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Skeletal Muscle Loss During Neoadjuvant Chemotherapy for Breast Cancer: Diabetes as an Independent Predictor

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ABSTRACT

Objective: This study examined body composition changes during neoadjuvant chemotherapy (NACT) for breast cancer and aimed to identify clinical parameters associated with skeletal muscle loss.

Materials and Methods: We retrospectively analyzed women with stage I–III breast cancer who received NACT. Skeletal muscle and subcutaneous fat areas at the third lumbar vertebra were quantified on computed tomography and normalized for height to calculate the skeletal muscle index (SMI, cm²/m²) and subcutaneous fat index (SFI, cm²/m²). Pre- and post-NACT values were compared, and the prevalence of low skeletal muscle mass (LSMM, SMI <38.5 cm²/m²) and sarcopenic obesity (body mass index ≥30 kg/m² with LSMM) was determined. Multivariable linear regression assessed independent predictors of post-NACT SMI.

Results: A total of 177 patients (mean age 51.0±10.7 years; 24% with diabetes) were included. Mean SMI declined significantly after NACT (43.1±7.4 to 41.4±7.1 cm²/m²; mean change -1.7±3.1, $p<0.001$). SFI also decreased (132.9±59.2 to 123.5±55.1 cm²/m²; mean change -9.5±27.0, $p<0.001$). The prevalence of LSMM increased from 27.7% to 37.3% ($p = 0.003$), and sarcopenic obesity from 8.5% to 12.4%. Patients with diabetes experienced greater muscle loss than those without diabetes (-2.7 *vs.* -1.4 cm²/m²). Diabetes mellitus was the only independent predictor of post-NACT SMI decline ($\beta = -1.42$, $p = 0.013$), while age and chemotherapy regimen were not significant.

Conclusion: NACT is associated with significant reductions in skeletal muscle and subcutaneous fat, together with increased rates of LSMM. Diabetes mellitus independently predicted lower post-treatment SMI.

Keywords: Body composition; breast cancer; diabetes; neoadjuvant chemotherapy; sarcopenia

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KEY POINTS

- Patients with breast cancer experienced significant skeletal muscle loss after neoadjuvant chemotherapy, based on computed tomography-derived measurements.
- The proportion with low skeletal muscle mass increased from approximately 28% to 37%, and sarcopenic obesity rose from approximately 9% to 12%.
- Diabetes mellitus was the only clinical factor independently associated with greater muscle loss; patients with diabetes lost more muscle than those without diabetes.
- Neither age nor chemotherapy regimen was independently associated with post-treatment skeletal muscle mass.
- Muscle-preserving care should be prioritized for patients with breast cancer undergoing neoadjuvant chemotherapy, particularly those with diabetes.

Introduction

Breast cancer remains a major global health challenge, representing the most commonly diagnosed malignancy in women worldwide. Approximately 2.3 million new breast cancer cases and 0.66 million deaths occur annually worldwide (1). Neoadjuvant chemotherapy (NACT) plays a central role in the management of breast cancer by downstaging tumors, increasing the likelihood of breast-conserving surgery, and offering prognostic insight. Achievement of a pathologic complete response after NACT is particularly associated with improved outcomes in aggressive subtypes such as human epidermal growth factor receptor 2 (HER2)-positive and triple-negative breast cancer (2, 3).

For all its benefits in tumor control, chemotherapy is a double-edged sword in that its systemic action will adversely affect normal tissues. Chemotherapy itself has been recognized as a direct cause of skeletal muscle wasting, independent of cancer cachexia (4). Treatment-induced muscle loss has been linked to higher rates of chemotherapy toxicity and inferior survival outcomes across solid tumors (5). The patient groups most vulnerable to chemotherapy-related muscle loss are not well defined. Although older patients are more likely to have baseline sarcopenia due to age-related muscle decline, current evidence does not indicate that age independently increases the risk of chemotherapy-related muscle loss (6-8). The chemotherapy regimen itself may influence the degree of muscle loss; for example, a dual HER2-targeted NACT regimen [docetaxel, carboplatin, trastuzumab, and pertuzumab; (TCHP)] was recently shown to induce significantly greater skeletal muscle depletion than an anthracycline-taxane regimen (6).

