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Changes in anthropometric nutritional status and physical activity levels and five-year survival in women with endometrioid endometrial cancer: a prospective cohort study

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Abstract

OBJECTIVES

To examine the association between longitudinal trajectories of anthropometric nutritional status, physical activity, and overall survival among women with endometrial cancer.

METHODS

In a prospective cohort study, we enrolled 241 women aged ≥ 20 years with endometrioid EC who underwent curative-intent surgery. Anthropometric measures (body weight, body mass index [BMI], and waist circumference) and physical activity levels, assessed using the International Physical Activity Questionnaire, were collected at five time points from baseline to three years after surgery. Longitudinal changes were evaluated using linear mixed-effects models adjusted for age and clinical stage. Associations between longitudinal trajectories and five-year overall survival were assessed using joint models combining linear mixed-effects and Cox proportional hazards submodels.

RESULTS

Increases in body weight, BMI, and waist circumference were observed over follow-up, except among women with advanced-stage disease. Physical activity levels remained relatively stable over time and showed limited variability. Increases in anthropometric measures were not significantly associated with a lower risk of all-cause mortality, whereas trajectories of vigorous physical activity showed a significant association with this outcome.

CONCLUSIONS

Increases in body weight, BMI, and waist circumference were observed during follow-up but were not associated with overall survival. In contrast, trajectories of vigorous physical activity were significantly associated with all-cause mortality, highlighting the potential prognostic relevance of higher-intensity physical activity in women with EC.

INTRODUCTION

Endometrial cancer (EC) is the most common gynecologic malignancy in developed countries, with obesity and sedentary behavior recognized as major risk factors for its development [1]. Beyond increasing disease incidence, these factors may also adversely affect clinical outcomes, contributing to poorer prognosis, including reduced overall survival and disease-free survival among patients with EC [2, 3].

However, the scientific evidence regarding the association between excess body weight and survival in EC remains controversial. A systematic review and meta-analysis conducted by Kokts-Porietis et al. (2021) [4] reported that women with a body mass index (BMI) ≥ 30 kg/m² experienced a 34% increase in all-cause mortality, as well as a higher risk of disease recurrence, compared with non-obese patients. In contrast, several retrospective studies, including those by Chaves et al. (2019) [5] and Pavone et al. (2024) [6], failed to demonstrate a significant association between excess body weight and worse survival. Conversely, other investigations have suggested an inverse association between higher body weight and mortality, both in EC and in other malignancies. This counterintuitive finding has been described as the “obesity paradox” in cancer, a phenomenon that remains incompletely understood and may reflect the influence of methodological factors, residual confounding, or differential clinical and biological characteristics across patient populations [7, 8].

Despite being widely discussed, the obesity paradox remains controversial and inconclusive. Much of the evidence linking obesity to survival outcomes is derived from retrospective studies that rely primarily on BM) as a proxy for adiposity. However, BMI does not distinguish between body compartments, which are closely related to clinical outcomes and prognosis. Consequently, alternative anthropometric measures, such as waist circumference, as well as changes in body weight during cancer treatment, may provide a more meaningful assessment of nutritional status and its relationship with survival outcomes [7, 9].

In addition, physical activity (PA) may influence body composition, systemic inflammation and metabolic profiles and has therefore been investigated as a potential prognostic factor in cancer survivorship [10]. Prospective data suggest that higher levels of PA before and after diagnosis may be associated with improved outcomes among women with EC. In the prospective cohort study by Friedenreich et al. (2020) [11], women who maintained higher PA levels (approximately 13 MET-h/week) during the pre- and post-diagnosis periods showed better overall and progression-free survival. Similarly, recent data from the Cancer Prevention Study II cohort showed that meeting twice the recommended public health guidelines (≥ 15 MET-h/week) was associated with a lower risk of all-cause mortality. Moreover, this large cohort study, with an average follow-up of 13 years, indicated that lower volumes of leisure-time walking (< 2 h/week) and high sedentary time, particularly when combined with low physical activity, were associated with an increased risk of mortality [12].

Despite these findings, the level of evidence supporting an association between post-diagnosis physical activity and mortality or prognostic outcomes in endometrial cancer remains limited. This limitation is largely attributable to the reliance of existing studies on self-reported physical activity measures, lack of BMI assessment, prospective designs based on single time-point measurements, and relatively short follow-up periods, which typically extend to an average of two years after diagnosis [12, 13].

Therefore, longitudinal prospective studies are needed to investigate the relationship between prognosis in EC, obesity status, and physical activity levels over time. In this context, the aim of the present study

was to examine the association between anthropometric nutritional status and physical activity and overall survival among women with EC, followed for up to five years after diagnosis.

