RESEARCH ARTICLE

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Impact of Pilates Exercise on Quality of Life, Functional Capacity, Cancer-related Fatigue, Depression and Salivary Cortisol of Colorectal Cancer Survivors: A Quasi-Experimental Study

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Abstract

Objective: This study aimed to investigate the effect of Pilates exercise on the quality of life, functional capacity, cancer-related fatigue, depression and salivary cortisol of colorectal cancer survivors. **Methods:** This is a quasi-experimental study which was conducted at Hospital Canselor Tuanku Muhriz, Universiti Kebangsaan Malaysia (UKM), and Hospital Al-Sultan Abdullah, Universiti Teknologi MARA (UiTM), Malaysia. The intervention group performed Pilates exercises with a certified Pilates instructor for eight weeks via online streaming from the participants' homes. Meanwhile, the control group participants received the usual care as stipulated by their oncologists. The primary outcome was the quality of life. The secondary outcomes were functional capacity, cancer-related fatigue, depression and salivary cortisol. Data was collected at baseline and eight weeks after the exercise intervention. The effects of the intervention were analyzed using Repeated Measures Analysis of Covariance (ANCOVA) statistical test. **Result:** Thirty-six (36) colorectal cancer survivors were allocated into either a Pilates exercise intervention group (N= 18) or a control group (N= 18). Over eight weeks, the Pilates exercise group revealed significant group x time interactions in terms of quality of life ($p = 0.003$), role functioning ($p = 0.012$), functional capacity ($p = 0.048$), and stool frequency ($p = 0.021$). However, only the stool frequency symptom ($p = 0.008$) remained significant after controlling for the confounders of age, gender and stage of cancer. No significant changes in cancer-related fatigue, depression and salivary cortisol levels between the groups were observed after the intervention. **Conclusion:** Pilates exercise had positive impacts on role functioning, bowel function, and functional capacity among colorectal cancer survivors, ultimately contributing to an improvement in quality of life.

Keywords: 6-minute walk test- health-related quality of life- role functioning- bowel function

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Introduction

The quality of life (QOL) of colorectal cancer survivors (CRC) post-treatment when compared to that of the general public improves considerably to being either at par or even better [1]. However, recurring complaints, both physically and psychologically, which are related to cancer and its treatment, in the form of declining physical fitness, poorer functional status, tenacious fatigue, and depression can negatively affect the QOL of colorectal cancer survivors to the extent of up to ten years after diagnosis [2,3]. Systematic reviews and meta-analyses of randomized controlled trials (RCT) reported that home-based exercise intervention trials improved physical fitness and functioning; enhanced quality of life; and reduced mood, depression, and fatigue among colorectal cancer survivors [4,5].

Pilates, a comparative alternative exercise with low-impact flexibility, focuses on muscular strength and endurance movements developed by Joseph Pilates in the 1920s [6]. In a randomized control trial study, several Pilates steps were prescribed for colon cancer survivors

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showing significant improvements in isometric abdominal strength and functional capacity after the intervention [7].

A review revealed a substantial decline in the level of depression and reduction in salivary cortisol levels after eight weeks of yoga intervention among breast and prostate cancer patients [8]. These results are critical because reducing cortisol levels early on might lessen depression level and potentially enhance quality of life [9,10].

There are few experimental studies involving Pilates exercise and QOL on colorectal cancer survivors. Therefore, this quasi-experimental study aimed to study the effect of Pilates exercise on the quality of life, functional capacity, cancer-related fatigue, depression, salivary cortisol and quality of life of colorectal cancer survivors in Kuala Lumpur and Selangor, Malaysia.

Materials and Methods

Study design

This is a quasi-experimental study conducted among colorectal cancer survivors at tertiary hospitals in Malaysia. All the colorectal cancer survivors who were treated and completed treatment at Hospital Canselor Tuanku Muhriz (HCTM), Universiti Kebangsaan Malaysia (UKM), and Hospital Al-Sultan Abdullah (HASA), Universiti Teknologi MARA (UiTM), Malaysia and met the eligibility criteria were recruited using convenience sampling. Figure 1 shows the CONSORT diagram for the study.