Type 2 diabetes mellitus is an established risk factor for sarcopenia, with meta-analyses showing a 1.5–2.0-fold higher prevalence compared with individuals without diabetes (9, 10). Several mechanisms underlie this association: insulin resistance disrupts the PI3K-AKT-mTOR pathway, leading to reduced protein synthesis, while activation of catabolic transcription factors such as FOXO enhances proteolysis; chronic low-grade inflammation amplifies catabolic signaling; and hyperglycemia-induced oxidative stress with mitochondrial dysfunction further compromises muscle integrity (11). In addition, diabetes promotes myosteatosis, the infiltration of fat into skeletal muscle, which worsens insulin resistance and reduces contractile function (4, 11). Taken together, these data support a strong biological and clinical basis for examining diabetes as a potential contributor to chemotherapy-related muscle loss in patients with breast cancer. Given these gaps in the evidence base, we designed a retrospective cohort study to assess the body composition changes during NACT in patients with breast cancer and to identify clinical predictors of skeletal muscle loss. In particular, we examined the influence of diabetes mellitus and other clinical parameters on post-therapy muscle mass.

Materials and Methods

Study Design and Setting

This retrospective cohort study was conducted at a single tertiary oncology center. Ethical approval was obtained from the Royal Medical Services Ethics Committee, Bahrain (approval number: 2023-717; date: 28.09.2023). The study was conducted in accordance with the Declaration of Helsinki.

Patient Selection

Eligible patients were women aged 18 years or older with histopathologically-confirmed invasive breast carcinoma (clinical stage I–III) who received NACT between November 2018 and July 2024, with a minimum treatment duration of four months, and had baseline and post-treatment radiologic assessments [abdominal computed tomography (CT) or positron emission tomography (PET)-CT] with post-treatment imaging performed ≥4 months after treatment initiation. Patients were excluded if they had metastatic disease at presentation or if imaging data were missing.

Data Collection

Patients were identified from the hospital oncology database. Clinical data were retrieved from electronic medical records and included age, date of diagnosis, clinical stage at presentation, baseline comorbidities, histopathology, NACT regimen, dates of

NACT initiation and completion, number of NACT cycles, NACT duration (days), dates of baseline and post-NACT imaging, body weight, height, and body mass index (BMI) before and after NACT. BMI was categorized according to World Health Organization cut-offs. Comorbidity burden was quantified using the Charlson comorbidity index, based on comorbidities documented before NACT initiation (12).

NACT regimens were classified as: (1) AC-T: anthracycline (doxorubicin or epirubicin) plus cyclophosphamide followed by a taxane-containing regimen, with or without carboplatin, trastuzumab, pertuzumab, or pembrolizumab, as clinically indicated; or (2) TCHP.

Imaging and Body Composition Analysis

Body composition was evaluated on baseline and post-NACT scans using a single axial slice at the third lumbar vertebra (Figure 1). CT (or the CT component of PET-CT) images were analyzed using ImageJ software (National Institutes of Health, Bethesda, MD, USA) to quantify skeletal muscle and subcutaneous fat cross-sectional areas (cm^2) applying the following Hounsfield Unit (HU) thresholds: skeletal muscle -29 to +150 HU, subcutaneous fat -190 to -30 HU (13, 14). Skeletal muscle index (SMI) and subcutaneous fat index (SFI) were calculated by dividing the respective areas by height squared (m^2). All body composition measurements were performed independently by two senior radiology consultants, who were blinded to patient clinical information and each other's results.

Low skeletal muscle mass (LSMM) was defined as an SMI <38.5 cm^2/m^2 (15). Sarcopenic obesity was defined as the coexistence of obesity (BMI ≥30 kg/m^2) and LSMM.

Statistical Analysis

Continuous variables are summarized as mean ± standard deviation (SD) and were compared between groups using two-sided Student's t-tests. Categorical variables are presented as counts (percentages) and were compared using chi-square (χ^2) tests. Within-patient changes from pre- to post-NACT were evaluated using paired t-tests for continuous variables and McNemar's test for paired categorical outcomes. The effect sizes were calculated using Cohen's d for paired samples, defined as the mean pre- to post-NACT change in SMI divided by the SD of the change. Values of 0.2, 0.5, and 0.8 were interpreted as small, moderate, and large effects, respectively.