METHODS

Study design and eligibility

This prospective cohort study was conducted at a high-complexity hospital in Rio de Janeiro, Brazil, between November 2016 and December 2019. Eligible participants were women aged over 20 years with a diagnosis of endometrioid EC, with no prior cancer treatment, who underwent surgery with curative intent. The eligibility criteria and the study flowchart are presented in Fig. 1.

Data collection

Data were collected at five time points throughout the study. The initial visit with the research team took place prior to treatment initiation, on the day the surgical approach was defined (T0). Subsequent follow-up visits were conducted at six months (T1) and at one, two, and three years (T2, T3, and T4, respectively) after the date of the surgical procedure.

All participants provided written informed consent. The study was approved by the Research Ethics Committee of the Brazilian National Cancer Institute (INCA) under protocol number 1,563,774, approved on May 29, 2016.

Information on clinical history and oncological treatment, including histopathological confirmation of cancer diagnosis and disease staging, was obtained from both physical and electronic medical records. Sociodemographic characteristics and comorbidities were also collected.

At each follow-up visit, nutritional status was assessed using anthropometric measurements, including body weight, height, and waist circumference. BMI was calculated and subsequently classified according to World Health Organization criteria [14].

PA levels were assessed using the International Physical Activity Questionnaire (IPAQ), translated into Portuguese and validated for the Brazilian population by Matsudo et al. (2012) [15]. Participants reporting outliers values were excluded from the analysis when the sum of daily time spent in walking, moderate-intensity, and vigorous-intensity activities exceeded 960 minutes (16 hours). Likewise, daily time spent in each activity domain exceeding 180 minutes was truncated to 180 minutes.

Total minutes spent in these activities were subsequently converted into metabolic equivalent (MET) values according to the Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire [16], allowing participants to be classified into different physical activity levels.

Overall survival (OS) was evaluated using information extracted from clinical follow-up notes available in electronic medical records. Time-to-event was calculated from the date of histopathological confirmation of malignancy in the surgical specimen to the date of death from any cause. Participants who were alive at the end of follow-up were censored at 60 months after diagnosis.

Statistical analysis

Continuous variables were assessed for distributional properties and summarized as means and standard deviations or medians and interquartile ranges, according to data normality. Categorical variables were described using absolute and relative frequencies.

To investigate the longitudinal changes in anthropometric variables (weight, BMI, and waist circumference) and physical activity levels, assessed as METs, linear mixed-effects models (LME) were fitted. These models included random intercepts and random slopes for time to account for within-subject correlation arising from repeated measurements and allowed for handling missing data under the missing at random assumption. All models were adjusted for age and clinical stage as fixed effects. Additionally, models evaluating BMI were further adjusted for physical activity levels.

To assess the association between the longitudinal trajectories of the independent variables and the 5-year risk of death, joint models were applied, simultaneously integrating the longitudinal submodel and the survival submodel, specified using a Cox proportional hazards model. The association between the two processes was modeled using the current value parameterization, in which the instantaneous risk of death is expressed as an exponential function of the expected current value of the longitudinal outcome. The association parameter (Assoct, α) quantifies the magnitude and direction of this relationship.

Results are presented as time-effect coefficients (β), association parameters (α), and hazard ratios (HR) derived from the survival submodel, along with their corresponding 95% confidence intervals (95% CI). A two-sided p-value < 0.05 was considered statistically significant.

Descriptive analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 22.0. Linear mixed-effects and joint models were fitted in R, version 4.0.3, using the nlme, survival, and JM packages.

RESULTS

A total of 241 patients diagnosed with endometrioid-type adenocarcinoma were eligible for the study. Table 1 presents the sociodemographic, clinical, and physical activity characteristics of the sample. The mean age of the participants at baseline (T0) was 59.2 ± 6.4 years. Most participants self-identified as White, had no partner, and had completed no more than nine years of formal education. Regarding income, the majority were engaged in paid employment, and a substantial proportion of the sample was concentrated in the lowest income categories, predominantly socioeconomic classes D and E (n = 203; 86.6%). Overall, 214 participants (89.5%) were classified as overweight at T0.

Walking and moderate physical activity volumes declined from baseline (T0) through T4, with the greatest reductions observed among patients with advanced-stage disease. These trends contributed to an overall decrease in total weekly METs across the cohort. Among women with stage III–IV disease, this reduction in physical activity was accompanied by a pattern of weight loss. All participants experienced a significant decline in vigorous physical activity at T1 compared with T0; however, those with stage I–II disease returned to baseline levels by T4. In contrast, participants with advanced-stage disease remained nearly inactive throughout the follow-up period.