Participants and Setting

Potential participants were screened at the surgical clinics and three hundred and four (n = 304) potential participants were identified through hospital records. However, two hundred and sixty-eight (n = 268) were excluded for various reasons, as shown in Figure 1. Then, the thirty-six interested participants (n = 36) were given an information sheet to read, and informed consent was obtained from the participants before the data collection started.

Prior to enrollment, the participants completed the Physical Activity Readiness Questionnaire (PAR-Q) and the ACSM Health/Fitness Facility Pre-Participation Screening Questionnaire to assess their ability to participate and safely increase their activity levels. The participants also were requested to answer the Global Physical Activity Questionnaire (GPAQ) to assess their physical activity level.

Participant Inclusion Criteria

The participants had to meet the following criteria: 1) Malaysian citizens or permanent residents aged 25 to 65 years old; 2) histologically confirmed diagnosis of colorectal cancer at Stages I, II, and III ; 3) had completed all the treatment within one year before the study ; 4) the time from diagnosis to study entry was one to 10 years.

Participant Exclusion Criteria

Participants were excluded from the study if they met the following criteria: 1) those who had developed metastasized and recurrent cancer; 2) diagnosed with colorectal cancer as a secondary cancer; 3) hereditary colorectal cancer syndrome(s); 4) known limitations in Activities of Daily Living (ADL); 5) diagnosed by specialists with musculoskeletal disorders, psychiatric illness and having chronic fatigue syndrome 6) history of neurological disorders, urological problem, abdominal hernia and autoimmune disease; 7) high-risk group screened using the PAR-Q and ACSM Health/Fitness Facility Pre-Participation Screening Questionnaire; and 8) intake of other complementary and alternative medicine.

Intervention Group

The intervention group performed Pilates exercises with a certified instructor in three 60-minute sessions per week for eight weeks via online streaming from the participants' homes. The Pilates exercise program was adapted from a study by Cantarero-Villanueva et al. (2016) [7]. An expert panel consisting of a sports medicine specialist, Pilates instructor, colorectal surgeon, and physiotherapist verified the program for its feasibility and safety. The tolerable heart rate in this study was set at only 55-65% of the maximum [11] and corresponded to a perceived exertion rating of between 12 and 13. The Pilates exercise session began with a warm-up, followed by the Pilates steps, and a cool-down period was used at the end of each session. The participants needed to attend all the exercise sessions and adherence was considered if they attended at least 75% of the sessions.

Control Group

During the study, the control group participants received the usual care as stipulated by their oncologists, which consisted of general recommendations for healthy lifestyle modifications.

Outcome Measures

Primary Outcomes

The primary outcomes were the quality of life, as reported by the participants and measured using the European Organization for Research and Treatment of Cancer (EORTC) QLQ-C30 and QLQ-CR29 tumour-specific questionnaire module for colorectal cancer. The QLQ-C30 consists of single-item measures and multiple-item scales composed of a global health status (GHS) scale, functional scales (FS), and symptom scales (SS). The GHS measures the overall health status and global QoL of colorectal cancer patients, ranging from very bad (0) to excellent (7). Meanwhile, the score for FS and SS is ranged from 0 (Not at all), 1 (A little), 2 (Quite a bit) and 4 (Very much).

The QLQ-CR29 consists of 29 questions that measure the functional scales and symptom scales associated with colorectal cancer. All scales in both questionnaires are converted into a linear transformation according to the algorithm recommended by the developer to provide a score between 0 and 100 [12]. High scores on a functional scale and global health status scale respectively indicate a high quality of life, and high scores on a symptom scale indicate a high degree of symptomatology or problems.