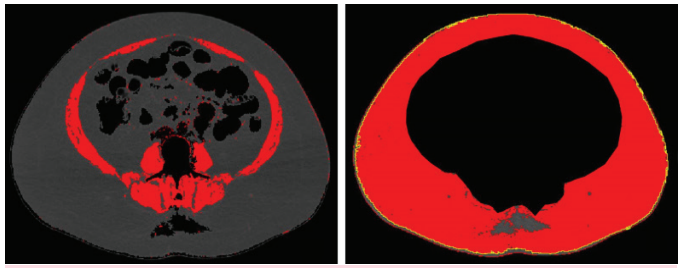

Figure 1. Representative computed tomography images at the third lumbar vertebral level of a 59-year-old woman illustrating segmentation of body composition using ImageJ software, (left) Skeletal muscle area highlighted in red, (right) Subcutaneous fat tissue highlighted in red

Inter-rater reliability between the two radiologists for SMI measurements was assessed using a two-way random-effects intraclass correlation coefficient (ICC) with 95% confidence intervals (CIs). Agreement was interpreted as follows: <0.50, poor; 0.50–0.75, moderate; 0.75–0.90, good; >0.90, excellent.

Predictors of post-NACT SMI were examined using linear regression. The first model was adjusted for baseline SMI. The second model (multivariable-adjusted model) included age, NACT regimen, and presence of diabetes in addition to baseline SMI. Results were reported as regression coefficients with 95% CIs. All tests were two-sided, and statistical significance was set at $p<0.05$. Analyses were performed using Stata version 14 (StataCorp, College Station, TX, USA). Statistical plots were generated in R version 4.5.1 (R Foundation for Statistical Computing, Vienna, Austria) using the "forestplot" and "ggplot2" packages.

Results

Patient Characteristics

A total of 177 breast cancer patients who underwent NACT were included in the analysis. The mean age was 51.0±10.7 years, with diabetic patients being significantly older than non-diabetic patients (58.3±7.7 *vs.* 48.6±10.5 years, $p<0.001$) (Table 1). The most common tumor subtype was HR+/HER2- (32.8%), followed by HR+/HER2+ (26.0%), HR-/HER2+ (19.2%), and triple-negative breast cancer (22.0%). Most patients presented with cT1–2 disease (60.4%) and cN1 nodal status (55.4%). The majority (71.8%) received AC-T-based NACT regimens, while 28.2% were treated with TCHP. Obesity (BMI ≥30 kg/m^2) was present in 54.8% of the cohort, including 69.8% of diabetic patients and 50.0% of non-diabetic patients. The mean NACT duration was 149±37.8 days, with no significant difference between diabetic and non-diabetic patients.

Changes in Skeletal Muscle Index and Fat Index

Inter-rater reliability for SMI measurements was excellent at both pre-NACT [ICC (2.1) = 0.92, 95% CI: 0.90–0.94] and post-NACT [ICC (2.1) = 0.93, 95% CI: 0.91–0.95] assessments. Given the high ICC values, the mean of the two raters' measurements was used for subsequent analyses.

Table 1. Clinical and demographic characteristics of the study cohort by diabetes status

		All (n = 177)	Non-diabetic (n = 134)	Diabetic (n = 43)	p-value
Age (years)		51±10.7	48.6±10.5	58.3±7.7	<0.001
Tumor subtype	HR+/HER2-	58 (32.8)	39 (29.1)	19 (44.2)	0.300
	HR+/HER2+	46 (26.0)	37 (27.6)	9 (20.9)	
	HR-/HER2+	34 (19.2)	28 (20.9)	6 (14.0)	
	TNBC	39 (22.0)	30 (22.4)	9 (20.9)	
cT stage	T1-2	107 (60.4)	79 (59.0)	28 (65.1)	0.761
	T3-4	66 (37.3)	52 (38.8)	14 (32.6)	
	Tx	4 (2.3)	3 (2.2)	1 (2.3)	
cN stage	N0	36 (20.3)	28 (20.9)	8 (18.6)	0.720
	N1	98 (55.4)	76 (56.7)	22 (51.2)	
	N2-3	31 (17.5)	21 (15.7)	10 (23.3)	
	Nx	12 (6.8)	9 (6.7)	3 (7.0)	
NACT type	TCHP	50 (28.2)	42 (31.3)	8 (18.6)	0.106
	AC-T*	127 (71.8)	92 (68.7)	35 (81.4)	
BMI categories	Underweight	3 (1.7)	3 (2.2)	0 (0.0)	0.134
	Normal weight	35 (19.8)	29 (21.6)	6 (13.9)	
	Overweight	42 (23.7)	35 (26.1)	7 (16.3)	
	Obese	97 (54.8)	67 (50.0)	30 (69.8)	
CCI	2	126 (71.2)	126 (94.0)	0 (0.0)	<0.001
	3	43 (24.3)	6 (4.5)	37 (86.0)	
	≥4	8 (4.5)	2 (1.5)	6 (14.0)	
NACT duration (days)		149±37.8	147±37.7	155.1±37.7	0.224