Table 1
Sociodemographic, clinical, and physical activity characteristics of the study population over the 3-year follow-up.

Variables	n	%
	241	**100**
Age group (years)[a]		
< 64	196	81.3
≥ 65	45	18.7
Skin color[b]		
White	109	53.4
Non-white	95	46.6
Marital status[c]		
Without partner	137	58.1
With partner	99	41.9
Years of education[d]		
0 a 9	140	58.3
10 a 12	80	33.3
≥ 13	20	8.3
Income source[e]		
Retirement	46	19.2
Paid work	104	43.3
Unpaid work	90	37.5
Income range in minimum wages[f]		
Class B	4	1.7
Class C	27	11.5
Class D	85	36.3

[a]Age group at T0; [b]n=204, missing: 37; [c]n=236, missing: 5; [d]n=240, missing: 1; [e]n=240, missing: 1; [f]n=234, missing: 7; Class B: 5 to 15 minimum wages; Class C: 3 to 5 minimum wages; Class D: 1 to 3 minimum wages; Class E: <1 minimum wages; [g]Body Mass Index (BMI) at T0; NS/NR: n = 2; [h]n=238, missing: 3;[i]n=224; missing: 17;[j]n=202; missing: 39; [k]n=181; missing: 60; [l]n=175, missing: 66.

Variables	n	%
	241	**100**
Class E	118	50.4
Body Mass Index (BMI)[g]		
Underweight	1	0.4
Normal weight	24	10.0
Overweight	53	22.2
Obesity	161	67.4
Comorbidities		
Hypertension	149	61.8
Diabetes	67	27.8
Dyslipidemia	39	16.2
Chronic obstructive pulmonary disease	1	0.4
Other comorbidities	55	22.8
Stage		
I-II	216	89.6
III-IV	25	10.4
Type of treatment perfomed		
Surgery	112	46.5
Surgery + adjuvante treatment	129	53.5
Total physical activity level per week (T0)[h]		
High	95	39.9
Moderate	90	37.8
Low	53	22.3
Total physical activity level per week (T1)[i]		

[a]Age group at T0; [b]n=204, missing: 37; [c]n=236, missing: 5; [d]n=240, missing: 1; [e]n=240, missing: 1; [f]n=234, missing: 7; Class B: 5 to 15 minimum wages; Class C: 3 to 5 minimum wages; Class D: 1 to 3 minimum wages; Class E: <1 minimum wages; [g]Body Mass Index (BMI) at T0; NS/NR: n = 2; [h]n=238, missing: 3;[i]n=224; missing: 17;[j]n=202; missing: 39; [k]n=181; missing: 60; [l]n=175, missing: 66.

Variables	n	%
	241	**100**
High	80	35.7
Moderate	92	41.1
Low	52	23.2
Total physical activity level per week (T2)[j]		
High	66	32.7
Moderate	90	44.6
Low	46	22.8
Total physical activity level per week (T3)[k]		
High	54	29.8
Moderate	86	47.5
Low	41	22.7
Total physical activity level per week (T4)[l]		
High	47	26.9
Moderate	84	48.0
Low	44	25.1

[a]Age group at T0; [b]n=204, missing: 37; [c]n=236, missing: 5; [d]n=240, missing: 1; [e]n=240, missing: 1; [f]n=234, missing: 7; Class B: 5 to 15 minimum wages; Class C: 3 to 5 minimum wages; Class D: 1 to 3 minimum wages; Class E: <1 minimum wages; [g]Body Mass Index (BMI) at T0; NS/NR: n = 2; [h]n=238, missing: 3;[i]n=224; missing: 17;[j]n=202; missing: 39; [k]n=181; missing: 60; [l]n=175, missing: 66.

Table 2 presents the results of the adjusted linear mixed-effects models. For the anthropometric variables, a significant effect of time was observed for weight, body mass index, and waist circumference, indicating an increasing trend in these measures over the follow-up period. However, the time × stage interaction was negative and statistically significant, suggesting that among patients with advanced-stage disease, the temporal trajectories of these measures showed a decreasing trend compared with patients with early-stage disease (Figs. 2A, 2B, and 2C).

Table 2
Mixed-effects models of longitudinal changes in anthropometric measures and physical activity according to cancer stage.