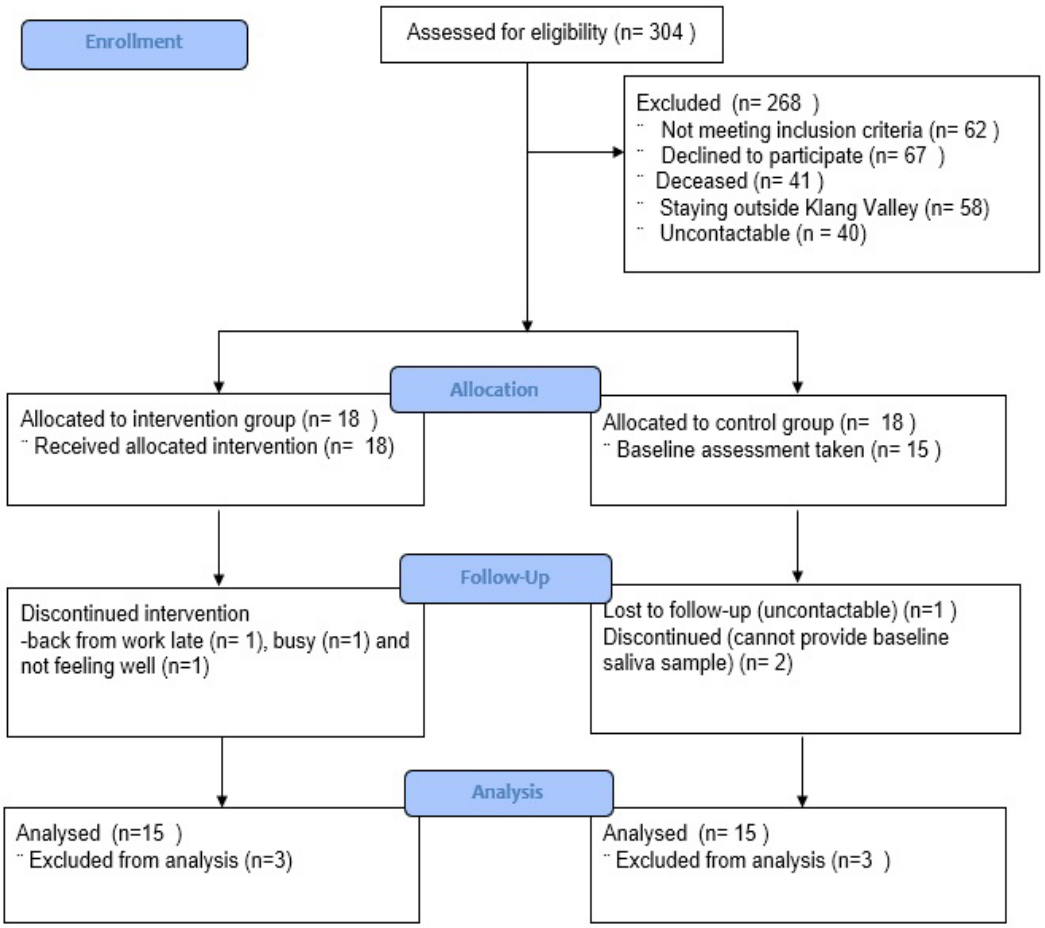

Figure 1. CONSORT Diagram

Secondary Outcomes

The cancer-related fatigue levels among the participants were measured using the Functional Assessment of Chronic Illness Therapy-Fatigue (FACIT-F). The FACIT-F is a valid and reliable 13-item fatigue subscale that utilizes a five-point Likert self-report scale measure of fatigue intensity for individuals during their usual daily activities over the past week. The total score ranges between 0 to 52 whereby the higher the score the lesser the fatigue experienced by the participants.

Depression was measured using the Patient Health Questionnaire-9 (PHQ-9). This is a nine-item self-scored multiple-choice questionnaire that measures the presence and degree of depression. The PHQ-9 instrument categorised the depression level as follows;0 - 4 (no depression), 5 – 9 (mild depression), 10 – 14 (moderate depression), 15 – 19 (moderately severe depression) and 20 – 27 (severe depression). The total score ranges between 0 to 27. A higher score indicates a higher level of depression.

Functional capacity was measured through a six-minute walk test. Participants were instructed to walk back and forth down a 20-meter hallway for six minutes at their fastest pace, covering as much distance as possible during the allocated time [13]. The total distance was calculated by summing up the distance (in meters) covered during the six minutes of walking. Longer distances indicate a better functional capacity.