*: AC-T regimens include an anthracycline plus cyclophosphamide followed by a taxane, with or without anti-HER2 agents, pembrolizumab, or carboplatin, AC-T: Anthracycline plus cyclophosphamide followed by a taxane; BMI: Body mass index; CCI: Charlson comorbidity index; NACT: Neoadjuvant chemotherapy; TCHP: Docetaxel, carboplatin, trastuzumab, and pertuzumab; TNBC: Triple-negative breast cancer; HER2: Human epidermal growth factor receptor 2

Mean SMI decreased significantly after NACT, from 43.1±7.4 cm²/m² to 41.4±7.1 cm²/m² (mean change -1.7±3.1 cm²/m², p<0.001) (Table 2). Both diabetic and non-diabetic patients experienced significant SMI loss, although the decline was greater in patients with diabetes (-2.7 *vs.* -1.4 cm²/m²). Similar reductions in SMI were observed in patients aged <50 and ≥50 years. Significant SMI reductions were observed with both chemotherapy regimens, with declines of -1.4 cm²/m² in the TCHP group and -1.8 cm²/m² in the AC-T group. The overall decline in SMI from pre- to post-NACT corresponded to a moderate effect size (Cohen's d = 0.55). When stratified by diabetes status, the magnitude of muscle loss was large among diabetic patients (d = 0.93) and moderate among non-diabetic patients (d = 0.45), indicating a greater degree of treatment-related muscle depletion in patients with diabetes.

SFI also decreased significantly overall (132.9±59.2 to 123.5±55.1 cm²/m², mean change -9.5±27.0, p<0.001). The decline was more pronounced in patients with diabetes (-19.8 cm²/m²) than in those without diabetes (-6.2 cm²/m²). SFI loss was greater in patients aged ≥50 years (-14.2 cm²/m², p<0.001) compared with younger patients (-4.2 cm²/m², p = 0.09). The TCHP group showed greater fat loss than the AC-T group (-13.7 *vs.* -7.8 cm²/m²).

Prevalence of LSMM and Sarcopenic Obesity

The prevalence of LSMM increased from 27.7% before NACT to 37.3% after treatment (p = 0.003) (Figure 2). This increase was significant in both non-diabetic (29.1% to 37.3%, p = 0.028) and diabetic patients (23.3% to 37.2%, p = 0.034). The prevalence of sarcopenic obesity rose from 8.5% pre-NACT to 12.4% post-NACT (p = 0.052). While the increase was not significant overall, it reached significance among diabetic patients (9.3% to 18.6%, p = 0.045), but not in non-diabetic patients.

Predictors of Post-NACT SMI

Linear regression analysis was performed to assess the predictors of post-NACT SMI. In the first model, after adjusting for baseline SMI, diabetes was significantly associated with lower post-NACT

SMI (coefficient -1.21; 95% CI: -2.22 to -0.20; $p = 0.019$). Age and NACT regimen (TCHP vs AC-T) were not significantly associated with post-NACT SMI in this model (Figure 3).

A multivariable-adjusted model was fitted that included age, NACT regimen, and presence of diabetes in addition to baseline SMI. Diabetes remained an independent predictor of lower post-NACT SMI (coefficient -1.42; 95% CI: -2.53 to -0.30; $p = 0.013$). In contrast, age and NACT regimen were not significantly associated with post-NACT SMI (Figure 3). The final multivariable model explained approximately 83% of the variance in post-NACT SMI (adjusted $R^2 = 0.832$). We subsequently performed a sensitivity analysis by including total NACT duration in the multivariable model to account for variability in imaging intervals. The association between diabetes and lower post-NACT SMI remained significant ($\beta = -1.50$, 95% CI: -2.60 to -0.41, $p = 0.007$).

