in moderate intensity PA. These participants performed no vigorous.

Table 2 compares the demographic characteristics of participants meeting GPAQ and GLTEQ recommendations; only gender, marital status, and cancer stage were statistically significantly associated with meeting recommendations. When the PA level was compared for participants wearing vs. not wearing the accelerometer (Table 3), those wearing the accelerometer were less likely to meet recommendations based on the GLTEQ only (p=0.045).

Discussion

Our study assessing PA among persons with a CRC diagnosis in Egypt revealed that nearly two-thirds of participants self-reported ≥600 METs/week of MVPA as measured by the GPAQ and approximately one in seven reported meeting the recommendation of 150 minutes of MVPA per week as measured by the GLTEQ. Accelerometer data demonstrated that four in 10 participants met weekly PA recommendations. Meanwhile, participants spent a median of about 70 hours of sedentary time each week based on GPAQ and accelerometer. Our finding related to the low prevalence of leisure-time PA is similar to that reported by Packel et al., (2015) among CRC survivors living in high-income countries. This may suggest that the influence of the disease course and treatment on PA in these populations overshadows other contextual influences, such as social norms and standards (Ball et al., 2010), public awareness of PA benefits (Bauman et al., 2006), and perceptions of environmental/neighborhood attributes (Cerin et al., 2014; Shanahan et

Table 1. Characteristics of Studied Colorectal Cancer Patients in Egypt (N= 86)

Demographic characteristics	n (%)
Gender	
Male	37 (43)
Female	49 (57)
Age in years, mean (SD)	52.32 (14.1)
Ever attended school (Yes)	65 (77.4)
Employed full time (Yes)	26 (30.6)
Reside in urban area (Yes)	67 (78.8)
Married (Yes)	68 (80)
BMI, mean (SD)	27.9 (7.8)
Cancer Stage	
Early (Stages I or II)	49 (63.6)
Late (Stages III or IV)	28 (36.4)
Treatment Status	
Currently under treatment	54 (62.8)
Survivor (post-treatment)	32 (37.2)
Agreed to wear Accelerometer	29 (33.7)
Met recommendations by GLTEQ (≥150 minutes MVPA weekly)	12 (14.0)
Met recommendations by GPAQ (≥600 METs MVPA weekly)	54 (62.8)
Met recommendations by accelerometer (≥150 minutes MVPA weekly)	12 (41.4)

Abbreviation: SD, Standard Deviation; BMI, body mass index; GLTEQ, Godin Leisure-Time Exercise Questionnaire; MVPA, moderate or vigorous physical activity; GPAQ, Global Physical Activity Questionnaire; MET, metabolic equivalent of task

Table 2. Participant Demographic Characteristics by Meeting Recommendations when Measured by GPAQ or GLTEQ (N=86)

		Met GPAQ [a]		Met GLTEQ [b]	
	n	% Yes	p-value	% Yes	p-value
Gender					
Male	37	56.8	0.314	5.4	0.047 [c]
Female	49	67.3		20.4	
Age in years					
<50	34	64.7	0.947	41.7	0.928
≥50	50	64		14	
Attended school					
Yes	65	66.2	0.283	10.8	0.242
No	19	52.6		21.1	
Employment					
Yes	26	65.4	0.814	7.7	0.259
No	59	62.7		16.9	
Residence					
City	67	62.7	0.755	14.9	0.68
Village	18	66.7		11.1	
Marital status					
Married	68	57.4	0.043 c	11.8	0.255
Not married	18	83.3		22.2	
Cancer stage					
Early (Stages 1 and II)	49	67.3	0.557	22.4	0.007 [c]
Late (Stages III and IV)	28	60.7		0	
BMI					
<30	65	63.1	0.879	13.8	0.762
≥30	18	61.1		11.1	
Treatment status					
Under treatment	54	59.3	0.379	16.7	0.346
Survivor	32	68.8		9.4	

[a] GPAQ threshold = ≥600 METs MVPA/week; [b] GLTEQ threshold = ≥150 minutes MVPA/week; [c] Statistically significant