In this study, the cortisol level was measured from the saliva collected for two consecutive days before and after the eight weeks of intervention. The saliva was collected using the passive drool protocol at awakening, 30-45 minutes thereafter and bedtime for two consecutive days at pre-and post-intervention. The cortisol concentrations were measured in µg/dL. The salivary cortisol was quantified using a commercial kit for human salivary cortisol using expanded range high sensitivity Enzyme-linked Immunoassay (ELISA) (Salimetrics LLC, State College, PA, USA). Three parameters of the salivary cortisol were measured to ascertain the effects of the exercise intervention on the salivary cortisol which are cortisol awakening response (CAR), diurnal cortisol slope (DCS) and total cortisol or area under the curve concerning ground (AUC_G) [14,15].

Statistical analysis

All data was analysed using the Statistical Package for Social Sciences software version 28.0. The significance level was set at $\alpha = 0.05$ and p-values were reported for two-sided. General linear model (GLM) repeated measures analysis of covariance (ANCOVA) model was used to compare the two groups on the changeover time (from baseline to follow-up) for each outcome measure adjusted for age, stage of cancer and gender as confounder

variables.

Ethical approval and trial registration

This study obtained approval from the Universiti Teknologi MARA Research Ethics Committee (REC 09/2020 (MR/288) and Medical Research Ethics Committee Hospital Canselor Tuanku Muhriz (HTM-2021-009). The study was registered under the Australian New Zealand Clinical Trials Registry (Registration No.: ACTRN12622000163707).

Results

A total of 304 Stage I, II, and III colorectal cancer survivors were assessed for eligibility, of whom 36 agreed to participate, giving a response rate of 11.96%. A total of 36 colorectal cancer survivors were allocated to either the intervention group (n = 18) or the control group (n = 18). However, after eight weeks of Pilates exercise intervention, only 30 had completed the study, giving a retention rate and mean adherence rate of 83.33% and 88.61+8.55% respectively.

Participants Characteristics

The demographic and medical data of the participants is summarized in Table 1. The mean age of the participants was 48.43 (± 9.42) years (ranging from 31 to 62). Most were female 18 (60%); 15 (50%) participants had stage III colorectal cancer with 20 (66.7%) colon cancer sites; and the mean time since diagnosis was 46.9 (± 28.82) months.

Table 1 also provides a comparison of the colorectal cancer survivors in the intervention and control groups in terms of their demographic characteristics and medical history. There was no statistically significant difference between the participant's characteristics ($p>0.05$) indicating that the groups were homogeneously distributed.

Quality of life and psychological outcomes

Table 2 presents the effects of a Pilates exercise intervention on the quality of life and psychological outcomes of colorectal cancer survivors. After eight weeks, two-way repeated measures analysis of variance, with global quality of life ($F = 11.004$, $p = 0.003$, $\eta p2 = 0.282$) and role functioning ($F = 7.221$, $p = 0.012$, $\eta p2 = 0.205$) subscales in EORTC QLQ-C30 and functional capacity ($F = 4.273$, $p = 0.048$, $\eta p2 = 0.132$) as the dependent variables, revealed significant group x time interactions. Although no significant interaction was observed for physical , emotional and social functioning there were score increments across the groups after the intervention. In addition, the symptom scales of EORTC-CR29 specific to colorectal cancer revealed a significant group x time interaction for stool frequency ($F = 5.954$, $p = 0.021$, $\eta 2 = 0.175$).

After adjusting for age, gender and stage of cancer, the two-way repeated measures ANCOVA shows no statistically significant group x time interactions for global quality of life ($F = 1.093$, $p = 0.423$, $\eta p2 = 0.435$), role functioning ($F = 1.894$, $p = 0.120$, $\eta p2 = 0.566$) and functional capacity ($F = 0.569$, $p = 0.838$, $\eta p2 = 0.287$). However, the stool frequency symptom remains statistically significant after adjustment ($F = 3.652$, $p = 0.008$, $\eta p2 = 0.721$). Additionally, there were symptoms of insomnia ($F = 2.538$, $p = 0.039$, $\eta p2 = 0.642$), blood and mucus in stool ($F = 4.262$, $p = 0.003$, $\eta p2 = 0.751$), loss of taste ($F = 2.572$, $p = 0.037$, $\eta p2 = 0.645$), having financial difficulties ($F = 2.557$, $p = 0.038$, $\eta p2 = 0.643$) and embarrassment ($F = 3.529$, $p = 0.009$, $\eta p2 = 0.714$) revealed statistically significant group x time interaction after adjusting for age, gender and stage of cancer. Meanwhile, cancer-related fatigue, depression score and salivary cortisol parameters remain not statistically significant group x time interaction ($p>0.05$) after adjustment for the confounders.