Weight (kg)	**Estimated coefficient**	***SE*[a]**	**p-value**
Time	1.35	0.54	0.01
Age	-0.04	0.13	0.75
Stage	1.39	4.01	0.73
Time*stage	-1.14	0.46	0.01
Body Mass Index (BMI) (kg/m^2)			
Time	0.66	0.23	0.00
Age	0.06	0.05	0.28
Stage	1.28	1.56	0.41
Weekly total METs[b]	-0.00	0.00	0.84
Time*stage	-0.49	0.19	0.01
Waist circumference (cm)			
Time	1.86	0.57	0.00
Age	0.05	0.12	0.66
Stage	0.98	3.07	0.75
Time*stage	-0.98	0.49	0.05
Weekly METs form walking			
Time	121.85	85.69	0.15
Age	-17.62	6.36	0.00
Stage	226.26	258.18	0.38
Time*stage	-106.47	75.04	0.16
Weekly METs form moderate PA[c]			
Time	-137.83	135.49	0.31
Age	-30.71	11.32	0.00

[a]Standard Error; [b]METs: metabolic equivalentes; [c]Physical activity; [d]Walking + moderate PA + vigorous PA + leisure PA.

Weight (kg)	**Estimated coefficient**	***SE*[a]**	**p-value**
Stage	-265.58	467.58	0.57
Time*stage	-1.50	118.57	0.99
Weekly METs form vigorous PA			
Time	44.26	117.28	0.71
Age	-13.39	5.54	0.02
Stage	-15.56	317.25	0.96
Time*stage	-42.54	102.61	0.68
Weekly METs form leisure PA			
Time	14.60	48.80	0.76
Age	-7.09	3.67	0.05
Stage	-37.99	124.60	0.76
Time*stage	16.33	42.77	0.70
Total weekly METs[d]			
Time	58.85	231.05	0.79
Age	-66.17	19.49	0.00
Stage	-89.59	746.50	0.90
Time*stage	-139.16	202.21	0.49

[a]Standard Error; [b]METs: metabolic equivalentes; [c]Physical activity; [d]Walking + moderate PA + vigorous PA + leisure PA.

With regard to physical activity, no statistically significant associations were observed between time or disease stage and the different MET strata. Age, in turn, showed a negative association with all physical activity domains, indicating lower levels of physical activity with increasing age.

As shown in Figs. 2D, 2F, 2G, and 2H, a decline from T0 to T1, corresponding to the postoperative period, was observed in nearly all MET strata, except for moderate physical activity (Fig. 2E). These levels were not fully recovered over the follow-up period, with the exception of leisure-time physical activity (Fig. 2G), which reached its highest mean MET value at T4.

Over the follow-up period, through July 2025, 36 participants died from all causes. Table 3 presents the joint models integrating the longitudinal trajectories of anthropometric and physical activity variables

with the five-year risk of death. Most variables did not show a significant association with mortality. Vigorous physical activity showed a statistically significant but small association with overall survival (association parameter = − 0.009, p < 0.01), indicating that higher levels of vigorous activity over time were associated with a slightly lower risk of death.

Table 3
Joint models of longitudinal anthropometric and physical activity measures and 5-year overall survival.

Variables	Time trend (β)	p-value	Association with survival (α)	p-value
Weight (kg)	+ 0.17	0.27	0.003	0.97
Body Mass Index (kg/m2)	+ 0.16	0.01	0.01	0.67
Waist circumference (cm)	+ 0.81	< 0.01	0.001	0.82
METs[a] from walking	+ 1.96	0.92	0	0.93
METs from moderate PA[b]	-145.10	< 0.01	0	0.74
METs from vigorou PA	-2.48	0.51	-0.009	< 0.01
METs from leisure PA	+ 30.53	NA[c]	0.01	NA[c]
Total METs	–82.33	0.12	-0.001	0.35

[a]METs: metabolic equivalents; [b]PA: physical activity; [c]p-value not available because the model could not estimate the standard error for this parameter. All joint models were adjusted for age and cancer stage (I–II vs III–IV).

DISCUSSION

Overweight and obesity in adulthood are well-established risk factors for several cancer types, including EC [17]. However, a phenomenon described in the literature as the “obesity paradox” suggests that obesity may have a protective effect on survival among cancer survivors [6, 7, 8, 18]. Although this paradox has been reported across different cancer sites, it remains controversial, and the underlying mechanisms are not fully understood.

Our findings showed that increases in body weight, BMI, and waist circumference over the follow-up were not associated with a lower risk of death. A recent systematic review and meta-analysis of gynecological malignancies did not identify a survival benefit for obese patients and reported lower 5-year overall survival among women with EC and BMI ≥ 30 kg/m². Notably, no significant differences were observed in disease-free survival, suggesting that the association between obesity and overall mortality in EC may be driven by non-oncological pathways or competing risks rather than cancer progression itself [6].