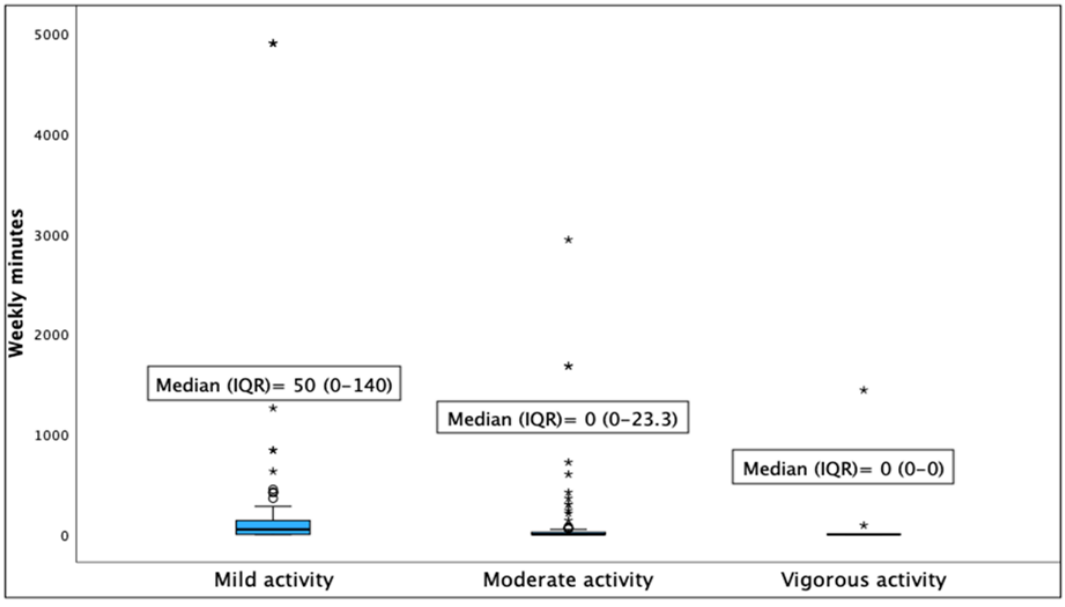

Figure 1. Participant Leisure-Time Activity Levels by Godin Leisure-Time Exercise Questionnaire (GLTEQ), Minutes per Week (n=86)

Table 3. Comparison of Participants' Physical Activity by Accelerometer Use (N=86)

	Accelerometer Acceptance		Total (N=86)	p-value
	Yes (n=29)	No (n=57)		
Weekly MVPA (minutes)				
Mean (SD)	71.6 (316)	149.2 (473)	152.7 (520.6)	0.815
Median [a]	0	0	0	
IQR	0.0-32.5	0.0-5.3	0.0-23.3	
Total METs per week				
Mean (SD)	3950.7 (4541.8)	4089.2 (6098.7)	4266.5 (6402.3)	0.318
Median [a]	2160	1260	1440	
IQR	420-6955	140-6720	225-6720	
GLTEQ [b]				
<150 minutes MVPA (%)	96.6	80.7	86	0.045
≥150 minutes MVPA (%)	3.4	19.3	14	
GPAQ [b]				
<600 METs MVPA (%)	31	40.4	37.2	0.398
≥600 METs MVPA (%)	69	59.6	62.8	

a, Mann Whitney test; b, Chi-square test; Abbreviations: SD, Standard Deviation; IQR, interquartile range; MET, metabolic equivalent of task; GLTEQ, Godin Leisure-Time Exercise Questionnaire; MVPA, moderate and vigorous physical activity; GPAQ, Global Physical Activity Questionnaire

al., 2016).

In contrast, our GPAQ estimates indicated more inactive time and less vigorous activity in our sample compared to cancer survivors in Spain reported by Ruiz-Casado et al., (2016). Moreover, accelerometer-measured PA in our sample recorded much lower PA than participants in Ruiz-Casado et al.,'s (2016) study. Our participants averaged less than one minute per week of vigorous activity and only 142 minutes of moderate activity compared with their participants clocking six minutes of vigorous and 360 minutes weekly of moderate activity. The variations in findings could be related to several possibilities as follows: 1) our sample was comprised exclusively of patients with CRC whereas their study included a variety of cancers (e.g. breast); 2) accelerometer use was optional in our participants while the Spanish study required an accelerometer assessment for all participants; 3) differing social influences between Spain and Egypt; and 4) environmental or economic factors, such as transportation, and occupation, which might influence different PA sources.

