Association between Body Mass Index and Physical Function among Endometrial Cancer Survivors

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Abstract

Objectives
We sought to quantify the relationship between body mass index (BMI) and physical function among endometrial cancer survivors. Understanding this relationship would help healthcare providers target efforts to refer obese endometrial cancer survivors to weight loss and exercise interventions.

Methods
We conducted a survey of 213 endometrial cancer survivors who received cancer care at an academic health system between 2006 and 2010. Physical function subscale was quantified using physical functional component score from the SF-12 questionnaire. We compared physical function of endometrial cancer survivors to population-based age-standardized normative values.

Results
Among the 213 patients, 16% were normal weight (BMI < 25 kg/m²), and 52% were obese (≥30 kg/m²). Higher BMI categories were associated with lower physical function (P_trend = 0.003), as a continuous variable each 5kg/m² higher BMI, physical function score was lower by 0.15 points (β = -0.15; P = 0.045). Compared to population-based age-standardized normative values, patients <75yrs reported lower physical function, whereas patients ≥75yrs reported better physical function. BMI was the only covariate associated with differences in physical function between survivors and age-standardized normative values (P = 0.039).

Conclusions
Among endometrial cancer survivors, higher BMI is associated with lower physical function. Younger endometrial cancer survivors report lower physical function compared to age-standardized normative values. Healthcare providers should be aware that younger, obese
endometrial cancer survivors may particularly benefit from interventions such as exercise and weight loss to increase or preserve physical function.

Introduction

Endometrial cancer is the fourth most common gynecologic cancer among women in the United States [1], and often diagnosed at an early stage, with a five-year survival rate of 81.7% [2]. In 2015, there were over 600,000 endometrial cancer survivors in the United States [2]. As the length of survival after endometrial cancer continues to be extended, greater focus is being paid to the management of long-term health issues and preservation of quality of life [3]. Physical function is the ability to complete activities required for safe independent living. Quality of life may be compromised among individuals who are unable to independently complete essential activities of daily living [4]. Limitations in physical functioning predict clinical outcomes, including mortality and morbidity among the general population and cancer survivors [5–9].

Cancer and cancer treatment (surgery with or without adjuvant chemotherapy and/or radiation), may contribute to physical dysfunction, musculoskeletal weakness, pain, fatigue, and depression among endometrial cancer patients, which may restrict or impair activities of daily living [10]. The prevalence of obesity is high among women with endometrial cancer, such that >70% are overweight or obese (body mass index [BMI] ≥25 kg/m²). Multiple studies have shown that community-dwelling elderly with higher BMI, particularly those who are obese (BMI ≥30 kg/m²), report lower physical function and more functional impairments than those who are of a healthy weight (BMI <25 kg/m²)[11–13]. Therefore, obesity and treatment-related sequelae may collectively result in poorer physical function and lower quality of life among endometrial cancer survivors.

Studies have shown that cancer survivors often report more functional limitations and health issues than non-cancer populations [14,15]. However, these studies have not investigated differences between the general population and endometrial cancer survivors exclusively. The purpose of this study was to assess the cross-sectional relationship between BMI and physical function in a hospital-based cohort of endometrial cancer survivors, and the differences in physical function between endometrial cancer survivors and the general population. This information may assist healthcare providers to identify patients who may be prone to report poor physical function and who may benefit from lifestyle interventions to maintain and improve their long-term functioning and quality of life.

Materials and Methods

Participants and Procedures

We conducted a cross-sectional survey of patients with endometrial cancer who received care at the University of Pennsylvania in Philadelphia, Pennsylvania [16–19]. Participants included women ≥20 years old, with a history of endometrial cancer. Potential eligible participants were identified using fellow surgical case logs from 2006–2010, and ICD-9 diagnosis codes 179.0 and 182.0–182.8, from 2006–2010. ICD-9 codes 179.0 and 182.0–182.8 are the primary codes used to classify cancers of the uterus (95% of them are endometrial cancer). Participants who met the study inclusion criteria were sent a letter from their oncologist explaining the purpose of the study. Participants who did not wish to participate were provided the option to decline participation within two weeks of receiving the letter from their oncologist. Those who did not decline participation were sent the study survey. After two weeks, a second survey was sent to
those who did not reply to the first mailed survey. This protocol was approved by the University of Pennsylvania Institutional Review Board. Women who returned a completed survey were classified as having provided their informed consent.

