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Research Article

Associations Between Physical Activity and Quality of Life in a Population-Based Sample of Kidney Cancer Survivors

Linda Trinh[1], Ronald C. Plotnikoff[1,2,5], Ryan E. Rhodes[4], Scott North[3], and Kerry S. Courneya[1]

Abstract

Background: Physical activity (PA) improves quality of life (QoL) in several cancer survivor groups, but no study to date has focused on kidney cancer survivors (KCS). The purpose of this study was to estimate the prevalence of PA in KCS and determine any associations with QoL.

Methods: All 1,985 KCS diagnosed between 1996 and 2010 identified through a Canadian provincial Registry were mailed a survey that consisted of the Godin Leisure Time Exercise Questionnaire and several Functional Assessment of Cancer Therapy QoL scales. Standard demographic and medical variables were also reported.

Results: Completed surveys were received from 703 (43%) of the 1,654 KCS that received the survey. Over half (56.3%) were completely sedentary (CS), 17.6% were insufficiently active, 11.9% were active within public health guidelines, and 14.1% exceeded public health guidelines. After adjustment for key demographic and medical covariates, analyses of covariance indicated a dose–response association between PA and most QoL outcomes from CS to within guidelines (WG) with no further improvements for exceeding guidelines. For the primary QoL outcome of patient-reported physical functioning, the overall difference between CS and WG was 8.6 points (95% CI: 4.2–12.9, $P < 0.001$) which exceeds the minimally important difference of 5.0 points for this scale. Few associations were moderated by demographic or medical variables.

Conclusion: Over half of KCS are CS; however, even some PA may be beneficial for QoL.

Impact: PA is a modifiable lifestyle factor that may have implications for QoL and disease outcomes in KCS.

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Introduction

Kidney cancer is the tenth most common cancer in Canada and the thirteenth leading cause of cancer death, with 4,800 new cases and 1,650 deaths in 2010 (1). In the United States, an estimated 58,240 new cases of kidney cancer are expected in 2010 (2). Renal cell carcinoma (RCC) is the most common type of kidney cancer accounting for 80% of all tumors (1). The prognosis for kidney cancer is fair, with a predicted 5-year survival rate of 67% for all stages. Despite increasing incidence rates, mortality rates due to kidney cancer have declined, and 5-year relative survival has improved (1). The increasing survival rate has placed greater emphasis on efforts to maintain quality of life (QoL) in kidney cancer survivors (KCS).

Surgery is the primary treatment for most kidney cancers and can result in significant treatment side effects that may impact QoL. The symptoms most evident among localized RCC patients include irritability, pain, fatigue, depression, anxiety, and sleep disturbance (3). These symptoms can affect the physical functioning, psychological functioning, social functioning, and role activities of KCS (3). Few interventions have focused on reducing symptoms and improving QoL in KCS.

A growing number of studies have indicated that physical activity (PA) may be useful for improving QoL in cancer survivors (4, 5). Recent systematic reviews in breast cancer survivors (6, 7), prostate cancer survivors (8), hematologic cancer survivors (9), mixed cancer survivors (10–12), advanced disease cancer survivors (13), and older adult cancer survivors (14) have indicated that PA may improve a variety of health outcomes including aerobic fitness, muscular strength, fatigue, depression, anxiety, self-esteem, functional ability, and overall QoL. No studies to date, however, have focused on KCS.

Here, we report what we believe to be the first study to examine PA in KCS. The primary objectives were to estimate the prevalence of PA in KCS and determine

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any associations with QoL. We hypothesized that the majority of KCS would not be meeting PA guidelines and that there would be a dose–response association between PA and QoL. A secondary objective was to explore if any medical or demographic variables moderated the association between PA and QoL.

Materials and Methods

Study population

Ethical approval for this study was granted by the Alberta Cancer Board Research Ethics Board and the University of Alberta Health Research Ethics Board. Eligibility for the study included (a) 18 years or older, (b) ability to understand English, (c) currently residing in Alberta, and (d) diagnosed with kidney cancer in Alberta between 1996 and 2010. There were 1,985 KCS from the Alberta Cancer Registry who met our eligibility and all were approached to participate in the survey. The study used a cross-sectional design with a mailed, self-administered survey.

The survey was conducted by the Alberta Cancer Registry on behalf of the researchers between May and September 2010. Eligible survivors were mailed a study package containing (a) an invitation letter from the Registry explaining the role of the Registry in this study and the general purpose of the Registry, (b) a letter from the researchers explaining the nature of the study, (c) the survey booklet, and (d) a postage paid return envelope. Participants were asked to return the completed survey. Participants not wishing to participate were informed that they could return the survey blank to avoid further contacts. The survey protocol followed a modified version of the Total Design Method (15) wherein prospective participants were mailed (a) the initial survey package, (b) a postcard reminder 3–4 weeks later to those who did not respond, and (c) a second survey package 3–4 weeks later to those who had not responded to the initial survey and reminder. The modification to the Total Design Method was that we did not include a follow-up telephone call to the nonresponders because our ethics board deemed it to be too intrusive.