There is general understanding that discrepancies between self-report and accelerometer-measured PA levels exist, (Dyrstad et al., 2014; Garriguet et al., 2015), possibly due to self-report susceptibility to social desirability and recall bias with a tendency to overreport PA and underestimate sedentary activities (Brenner and DeLamater, 2014; VandeBunte et al.,

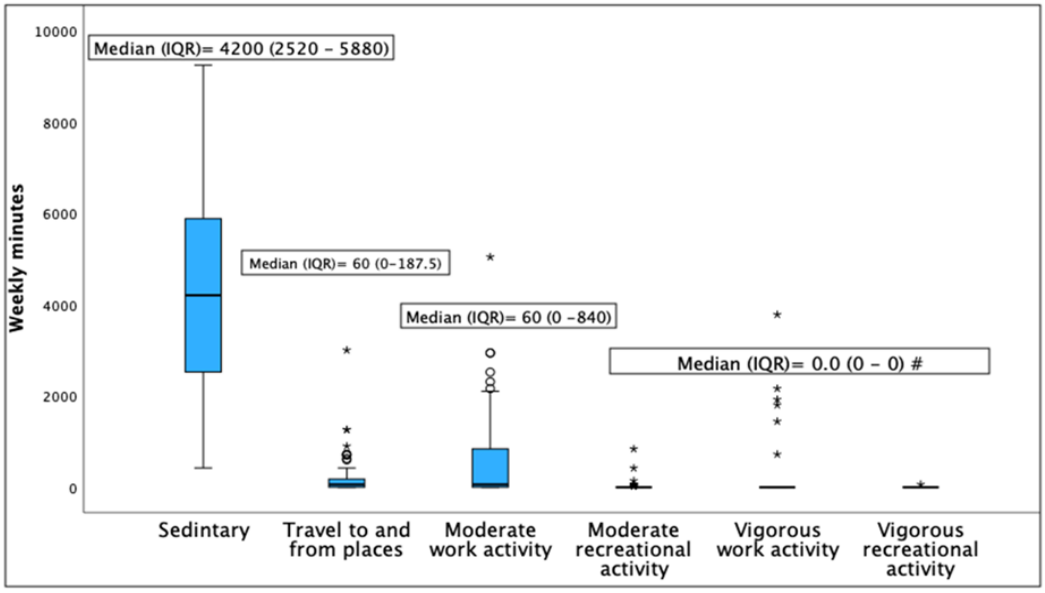

Figure 2. Participant Physical Activity Levels by Global Physical Activity Questionnaire (GPAQ), METs per week (n=86)

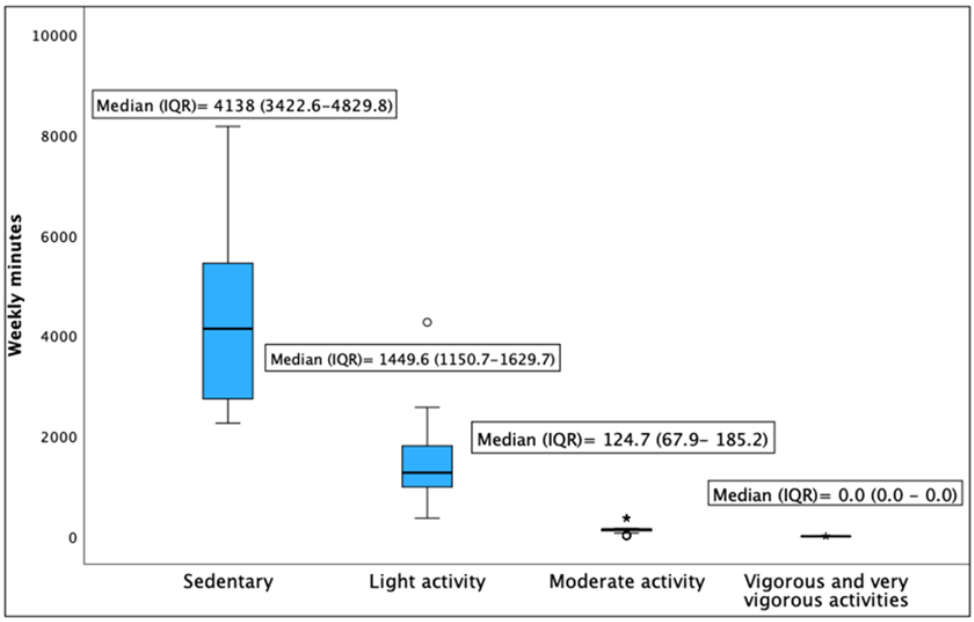

Figure 3. Participant Physical Activity Levels by the Accelerometer, Minutes per week (n=29)