Table 2. Changes in skeletal muscle index and subcutaneous fat index during neoadjuvant chemotherapy by clinical subgroups

	Group	Before NACT	After NACT	Mean change	*p*-value
SMI (cm^2/m^2)	All patients	43.1±7.4	41.4±7.1	-1.7±3.1	<0.001
	Non-diabetic	42.8±7.0	41.4±6.9	-1.4±3.1	<0.001
	Diabetic	44.2±8.5	41.4±7.9	-2.7±2.9	<0.001
	Age <50	44.0±6.8	42.4±6.2	-1.7±3.2	<0.001
	Age ≥50	42.3±7.9	40.6±7.7	-1.7±2.9	<0.001
	NACT type: TCHP	42.3±6.8	40.9±6.1	-1.4±3.2	0.004
	NACT type: AC-T	43.5±7.7	41.6±7.5	-1.8±3.0	<0.001
SFI (cm^2/m^2)	All patients	132.9±59.2	123.5±55.1	-9.5±27.0	<0.001
	Non-diabetic	127.3±58.2	121.2±57.1	-6.2±21.0	<0.001
	Diabetic	150.4±59.7	130.6±48.3	-19.8±38.8	0.0017
	Age <50	128.3±59.7	124.0±59.6	-4.2±22.9	0.09
	Age ≥50	137.2±58.7	122.9±51.1	-14.2±29.5	<0.001
	NACT type: TCHP	113.4±48.6	99.6±44.7	-13.7±19.4	<0.001
	NACT type: AC-T	140.7±61.4	132±56.2	-7.8±29.3	0.003

Reported values are mean ± standard deviation. *p*-values were calculated using paired Student's t-test. AC-T: Anthracycline plus cyclophosphamide followed by a taxane; NACT: Neoadjuvant chemotherapy; SFI: Subcutaneous fat index; SMI: Skeletal muscle index; TCHP: Docetaxel, carboplatin, trastuzumab, pertuzumab

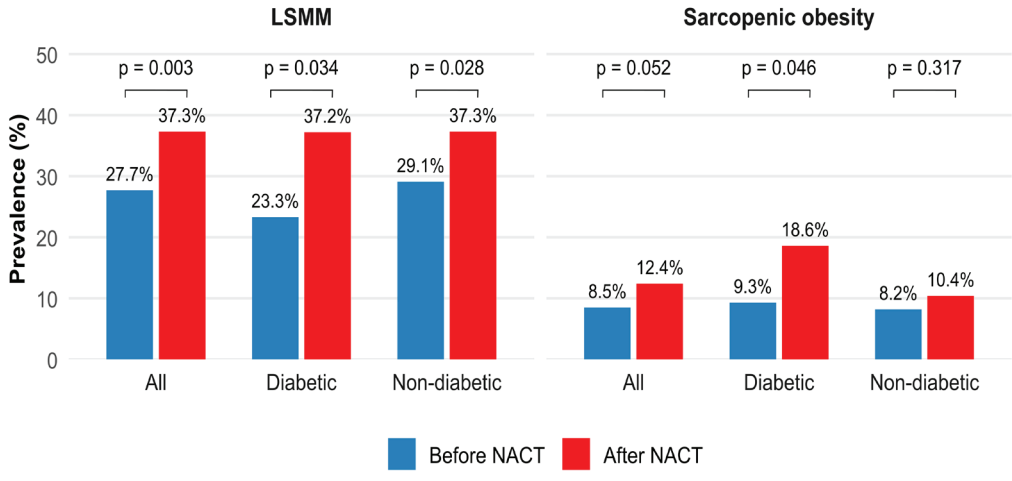

Figure 2. Prevalence of LSMM and sarcopenic obesity before and after NACT. McNemar's test was used to compare paired proportions