Discussion

Eight weeks of Pilates exercise effectively improved the health-related quality of life among stage I to stage III colorectal cancer survivors, including their global quality of life, role functioning, functional capacity, and stool frequency. However, it did not affect cancer-related fatigue, depression and salivary cortisol levels in this study.

Although the recruitment rate was low, there was an excellent retention rate (83.3%) of more than 80%, which would be acceptable and sufficient for generating reliable and valid results [16]. In this study, the mean adherence rate to the Pilates exercise intervention was 88.61%, which was good, based on a report by a meta-analysis study of a supervised and home-based exercise intervention among colorectal cancer survivors [17]. The authors verified that >80% adherence to the supervised and home-based exercise intervention effectively improved the functional capacity and quality of life of colorectal cancer survivors.

In the current study, Pilates exercise significantly improved the global quality of life between the groups after the intervention. This finding was similar to that of a randomized control trial study that reported a significant improvement in cancer-specific quality of life after a high-dose aerobic exercise intervention among low-dose and high-dose groups of early-stage colon cancer survivors [18]. Nevertheless, insignificant improvements in quality of life in the home-based exercise intervention group compared to the control group were noted in other randomized control trials among colorectal cancer survivors [19,20].

The current findings might contrast with those from previous trials because the younger colorectal cancer survivors in this study (mean age = 48.43 (9.42)) may have been particularly inclined to address a diminishing QOL and more motivated to participate in healthy lifestyle modifications [1]. The participants in our intervention group were motivated to engage in the Pilates exercise intervention as they were provided with a pre-recorded Pilates exercise session video and live streaming from home with a certified instructor, which may have maximized their attendance and adherence rate.

The significant finding related to role functioning in this study follows other observational studies [21,22] , which have shown that physically active colorectal cancer

Table 1. Comparison of the Participants' Characteristics in the Intervention and Control Groups (n=30).

	Intervention group (15)		Control group (n=15)		p-value
Variables	Mean ± SD	n (%)	Mean ±SD	n (%)	
Age	46.93±10.63		49.93± 8.14		0.393[a]
Gender					>0.999[b]
Male		6 (40.0)		6 (40.0)	
Female		9 (60.0)		9 (60.0)	
Weight (kg)	78.75±19.69			78.17±13.52	0.925[a]
Height (cm)	163.27±9.32			159.47±9.75	0.285[a]
Smoking status					0.397 [b]
Non-smoker		14 (93.3)		11 (73.3)	
Ex-smoker		1 (6.7)		2 (13.3)	
Active smoker		0 (0)		2 (13.3)	
Alcohol consumption					
No		15 (0.0)		14 (93.3)	>0.999[b]
Yes (once/month)		0 (0.0)		1 (6.7)	
Hypertension					>0.999[b]
Yes		5 (33.3)		4 (26.7)	
No		10 (66.7)		11 (73.3)	
Diabetic					>0.999[b]
Yes		2 (13.3)		2 (13.3)	
No		13(86.7)		13 (86.7)	
Stage of cancer					>0.999[b]
Stage I		2 (13.3)		2 (13.3)	
Stage II		5 (33.3)		6 (40.0)	
Stage III		8 (53.3)		7 (46.7)	
Treatment					0.245[b]
Radical		7 (46.7)		3 (20.0)	
Adjuvant		8(53.3)		12 (80.0)	
Site of cancer					0.249[b]
Colon		8 (53.3)		12 (80.0)	
Rectum		5 (33.3)		1 (6.7)	
Rectosigmoid		2 (13.3)		2 (13.3)	
Radiotherapy					0.700[b]
Yes		6 (40.0)		4 (26.7)	
No		9 (60.0)		11 (73.3)	
Chemotherapy					>0.999[b]
Yes		12 (80.0)		11 (73.3)	
No		3 (20.0)		4 (26.7)	
Duration of diagnosis (months)	50.93±34.78		42.87±21.82		0.453[a]
Physical activity level					>0.999[b]
Low		7 (46.7)		7 (46.7)	
Moderate		4 (26.7)		3 (20.0)	
High		4 (26.7)		5 (33.3)	

