RESEARCH ARTICLE

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Evaluating the Effectiveness of Geriatric-Specific Cancer Rehabilitation Programs on Patient Health Outcomes

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Abstract

Objective: This study evaluated a specialized rehabilitation program's impact on senior cancer patients' quality of life. **Methods:** one hundred and thirty patients aged ≥65 years with various cancer types undergoing/recovering from treatment were enrolled in oncology clinics in Al-Ahsa, Saudi Arabia. The intervention arm (n=65) participated in a tailored geriatric cancer rehabilitation program. The control group (n=65) received standard oncology care. The Functional Assessment of Cancer Therapy-General (FACT-G) tool assessed the quality of life across physical, social, emotional, and functional domains. T-tests and multivariate regression analyses compared outcomes. **Result:** Total FACT-G scores showed a significantly higher quality of life for the geriatric cancer rehabilitation group versus standard care. Rehabilitation patients also demonstrated meaningful improvements across physical, social, and functional subscales. Rehabilitation involvement was the most predictive factor for optimized outcomes. **Conclusion:** Specialized geriatric cancer rehabilitation meaningfully improved several quality of life domains in older patients over standard care. Despite persistent barriers, rehabilitation programming optimized older cancer patients' physical and psychosocial health. Oncology and geriatrics must collaborate to ensure evidence-based rehabilitation access meets older cohorts' unique needs.

Keywords: Geriatric Oncology- Cancer Rehabilitation- Quality of Life- Senior Health- Function

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Introduction

As the population continues to age, the number of older adults diagnosed with cancer is expected to rise substantially. By 2040, over 70% of all cancers will occur in patients aged 65 years and older [1]. Older cancer patients often present with complex health needs due to comorbidity chronic conditions, functional impairments, malnutrition, cognitive decline, and geriatric syndromes that negatively impact their ability to tolerate and recover from cancer treatment [2]. Compared to their younger counterparts, older cancer patients experience higher rates of toxicity during systemic therapy, longer hospital stays after surgery, delays in adjuvant therapy, incomplete treatment regimens, accelerated functional decline, higher risk of physical deconditioning, increased healthcare utilization, and overall poorer quality of life [3, 4]. Up to half of older cancer survivors report persistent physical disability and one-third rate their health as fair or poor up to a decade after initial diagnosis [5].

The poor health outcomes observed in many older cancer patients may be partly attributable to the historical lack of evidence-based standards for managing this complex patient population [6]. Geriatric oncology principles have not been well integrated into cancer care delivery models, education curriculums, research priorities, or reimbursement schemes. As a result, rigid chronological age cutoffs remain the basis for most cancer treatment decisions over comprehensive appraisal of physiological reserve [7]. However, physiological fitness as determined by life expectancy, comorbidities, genetics, and functional status - not chronological age alone - should guide appropriate treatment plans that balance efficacy and toxicity [8, 9].

Comprehensive geriatric assessment (CGA) facilitates this more patient-centered, function-focused care approach by providing detailed information about an older cancer patient's medical, psychosocial, and functional capacity [10]. In turn, CGA facilitates personalized care plans that optimize cancer outcomes while meeting each patient's unique health needs and goals. Components of CGA include evaluation of comorbidities, medications,

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function, fall risk, cognition, mental health, nutritional status, social support, and more [11–13]. Substantial evidence demonstrates CGA use significantly improves diagnostic accuracy, treatment tolerance, survival outcomes, and quality of life for vulnerable older cancer patients compared to standard oncology evaluation alone [14]. As a result, CGA is increasingly recommended as a fundamental component of high-quality geriatric oncology care, yet implementation into routine practice remains limited [15]. Additional knowledge translation initiatives are essential for CGA to guide evidence-based, patient-centered treatment decisions and systemic improvements in geriatric cancer care delivery [16].

In addition to CGA, geriatric-specific cancer rehabilitation interventions represent promising tools for better managing complex older cancer patients and improving their health outcomes [17]. Cancer rehabilitation encompasses medical, physical, functional, psychological, and vocational interventions that help patients obtain maximum physical, social, psychological, and occupational functioning within the limits imposed by their health status [18]. Components include physical and occupational therapy for deconditioning, strength, and balance deficits; nutritional counseling; pain management; cognitive behavioral therapy for mental health needs; patient education; and coordination of community services post-treatment [19].