Measures

Demographic and medical information. Demographic variables were assessed by using self-report and included age, sex, education level, marital status, annual income, employment status, ethnicity, and height and weight to compute body mass index (BMI). Medical variables were also assessed by using self-report and included time since diagnosis, type of kidney cancer, lymph node involvement, disease stage, previous and current treatments, previous recurrence, and current disease status. Smoking and drinking status were assessed by single-items that asked participants to check one of several options as follows: smoking status—never smoke, exsmoker, occasional smoker, regular smoker; drinking status—never drink, social drinker, regular drinker (drink every day; ref. 16). Comorbidities were assessed by asking participants to check all of the conditions listed that apply to them. The list included the most commonly reported conditions such as high blood pressure, heart attack, emphysema, diabetes, angina, high cholesterol, stroke, chronic bronchitis, other cancer, arthritis, and an open-ended question that asked if they had any other long term health condition.

PA. A modified version of the validated Leisure Score Index from the Godin Leisure-Time Exercise Questionnaire (17, 18) was used to assess PA behavior. Participants were asked to recall their average weekly frequency and duration of light (minimal effort, no perspiration), moderate (not exhausting, light perspiration), and vigorous (heart beats rapidly, sweating) PA that lasted at least 10 minutes and was done during free time in the past month. We calculated the percentage of participants meeting the public health PA guidelines established by the 2008 Physical Activity Guidelines for Americans (19) which have also been recommended for cancer survivors by the American Cancer Society (20) and the American College of Sports Medicine (21). These guidelines suggest that individuals should obtain 75 minutes of vigorous PA per week, 150 minutes of moderate PA per week, or an equivalent combination. Therefore, we calculated "PA minutes" as moderate minutes plus 2 times the vigorous minutes. These PA minutes were then transformed into the following 4 categories based on the guidelines: (a) completely sedentary (CS; no PA minutes), (b) insufficiently active (IA; 1–149 PA minutes), (c) within guidelines (WG; 150–299 PA minutes), and (d) above guidelines (AG; $\geq$300 PA minutes).

QoL. QoL was assessed by the well-validated Functional Assessment of Cancer Therapy-Fatigue (FACT-F) scale which includes the 27 items from the FACT-General (FACT-G) scale plus the 13 item fatigue subscale (22, 23). The FACT-G consists of physical well-being (PWB), functional well-being (FWB), emotional well-being (EWB), and social well-being (SWB). The PWB, FWB, and fatigue scale can be summed to form the Trial Outcome Index-Fatigue (TOI-F). We also included the validated FACT-Kidney Symptom Index-15 item (FKSI-15) which contains a combination of questions from the FACT-G subscales including PWB, FWB, and EWB, as well as questions that assess the most important targeted symptoms and concerns for KCS (24). On all scales, higher scores indicate better QoL.

Statistical analyses

The primary outcome in our study was the TOI-F. Our planned sample size of 700 provided ample power to detect differences in QoL among the PA categories of $d = 0.25$, which includes the minimally important differences for these QoL scales. Our primary analyses examined differences in QoL across the 4 PA categories by using analyses of covariance (ANCOVA) that adjusted for important demographic and medical variables determined a priori including age, sex, marital status,

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education level, BMI, months since diagnosis, number of comorbidities, drug therapy status, current treatment status, current disease status, previous recurrence, smoking status, and drinking status.

We explored several demographic and medical variables as potential moderators of the association between PA and the TOI-F (our primary outcome). Interactions were tested by using ANCOVAs adjusting for the same variables with potential moderators identified a priori as age (<60 vs. 60–69 vs. ≥70 years), sex, marital status (married vs. not married), education level (some/completed high school vs. some/completed university), BMI (healthy weight vs. overweight vs. obese), number of comorbidities (<3 comorbidities vs. ≥3 comorbidities), months since diagnosis (<60 months vs. ≥60 months), disease stage (localized vs. metastasized), type of surgery (partial nephrectomy vs. radical nephrectomy), type of incision (laparoscopic vs. open cut), drug therapy treatment (yes vs. no), current treatment status (not receiving treatment vs. receiving treatment), and current disease status (disease free vs. existing disease). Pearson correlations were carried out to test for a linear dose–response association between the PA categories and QoL.

Results

Figure 1 reports the participant flow through the study. Briefly, of the 1,985 mailed surveys, 331 were returned to sender for the following reasons: wrong address ($n = 317$), no history of kidney cancer ($n = 8$), and deceased ($n = 6$). Of the remaining 1,654 surveys, 793 did not respond, 100 were returned blank (indicating no interest), 49 contacted us to decline participation, 5 were returned incomplete, 4 were returned completed after the deadline, and 703 were returned completed, resulting in a 35% completion rate (703/1,985) and a 43% response rate (703/1,654) excluding the return to sender surveys.