[a], independent sample t-test; [b], chi-square test.

survivors had better role functioning than physically inactive groups. However, this finding contrasted with another study [23] that reported how role functioning scores increased - but not statistically significant - after a home-based aerobic and resistance training intervention. The Pilates exercise steps used in this study promote core muscle endurance, which is crucial for the successful performance of everyday activities and the continuation of a healthy life, which may have had a positive impact on role functioning [24].

Evidently, there is a lack of studies involving how online Pilates exercise intervention affects the cancer-

Table 2. Quality of Life and Psychological Outcomes at Baseline and 8 Weeks (n = 30).

Variables	Intervention group (mean±SD)		Control group (mean±SD)		Unadjusted*	Adjusted**
	Baseline	After 8 weeks	Baseline	After 8 weeks	(p-value)	(p-value)
1) Quality of Life (EORTC QLQ-30						
Global health status	68.89±20.04	80.56±13.97	77.78±18.28	73.33±18.69	0.003a	0.423
Physical functioning	86.67±13.57	89.33±11.76	88.44±13.44	91.56±13.21	0.898	0.074
Role functioning	87.78±19.38	96.67±9.34	95.56±11.73	88.89±15.00	0.012a	0.12
Emotional functioning	73.33±20.70	81.67±15.17	76.67±18.42	77.22±19.02	0.153	0.752
Cognitive functioning	78.89±23.96	83.33±18.90	80.00±23.74	81.11±19.79	0.632	0.085
Social functioning	82.22±20.38	86.67±20.12	83.33±30.21	78.89±31.79	0.231	0.067
Fatigue	24.44±18.87	22.96±15.97	25.18±21.6	28.14±24.07	0.334	0.307
Nausea and vomiting	4.44±17.21	3.33±6.90	4.44±11.73	2.22±5.86	0.858	0.588
Pain	18.89±17.67	11.11±13.61	15.56±19.38	17.78±20.38	0.071	0.147
Dyspnoea	13.33±21.08	4.44±11.73	4.44±11.73	6.67±13.80	0.096	0.774
Insomnia	26.67±31.37	33.33±25.20	40.0±25.82	28.89±21.33	0.109	0.039a
Appetite loss	20.0±24.56	6.67±18.69	15.56±17.21	11.11±16.26	0.165	0.866
Constipation	24.44±34.43	6.67±13.80	26.67±28.73	22.22±29.99	0.176	0.349
Diarrhoea	35.56±44.48	15.56±27.80	17.78±24.77	22.22±24.13	0.06	0.691
Financial difficulties	31.11±29.46	22.22±29.47	22.22±29.99	22.22±29.99	0.207	0.038a
2) Cancer-specific quality of life EORTC QLQ-CR29						
Urinary frequency	30.0±26.87	24.44±33.85	34.44±31.16	36.67±30.34	0.409	0.207
Urinary incontinence	15.56±21.33	13.33±21.08	6.67±13.80	13.33±16.90	0.165	0.272
Dysuria	0.0±0.0	2.22±8.61	2.22±8.61	2.22±8.61	0.577	0.143
Abdominal pain	13.33±21.08	15.56±21.33	22.22±20.57	26.67±25.82	0.815	0.445
Buttock pain	8.89±19.79	11.11±20.57	6.67±13.80	15.56±17.21	0.443	0.942
Bloating	22.22±32.5	13.33±16.90	24.44±29.46	31.11±29.46	0.154	0.516
Blood and mucus in stool	3.33±6.90	2.22±5.87	6.67±15.17	4.44±7.63	0.815	0.003a
Dry mouth	8.89±19.79	11.11±16.27	13.33±16.90	17.78±24.77	0.77	0.487
Hair loss	2.22±8.61	0.0±0.0	2.22±8.60	4.44±11.73	0.168	0.694
Taste	17.78±33.01	0.0±0.0	11.11±20.57	11.11±27.22	0.153	0.037a
Flatulence	33.33±30.86	33.33±30.86	24.44±23.46	26.67±18.69	0.749	0.656
Faecal incontinence	15.56±27.79	13.33±21.08	4.44±11.73	6.67±13.80	0.334	0.053
Sore skin	13.33±21.08	15.56±27.79	13.33±21.08	13.33±16.90	0.804	0.962