Mounting high-quality evidence demonstrates participation in these types of multidisciplinary cancer rehabilitation programs significantly improves physical and emotional symptom burden, treatment tolerance, strength, mobility, functional independence, hospitalization risk, and overall quality of life in mixed-age cancer cohorts [20]. In turn, optimized patient function and resilience with rehabilitation facilitates simpler, safer discharge processes and reduces acute care utilization and costs [21]. Unfortunately, healthcare system barriers including poor integration into oncology care models, limited clinician awareness, narrow eligibility criteria, logistical challenges, and reimbursement policies severely restrict access and utilization of standard cancer rehabilitation services [22]. As a result, cancer rehabilitation remains vastly underutilized representing missed opportunities to maximize patient health [23].

The impact and utilization patterns of cancer rehabilitation programs specifically tailored to meet the more complex needs of the older cancer population remain particularly understudied [24]. Older patients face considerable age-associated barriers to participating in and benefiting from traditional rehabilitation programs, including multimorbidity, fatigue, transportation limitations, caregiving responsibilities, fear of injury, and mobility/safety challenges [25]. Geriatric care models acknowledge these barriers through reduced intensity approaches, incorporation of rest periods, in-home programs, tele-rehab modalities, group vs. individual therapy, caregiver training, geriatric interdisciplinary care coordination, and other key modifications [26, 27].

Evidence indicates these specialized geriatric cancer rehabilitation initiatives lead to significant and clinically meaningful improvements in physical function, strength, balance/fall risk, fatigue, nausea, pain, depression, anxiety, social isolation, treatment tolerance, hospitalizations, and overall quality of life [28]. Additional benefits for healthcare resource utilization and costs have been proposed based on demonstrated reductions in postsurgical lengths of stay, hospital readmissions, and nursing home placement following geriatric trauma rehabilitation models [29]. However, high-quality comparative effectiveness studies focused specifically on specialized geriatric cancer rehabilitation programs remain scarce [30].

Given unprecedented population aging trends, determining the safest and most effective geriatric cancer care models is an urgent public health priority with widespread economic, clinical, and humanistic consequences [31]. Optimizing rehabilitation approaches to meet geriatric patients' unique needs shows immense potential value [32]. However, the impact of emerging geriatric-specific cancer rehabilitation models warrants further rigorous evaluation to strengthen the benefit-risk evidence base during stakeholder decision-making processes [33].

This manuscript aims to contribute to that growing evidence base by evaluating geriatric cancer rehabilitation program effectiveness on patient physical function, psychological well-being, healthcare resource utilization, safety metrics, and costs of care compared to usual geriatric oncology management. Findings will help inform clinical practice guidelines, resource allocation policies, reimbursement strategies, and models of care delivery as health systems adapt to meet the needs of the rapidly expanding older cancer population.

Materials and Methods

Study Design

This research utilizes a detailed cross-sectional study design to assess the effectiveness of geriatric-specific cancer rehabilitation programs on the health outcomes of older cancer patients. The focus was on comparing the quality of life between participants engaged in rehabilitation programs and those receiving standard cancer care.

Sample

Sample Size Determination

For the cross-sectional study, a total sample size of 130 older adults diagnosed with cancer was determined. This size was calculated based on a statistical power analysis, which took into account the expected effect size, the alpha error level, and the desired power of the study.

Sampling Frame

The sampling frame for the study encompassed all older adult patients diagnosed with cancer who visited the outpatient cancer clinics in Al-Ahsa, Saudi Arabia, during the study period.

Sampling Technique

A random sampling method was employed.

Inclusion Criteria

Age

Participants were 65 years or older.

Cancer Diagnosis

All participants were diagnosed with any type of cancer.

Treatment Status

Participants were either currently receiving cancer treatment or had recently completed treatment.

Consent

Participants were able and willing to provide informed consent.

Exclusion Criteria

Cognitive Impairment: Individuals with severe cognitive impairments or psychiatric conditions that impeded their ability to provide informed consent or understand the study requirements were excluded.

Palliative Care

Patients receiving palliative care only were excluded, as their needs and outcomes might significantly differ from those in active treatment or recovery.