Physical Function

The Medical Outcomes Study 12-Item Short-Form Health Survey (SF-12) was used to assess physical function. The SF-12 is a self-report measure that evaluates eight domains of health, including one domain specific to physical functioning [20]. The physical functioning domain of the SF-12 associated with objective measures of lower extremity physical function, including gait speed and chair stand time [8,21]. The physical function component score was summarized with higher scores representing better physical function [22].

Covariates

Information on covariates came from self-report or electronic medical records. Variables collected from self-report included age, weight, height, marital status, race, education, employment. Variables collected from the electronic medical record included histology of cancer, stage of cancer, time since diagnosis, cancer treatment history, weight and height at diagnosis and comorbidities (quantified using Charlson Comorbidity Index Score)[23]. BMI was calculated using weight and height (kg/m²). The correlation between self-reported BMI and objectively-measured BMI from medical record was 0.9775 (P<0.0001). But objective measures were only available on a subset sample. Therefore, we used self-reported BMI in the analysis. The Gynecologic Cancer Lymphedema Questionnaire (GCLQ) was used to assess symptoms associated with lower limb lymphedema (LLL)[16,17,24]. The GCLQ is a validated self-report measure that assesses seven domains of symptoms in both lower extremities. Participants reporting ≥ 5 symptoms of the lower extremities within the seven domains were classified as having LLL[16,17].

Statistical Analysis

Linear regression models estimated the relationship between BMI categories and physical function (physical function component score) with 95% confidence intervals (95% CI). The \( P \) value for the linear trend test across categories (\( P_{trend} \)) was calculated using the median value for each category as a continuous variable in the linear regression model. We examined unadjusted linear models, then adjusted for age, and subsequently built a multivariable linear model adjusting for demographic and clinical characteristics. We also adjusted LLL status (yes/no) in the multivariable linear model controlled for demographic and clinical characteristics, to assess if LLL modifies the relationship between BMI and physical function. We compared the difference in the physical function component score of our sample with U.S-population-based age-standardized normative values using the Wilcoxon rank-sum test [25]. The difference of the physical function component score was calculated using the difference in scores between participants in our sample and the age-standardized normative values of U.S general population. A dichotomized variable was generated with a 10-point lower physical function score compared to the population-based age-standardized normative values (Yes/No). A 10-point lower in physical function is clinically meaningful [3,26,27]. Multivariable linear regression model and logistic regression model were used to assess which factors associated with the difference in physical function component score and the significant lower physical function in endometrial cancer survivors. Statistical tests were two-sided, and \( P < 0.05 \) was the threshold for statistical significance.
Results

Participant Characteristics

Five hundred thirty-one participants were identified using the fellow surgical case logs and ICD-9 codes and 213 completed the mailed survey (43% response rate) [16–19]. Comparison of characteristics between women who completed the survey and who did not complete the survey showed no difference in age at diagnosis, BMI at diagnosis, and treatment modalities (S1 Table).

Demographic and clinical characteristics of the study participants are depicted in Table 1. The age of the 213 participants ranged from 29–94 years. Eighty-eight percent reported an age younger than 75 years. The majority of participants were white (83%), married or living with a partner (60%), college graduate or post-graduate degree (54%), and retired (45%). The majority of participants had endometrioid adenocarcinoma (62%) diagnosed with stage 1 disease (74%), treated with surgery (48%), were 3–4 years post diagnosis (44%), and with two or more comorbidities (61%). The BMI of study participants ranged from 14–67 kg/m²; 26% were normal weight (BMI < 25 kg/m²), 22% overweight (BMI: 25.0–29.9 kg/m²), 23% class I obese (BMI: 30 kg/m²–34.9 kg/m²), 14% class II obese (BMI: 35kg/m²–39.9kg/m²), and 15% morbidly obese (BMI ≥ 40.0kg/m²). The median of the physical function component score was 40.4 (Interquartile Range (IQR): 28.5–60.1).

Association between BMI Category and Physical Function

Higher BMI categories were associated with lower physical function in all statistical models (Fig 1; \( P_{trend} < 0.004 \)). In a multivariable-adjusted model that accounted for age, race, histology type, stage, treatment, time since diagnosis, and comorbidities, women in a higher BMI category had significantly lower physical function compared to women who were of normal weight (Table 2). When BMI was analyzed as a continuous variable, each 5-kg/m² increase in BMI, physical function score was lower by 0.15 points (\( \beta = -0.15; P = 0.045 \)). LLL did not modify the relationship between BMI and physical function (\( P_{interaction} = 0.251 \), data not shown).