LSMM: Low skeletal muscle mass; NACT: Neoadjuvant chemotherapy

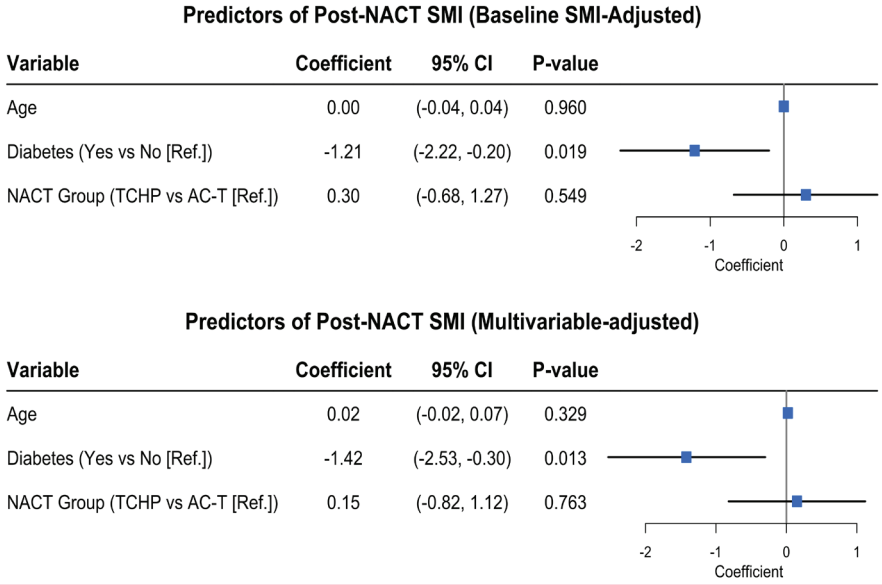

Figure 3. Forest plots of linear regression models for predictors of post-NACT SMI. The upper panel shows the baseline SMI-adjusted model, in which each predictor was evaluated while controlling for baseline SMI. The lower panel shows the multivariable-adjusted model, which included baseline SMI, age, diabetes mellitus, and chemotherapy regimen (TCHP *vs.* AC-T). Regression coefficients are displayed with 95% CIs. Negative coefficients indicate lower post-NACT SMI

NACT: Neoadjuvant chemotherapy; SMI: Skeletal muscle index; TCHP: Docetaxel, carboplatin, trastuzumab and pertuzumab; CI: Confidence interval; AC-T: Anthracycline plus cyclophosphamide followed by a taxane

Discussion and Conclusion

In this retrospective study of breast cancer patients undergoing NACT, we observed a significant decline in SMI from pre- to post-NACT. The loss of muscle mass was evident across the entire cohort, confirming that cytotoxic therapy induces measurable skeletal muscle wasting. Importantly, our analysis identified diabetes as a novel and independent predictor of greater SMI loss. Patients with pre-existing diabetes experienced significantly greater muscle depletion than non-diabetic patients, and this association remained robust after adjusting for age, baseline SMI, and chemotherapy regimen. In contrast, neither patient age nor chemotherapy regimen (TCHP *vs.* AC-T) emerged as significant independent predictors of muscle loss in our multivariable model. Furthermore, the prevalence of LSMM increased from 27.7% to 37.3%, and the prevalence of sarcopenic obesity increased from 8.5% to 12.4% after NACT; these increases were more pronounced in patients with diabetes. Taken together, these findings highlight that muscle loss is a common consequence of NACT and that diabetes may substantially exacerbate this process.

Chemotherapy induces muscle wasting through several interrelated mechanisms. Adverse events of chemotherapy, such as nausea, anorexia, and mucositis can lead to decreased caloric intake, whereas fatigue may reduce physical activity. In addition, chemotherapy may induce systemic inflammation, oxidative stress, and direct activation of catabolic pathways within skeletal muscle (16, 17). Diabetes can exacerbate this process, as chronic hyperglycemia and insulin resistance impair anabolic signaling through the PI3K-Akt-mTOR pathway, while simultaneously amplifying oxidative stress and inflammation. Both conditions converge on similar molecular cascades, including mitochondrial dysfunction and increased pro-inflammatory cytokine activity, leading to enhanced muscle catabolism and reduced protein synthesis (11). This overlap in pathogenic mechanisms provides a biologically plausible explanation for our observation that patients with diabetes experienced greater chemotherapy-related muscle loss. In addition, corticosteroids routinely administered before chemotherapy can worsen insulin resistance and hyperglycemia, thereby worsening glycemic control in patients with diabetes and potentially further contributing to treatment-related muscle loss.

Among the additional clinical parameters assessed, age was not identified as a significant predictor of post-NACT SMI in our study, consistent with findings from prior retrospective cohorts of breast cancer patients undergoing neoadjuvant therapy (6, 7, 18). However, throughout these studies, including ours, the mean patient age was below 55 years, with older individuals being underrepresented. As a result, the potential impact of advanced age on chemotherapy-related muscle loss cannot be ruled out and warrants further investigation in cohorts with a broader

age distribution. We did not find a significant difference in post-NACT SMI between patients treated with TCHP and those treated with AC-T, although the decline in SFI was more pronounced in the TCHP group. These results contrast with the findings of Jang et al. (6), who reported significantly greater muscle loss with TCHP compared to AC-T. This discrepancy may reflect differences in study populations, sample size, or unmeasured confounders.