To assess the representativeness of our sample, we compared responders ($n = 703$) and nonresponders ($n = 1,282$) on the limited available demographic and medical variables from the Registry. Responders and nonresponders did not differ in terms of mean age (66.2 years vs. 67.2 years; $P = 0.072$), sex (61.9% men vs. 61.8% men; $P = 0.961$), or surgery rate (93.6% vs. 92.7%; $P = 0.437$). Responders were about 1 year closer to their date of diagnosis compared with nonresponders (mean = 72 months vs. 84 months; $P < 0.001$) and had a slightly higher rate of treatment with systemic therapy (5.8% vs. 3.0%; $P = 0.003$). Moreover, there was a difference in kidney cancer morphology ($P < 0.001$) with responders having a lower rate of RCC (36.4% vs. 48.5%), a higher rate of clear cell carcinoma (46.1% vs. 35.9%), but no difference in the rate of papillary carcinoma (8.0% vs. 8.0%).

To assess the validity of our self-report data, we compared our self-report data to the Registry data on the

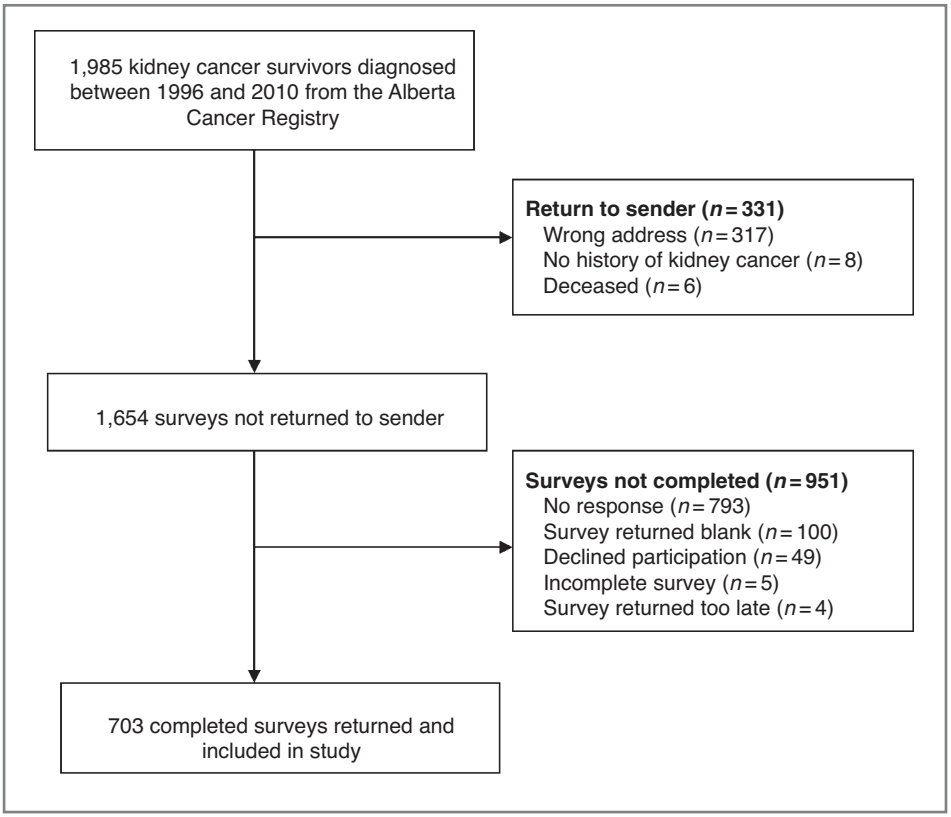

Figure 1. Flow of participants through the study.

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Table 1. Demographic and medical characteristics of KCS in Alberta, Canada, May 2010 ($N = 703$)

Variable	*n* (%)
Age (Mean ± SD = 65.0 ± 11.1)	
<60	251 (35.7)
60–69	213 (30.3)
≥70	239 (34.0)
Sex	
Male	442 (62.9)
Female	261 (37.1)
Marital status	
Married/common law	518 (73.6)
Not married	185 (26.3)
Education	
Some high school	162 (23.0)
Completed high school	158 (22.5)
Some university/college	99 (14.1)
Completed university/college	194 (27.6)
Some/completed graduate school	90 (12.8)
Annual family income	
<$20 000	73 (10.4)
$20 000–$59 999	223 (31.7)
$60 000-$99 999	164 (23.3)
>$100 000	128 (18.2)
Missing data	115 (16.4)
Employment status	
Employed full/part time	267 (38.0)
Retired	356 (50.6)
Other	80 (11.4)
Ethnicity	
White	640 (91.0)
Other	63 (9.0)
BMI (Mean ± SD = 28.5 ± 5.2)	
Healthy weight	174 (24.8)
Overweight	307 (43.7)
Obese	222 (31.6)
Number of comorbidities	
None	66 (9.4)
1	130 (18.5)
2	161 (22.9)
≥3	346 (49.2)
[a]Most common comorbidities	
High blood pressure	415 (59.0)
Arthritis	328 (46.7)
High cholesterol	294 (41.8)
Other cancer	183 (26.0)
Not specified	101 (55.2)
Prostate	25 (33.8)
Skin	11 (15.1)
Breast	10 (13.7)
Diabetes	129 (18.3)
Angina	80 (11.4)
Heart attack	72 (10.2)