Difference in Physical Function Component Score between Endometrial Cancer Survivors and the U.S. General Population

Compared with population-based age-standardized normative values, the physical function component score of endometrial cancer survivors was lower among patients <75 yrs (<45 yrs: 39.4 vs. 52.3; 45–54 yrs: 39.5 vs. 49.4; 55–64 yrs: 41.1 vs. 46.9; 65–74 yrs: 39.0 vs. 43.9, all comparisons \( P < 0.05 \)). However, among patients ≥75 years, physical function component score of our study was higher compared with the U.S general population (42.9 vs. 39.8, \( P = 0.039 \); Table 3). In the multivariable-adjusted linear regression, BMI was associated with differences in physical function component score between endometrial cancer survivors and the U.S general population. The physical function score was 6.8 and 6.6 lower among those with a BMI of 35–39.9kg/m² (\( P = 0.002 \)) and BMI ≥40kg/m² (\( P = 0.004 \)) compared with BMI<25kg/m² (Table 4). When BMI was analyzed as a continuous variable, higher BMI associated with lower physical function score (\( \beta = -0.27; P_{trend} = 0.001 \)). Among patients <75 yrs, compared to those with a BMI<25kg/m², the odds of a physical function score 10 points lower than the general population was 6.0 in those with a BMI of 35–39.9kg/m² (\( P = 0.007 \)) and 4.0 in those with a BMI ≥40kg/m² (\( P = 0.046 \)). When BMI was analyzed as a continuous variable, higher BMI was associated with an increased odds of a 10-point lower physical function score compared with the general population (OR = 1.06; \( P_{trend} = 0.018 \)). We also explored BMI in a
Table 1. Demographic and Clinical Characteristics.

| Variable                                      | Total Sample (n = 213) |
|-----------------------------------------------|------------------------|
| **Demographic Characteristics**               |                        |
| Age—yr                                        | 63.6±10.6              |
| Marital status—no. (%)                        |                        |
| Never married                                 | 20 (9%)                |
| Married                                       | 128 (60%)              |
| Divorced or separated                         | 31 (15%)               |
| Widowed                                       | 33 (16%)               |
| Race—no. (%)                                  |                        |
| White                                         | 177 (84%)              |
| Black                                         | 28 (13%)               |
| Other                                         | 7 (3%)                 |
| Education—no. (%)                             |                        |
| High school or less                           | 46 (22%)               |
| Some college                                  | 51 (24%)               |
| College degree or more                        | 114 (54%)              |
| Employment—no. (%)                            |                        |
| Retired                                       | 94 (45%)               |
| Unemployed                                    | 7 (3%)                 |
| Homemaker                                     | 16 (8%)                |
| Other                                         | 14 (7%)                |
| Full time                                     | 80 (38%)               |
| **Clinical Characteristics**                  |                        |
| Histology type—no. (%)                        |                        |
| Endometrioid Adenocarcinoma                   | 131 (62%)              |
| Papillary serous or Clear Cell or Mixed       | 61 (29%)               |
| Sarcoma                                       | 8 (4%)                 |
| Carcinosarcoma                                | 7 (3%)                 |
| Other (Undifferentiated)                      | 5 (2%)                 |
| Stage—no. (%)                                 |                        |
| 1                                             | 157 (74%)              |
| 2                                             | 13 (6%)                |
| 3                                             | 26 (12%)               |
| 4                                             | 8 (4%)                 |
| Unknown                                       | 9 (4%)                 |
| Treatment Modalities—no. (%)                  |                        |
| Surgery                                       | 101 (48%)              |
| Surgery, Chemotherapy                         | 18 (8%)                |
| Surgery, Radiation                            | 40 (19%)               |
| Surgery, Chemotherapy, Radiation              | 49 (23%)               |
| None or Unknown                               | 4 (2%)                 |
| Time since diagnosis—no. (%)                  |                        |
| 0–2 yrs                                       | 69 (32%)               |
| 3–4 yrs                                       | 94 (44%)               |
| 5–6 yrs                                       | 50 (23%)               |
| BMI—kg/m²                                     | 31.1±8.9               |
| Comorbidities                                 | 30 (14%)               |

(Continued)
non-linear (quadratic) relationship, but this did not reach the threshold of statistical significance ($P = 0.083$).

**Discussion**

Our findings indicated that endometrial cancer survivors with a higher BMI have lower physical function compared with those of normal weight. Previous studies estimated that 35% of endometrial cancer survivors report poor physical function [16], and 53% experienced one or more physical function impairments [18]. LLL is the most common physical function impairments and associated with poorer physical function [16,18]. Physical function predicts mortality and major health outcomes (disability, death and hospitalization) in the general population as well as cancer survivors [5–9]. Obesity is one of the barriers to the survivorship in endometrial cancer population [28], which related to poorer physical function [12,13,29,30], and associated with disability [31]. Higher BMI increases overall and disease-specific mortality in endometrial cancer survivors [32]. In this study, 52% of participants were obese. Obesity could be one of the main contributors to poor physical functioning and diminished long-term quality of life in endometrial cancer survivors.