Our findings reinforce the suggestion that skeletal muscle health deserves attention during breast cancer treatment. LSMM is associated with increased chemotherapy toxicity, which may lead to decreased treatment compliance (19, 20). Furthermore, low baseline SMI is linked to poorer survival across solid tumors (21). A recent study showed that patients who lost significant muscle mass during NACT had inferior disease-free survival compared with those who maintained or gained muscle (22). In particular, patients with diabetes should be considered a high-risk group for chemotherapy-induced skeletal muscle loss, and oncologists should have a low threshold to implement preventive strategies in these individuals. Such strategies may include detailed nutritional assessment and counseling, physical exercise or physiotherapy programs aimed at preserving muscle mass, and close collaboration with endocrinologists to ensure optimal control of blood glucose and other metabolic parameters. A growing body of evidence suggests that exercise programs in patients undergoing chemotherapy and in cancer survivors can improve muscle mass and function, enhance physical capacity, and reduce fatigue (17); and in some populations they can also improve disease-free survival (23, 24). Notably, a randomized clinical trial involving breast cancer patients undergoing adjuvant chemotherapy showed that supervised exercise programs, especially resistance training, improved skeletal muscle mass, and 27% of the patients with sarcopenia experienced a reversal of sarcopenia (25). Accordingly, the American Society of Clinical Oncology guidelines endorse exercise during active, curative-intent treatment to mitigate systemic therapy-related adverse effects (26).

Study Limitations

Several limitations of this study must be acknowledged. First, this was a single-center study, so the generalizability of the findings may be limited. The patient population (in terms of ethnicity, comorbidity prevalence, and lifestyle factors) and practice patterns at our institution may not fully represent other settings. Second, we did not capture certain variables such as dietary patterns, physical activity, or the severity and management of diabetes, which could confound or mediate muscle loss. Third, our assessment of body composition focused on muscle quantity but did not include measures of muscle quality such as muscle density or the presence of myosteatosis due to limitations in imaging analysis. Finally, we did not directly measure functional outcomes related to muscle loss (such as changes in muscle strength, fatigue, or physical performance). Of note, we deliberately used the term "low skeletal muscle mass" rather than "sarcopenia", because the contemporary consensus definition of sarcopenia requires low muscle strength in addition to low muscle quantity (27).

Our study opens several avenues for future investigation. A priority is to conduct prospective studies monitoring body composition in patients with breast cancer receiving NACT to validate our findings under controlled conditions. It remains to be determined whether patients who lose more muscle during treatment have worse tolerance of chemotherapy, higher complication rates, or impaired postoperative recovery. The clinical consequences of the observed muscle loss and its long-term reversibility remain uncertain. In parallel, interventional trials are needed to test strategies to preserve muscle during NACT. These could include randomized evaluations of structured resistance or multimodal exercise programs and targeted nutritional support. It may also be worthwhile to test whether optimizing diabetes management mitigates muscle wasting during cancer treatment.

In conclusion, this study contributes to the growing recognition that NACT for breast cancer may reduce skeletal muscle mass. We identified diabetes mellitus as an independent risk factor for greater treatment-related muscle loss. This is a novel observation that warrants heightened clinical attention. In light of our findings and prior evidence, clinicians should recognize chemotherapy-associated muscle depletion as a clinically meaningful adverse effect and consider integrating muscle-preserving strategies, especially in high-risk patients such as those with diabetes, into routine care.

Ethics

Ethics Committee Approval: This retrospective cohort study was conducted at a single tertiary oncology center. Ethical approval was obtained from the Royal Medical Services Ethics Committee, Bahrain (approval number: 2023-717; date: 28.09.2023).

Informed Consent: Retrospective study.

Footnotes

Authorship Contributions

Surgical and Medical Practices: Z.G.S., A.A., M.G., S.A., M.S., S.L., N.A., H.A., T.A., M.K.; Concept: Z.G.S., A.A.; Design: Z.G.S., A.A.; Data Collection or Processing: Z.G.S., A.A., M.G., S.A., M.S., S.L., N.A., H.A., T.A., M.K.; Analysis or Interpretation: Z.G.S., A.A., M.K.; Literature Search: Z.G.S.; Writing: Z.G.S.

Conflict of Interest: No conflict of interest was declared by the authors.

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