*Repeated measures ANOVA, ** Repeated measures ANCOVA (adjusted for age, gender and stage of cancer variables); a, group x time interaction; significant at p<0.05

Table 2. Continued

Variables	Intervention group (mean±SD)		Control group (mean±SD)		Unadjusted*	Adjusted**
	Baseline	After 8 weeks	Baseline	After 8 weeks	(p-value)	(p-value)
2) Cancer-specific quality of life EORTC QLQ-CR29						
Stool frequency	37.78±33.61	23.33±24.23	24.44±23.46	27.78±26.48	0.021a	0.008a
Embarrassment	15.56±27.79	11.11±20.57	13.33±21.08	11.11±27.21	0.77	0.009a
Anxiety	57.78±40.76	44.44±32.53	53.33±32.85	51.11±35.34	0.338	0.262
Weight	60.0±38.21	48.89±30.52	40.0±38.21	55.56±37.09	0.06	0.625
Body image	76.29±25.84	66.67±26.56	71.85±28.75	72.59±30.24	0.257	0.325
3) Cancer-related fatigue (FACIT-F)	43.33±9.45	45.2±3.53	45.13±6.47	44.0±9.69	0.305	0.658
4) Depression (PHQ-9)	3.6±4.26	3.0±4.86	3.27±2.89	3.53±4.52	0.49	0.658
5) Functional capacity (6-minutes walk test)(metres)	326.41±37.28	350.07±30.42	304.14±67.31	301.97±55.71	0.048a	0.838
7) Cortisol awakening response (CAR)	0.1720±0.0899	0.1949±0.090	0.2136±0.1727	0.1973±0.1078	0.476	0.393
8) Diurnal cortisol slope (DCS)	0.0148±0.0064	0.0147±0.089	0.0120±0.0088	0.0138±0.0083	0.847	0.192
9) Area under the curve (ground) (AUCG)	4.1128±1.4696	4.444±3.359	4.3099±2.5910	4.9407±3.8161	0.83	0.988

*Repeated measures ANOVA, ** Repeated measures ANCOVA (adjusted for age, gender and stage of cancer variables); a, group x time interaction; significant at p<0.05

specific quality of life among colorectal cancer survivors for comparison. However, the effect of online Pilates exercise which was further explored among breast cancer survivors reported a significant improvement of quality of life, advanced performance in the 6-minute walk test and fatigue score after 8 weeks [22].

The insignificant findings concerning cancer-related fatigue and depression between the groups after Pilates exercise in this study were similar to those of other studies [21,22]. One explanation for this outcome could be that neither the intervention nor control groups had severe fatigue at baseline and were non-depressed, as evidenced by the fact that their respective mean values for fatigue and depression severity were not clinically significant [21].

In this study, functional capacity, which determines an individual's ability to perform essential, frequent everyday activities, improved significantly after eight weeks of the Pilates exercise intervention, compared to the usual care group. These findings align with results indicating that Pilates exercise steps can be used for muscle stabilization, which consequently improved the quality of life of colorectal cancer survivors [7].

Among colorectal cancer survivors, poor bowel function has been linked to a lower quality of life. Frequent stools, as a measure of poor bowel function, were associated with a low quality of life [18]. This finding was further highlighted in our study, which showed that the Pilates exercise lessened the stool frequency and consequently improved bowel activity in the intervention group, compared to the usual care group. Although the exact mechanism by which exercise reduced stool frequency was unclear, it is known to improve digestion and abdominal flexibility [25].

Nevertheless, a significant improvement over time after Pilates exercise revealed that constipation symptoms decreased over time after physical activity in the intervention group [26] in contrast to other study [27]. The mechanism underpinning the link between exercise and reduced constipation symptoms could be due to increased peristaltic activity and a shorter colon transit time [26].