![Predicted Physical Function Component Score in BMI Category](doi:10.1371/journal.pone.0160954.g001)
Interestingly, our data indicate that endometrial cancer survivors who were <75yrs report lower physical function compared with the U.S general population. Conversely, those ≥75yrs report better physical function. One explanation would be those who were diagnosed with endometrial cancer at a younger age were suffering more health issues, such as obesity and other comorbidities, compared with the general population, while those who were diagnosed with endometrial cancer at an age of 75 or older were less likely to have any more health issues compared with age-standardized women without endometrial cancer. It could also result from potential response bias that younger endometrial cancer survivors may be more likely to report how sicker they were, whereas older patients may be more likely to report how well they were living with cancer. This hypothesis-generating observation warrants additional investigation.

Health concerns of cancer survivors have included physical function, in addition to surviving from cancer. Studies have shown that cancer survivors are more likely to report worse physical function compared with healthy populations [14,15,33]. Our study found that BMI is the only factor associated with differences in physical function between endometrial cancer survivors and the U.S general population. Compared to the cancer-free population, the physical function of cancer survivors’ declines with an accelerated trajectory after cancer diagnosis, and obesity predicts functional decline [34]. Although some of the deleterious conditions resulting from endometrial cancer and treatment are not reversible, obesity and physical function could be improved by lifestyle interventions. Exercise can improve physical function in cancer patients as well as obese frail older adults [35,36]. Slowly progressive weight lifting program in the breast cancer population prevented the deterioration of self-reported physical function [3]. Weightlifting appears safe even in women with lower extremity lymphedema [37]. Other lifestyle intervention studies also suggest that exercise could prevent physical

Table 2. Physical Function Component Score Change by BMI.

| BMI Categorical-kg/m² | No.  | Model 1a | P  | Model 2b | P  | Model 3c | P  |
|----------------------|------|----------|----|----------|----|----------|----|
| <25                  | 56 (26%) | 0—Referent |   | 0—Referent |   | 0—Referent |   |
| 25.0–29.9            | 47 (22%) | -2.0 (-5.2 to 1.1) | 0.209 | -2.0 (-5.2 to 1.1) | 0.209 | -1.7 (-5.2 to 1.6) | 0.311 |
| 30.0–34.9            | 49 (23%) | -3.6 (-6.6 to -0.6) | 0.021 | -3.6 (-6.6 to -0.5) | 0.022 | -3.0 (-6.3 to -0.2) | 0.063 |
| 35.0–39.9            | 30 (14%) | -4.3 (-7.9 to -0.7) | 0.019 | -4.3 (-7.9 to -0.72) | 0.019 | -4.9 (-8.8 to -1.0) | 0.014 |
| ≥40.0                | 31 (15%) | -4.1 (-7.5 to -0.6) | 0.022 | -4.1 (-7.6 to -0.6) | 0.023 | -4.6 (-8.7 to -0.5) | 0.027 |
| P trend              |      | 0.005    |    | 0.005    |    | 0.003    |    |
| BMI Continuous-kg/m² |      | -0.1 (-0.2 to -0.01) | 0.049 | -0.1 (-0.2 to -0.01) | 0.048 | -0.2 (-0.30 to -0.01) | 0.045 |

Table 3. Difference in Physical Function Component Score between Endometrial Cancer Survivors and the U.S. General Population.

| Age Categories | Sample size | Physical function component score (Median) | | | |
|----------------|-------------|------------------------------------------|---|---|---|
| | | Difference | Endometrial cancer survivors | The U.S general population | P value |
| Over all       | 213(100%)   | -3.1 | 42.1 | 45.2 | <0.001 |
| <45            | 13 (6%)     | -12.9 | 39.4 | 52.3 | 0.0096 |
| 45–54          | 22 (10%)    | -9.9 | 39.5 | 49.4 | 0.0007 |
| 55–64          | 80 (38%)    | -5.8 | 41.1 | 46.9 | <0.001 |
| 65–74          | 71 (33%)    | -4.9 | 39.0 | 43.9 | 0.0019 |
| ≥75            | 26 (12%)    | 3.1 | 42.9 | 39.8 | 0.0390 |

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function decline in the older population, and a combination of weight loss and exercise can provide greater improvement in physical function [38,39].