Table 1. Demographic and medical characteristics of KCS in Alberta, Canada, May 2010 (N = 703) (Cont'd)

Variable	*n* (%)
Smoking status	
Never smoked	287 (40.8)
Exsmoker	321 (45.7)
Regular/occasional smoker	95 (13.5)
Drinking status	
Never drink	229 (32.6)
Social drinker	438 (62.3)
Regular drinker	36 (5.1)
General health rating	
Excellent	38 (5.4)
Very good	178 (25.3)
Good	300 (42.7)
Fair	159 (22.6)
Poor	28 (4.0)

[a]Could check more than one response.

limited variables available in the Registry. We found that self-reported age was highly correlated with Registry age ($r = 0.98$, $P < 0.001$) and self-reported sex was highly concordant with Registry sex (99% concordance; $P < 0.001$). Moreover, self-reported months since diagnosis was highly correlated with Registry recorded months since diagnosis ($r = 0.79$, $P < 0.001$). Unfortunately, treatment data are not required to be recorded in the Registry and it is often recorded in a less rigorous fashion. The typical "error" is that treatments are underreported to the Registry and this was found in our data. For example, for KCS who self-reported no systemic therapy ($n = 611$), 99.8% had no systemic therapy recorded in the Registry. Conversely, for KCS who self-reported yes to systemic therapy ($n = 92$), only 43.5% had yes recorded in the Registry (i.e., likely underreporting to the Registry). Consequently, given the accuracy of the self-report demographic data, and the limitations of the Registry medical data, we elected to use the self-report data for all demographic and medical variables.

Sample characteristics

The self-reported demographic, medical, and cancer characteristics of participants are displayed in Tables 1 and 2 respectively. Briefly, the mean age was 65.0 ± 11.1, 62.9% were male, 73.6% were married, 38.0% were employed full/part time, and 27.6% completed university/college. The mean BMI was 28.5 ± 5.2, with 43.7% being overweight and another 31.6% being obese. The mean number of months since diagnosis was 69.0 ± 55.5, with 86.8% disease free, 97.3% having received surgery, and 81.8% having localized kidney cancer.

Descriptive statistics for PA and QoL variables are displayed in Table 3. The mean number of PA minutes

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Table 2. Cancer and treatment characteristics of KCS in Alberta, Canada, May 2010 ($N = 703$)

Variable	*n* (%)
Months since diagnosis	
(Mean ± SD = 69.0 ± 55.5)	
<24	145 (20.6)
24–59	199 (28.3)
≥60	359 (51.1)
Type of kidney cancer	
Papillary	140 (19.9)
Nonpapillary	246 (35.0)
Do not know	317 (45.1)
Lymph nodes involved	
Yes	37 (5.3)
No	517 (73.5)
Do not know	149 (21.2)
Disease stage	
Localized	574 (81.7)
Metastatic	88 (12.5)
Do not know	41 (5.8)
Location of metastases ($N = 88$)	
Lung	47 (53.4)
Lymph	18 (20.5)
Liver	15 (17.0)
Other	28 (31.8)
Surgery treatment	
Yes	684 (97.3)
No	19 (2.7)
Type of surgery ($N = 684$)	
Partial nephrectomy	124 (18.1)
Radical nephrectomy	535 (78.2)
Do not know	25 (3.7)
Type of incision ($N = 684$)	
Laparoscopic	206 (30.1)
Open incision	459 (67.1)
Do not know	19 (2.8)
Radiation treatment	
Yes	27 (3.8)
No	676 (96.2)
Drug treatment	
Yes	92 (13.1)
No	611 (86.9)
[a]Type of drug treatment ($N = 92$)	
Sunitinib (Sutent)	53 (57.6)
Sorafenib (Nexavar)	18 (19.6)
Everolimus (Afinitor)	7 (7.6)
Interferon	7 (7.6)
Do not know	32 (34.8)
Current treatment status	
Completed treatment	642 (91.3)
Receiving treatment	61 (8.7)
Recurrence	
Yes	54 (7.7)
No	649 (92.3)
Current disease status	
Disease free	610 (86.8)
Existing disease	93 (13.2)

[a]could check more than 1 response.

was 135 ± 425 which consisted of 71 ± 231 moderate minutes and 32 ± 174 vigorous minutes. On the basis of the public health guideline categories, 396 (56.3%) KCS were CS, 124 (17.6%) were IA, 84 (11.9%) were WG, and 99 (14.1%) were AG. Overall, 183 (26.0%) were meeting public health PA guidelines.