Participant Recruitment

Participants were recruited directly from the outpatient clinics. Oncologists, nurses, and clinic staff were briefed about the study criteria and assisted in identifying potential participants. Eligible patients were approached in the clinic and provided with detailed information about the study. Those who expressed interest and met the inclusion criteria were invited to participate.

Data Collection Tool

Selection of Data Collection Tool

For the study, the Functional Assessment of Cancer Therapy-General (FACT-G, Version 4) was selected as the primary data collection tool [34]. This choice was made due to FACT-G's established validity and reliability in assessing the quality of life in cancer patients, particularly in older adults.

Adaptation and Translation

Considering the demographic and cultural context of Al-Ahsa, Saudi Arabia, the FACT-G questionnaire was adapted and translated as necessary to ensure cultural appropriateness and linguistic accuracy. This adaptation was done carefully to maintain the integrity of the tool while ensuring its applicability to the local population.

Tool Description

FACT-G, a self-reported questionnaire, was utilized to measure the general quality of life across four primary domains: physical well-being, social/family well-being, emotional well-being, and functional well-being. Each domain contained specific questions designed to capture the various aspects of a cancer patient's life affected by their condition and treatment. The Cronbach's alpha for the overall FACT-G score was found to be 0.89, indicating high internal consistency. The subscale Cronbach alpha were as follows: Physical Well-being (0.85), Social/ Family Well-being (0.82), Emotional Well-being (0.86), and Functional Well-being (0.84). These scores suggest that the items within each domain are highly correlated and reliably measure the respective constructs.

Additional Data Collection

Alongside the FACT-G questionnaire, additional data regarding participants' demographic information, cancer type, and treatment details were collected. This information was gathered through a combination of patient self-report and review of medical records, ensuring a comprehensive understanding of each participant's cancer journey.

Data Collection Procedure

Identification of Participants

Participants for the study were identified during their routine visits to the cancer outpatient clinics in Al-Ahsa, Saudi Arabia. Clinic staff, informed about the study's objectives and criteria, assisted in the identification process. They approached potential participants, providing them with a brief overview of the study and determining their eligibility based on the predefined inclusion and exclusion criteria.

Informed Consent Process

Once potential participants were identified, they were provided with detailed information about the study, including its purpose, what participation entailed, potential risks and benefits, and the confidentiality of their data. This information was delivered in a manner that was clear and understandable, respecting the cultural and educational background of the participants. After ensuring that all their questions were answered, informed consent was obtained from those who agreed to participate.

Administration of FACT-G Questionnaire

Following the consent process, the FACT-G questionnaire was administered to the participants. This was done either through self-completion or via an interview conducted by trained staff, depending on the participant's preference and ability. Care was taken to ensure that the environment was comfortable and conducive to honest and thoughtful responses.

Collection of Demographic and Clinical Data

In addition to the FACT-G questionnaire, demographic and clinical data were collected. This included age, gender, type of cancer, stage of cancer, treatment details, and other relevant medical history. The information was gathered through a combination of direct interviews and reviews of medical records, ensuring accuracy and completeness.

Data Recording and Management

All collected data were carefully recorded. The responses from the FACT-G questionnaires, along with the demographic and clinical information, were entered into a secure electronic database. This task was performed by

staff trained in data management to ensure confidentiality and minimize errors in data entry.

Data analysis

In our study, data analysis was performed using SPSS software version 26, starting with descriptive statistics to summarize participants' demographic and clinical profiles, followed by independent samples t-tests to compare Quality of Life (QoL) scores from the FACT-G questionnaire between those in geriatric-specific cancer rehabilitation programs versus standard care. To address the complexities of our data, particularly when reporting both Beta coefficients and Odds Ratios (OR), we conducted multivariate regression analysis for continuous outcomes and logistic regression for categorical outcomes. Beta coefficients, derived from linear regression, indicate the change in QoL scores for a one-unit change in predictor variables, adjusting for confounders like age and cancer type, thereby revealing the strength and direction of these relationships. ORs, calculated through logistic regression, compare the odds of higher QoL scores between groups, adjusted for the same confounders. This approach, developed in consultation with a statistician, ensures a comprehensive understanding of the effects of geriatric-specific cancer rehabilitation on QoL, accurately adjusted for potential confounders and thoroughly explained by integrating both Beta coefficients and ORs within our statistical analysis to provide a nuanced interpretation of our findings.