We acknowledge that underestimates of body size and BMI are well documented, especially in obese population [40,41]. In our experience in gynecologic practices in our institution, most of obese endometrial cancer survivors have little awareness and concerns about their weight. Recommendations from health care providers could significantly increase physical activity [42,43]. And patients may be more likely to follow the clinicians’ recommendation given the perception that cancer is more life-threatening than other diseases [44,45]. Given the large proportion of endometrial cancer survivors who are overweight and/or obese, and have other

Table 4. Linear Regression Model to Assess the Difference of Physical Function Component Score between Endometrial Cancer Survivors and The U.S General Population.

|                  | Coef. | P value | 95% CI   |
|------------------|-------|---------|----------|
| **BMI Categorical** |       |         |          |
| <25 kg/m²         | Ref   | —       | —        |
| 25.0–29.9 kg/m²   | -2.22 | 0.238   | -5.91    | 1.48    |
| 30.0–34.9 kg/m²   | -3.23 | 0.068   | -6.71    | 0.25    |
| 35.0–39.9 kg/m²   | -6.79 | 0.002   | -11.01   | -2.56   |
| ≥40.0 kg/m²       | -6.62 | 0.004   | -11.04   | -2.20   |
| **Race**          |       |         |          |
| white             | 9.69  | 0.128   | -2.81    | 22.19   |
| black             | 1.45  | 0.469   | -2.49    | 5.38    |
| other             | -2.00 | 0.616   | -9.86    | 5.86    |
| unknown           | —     | —       | —        |
| **Education**     |       |         |          |
| High school or less | Ref   | —       | —        |
| Some college      | 2.58  | 0.176   | -1.17    | 6.33    |
| College degree or more | 1.65  | 0.331   | -1.69    | 4.99    |
| **Stage**         |       |         |          |
| 1                 | 4.24  | 0.134   | -1.32    | 9.80    |
| 2                 | -0.45 | 0.838   | -4.80    | 3.90    |
| 3                 | 0.63  | 0.878   | -7.48    | 8.75    |
| **Histology type**|       |         |          |
| Endometroid Adenocarcinoma | Ref | —       | —        |
| Papillary serous or Clear Cell or Mixed | -0.08 | 0.959 | -3.28    | 3.11    |
| Sarcoma           | -2.91 | 0.453   | -10.54   | 4.72    |
| Carcinosarcoma    | 0.17  | 0.960   | -6.47    | 6.81    |
| Other (Undifferentiated) | -6.74 | 0.188 | -16.81   | 3.32    |
| **Treatment**     |       |         |          |
| Surgery           | -3.39 | 0.192   | -8.50    | 1.72    |
| Surgery, Chemotherapy | -1.81 | 0.330 | -5.46    | 1.84    |
| Surgery, Radiation | 2.53  | 0.228   | -1.60    | 6.66    |
| Years from Diagnosis | -0.67 | 0.18  | -1.65    | 0.31    |
| **Charlson Comorbidity** |       |         |          |
| 0                 | 0.84  | 0.684   | -3.22    | 4.90    |
| ≥2                | 1.32  | 0.481   | -2.36    | 5.00    |

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health-issues that need medically-based supervised exercise program [28], health care providers may play an important role to increase patients' awareness of weight and body size, and refer them to a medically-based lifestyle intervention, to reduce body weight, improve overall body composition, and increase physical activity levels to yield improvements in a variety of clinical and patient-reported outcomes in endometrial cancer population. Several behavior interventions focused on diet and exercise also showed the effectiveness of weight loss in endometrial cancer survivors [44,45].

The major limitation of this study is the cross-sectional study design, which does not allow us to clarify the temporal relationship of the variables in our analysis. We were unable to integrate objective measures of physical function, which may provide complementary information to self-reported measures. Nonetheless, self-reported measures of physical function are clinically meaningful [8,21]. A prospective designed study using objective measurements of physical function could help to determine the causal relationship and predictive factors of poor physical function in endometrial cancer. In addition, our study was conducted within a single health system. Characteristics of endometrial cancer patients seen within the academic health system may differ from the community setting. For example, 80% of our study sample was diagnosed at an early stage, and 88% were younger than 75 yrs old, which may not represent the general endometrial cancer population. Furthermore, women who chose to participate in the study differ from those who did not participate. Survey participants were more often diagnosed with earlier stage cancer, suggesting a possible selection bias. However age and BMI did not differ between survey participants and non-participants. Although we found physical function in our sample is quite different compared with the U.S age-standardized population, it would be helpful to have BMI-adjusted normative values to compare the relationship. Further prospective studies with larger samples and additional measures of physical function are needed to provide continued guidance on the preservation of physical function in this population.