2022). Our study mirrored findings among other studies that included CRC survivors and reported disagreement between self-reported and accelerometer-measured PA (Boyle et al., 2015). In addition, there are several methodological factors that may have contributed to the poor agreement found between the GLTEQ self-reports and the accelerometer readings. As noted by Broderick et al. (2014), the GLTEQ questionnaire asks about PA performed only in the recreational domain, whereas the accelerometer and GPAQ capture PA across all waking domains. Although the accelerometer is considered more accurate than self-report, it is also likely to underestimate PA resulting from activities, such as cycling, weightlifting, carrying a load, or measuring activities in water (e.g., water aerobics, swimming) when not waterproof.

Unfortunately, there is a paucity of data regarding PA and CRC survivors in LMICs, particularly in Egypt; therefore, our study is crucial in informing PA intervention development and evaluation. We identified two distinct factors that support the use of the GPAQ to assess PA among CRC patients and survivors in Egypt: 1) the GPAQ assesses PA across multiple domains, data useful for determining future intervention targets (e.g., sedentary, and recreational activities) and 2) our experience with participants' refusal to wear the accelerometer for research purposes suggests that self-report PA using the GPAQ may be the most feasible approach. Further, many participants' refusal to wear the accelerometer due to perceived danger from 'waves' emitting from the device reiterates the importance of CRC researchers in LMICs assessing the cultural context and unique barriers to PA adherence and assessment.

Our study demonstrated several strengths. We are one of very few examining PA in CRC patients and survivors in Egypt. We assessed PA using three methods: 1) GLTEQ (measures recreational/leisure activity), 2) GPAQ (measures all activities), and 3) accelerometer (measures PA objectively). This provided the opportunity to compare instruments and differentiate between sources of PA. In so doing, we identified two potential targets for future interventions (i.e., reducing sedentary time and increasing intensity of PA across all domains, especially recreation and transportation via walking or bicycling). Finally, conducting this study in an LMIC may inform similar studies in other under-resourced countries.

This study has some limitations to note. First, only one-third of participants agreed to wear an accelerometer, limiting the number of participants with an objective measure of PA. In addition, our original plan was to include only CRC survivors who were post-treatment. Due to the limited number of post-cancer treatment survivors in the clinics targeted for recruitment, we expanded our eligibility pool to include persons undergoing CRC treatment, which became our majority subsample. Moreover, survival bias may partly limit the generalizability of our findings, as only 28 survivors were diagnosed at Stage IV. Data on the two PA questionnaires were self-reported, introducing the possibility of recall bias and/or under- or over-reporting for social desirability. Finally, our sample was not large enough to draw firm conclusions regarding differences in agreement by various sociodemographic and behavioral factors, as suggested by previous research (Bull et al., 2009; Dyrstad et al., 2014).

In conclusion, Regardless of the discrepancies among the different measures, there is still a substantial number of CRC patients and survivors in Egypt who are not meeting PA guidelines. Thus, more research is needed to understand PA barriers, facilitators, and preferences in this population with which to inform culturally relevant, targeted PA interventions. Gender-specific interventions should be examined as well as components to address the high levels of sedentary behavior in this population. Due to the overwhelming refusal to use an accelerometer, future research in Egypt should study the causes behind this refusal and develop educational materials explaining the safety of such devices. Doing so would increase

feasibility of combining accelerometer assessment with the self-report GPAQ and optimize evaluation of PA for intervention development and evaluation in this LMIC.

Author Contribution Statement

SMA, DG, LBB, JMS, MNF, WOA, SEA, BS, ICS, LQR, SB – contributed to the study design. DG, JMS, WOA, SEA – assisted with participant recruitment. SMA, MH, JA – performed the data collection. SMA, MH, MA, SB – assisted with data entry, management, and analyses. SMA, DG, LQR, SB – led data interpretation. SMA, LBB, MH, MA, YH, LQR – contributed to the original manuscript draft. All authors contributed to revisions of manuscript. All authors reviewed the manuscript and approved the final version.