The insignificant findings for diurnal cortisol slope and cortisol awakening response in this study after the Pilates exercise could be attributed to the non-depressed sample [28-30]. Meanwhile, even though the AUCG findings were not significant the reduction level in the Pilates intervention group was considered encouraging given earlier research showing poor survival outcomes for cancer survivors which were associated with increased cortisol levels [29]. This is further corroborated in a randomized control trial, practising traditional Iyengar yoga may either primarily modify the stress response, which lowers cortisol secretion and improves diurnal slope then subsequently improves fatigue and emotional well-being [8, 31].

After controlling the confounders for age, gender and stage of cancer, our findings revealed that only stool frequency symptoms were statistically significant for the group x time interaction. However, the other outcomes that were not statistically significant such as global quality of life, role functioning and functional capacity obtained a high effect size with a low power of study.

Therefore, future studies with a larger sample size are recommended to ascertain the effect of Pilates exercise on these outcomes.

Although the majority of the outcomes included in this study revealed no significant difference after the intervention compared to the control group, an improvement of approximately one-half of a standard deviation (d = 0.5) is considered a minimally clinically important difference for patient-reported quality of life measures [32]. Therefore, the degree of quality of life improvement seen in this study is consistent with a clinically substantial effect.

The findings from this study should be acknowledged with caution due to its limitations. Owing to limited resources and time constraints, the best study design used in this research was the quasi-experimental study. Therefore, the non-randomization in this study limits the study's ability to conclude a causal association between an intervention and an outcome due to a variety of extraneous and confounding variables that exist in a social environment.

Besides that, our study only looked at how eight weeks of Pilates exercise impacted the quality of life, so it is unknown whether exercise regimens that did not significantly enhance quality of life after eight weeks would do so after longer periods (such as 24 or 48 weeks). Next, the fact that the patients in the control group started exercising could have tainted the results. The lack of available information impeded our ability to assess the impacts of contamination on the consequences. Then, ceiling effects probably made it impossible for us to find the effect of the Pilates exercise on other outcomes in the intervention group compared to the control group because of the research participants' comparatively high functioning.

Meanwhile, the insignificant cortisol effect after Pilates intervention could be attributed to the methodology in saliva collection. According to Segerstrom et al. (2014) [33], the saliva must be collected for 4-8 days necessary to reliably assess AUCG, and 10 days for cortisol diurnal slope. However, for budgetary reasons, this study only managed to collect saliva for two consecutive days at awakening, 30 to 45 minutes afterwards and before bedtime.

Furthermore, the participant recruitment challenges were crucial as the study was conducted during the peak of the COVID-19 pandemic in 2020. Most potential participants, when contacted, were reluctant to participate because of fear of COVID-19 infection during the baseline assessment. Future trials to determine the effect of Pilates exercise on quality of life, functional capacity, depression, and cancer-related fatigue should consider enrolling a large number of colorectal cancer survivors as participants as well as introducing a longer duration of study and a period of extension for follow-up.

In conclusion, the findings of this study highlight the beneficial effects of Pilates exercises on the role functioning, bowel function, and functional capacity among colorectal cancer survivors, ultimately improving the quality of life. Therefore, we propose that Pilates exercise steps could be included as an alternative exercise package to be implemented in clinical practice to enhance quality of life among colorectal cancer survivors.

Author Contribution Statement

ZIA, ZI and ZA conceptualized the study. SA, NJ, NR and CH collected the data. NJ and ZIA analyzed the data. NJ and ZIA prepared the first manuscript and all author reviewed, revised and approved the final draft.

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Ethical Declaration

This study obtained approval from the Universiti Teknologi MARA Research Ethics Committee (REC 09/2020 (MR/288) and Medical Research Ethics Committee Hospital Canselor Tuanku Muhriz (HTM- 2021-009).

Data Availability

Data not available for sharing as it requires ethical approval.

Study Registration

The study was registered under the Australian New Zealand Clinical Trials Registry (Registration No.: ACTRN12622000163707).

Conflict of Interest

The authors declare no conflict of interest.

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