Ethical consideration

the study obtained prior approval from a King Faisal University review board (ETHICS1,884) to ensure adherence to ethical standards. Informed consent was rigorously sought, with participants fully briefed about the study's purpose, procedures, and their rights, including the assurance of voluntary participation and the option to withdraw at any time without affecting their medical care. Participant confidentiality and data privacy were stringently upheld, with personal information anonymized and access to data restricted to the research team. Data security was maintained through encrypted electronic systems and secure physical storage. The study involved minimal risk, primarily related to the collection of questionnaire data, and was conducted with a high degree of cultural sensitivity to respect the diverse backgrounds of participants in Al-Ahsa, Saudi Arabia.

Results

Table 1 illustrates the demographics and clinical characteristics of 130 participants, divided evenly between those in a rehabilitation group and those receiving standard care. The age distribution shows a slight concentration in the 70-74 age group (22 in rehabilitation, 24 in standard care, totaling 46), reflecting the prevalence of cancer in this age bracket among older adults. The youngest group (65-69) and the oldest group (≥80) are the smallest, with 38 and 15 participants, respectively. Gender distribution is almost equal, with a slight female majority (32 in rehabilitation, 34 in standard care, totaling 66). This balance ensures that the study's outcomes can be generalized across genders.

In terms of cancer types, breast cancer is the most common (23 in rehabilitation, 21 in standard care, totaling 44), followed by prostate cancer (18 in rehabilitation, 22 in standard care, totaling 40), lung cancer (16 in rehabilitation, 14 in standard care, totaling 30), and colorectal cancer (8 in each group, totaling 16). This variety in cancer types reflects the common cancers affecting older adults and indicates that the study's findings may have broad applicability. Most participants are currently undergoing treatment (42 in rehabilitation, 40 in standard care, totaling 82), highlighting the relevance of the study for patients in the active treatment phase. Those who have completed treatment (23 in rehabilitation, 25 in standard care, totaling 48) represent a significant portion as well, offering insights into post-treatment care. The prevalence of comorbidities is high in both groups (47 in rehabilitation, 45 in standard care, totaling 92), emphasizing the complex health profiles often seen in older cancer patients. The number of participants without comorbidities is significantly lower (18 in rehabilitation, 20 in standard care, totaling 38), underscoring the importance of considering co-morbid conditions in cancer care and rehabilitation for older adults.

Table 2 in the study presents a comparative analysis of the quality of life scores between the rehabilitation group and the standard care group, utilizing the FACT-G questionnaire. The rehabilitation group shows a higher overall quality of life mean score (72.3) compared to the standard care group (68.5), with a statistically significant t-value of 2.45 and a p-value of 0.014. This indicates that participants in the rehabilitation program experienced a better overall quality of life than those receiving standard care. In the domain of Physical Well-being, the rehabilitation group's mean score (18.6) was significantly higher than that of the standard care group (16.4), as reflected by a t-value of 3.68 and a p-value of 0.005. This suggests that physical aspects of quality of life, such as strength, energy levels, and physical pain, were better managed or experienced in the rehabilitation group.

The Social/Family Well-being scores also favored the rehabilitation group, with a mean score of 19.8 compared to 18.0 in the standard care group. The t-value of 3.30 and a p-value of 0.007 here imply a significant positive impact of rehabilitation on social and family relationships and support. Emotional Well-being showed a similar trend, with the rehabilitation group scoring higher (16.7) than the standard care group (15.1), supported by a t-value of 3.22 and a p-value of 0.008. This result highlights the potential benefits of rehabilitation in managing emotional challenges such as anxiety, depression, and overall mood. Lastly, Functional Well-being scores were also higher in the rehabilitation group (17.2) compared to the standard care group (15.5), with a t-value of 3.28 and a p-value of 0.008. This underscores the positive influence of rehabilitation on participants' ability to perform daily activities and maintain a level of independence.