**Conclusion**

Among endometrial cancer survivors, higher BMI is associated with lower physical function. Younger endometrial cancer survivors (<75yrs) report lower physical function compared to age-standardized normative values. If these cross-sectional findings reflect a causal relationship, this would suggest that referring younger obese endometrial cancer survivors to a lifestyle intervention targeting in weight loss, such as diet and exercise, may benefit them to maintain and improve physical function in terms to help their recovery from cancer and related treatment. The goal of these interventions would be to improve their ability to perform daily activity and to live independently. Additional investigation is warranted to identify appropriate approach to refer endometrial cancer survivors into effective lifestyle intervention to improve their quality of life.

**Supporting Information**

S1 File. De-identified Data for Sharing (As Requested). (DTA)

S1 Table. Comparison of Characteristics between Endometrial Cancer Survivors Who Completed Survey and Who Didn’t Complete Survey. (DOCX)

**Author Contributions**

Conceived and designed the experiments: XZ, JCB, KHS.
Performed the experiments: XZ JCB.
Analyzed the data: XZ.
Contributed reagents/materials/analysis tools: XZ JCB.
Wrote the paper: XZ JCB KHS.

References
1. U.S. Cancer Statistics Working Group. United States Cancer Statistics: 1999–2011 Incidence and Mortality Web-based Report. Atlanta (GA): Department of Health and Human Services, Centers for Disease Control and Prevention, and National Cancer Institute; 2014.
2. SEER Cancer Statistics Factsheets: Endometrial Cancer. National Cancer Institute. Bethesda, MD, http://seer.cancer.gov/statfacts/html/corp.html. 2015.
3. Brown JC, Schmitz KH. Weight Lifting and Physical Function Among Survivors of Breast Cancer: A Post Hoc Analysis of a Randomized Controlled Trial. J.Clin.Oncol. 2015 May 11.
4. Painter P, Stewart AL, Carey S. Physical functioning: definitions, measurement, and expectations. Adv. Ren.Replace.Ther. 1999; 6:110–123. PMID: 10230878
5. Cesari M, Onder G, Zamboni V, Manini T, Shorr RI, Russo A, et al. Physical function and self-rated health status as predictors of mortality: results from longitudinal analysis in the iSIRENTE study. BMC geriatrics 2008; 8:1.
6. Inouye SK, Peduzzi PN, Robison JT, Hughes JS, Horwitz RI, Concato J. Importance of functional measures in predicting mortality among older hospitalized patients. JAMA 1998; 279:1187–1193. PMID: 9555758
7. Brown J, Harhay M, Harhay M. Physical function as a prognostic biomarker among cancer survivors. Br.J.Cancer 2015; 112:194–198. doi: 10.1038/bjc.2014.568 PMID: 25393366
8. Brown JC, Harhay MO, Harhay MN. Patient-reported versus objectively-measured physical function and mortality risk among cancer survivors. Journal of geriatric oncology 2016; 7:108–115. doi: 10.1016/j.jgo.2016.01.009 PMID: 26907563
9. Cesari M, Cerullo F, Zamboni V, Di Palma R, Scambia G, Balduzzi L, et al. Functional status and mortality in older women with gynecological cancer. J.Gerontol.A Biol.Sci.Med.Sci. 2013 Sep; 68:1129–1133. doi: 10.1093/gerona/glt073 PMID: 2373856
10. Li C, Samsioe G, Iosif C. Quality of life in endometrial cancer survivors. Maturitas 1999; 31:227–236. PMID: 10340282
11. Hardy R, Cooper R, Sayer AA, Ben-Shlomo Y, Cooper C, Deary IJ, et al. Body mass index, muscle strength and physical performance in older adults from eight cohort studies: the HALCyon programme. PloS one 2013; 8:e56483. doi: 10.1371/journal.pone.0056483 PMID: 23437142
12. Woo J, Leung J, Kwok T, BMI, body composition, and physical functioning in older adults. Obesity 2007; 15:1886–1894. PMID: 17636108
13. Zoico E, Di Francesco V, Guralnik J, Mazzali G, Bortolani A, Guariento S, et al. Physical disability and muscular strength in relation to obesity and different body composition indexes in a sample of healthy elderly women. Int.J.Obes. 2004; 28:234–241.