Associations between PA and QoL

Differences in QoL across the PA categories are presented in Table 4. ANCOVAs indicated significant differences across the PA public health categories for PWB,

Table 3. Descriptive statistics for PA and QoL in KCS in Alberta, Canada, May 2010 ($N = 703$)

Variable	M ± SD or *n* (%)
Average weekly PA in the past month	
Light minutes	115 ± 265
Moderate minutes	71 ± 231
Vigorous minutes	32 ± 174
PA minutes[a]	135 ± 425
Public health PA categories	
CS	396 (56.3%)
IA	124 (17.6%)
WG	84 (11.9%)
AG	99 (14.1%)
Meeting guidelines[b]	183 (26.0%)
QoL	
PWB (0–28)	23.3 ± 4.9
FWB (0–28)	21.2 ± 5.7
EWB (0–24)	19.3 ± 4.4
SWB (0–24)	18.7 ± 5.4
Fatigue (0–52)	38.1 ± 11.3
Kidney symptom index (0–60)	46.7 ± 8.9
FACT-general (0–104)	82.6 ± 15.4
FACT-F (0–156)	120.6 ± 24.6
Trial outcome index-fatigue (0–108)	82.6 ± 19.6

[a]PA minutes are calculated as moderate minutes plus 2 times vigorous minutes.
[b]Combines WG and AG.

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Table 4. Differences in QoL across public health PA categories in KCS, Alberta, Canada, May 2010 ($N = 703$)

	CS; $n = 396$	IA; $n = 124$	WG; $n = 84$	AG; $n = 99$	*P*-difference	*P* for trend
PWB[a]	22.5 (5.4)	24.2 (4.3)	24.7 (4.1)	24.4 (4.0)	<0.001	
PWB[b]	22.7 (0.23)	23.9 (0.41)	24.3 (0.50)	24.3 (0.46)	= 0.001	<0.001
FWB[a]	20.1 (6.0)	22.1 (4.9)	23.1 (4.9)	23.1 (5.2)	<0.001	
FWB[b]	20.3 (0.28)	21.8 (0.49)	22.6 (0.60)	22.8 (0.55)	<0.001	<0.001
EWB[a]	19.1 (4.5)	19.2 (4.2)	20.5 (3.3)	19.4 (4.6)	0.083	
EWB[b]	19.1 (0.21)	19.2 (0.38)	20.4 (0.46)	19.5 (0.42)	0.102	=0.097
SWB[a]	18.3 (5.7)	18.7 (4.8)	19.4 (5.0)	19.7 (5.0)	0.073	
SWB[b]	18.2 (0.27)	18.8 (0.48)	19.4 (0.59)	19.7 (0.54)	0.059	=0.01
Fatigue[a]	35.7 (11.5)	39.4 (10.0)	42.4 (9.3)	42.0 (10.9)	<0.001	
Fatigue[b]	36.3 (0.54)	38.8 (0.94)	41.1 (1.16)	41.6 (1.06)	<0.001	<0.001
Kidney symptom index[a]	45.0 (9.1)	48.2 (7.8)	50.4 (7.5)	48.6 (9.1)	<0.001	
Kidney symptom index[b]	45.5 (0.41)	47.6 (0.72)	49.3 (0.88)	48.1 (0.80)	<0.001	<0.001
FACT-G[a]	80.0 (15.9)	84.1 (14.2)	87.6 (13.0)	86.6 (14.8)	<0.001	
FACT-G[b]	80.4 (0.74)	83.8 (1.29)	86.6 (1.59)	86.5 (1.45)	<0.001	<0.001
FACT-F[a]	115.7 (25.1)	123.5 (22.7)	129.9 (20.6)	128.7 (23.3)	<0.001	
FACT-F[b]	116.7 (1.16)	122.6 (2.04)	127.7 (2.51)	128.1 (2.29)	<0.001	<0.001
Trial outcome index-fatigue[a]	78.3 (20.2)	85.6 (17.5)	90.1 (15.7)	89.5 (17.7)	<0.001	
Trial outcome index-fatigue[b]	79.3 (0.91)	84.6 (1.60)	87.9 (1.97)	88.8 (1.80)	<0.001	<0.001

[a]Unadjusted mean (standard deviation).

[b]Adjusted mean (standard error) is adjusted for age, sex, martial status, education, BMI, months since diagnosis, drug treatment, current treatment status, recurrence, current disease status, smoking, drinking, and number of comorbidities.