Additionally, a cohort study in which most participants were overweight or obese at the time of diagnosis also found no association between BMI and disease-free survival or overall survival [5]. Furthermore, the literature suggests that weight loss, although associated with metabolic and cardiovascular benefits, has not been shown to be an independent predictor of survival among endometrial cancer survivors [19]. These findings reinforce the importance of considering clinical, metabolic, and behavioral factors when evaluating survival outcomes in cancer survivors.

A systematic review by Agnew et al.[20] found no robust evidence that lifestyle interventions aimed at weight loss, including dietary modification and increased physical activity, improve survival among women with endometrial cancer. However, these trials had relatively short follow-up periods, limiting their ability to assess long-term survival outcomes. In contrast, we observed that higher levels of vigorous physical activity during follow-up were significantly associated with a better 5-year overall survival. This finding suggests that, although general weight-loss strategies may not directly influence mortality, maintaining higher levels of physical activity may represent a modest independent prognostic factor.

Another systematic review and meta-analysis evaluating the association between physical activity and survival among survivors of various cancer types found that higher levels of physical activity, both before and after diagnosis, were associated with improved survival outcomes [21]. These findings support the recommendation to promote physical activity as a strategy for cancer prevention and survivorship.

While meta-analyses have reported inverse associations between moderate-to-vigorous or vigorous PA and mortality risk in endometrial cancer, some large studies have not observed significant associations after adjustment for BMI or differences in the timing of PA assessment [22, 23]. Several biological mechanisms may explain these findings. Vigorous PA may be more effective in reducing excess body weight, while improving insulin sensitivity and lowering insulin-like growth factor levels compared with light or moderate PA [24]. Additionally, vigorous PA may reduce chronic systemic inflammation and estrogen exposure, factors particularly relevant to endometrial tumorigenesis. Beyond cancer-specific mechanisms, higher levels of vigorous PA may also improve cardiovascular fitness and reduce comorbidities common among endometrial cancer survivors [25]. However, further research is needed to clarify optimal dose prescription and prove causality.

Despite these potential benefits, several barriers may limit the adoption and maintenance of an active lifestyle among cancer survivors. Socio-demographic factors, including lower educational attainment and lower income levels, both prevalent in our study population, are recognized structural barriers to engagement in regular physical activity [26].

Moreover, qualitative evidence suggests that traditional exercise prescriptions may not adequately address the specific needs and preferences of women surviving endometrial cancer. Programs perceived as more supportive, enjoyable, and focused on improvements in body composition, physical function, and maintenance of functional independence—rather than weight loss alone—have been

identified as more acceptable and potentially more effective strategies to enhance long-term adherence to physical activity in this population [27].

This study has several limitations that should be acknowledged. First, obesity was assessed using anthropometric measures, such as BMI and waist circumference, which do not allow differentiation between fat and lean mass and may fail to capture conditions such as sarcopenia or sarcopenic obesity. Second, physical activity was self-reported, which is subject to recall bias and social desirability bias, and may have limited sensitivity to detect small longitudinal changes, particularly in a population with generally low activity levels. In addition, the generally low levels and limited variability of PA during follow-up may have reduced the sensitivity of the models to detect associations with survival for some activity domains. Third, some PA variables presented unstable estimates in the joint models, including parameters with large β coefficients or models in which the standard error could not be estimated. This likely reflects sparse data in certain activity categories, particularly for leisure and moderate physical activity, and should be interpreted with caution. Moreover, inflammatory biomarkers were not available, precluding formal assessment of systemic inflammation as a potential mediator of the observed associations between anthropometric changes and survival. Finally, part of the follow-up occurred during the COVID-19 pandemic, a period marked by mobility restrictions and disruptions in daily routines, which may have influenced both physical activity patterns and weight trajectories.

In conclusion, our findings contribute to the ongoing discussion of the obesity paradox in cancer and suggest that longitudinal measures of nutritional status may be more informative for prognosis than isolated assessments at a single time point. Future studies with larger sample sizes and the incorporation of inflammatory and systemic biomarkers are warranted to more comprehensively elucidate the complex interplay between adiposity, physical activity, and survival outcomes among endometrial cancer survivors.

Declarations

Funding

No funding was received for conducting this study.

Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Ethics Approval

This study was approved by the Research Ethics Committee of the National Cancer Institute under protocol number 1,563,774 on May 29, 2016.

Consent to participate

Informed consent was obtained from all individual participants included in the study.

Author Contributions

Gabriela Villaça Chaves and Fernando Frajacomo contributed to the conception and design of the study. Material preparation, data collection, and analysis were performed by Luiza Vianna Conteville and Gabriela Villaça Chaves. All authors contributed to the writing of the manuscript, read, and approved the final version.