Acknowledgements

We wish to thank the Clinical Oncology Outpatient Clinic at Alexandria Main Hospital and the Alexandria Comprehensive Cancer Care Center for their assistance in providing space for the recruitment of patients.

Funding statement

We also thank our funding support; this article is derived from the Subject Data funded in whole or part by USAID and NAS through Subaward #2000007148. Any opinions, findings, conclusions, or recommendations expressed in the article are those of the authors alone and do not necessarily reflect the views of USAID or NAS. This study was also supported by a pilot grant from the Sparkman Center for Global Health, Ryals School of Public Health at The University of Alabama at Birmingham.

Acknowledgements

This study was reviewed by the funding agency before approved for funding. This study was not part of a student thesis.

The institutional review boards from Alexandria University and University of Alabama at Birmingham approved the study. Written informed consent was given by all participants. Consent forms were in Arabic.

Availability of data

De-identified data is available upon request and after appropriate institutional agreements have been fully executed.

C*onflict of interest*

The authors have no conflicts of interest to report.

References

ActiGraph Ltd. (2011). ActiGraph Activity Monitors: Pensacola, Florida [Online]. Pensacola, FL. Available: https://www.actigraph.nl/en/article/7/het-bedrijf.html [Accessed April 11, 2022].

Ainsworth BE, Haskell WL, Whitt MC, et al (2000). Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sport Exer*, **32**, 498-504.

Ball K, Jeffery RW, Abbott G, et al (2010). Is healthy behavior contagious: Associations of social norms with physical activity and healthy eating. *Int J Behav Nutr Phy*, **7**, 86.

Bauman A, Smith BJ, Maibach EW, et al (2006). Evaluation of mass media campaigns for physical activity. *Eval Program Plann*, **29**, 312-22.

Boyle T, Lynch BM, Courneya KS, et al (2015). Agreement between accelerometer-assessed and self-reported physical activity and sedentary time in colon cancer survivors. *Support Care Cancer*, **23**, 1121-6.

Brandenbarg D, Korsten JHWM, Berger MY, et al (2018). The effect of physical activity on fatigue among survivors of colorectal cancer: a systematic review and meta-analysis. *Support Care Cancer*, **26**, 393-403.

Brenner PS, DeLamater JD (2014). Social Desirability Bias in Self-reports of Physical Activity: Is an Exercise Identity the Culprit?. *Soc Indic Res*, **117**, 489-504.

Broderick JM, Ryan J, O'Donnell DM, et al (2014). A guide to assessing physical activity using accelerometry in cancer patients. *Support Care Cancer*, **22**, 1121-30.

Buffart LM (2012). Self-reported physical activity: its correlates and relationship with health-related quality of life in a large cohort of colorectal cancer survivors. *PLoS One*, **7**, e36164.

Bull FC, Maslin TS, Armstrong T (2009). Global physical activity questionnaire (GPAQ): Nine country reliability and validity study. *J Phys Act*, **6**, 790-804.

Campbell KL (2019). An Executive Summary of Reports From an International Multidisciplinary Roundtable on Exercise and Cancer: Evidence, Guidelines, and Implementation. *Rehabilitat Oncol*, **37**.

Cerin E, Cain KL, Conway TL, et al (2014). Neighborhood environments and objectively measured physical activity in 11 countries. *Med Sci Sport Exer*, **46**, 2253-64.

Choy KT (2022). Exercise and colorectal cancer survival: an updated systematic review and meta-analysis. *Int J Colorectal Dis*, **37**, 1751-8.

Chung JY, Lee DH, Park J-H, et al (2013). Patterns of physical activity participation across the cancer trajectory in colorectal cancer survivors. *Support Care Cancer*, **21**, 1605-12.

Cuthbert CA, Hemmelgarn BR, Xu Y, et al (2018). The effect of comorbidities on outcomes in colorectal cancer survivors: A population-based cohort study. *J Cancer Surviv*, **12**, 733-43.

Dartois L, Fagherazzi G, Boutron-Ruault M-C, et al (2014). Association between five lifestyle habits and cancer risk: Results from the E3N cohort. *Cancer Prev Res*, **7**, 516-25.

Dyrstad SM, Hansen BH, Holme IM, et al (2014). Comparison of self-reported versus accelerometer-measured physical activity. *Med Sci Sport Exer*, **46**, 99-106.