FWB, fatigue, FKSI-15, FACT-G, FACT-F, and TOI-F. Significant linear trends were noted across the PA categories for PWB, FWB, fatigue, FKSI-15, FACT-G, FACT-F, and TOI-F. The general pattern for the QoL variables was a linear increase from CS to WG with no further increases for AG. In terms of the magnitude of the associations, the overall differences among the PA categories from CS to WG were 1.6 points for PWB (95% CI: 0.5–2.7; $d = 0.33$), 2.2 points for FWB (95% CI: 0.9–3.5; $d = 0.39$), 4.8 points for fatigue (95% CI: 2.2–7.3; $d = 0.42$), 3.8 points for the FKSI-15 (95% CI: 1.9–5.8; $d = 0.43$), 6.2 points for FACT-G (95% CI: 2.7–9.7; $d = 0.40$), 11.0 points for FACT-F (95% CI: 5.5–16.5; $d = 0.45$), and 8.6 points for TOI-F (95% CI: 4.2–12.9; $d = 0.44$; ref. Fig. 2A).

Moderators of the association between PA and QoL

Education moderated the association between public health PA guidelines and the TOI-F (*P* for interaction = 0.008; Fig. 2B). There was a strong dose-response relationship from CS to AG for participants who completed at least some college/university (12.8 points). Conversely, there was an "inverted U" association for those who had not completed at least some college/university with a sharp increase from CS to IA of 10.3 points and a decline from IA to AG of 6.6 points. Number of comorbidities also moderated the association between PA and the TOI-F (*P* for interaction = .017; Fig. 2C). There was a strong dose–response association from CS to AG for participants who had fewer than 3 comorbidities (8.9 points). Conversely, for participants with 3 or more comorbidities, there was a threshold association that consisted of a sharp increase from CS to IA of 11.8 points that leveled off for higher PA categories. Finally, age was a borderline significant moderator of the association between PA and the TOI-F (*P* for interaction = .067; Fig. 2D). There was a threshold association between IA and WG of 8.4 points for those of less than 60 years of age whereas there was an "inverted U" association for those between 60–69 years with a sharp increase of 11.5 points between CS and WG and a decline of 6.4 points when exceeding the guidelines. Finally, there was a threshold association between CS and IA of 11.6 points for those ages 70 years or more.

Discussion

Over half of KCS in our Alberta sample are CS and only a quarter are meeting the PA guidelines. This participation rate is lower than the 56.5% in the general adult Alberta population (25) but similar to other cancer survivor groups in Alberta (5, 26–30). No previous data exist on the prevalence of PA among KCS. Moreover, 43.7% of KCS are overweight and another 31.6% are obese. The low PA rate and high obesity rate in KCS may have implications for health and disease outcomes. Although no research has examined lifestyle and disease outcomes in KCS, research into kidney cancer risk factors has

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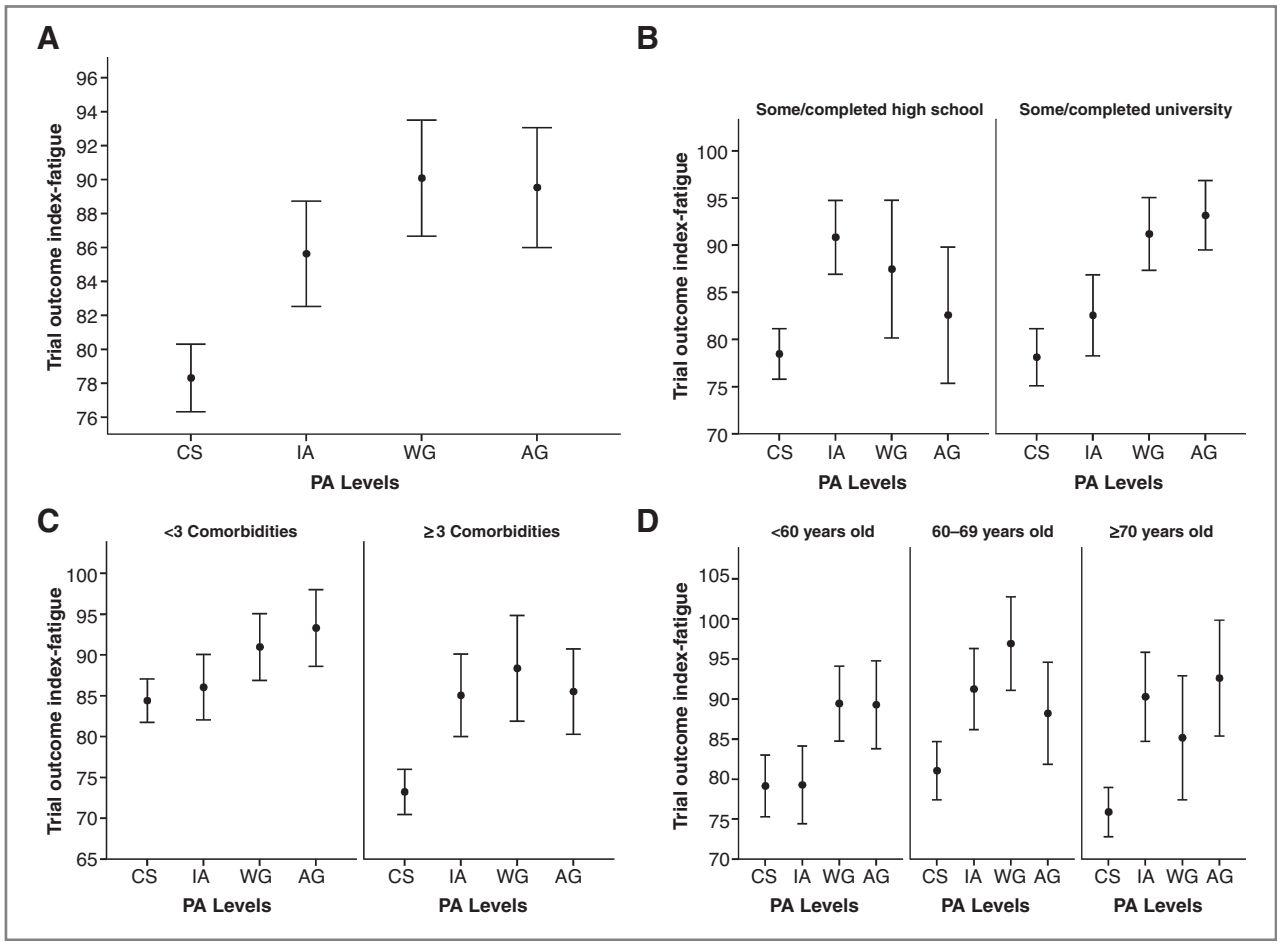