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

1. Feng J et al (2024) Global and regional trends in the incidence and mortality burden of endometrial cancer, 1990–2019: Updated results from the Global Burden of Disease Study, 2019. Chin Med J 137(3):294–302. https://doi.org/10.1097/CM9.0000000000002841
2. Crosbie EJ et al (2022) Endometrial cancer. Lancet 399(10333):1412–1428. https://doi.org/10.1016/S0140-6736(22)00323-3
3. Somasegar S et al (2025) Obesity, demographic, and lifestyle risk factor patterns associated with endometrial cancer diagnosis and survival: insights from the Women's Health Initiative. Eur J Gynaecol Oncol 46(8):11. https://doi.org/10.22514/ejgo.2025.105
4. Kokts-Porietis RL et al (2021) Obesity and mortality among endometrial cancer survivors: A systematic review and meta-analysis. Obes Rev 22(12):e13337. https://doi.org/10.1111/obr.13337
5. Chaves GV et al (2019) Overweight and obesity do not determine worst prognosis in endometrioid endometrial carcinoma. Arch Gynecol Obstet 300(6):1671–1677. https://doi.org/10.1007/s00404-019-05281-y
6. Pavone M et al (2024) Obesity paradox: is a high body mass index positively influencing survival outcomes in gynecological cancers? A systematic review and meta-analysis. Int J Gynecol Cancer 34(8):1253–1262. https://doi.org/10.1136/ijgc-2023-005252
7. Cardoso ICR, de Paula NS, Chaves GV (2025) Body composition phenotypes and long-term survival of endometrial cancer. Clin Nutr ESPEN 68:88–94. https://doi.org/10.1016/j.clnesp.2025.04.010
8. Li Y et al (2022) The obesity paradox in patients with colorectal cancer: a systematic review and meta-analysis. Nutr Rev 80(7):1755–1768. https://doi.org/10.1093/nutrit/nuac005
9. Bradshaw PT (2024) Body composition and cancer survival: a narrative review. Br J Cancer 130:176–183. https://doi.org/10.1038/s41416-023-02470-0
10. Shachar SS, Williams GR (2017) The obesity paradox in cancer—moving beyond BMI—response. Cancer Epidemiol Biomarkers Prev 26(6):981–981. https://doi.org/10.1158/1055-9965

11. Friedenreich CM et al (2020) Prospective Cohort Study of Pre- and Postdiagnosis Physical Activity and Endometrial Cancer Survival. J Clin Oncol 38(34):4107–4117. https://doi.org/10.1200/JCO.20.01336
12. Bates-Fraser LC et al (2025 Aug) Every move matters: physical activity, walking, sedentary behavior, and endometrial cancer survival. Cancer Causes Control 26. https://doi.org/10.1007/s10552-025-02060-w
13. Gorzelitz JS et al Mortality risk and physical activity across the lifespan in endometrial cancer survivors. Cancer Causes Control 2022a Mar;33(3):455–461. https://doi.org/10.1007/s10552-021-01540-z
14. World Health Organization (2000) Obesity: preventing and managing the global epidemic. World Health Organization, Geneva
15. Matsudo S et al (2001) Questionário Internacional de Atividade Física (IPAQ): estudo de validade e reprodutibilidade no Brasil. Rev Bras Ativ Fís Saúde 6(2). https://doi.org/10.12820/rbafs.v.6n2p5-18
16. IPAQ (2005) Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ). IPAQ
17. International Agency for Research on Cancer (2020) World cancer report: cancer research for cancer prevention. IARC, Lyon
18. Lennon H et al (2016) The Obesity Paradox in Cancer: a Review. Curr Oncol Rep 18:56. https://doi.org/10.1007/s11912-016-0539-4
19. Santana BN et al (2023) Impact of weight loss after treatment on survival outcomes of overweight and obese patients with early–stage endometrial cancer. Oncol Lett 27(2):44. https://doi.org/10.3892/ol.2023.14177
20. Agnew H, Kitson S, Crosbie EJ (2023) Interventions for weight reduction in obesity to improve survival in women with endometrial cancer. Cochrane Database Syst Rev 3(3):CD012513. https://doi.org/10.1002/14651858.CD012513.pub3
21. Friedenreich CM, Stone CR, Cheung WY, Hayes SC (2019) Physical Activity and Mortality in Cancer Survivors: A Systematic Review and Meta-Analysis. JNCI Cancer Spectr 4(1):pkz080. https://doi.org/10.1093/jncics/pkz080
22. Arem H et al (2013) Prediagnosis body mass index, physical activity, and mortality in endometrial cancer patients. J Natl Cancer Inst 105(5):342–349. https://doi.org/10.1093/jnci/djs530
23. Matthews CE et al (2020) Amount and Intensity of Leisure-Time Physical Activity and Lower Cancer Risk. J Clin Oncol 38(7):686–697. https://doi.org/10.1200/JCO.19.02407
24. Friedenreich CM, Ryder-Burbidge C, McNeil J (2021) Physical activity, obesity and sedentary behavior in cancer etiology: epidemiologic evidence and biologic mechanisms. Mol Oncol 15(3):790–800. https://doi.org/10.1002/1878-0261.12772
25. Gorzelitz JS et al Mortality risk and physical activity across the lifespan in endometrial cancer survivors. Cancer Causes Control 2022b Mar;33(3):455–461. https://doi.org/10.1007/s10552-021-01540-z