Table 3's multivariate regression analysis reveals significant insights into the factors influencing health outcomes in older cancer patients. Age emerges as a

Table 1. Participant Demographics and Clinical Characteristics

Demographic/Clinical Characteristic	Rehabilitation Group (n=65)	Standard Care Group (n=65)	Total (n=130)
Age			
65-69	18 (27.7%)	20 (30.8%)	38 (29.2%)
70-74	22 (33.8%)	24 (36.9%)	46 (35.4%)
75-79	17 (26.2%)	14 (21.5%)	31 (23.8%)
≥80	8 (12.3%)	7 (10.8%)	15 (11.5%)
Gender			
Male	33 (50.8%)	31 (47.7%)	64 (49.2%)
Female	32 (49.2%)	34 (52.3%)	66 (50.8%)
Cancer Type			
Lung	16 (24.6%)	14 (21.5%)	30 (23.1%)
Breast	23 (35.4%)	21 (32.3%)	44 (33.8%)
Prostate	18 (27.7%)	22 (33.8%)	40 (30.8%)
Colorectal	8 (12.3%)	8 (12.3%)	16 (12.3%)
Treatment Status			
Undergoing Treatment	42 (64.6%)	40 (61.5%)	82 (63.1%)
Completed Treatment	23 (35.4%)	25 (38.5%)	48 (36.9%)
Comorbidities			
Yes	47 (72.3%)	45 (69.2%)	92 (70.8%)
No	18 (27.7%)	20 (30.8%)	38 (29.2%)

significant factor, with younger participants (65-69) having better outcomes compared to the oldest group (≥80), as indicated by negative Beta coefficients and odds ratios less than 1. Gender also plays a crucial role; females show a positive association with improved outcomes (Beta = 0.12, OR = 1.10). In terms of cancer types, none show a statistically significant impact compared to colorectal cancer, the reference category. Notably, undergoing treatment is associated with better outcomes than completed treatment (Beta = 0.18, OR = 1.16), highlighting the importance of ongoing care. However, the most significant finding is the positive impact of participation in rehabilitation (Beta = 0.25, OR = 1.22), suggesting that rehabilitation significantly enhances health outcomes in this population, independent of other factors such as age, gender, and cancer type.

Discussion

The findings from this cross-sectional study provide compelling evidence that specialized geriatric cancer rehabilitation programs can significantly improve health outcomes in older patients undergoing or recovering from cancer treatment. Participation in multidisciplinary rehabilitation incorporating physical, functional, nutritional, and psychosocial support tailored to complex geriatric needs demonstrated clear benefits across several quality-of-life domains compared to standard oncology care alone.

The overall quality of life showed clinically and statistically meaningful improvements with geriatric cancer rehabilitation interventions based on FACT-G scores. This critical patient-reported outcome encapsulates the multifaceted physical, social, emotional, and functional burdens imposed by a cancer diagnosis and intense treatments in already vulnerable seniors.

Table 2. Quality of Life Scores - Overall and by Domain (FACT-G)

FACT-G Domain		Rehabilitation Group (n=65)	Standard Care Group (n=65)	Total (n=130)	p-value
Overall Quality of Life	Mean Score	72.3	68.5	70.4	0.014
	SD	8.4	9.2	8.8	
Physical Well-being	Mean Score	18.6	16.4	17.5	0.005
	SD	3.2	3.6	3.4	
Social/Family Well-being	Mean Score	19.8	18	18.9	0.007
	SD	2.9	3.3	3.1	
Emotional Well-being	Mean Score	16.7	15.1	15.9	0.008
	SD	2.5	2.8	2.7	
Functional Well-being	Mean Score	17.2	15.5	16.4	0.008
	SD	2.8	3.1	2.9	

Table 3. Multivariate Regression Analysis Showing the Impact of Various Factors on Rehabilitation Outcomes

Variable	B Coefficient	Beta Coefficient	Standard Error	Adjusted Odds Ratio (95% CI)	p-value
Age					
134	-0.12	-0.15	0.05	0.88 (0.80 - 0.97)	0.045
144	-0.08	-0.1	0.06	0.92 (0.83 - 1.02)	0.072
154	-0.04	-0.05	0.07	0.96 (0.85 - 1.08)	0.21
≥80	(Reference)				
Gender					
Male	(Reference)				
Female	0.1	0.12	0.04	1.10 (1.01 - 1.20)	0.031
Cancer Type					
Lung	0.05	0.06	0.06	1.05 (0.94 - 1.18)	0.4
Breast	0.08	0.1	0.05	1.08 (0.98 - 1.19)	0.056
Prostate	0.03	0.04	0.06	1.03 (0.91 - 1.16)	0.52
Colorectal	(Reference)				
Treatment Status					
Undergoing Treatment	0.15	0.18	0.05	1.16 (1.07 - 1.26)	0.008
Completed Treatment	(Reference)				
Participation in Rehabilitation	0.2	0.25	0.04	1.22 (1.14 - 1.31)	<0.001
Completed Treatment	(Reference)				
Participation in Rehabilitation	0.2	0.04	0.25	<0.001	

Rehabilitation appears to facilitate physical symptom management, nurture social connections, foster emotional support, and enable maintenance of valued daily activities – culminating in nearly a 4-point higher total FACT-G quality of life score for the intervention group.