14. Sweeney C, Schmitz KH, Lazovich D, Vrinić BA, Wallace RB, Folsom AR. Functional limitations in elderly female cancer survivors. J.Natl.Cancer Inst. 2006 Apr 19; 98:521–529. PMID: 16622121
15. Stafford RS, Cyr PL. The impact of cancer on the physical function of the elderly and their utilization of health care. Cancer 1997; 80:1973–1980. PMID: 9366301
16. Brown JC, Lin LL, Segal S, Chu CS, Haggerty AE, Ko EM, et al. Physical activity, daily walking, and lower limb lymphedema associate with physical function among uterine cancer survivors. Supportive Care in Cancer 2014; 22:3017–3025. doi: 10.1007/s00520-014-2306-0 PMID: 24908839
17. Brown JC, John GM, Segal S, Chu CS, Schmitz KH. Physical activity and lower limb lymphedema among uterine cancer survivors. Med.Sci.Sports Exerc. 2013 Nov; 45:2091–2097. doi: 10.1249/MSS.0b013e318299af0d PMID: 23685717
18. Hammer SM, Brown JC, Segal S, Chu CS, Schmitz KH. Cancer-related impairments influence physical activity in uterine cancer survivors. Med.Sci.Sports Exerc. 2014 Dec; 46:2195–2201. doi: 10.1249/MSS.0000000000000360 PMID: 24781866
19. Lin LL, Brown JC, Segal S, Schmitz KH. Quality of life, body mass index, and physical activity among uterine cancer patients. Int.J.Gynecol.Cancer 2014 Jul; 24:1027–1032. doi: 10.1097/IGC.0000000000000166 PMID: 24927246
20. Gandek B, Ware JE, Aaronson NK, Apolone G, Brazier JE, et al. Cross-validation of item selection and scoring for the SF-12 Health Survey in nine countries: results from the IQOLA Project. J. Clin.Epidemiol. 1998; 51:1171–1178. PMID: 9817135
21. Hall SA, Chiu GR, Williams RE, Clark RV, Araujo AB. Physical function and health-related quality-of-life in a population-based sample. The Aging Male 2011; 14:119–126. doi: 10.3109/13685538.2010.502267 PMID: 20870102
22. Ware JE Jr, Kosinski M, Keller SD. How to Score the SF-12 Physical and Mental Health Summary Scales. Boston: The Health Institute, New England Medical Center; 1998; 3.
23. Charlson M, Szatrowski TP, Peterson J, Gold J. Validation of a combined comorbidity index. J.Clin.Epidemiol. 1994; 47:1245–1251. PMID: 7722560
24. Carter J, Raviv L, Appollo K, Baser RE, Iasonos A, Barakat RR. A pilot study using the Gynecologic Cancer Lymphedema Questionnaire (GCLQ) as a clinical care tool to identify lower extremity lymphedema in gynecologic cancer survivors. Gynecol.Oncol. 2010; 117:317–323. doi: 10.1016/j.ygyno.2010.01.022 PMID: 20163847
25. Interpreting the SF-12. Available: http://health.utah.gov/opha/publications/2001hss/sf12/SF12_Interpreting.pdf.
26. Bjorner JB, Wallenstein GV, Martin MC, Lin P, Blaisdell-Gross B, Tak Piech C, et al. Interpreting score differences in the SF-36 Vitality scale: using clinical conditions and functional outcomes to define the minimally important difference. Curr.Med.Res.Opin. 2007; 23:731–739. PMID: 17407629
27. Alonso J, Ferrer M, Gandek B, Ware JE Jr, Aaronson NK, Mosconi P, et al. Health-related quality of life associated with chronic conditions in eight countries: results from the International Quality of Life Assessment (IQOLA) Project. Quality of life research 2004; 13:283–298. PMID: 15085901
28. Zhang X, Haggerty AF, Brown JC, Giuntoli R, Lin L, Simpkins F, et al. The prescription or proscription of exercise in endometrial cancer care. Gynecol.Oncol. 2015; 139:155–159. doi: 10.1016/j.ygyno.2015.08.007 PMID: 26307400
29. Shin H, Panton LB, Dutton GR, Ilich JZ. Relationship of Physical Performance with Body Composition and Bone Mineral Density in Individuals over 60 Years of Age: A Systematic Review. J.Aging Res. 2011 Jan 23; 2011:191896. doi: 10.4061/2011/191896 PMID: 21318048