Figure 2. A, QoL of KCS across public health PA categories in Alberta, Canada, May 2010 ($N = 703$). B, interaction between education and public health PA categories on QoL in KCS in Alberta, Canada, May 2010 ($N = 703$). C, interaction between number of comorbidities and public health PA categories on QoL in KCS in Alberta, Canada, May, 2010 ($N = 703$). D, interaction between age and public health PA categories on QoL in KCS in Alberta, Canada, May 2010 ($N = 703$).

shown that lower PA and higher obesity are associated with an increased risk of kidney cancer incidence (31–37). It is possible that these same lifestyle factors are also implicated in disease recurrence, other chronic diseases, and early mortality in KCS as has been shown in breast (7) and colorectal cancer survivors (38–40). Nevertheless, even if PA is not related to disease outcomes in KCS, the present study provides compelling data that it is linked to QoL.

The main finding of our study was that there is a strong association between PA and QoL in KCS. The general pattern was a dose–response association from CS to WG with no further increases for exceeding guidelines. The associations seem to be meaningful based on guidelines for minimal important differences (MID) on the FACT scales (41). Specifically, the observed difference for the TOI-F in our study was 8.6 points which exceeds the MID of 5.0 points (42). Moreover, the observed difference on the FACT-F was 11.0 points which exceeds the MID of 7.0 points (42). For the FKSI-15, a difference of 3.8 points was observed which is within the range of the MID of 3.0 to 5.0 points for this scale (24). Finally, the difference in the fatigue subscale of 4.8 points exceeds the MID of 3.0 to 4.0 points (42).

There are no published studies that have examined PA and QoL in KCS with which to compare our results. Research in other cancer survivors groups has examined the association between PA guidelines and QoL with the general pattern of results showing better QoL in those cancer survivors meeting guidelines (5, 26–30, 43–45). Few of these studies, however, have examined more than the simple distinction between meeting versus not meeting guidelines.

Our study is one of the few to further divide PA into 4 categories based on public health guidelines. These additional categories were created because, although the recommended guidelines are for 150 "PA minutes" per week, the guidelines also note that some PA is better than none and that additional benefits can be achieved by exceeding the guidelines of 300 PA minutes (20, 21). Only

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a handful of studies have examined this issue in cancer survivors. Karvinen and colleagues (29) examined the association between 3 PA categories (CS, IA, and WG) and QoL in 525 bladder cancer survivors and found a similar dose–response association as reported in the present study. Similar findings were also shown in 200 endometrial cancer survivors (45). Similar to our study, Bélanger and colleagues (43) examined all 4 PA categories in young adult cancer survivors and found the same steep dose–response association from CS to WG with no further increases AG. Conversely, also by using all 4 PA categories, Stevinson and colleagues (5) reported a threshold association between IA and WG in 359 ovarian cancer survivors, suggesting that the association between PA and QoL may vary by cancer survivor group.