While this may seem a relatively small numerical difference, prior research identified a 3-7 point change as clinically important from the patient perspective [35–37]. As such, the rehabilitation program's impact resonates as highly meaningful. The multivariate regression further demonstrates that rehabilitation involvement exerts the greatest independent influence on improved outcomes of all evaluated parameters [38, 39]. In conjunction with past evidence, these findings underscore the immense potential of customized geriatric rehabilitation approaches to enhance healing, function, and comfort during the cancer journey [40].

The positive effects of tailored geriatric cancer rehabilitation are further substantiated by domain-specific impacts on physical well-being/functioning and social connectedness. Physical fitness and stamina frequently decline precipitously during cancer treatment due to direct therapeutic effects coupled with aggravated age-related sarcopenia, deconditioning, malnutrition, and comorbidity burden [41]. Our rehabilitation subjects reported significantly better physical quality of life based on symptom severity, self-care ability, strength, sleep quality, fatigue, and activity tolerance. These outcomes align with past geriatric cancer rehabilitation research highlighting meaningful improvements in fatigue, weakness, mobility limitations, fall risk, and frailty status [42, 43]. Rehabilitation's physical benefits likely stem from supervised exercise cautioning against over-exertion, nutritional guidance to counter cachexia, education on energy conservation techniques, assistive equipment prescriptions, and guidance on safe home exercise programs with caregiver training [44].

The adverse physical impacts of cancer treatment often trigger declines in social functioning due to barriers to exiting the home, visiting loved ones, and participating comfortably in gatherings or activities [45]. Our findings reveal geriatric cancer rehabilitation participation significantly buffered declines in social well-being and familial interactions compared to standard care older cancer cohorts based on the FACT-G social domain. This protective effect against social isolation aligns with previous rehabilitation research demonstrating benefits for loneliness, community participation, and patient-reported social fitness [46]. The social well-being advantages probably arise through counseling and skills building to promote safe, sustainable social connections along with occupational therapy facilitating community mobility [47]. Additional speculation suggests that group-based rehabilitation interventions may organically stimulate peer support networks reducing isolation. All considered, geriatric cancer rehabilitation appears to distinctly nurture seniors' social health as they navigate cancer's threats to engagement [48].

Interestingly, the positive effects of geriatric cancer rehabilitation were less pronounced (non-significant) regarding emotional well-being on the FACT-G, contrasting some prior research [49]. This discrepancy could reflect differences in program components, outcome measures, or study populations. Additional research should explore which elements of geriatric cancer rehabilitation most strongly support emotional health. Speculation suggests structured stress management training, counseling/therapy access, caregiver skills building, and peer support networks embedded in rehabilitation may most directly nurture the emotional quality of life for vulnerable older

adults facing cancer's psychological challenges [50, 51].

Beyond patient-reported outcomes, the multivariate regression sheds light on how demographic, clinical, and treatment factors interact with geriatric cancer rehabilitation's effectiveness [52]. The differential, negative relationship between age and rehabilitation outcomes seems logical considering amplified complication risks and treatment toxicity with advancing senior age [53]. Younger seniors may tolerate and respond better to rehabilitation programming, while utilization and effectiveness wane at older extremes due to extreme frailty. Rehabilitation programs should consider age-stratified approaches [54].

In light of unprecedented cancer growth among all seniors combined with amplified complication risks in older cohorts, developing specialized geriatric oncology care models is an urgent mandate [55]. This study demonstrates geriatric cancer rehabilitation programs represent one promising approach to maximizing health outcomes in this unique patient demographic [56]. Rehabilitation optimizes symptom control and nurtures physical strength/function to support treatment tolerance while also protecting against declines in emotional well-being and social connectedness [57]. Collectively, these benefits culminate in meaningful quality of life improvements signaling healthier aging with cancer. As the costs of delivering intensive cancer regimens to potentially frail seniors under status quo models escalate, rehabilitation further holds immense potential to dampen downstream acute care utilization through fostering function, resilience, and treatment adherence [58].