El Haddad S, Abdel Hady I, Sakr A, et al (2014). Epidemiological evaluation focusing on prognostic impact of young age in Egyptian patients with colorectal Cancer, NEMROCK experience. *Kasr El-Aini J Clin Oncol Nucl Med*, **10**, 6-11.

Freedson PS, Melanson E, Sirard J (1998). Calibration of the Computer Science and Applications, Inc. accelerometer. *Med Sci Sport Exer*, **30**.

Garriguet D, Tremblay S, Colley RC (2015). Comparison of physical activity adult questionnaire results with accelerometer data. *Health Rep*, **26**, 11.

Godin G, Jobin J, Bouillon J (1986). Assessment of leisure time exercise behavior by self-report: A concurrent validity study. *Can J Public Health*, **77**, 359-62.

Godin G, Shephard RJ (1985). A simple method to assess exercise behavior in the community. *Can J Appl Sport Sci*, **10**, 141-6.

Haydon AM (2006). Effect of physical activity and body size on

survival after diagnosis with colorectal cancer. *Gut*, **55**, 62-7.
Katzke VA, Kaaks R, Kühn T (2015). Lifestyle and cancer risk. *Cancer J*, **21**.
Kenkhuis MF, Van Roekel EH, Breedveld-Peters JJL, et al (2021). Longitudinal Associations of Sedentary Behavior and Physical Activity with Quality of Life in Colorectal Cancer Survivors. *Med Sci Sport Exer*, **53**, 2298-308.
Kim JY (2019). Effects of a 12-week home-based exercise program on quality of life, psychological health, and the level of physical activity in colorectal cancer survivors: a randomized controlled trial. *Support Care Cancer*, **27**, 2933-40.
Lynch BM (2008). Prospective relationships of physical activity with quality of life among colorectal cancer survivors. *J Clin Oncol*, **26**, 4480-7.
Mols F, Beijers T, Lemmens V, et al (2013). Chemotherapy-induced neuropathy and its association with quality of life among 2- to 11-year colorectal cancer survivors: results from the population-based PROFILES registry. *J Clin Oncol*, **31**, 2699-707.
Packel LB, Prehn AW, Anderson CL, et al (2015). Factors Influencing Physical Activity Behaviors in Colorectal Cancer Survivors. *Am J Health Promot*, **30**, 85-92.
Peddle CJ (2008). Medical, demographic, and psychosocial correlates of exercise in colorectal cancer survivors: an application of self-determination theory. *Support Care Cancer*, **16**, 9-17.
Ruiz-Casado A, Alejo LB, Santos-Lozano A, et al (2016). Validity of the physical activity questionnaires IPAQ-SF and GPAQ for cancer survivors: Insights from a Spanish cohort. *Int J Sports Med*, **37**, 979-85.
Shanahan DF, Franco L, Lin BB, et al (2016). The benefits of natural environments for physical activity. *Sports Med*, **46**, 989-95.
Sirard JR, Melanson EL, Li L, et al (2000). Field evaluation of the Computer Science and Applications, Inc. physical activity monitor. *Med Sci Sport Exer*, **32**.
Sung H, Ferlay J, Siegel RL, et al (2021). Global Cancer Statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*, **71**, 209-49.
Surveillance Research Program (2021). SEER Explorer: An interactive website for SEER cancer statistics [Online]. National Cancer Institute,. Available: https://seer.cancer.gov/explorer/ [Accessed March 28, 2022].
Tofthagen C, Donovan KA, Morgan MA, et al (2013). Oxaliplatin-induced peripheral neuropathy's effects on health-related quality of life of colorectal cancer survivors. *Support Care Cancer*, **21**, 3307-13.
Van Blarigan EL, Meyerhardt JA (2015). Role of physical activity and diet after colorectal cancer diagnosis. *J Clin Oncol*, **33**, 1825-34.
VandeBunte A, Gontrum E, Goldberger L, et al (2022). Physical activity measurement in older adults: Wearables versus self-report. *Front Digit Health*, **4**, 869790.
World Health Organization (2020). WHO Guidelines on Physical Activity and Sedentary Behaviour [Online]. Available: https://apps.who.int/iris/bitstream/handle/10665/337001/9789240014886-eng.pdf [Accessed June 15, 2022].