26. Depenbusch J et al (2022) Impact and Determinants of Structural Barriers on Physical Activity in People with Cancer. Int J Behav Med 29(3):308–320. https://doi.org/10.1007/s12529-021-10014-0
27. Rossi A et al (2023) Perceptions of a comprehensive physical activity behavior intervention among endometrial cancer survivors with obesity. A qualitative study. Gynecol Oncol Rep 50:101313. https://doi.org/10.1016/j.gore.2023.101313

Figures

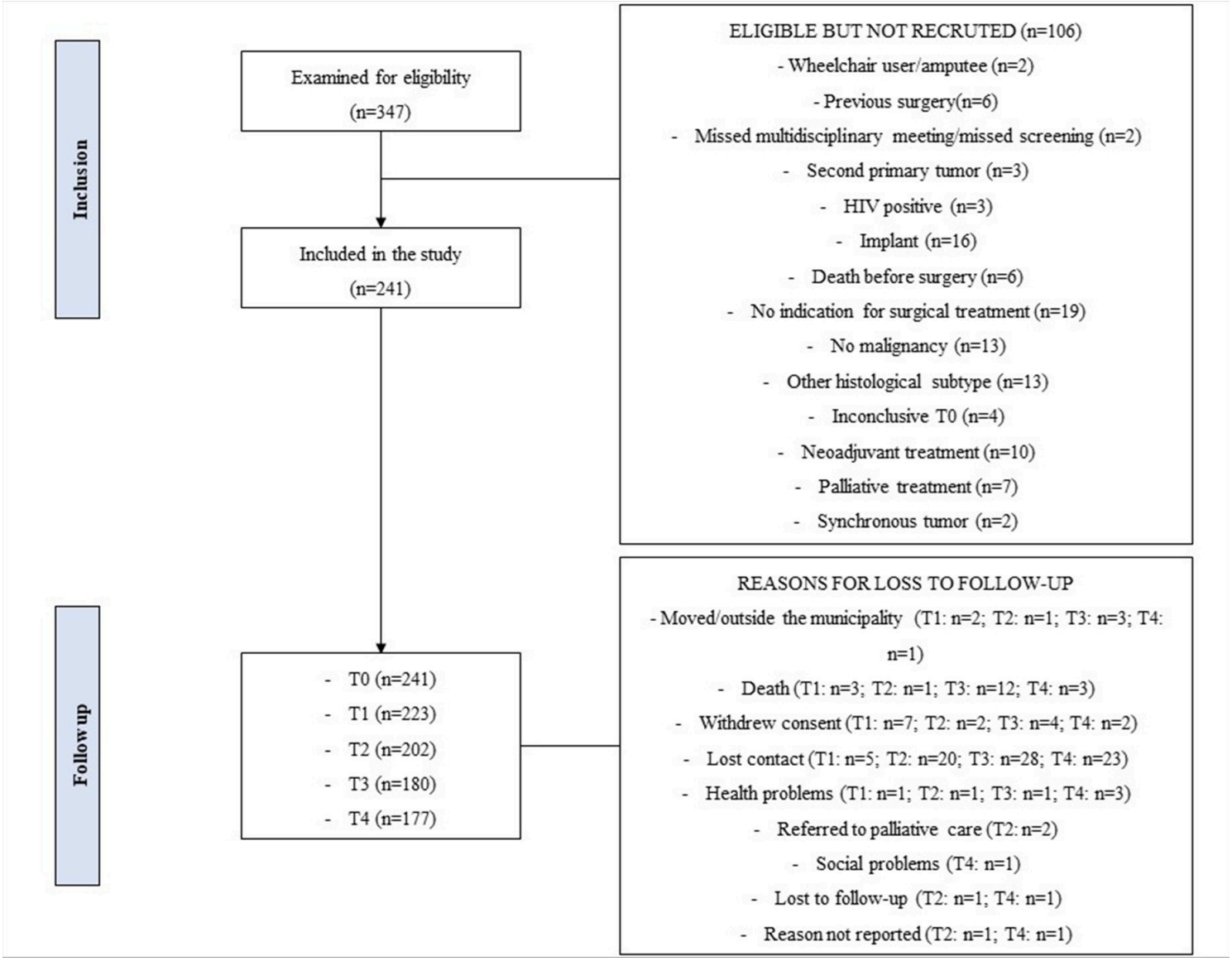


Figure 1

The eligibility criteria and the study flowchart

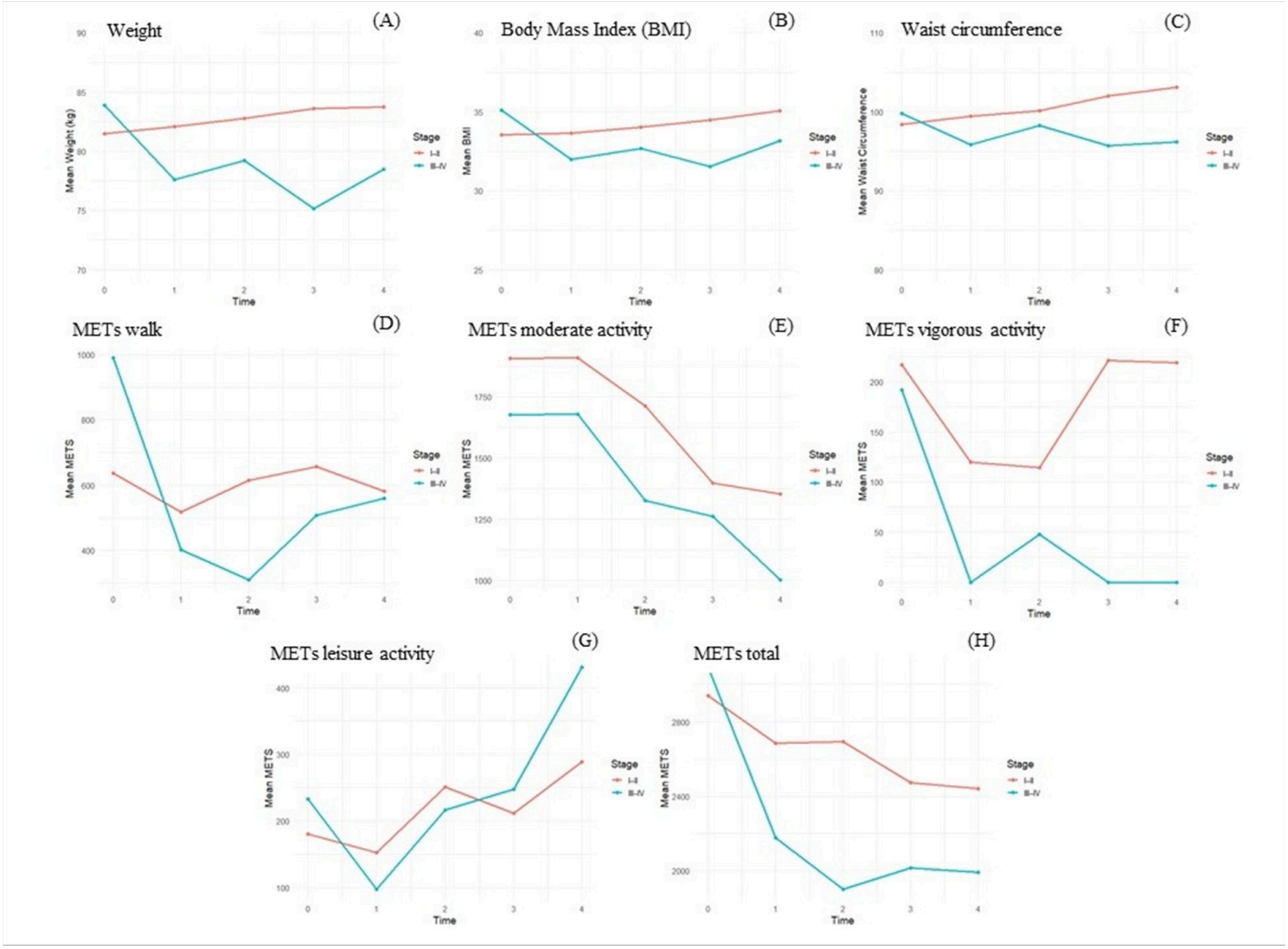


Figure 2

Longitudinal changes in anthropometric measures and physical activity according to cancer stage.