Data from our study also suggest that PA is most strongly associated with the physical and functional aspects of QoL, including fatigue, rather than the social and emotional dimensions. This finding is consistent with established evidence in other cancer survivors showing that PA has the most benefits for cancer survivors in the physical and functional domains of QoL, including fatigue (5, 30, 31, 42). Our study also found that the kidney symptom index was positively associated with PA. This suggests that even the symptoms most important to KCS such as irritability, pain, fatigue, worry, sleep disturbance, weakness, and shortness of breath (3) may also benefit from PA participation. Mechanisms through which PA may influence physical, functional, and symptom-related QoL in KCS include improved cardiorespiratory fitness, muscular strength, body composition, flexibility, balance, and reduced risk of other chronic diseases.

We found that only education, age, and comorbidities moderated the association between PA and our primary QoL outcome, the TOI-F. Specifically, among survivors who had some or completed college/university, there was a strong dose-response relationship with a 12.8 point difference observed from CS to AG. Conversely, those survivors who had only some or completed high school showed a sharp increase from CS to IA (10.3 points) with a decline from IA to AG (6.6 points). The explanation for this finding is unclear and may be because of chance given the large number of moderators tested. Nevertheless, one possibility is that KCS who have only completed high school may have occupations that require higher levels of PA (e.g., carpenters, farmers, labourers) resulting in benefits from some additional leisure-time PA but not from higher levels that may be unhelpful or even harmful to QoL. Conversely, KCS who have some/completed university may have more sedentary occupations for which successively higher levels of leisure-time PA may be beneficial. It is also possible that KCS who have lower literacy levels may have had difficulty completing the self-report measures. Nevertheless, Hahn and colleagues (46) developed a multimedia touchscreen program to assess QoL by using the FACT-G, and evaluated its use in low and high literacy among cancer patients. The researchers found that the touchscreen program was valid and useful for QoL assessment in lower literacy populations, and that most QoL items carried out similarly across literacy levels, indicating unbiased measurement.

Age was a borderline significant moderator of PA and QoL in a fairly complex manner. Nevertheless, the general pattern suggests that KCS under 60 years of age need to meet the PA guidelines to derive QoL benefit whereas for those KCS between 60 and 69 years, and over 70 years, doing some PA seems to be beneficial, with no clear association with additional PA. These data are consistent with findings showing that smaller amounts of PA may be beneficial for older adults compared with younger adults (19). The only medical variable to moderate the association between PA and TOI-F was the number of comorbidities. In general, those survivors who had fewer than 3 comorbidities showed a steady dose–response association between PA and TOI-F. For those survivors with 3 comorbidities or more, a sharp increase was observed from CS to IA of 11.8 points that declined slightly with higher PA categories. This finding suggests that engaging in some PA generates substantial improvements in the health status of KCS with established comorbidities. Additional moderators were examined but showed that the association between PA and QoL was not influenced by sex, marital status, BMI, months since diagnosis, disease stage, type of surgery, type of surgical incision, drug treatment, current treatment status, and current cancer status.

Overall, a valuable insight from our study was the improvement in QoL observed among KCS who reported some PA but less than meeting the public health PA guidelines. This is consistent with a previous study of 319 non-Hodgkin's lymphoma survivors (47). This finding has practical implications in the development of appropriate PA interventions in this population. Because more than half of KCS are CS, it is essential to develop appropriate messages that might play a role in the motivation of sedentary individuals to engage in some PA. PA does not necessarily need to be carried out at a high volume for survivors to derive benefit. Beginning a PA program at lower levels of frequency, intensity, and duration may be less daunting and more attainable for many KCS who are CS, and may still potentially improve QoL.

Our study needs to be interpreted within the context of important strengths and limitations. To the best of our knowledge, our study is the first to examine PA in KCS. Furthermore, we sampled all KCS diagnosed between 1996 and 2010 from a comprehensive Registry in Alberta, Canada. Our study is also one of the few studies to have examined a dose-response relationship between PA and QoL across 4 PA categories. One limitation of our study is the cross-sectional design which precludes any inferences about causality. Randomized controlled trials on the effects of PA on QoL and other health outcomes in KCS are needed. Moreover, our study also relied on a self-report measure of PA which, although validated, can

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introduce measurement error. Our study also used self-reported medical data which is not as reliable as data from medical records. Finally, our study achieved a modest response rate that resulted in a sample that was not entirely representative of Alberta KCS in terms of kidney cancer morphology, rate of systemic treatment, months since diagnosis, and likely other unmeasured variables (e.g., QoL and PA levels). Our response rate (43%) is lower compared with some U.S.-based PA studies in cancer survivors (48), however, many of these studies employ prescreening of patient eligibility based on health conditions to eliminate unlikely responders whereas our study approached all KCS without any prescreening.

In conclusion, our study presents the first data on PA in KCS. We found that over half of KCS are CS and only a quarter are meeting PA guidelines. Moreover, PA has a strong association with QoL including potential gains even for small amounts of PA. Future research should consider testing these dose-response findings in randomized controlled trials to determine the causal effects of PA on QoL and other health outcomes. Moreover, research into the determinants of PA in KCS is needed to inform strategies for promoting PA in this understudied cancer survivor group.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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