Implementing more routine, standardized geriatric screening aligning treatment decisions to patients' comprehensive fitness, vulnerabilities, and preferences rather than age cutoffs alone also promises to expand rehabilitation eligibility and better match programming to capability [59]. Integrating geriatric assessments and rehabilitation referrals into oncology care pathways can further stimulate utilization. Reimbursement policies limiting access, especially for home-based modalities, should evolve to incentivize rehabilitation delivery models meeting common transportation and functional barriers among seniors [60]. Finally, systematic coordination between geriatric specialists and oncology providers remains essential for nurturing familiarity and trust in rehabilitation's benefits.

This study has limitations worth acknowledging. The single-center, non-randomized, cross-sectional design and potential residual confounders beyond multivariate adjustments preclude causal conclusions regarding geriatric cancer rehabilitation's effectiveness. Still, the reasonably large sample together with the inclusion of a control group adds valuable comparative insights. Future multicenter randomized controlled trials more rigorously evaluating rehabilitation's efficacy and cost-effectiveness outcomes across settings could better inform resource allocation decisions and strengthen clinical practice guidelines. Additionally, this study relied predominantly on patient-reported outcome measures versus objective physical functioning assessments, introducing subjectivity and reporter biases. Subsequent research could couple patient-reported metrics with performance-based measures along with healthcare utilization data to capture rehabilitation's holistic impacts.

In conclusion, this study provides compelling evidence that specialized geriatric cancer rehabilitation programs can significantly enhance health outcomes and quality of life for older adults undergoing cancer treatment. Across several domains, patients participating in tailored interdisciplinary rehabilitation interventions demonstrated meaningful improvements in self-reported physical, emotional, and social well-being compared to those receiving standard oncology care.

The differences in quality of life scores translated to clinically important benefits based on established parameters for meaningful change from the patient's perspective. This positive impact spanned reduced symptom burden and functional deficits with rehabilitation to buffering declines in emotional health and social connectedness imposed by intensive cancer therapy. Collectively, these advantages enabled seniors to maintain independence, retain a sense of normalcy and personhood, tolerate necessary anti-cancer treatments, and achieve some control over their healing journey.

The benefits align with peak geriatric care principles prioritizing holistic support to nurture patient priorities, dignity, and realistic functionality within the context of health-related limitations. As such, this study underscores the significant value specialized geriatric cancer rehabilitation interventions can provide – optimizing the quality of life and thereby facilitating patients' ability to continue engaging meaningfully with family, friends, and communities throughout the cancer experience.

Realizing the immense potential of rehabilitation to transform outcomes for rising numbers of seniors with cancer rests on addressing persistent health system barriers limiting referral and access, including ageist assumptions, rigid eligibility criteria, lack of integration into oncology care pathways, transportation challenges, and reimbursement limits. As cancer incidence among older adults reaches epidemic proportions, no evidence-based intervention offering meaningful improvements to health, function or comfort should remain restrictively inaccessible – including rehabilitation.

Oncology, geriatrics, policy, and funding spheres must collaborate to standardize geriatric screening and needs assessments and embed customized rehabilitation into care pathways for vulnerable senior cancer populations. We must evolve towards more ethical, patient-centered models guiding practice if we hope to deliver quality cancer care to rapidly expanding older cohorts. The meaningful quality-of-life improvements demonstrated here compel systems to make that alignment an urgent priority.

Author Contribution Statement

S.I.A. conceived of and designed the study; K.E. and N.B. were responsible for data collection and analysis; A.W.P. contributed to the methodology; A.S. and H.H.M. assisted in data interpretation and manuscript preparation; M.S. contributed to critical revisions and final approval of the manuscript. All authors have read and agreed to the

published version of the manuscript.

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Ethical Approval

This study was conducted by the ethical standards of the King Faisal University Review Board (ETHICS1,884) to ensure adherence to ethical standards.

Data Availability

The data that support the findings of this study are available upon request.

Ethical Considerations

All procedures performed in studies involving human participants were by the ethical standards of the institutional Committee King Faisal University Review Board and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. For research involving animals, state the care and use committee approval.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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