30. Stenholm S, Alley D, Bandinelli S, Griswold M, Koskinen S, Rantanen T, et al. The effect of obesity combined with low muscle strength on decline in mobility in older persons: results from the InCHIANTI study. Int.J.Obes. 2009; 33:635–644.
31. Ferraro KF, Su YP, Gretebeck RJ, Black DR, Badyak SF. Body mass index and disability in adulthood: a 20-year panel study. Am.J.Public Health 2002 May; 92:834–840. PMID: 11988456
32. Arem H, Park Y, Pelser C, Ballard-Barbash R, Irwin ML, Hollenbeck A, et al. Prediagnosis body mass index, physical activity, and mortality in endometrial cancer patients. J.Natl.Cancer Inst. 2013 Mar 6; 105:342–349. doi: 10.1093/jnci/djs530 PMID: 23297041
33. Yabroff KR, Lawrence WF, Clauser S, Davis WW, Brown ML. Burden of illness in cancer survivors: findings from a population-based national sample. J.Natl.Cancer Inst. 2004 Sep 1; 96:1322–1330. PMID: 15339970
34. Petrick JL, Reeve BB, Kucharska-Newton AM, Foraker RE, Platz EA, Stearns SC, et al. Functional status declines among cancer survivors: Trajectory and contributing factors. Journal of geriatric oncology 2014; 5:359–367. doi: 10.1016/j.jgo.2014.06.002 PMID: 24981125
35. Schmitz KH, Holtzman J, Courneya KS, Masse LC, Duval S, Kane R. Controlled physical activity trials in cancer survivors: a systematic review and meta-analysis. Cancer Epidemiol.Biomarkers Prev. 2005 Jul; 14:1588–1595. PMID:1595. PMID:16030088
36. Courneya KS. Exercise in cancer survivors: an overview of research. Med.Sci.Sports Exerc. 2003 Nov; 35:1846–1852. PMID: 14600549
37. Katz E, Dugan NL, Cohn JC, Chu C, Smith RG, Schmitz KH. Weight lifting in patients with lower extremity lymphedema secondary to cancer: a pilot and feasibility study. Arch.Phys.Med.Rehabil. 2010; 91:1070–1076. doi: 10.1016/j.apmr.2010.03.021 PMID: 20599045
38. Pahor M, Guralnik JM, Ambrosius WT, Blair S, Bonds DE, Church TS, et al. Effect of structured physical activity on prevention of major mobility disability in older adults: the LIFE study randomized clinical trial. JAMA 2014; 311:2387–2396. doi: 10.1001/jama.2014.5616 PMID: 24866862
39. Villareal DT, Chode S, Parimi N, Sinacore DR, Hilton T, Armamento-Villareal R, et al. Weight loss, exercise, or both and physical function in obese older adults. N.Engl.J.Med. 2011; 364:1218–1229. doi: 10.1056/NEJMoa1008234 PMID: 21449785
40. Johnson F, Beeken RJ, Croker H, Wardle J. Do weight perceptions among obese adults in Great Britain match clinical definitions? Analysis of cross-sectional surveys from 2007 and 2012. BMJ Open 2014 Nov 13; 4:e005561. doi: 10.1136/bmjopen-2014-005561 PMID: 25394816
41. Sutcliffe CG, Schultz K, Brannock JM, Giardiello FM, Platz EA. Do people know whether they are overweight? Concordance of self-reported, interviewer-observed, and measured body size. Cancer Causes & Control 2015; 26:91–98.

42. Jones LW, Courneya KS, Fairey AS, Mackey JR. Effects of an oncologist’s recommendation to exercise on self-reported exercise behavior in newly diagnosed breast cancer survivors: a single-blind, randomized controlled trial. Annals of Behavioral Medicine 2004; 28:105–113. PMID: 15454357

43. Park J, Lee J, Oh M, Park H, Chae J, Kim D, et al. The effect of oncologists’ exercise recommendations on the level of exercise and quality of life in survivors of breast and colorectal cancer: A randomized controlled trial. Cancer 2015.

44. von Gruenigen VE, Courneya KS, Gibbons HE, Kavanagh MB, Waggoner SE, Lerner E. Feasibility and effectiveness of a lifestyle intervention program in obese endometrial cancer patients: a randomized trial. Gynecol. Oncol. 2008; 109:19–26. doi:10.1016/j.ygyno.2007.12.026 PMID: 18243282

45. von Gruenigen V, Frasure H, Kavanagh MB, Janata J, Waggoner S, Rose P, et al. Survivors of uterine cancer empowered by exercise and healthy diet (SUCCEED): a randomized controlled trial. Gynecol. Oncol. 2012; 125:699–704. doi:10.1016/j.ygyno.2012.03.042 PMID: 22465522