**Balance and Vestibular Function and Survival in US Cancer Survivors**

Heidy N. Medina, MPH1; Qinran Liu, MPH1; Chao Cao, MPH2; and Lin Yang, PhD3,4

**BACKGROUND:** Cancer and its treatment damage the musculoskeletal system and induce neurotoxicity, affecting the key sensory inputs for maintaining balance. The present study describes the pattern of balance impairment and evaluated its association with mortality among US cancer survivors. **METHODS:** Data on a nationally representative sample of cancer survivors from the US National Health and Nutrition Examination Survey from 1999 to 2015 was analyzed. Sensory-specific balance impairment was measured at baseline by the modified Romberg test of standing balance on firm and compliant support surfaces. The linked mortality data were updated through December 31, 2015. **RESULTS:** Among 511 cancer survivors, 282 (48.3%) had a balance impairment, predominantly attributing to vestibular dysfunction (251; 89.0% of 282 and 44.5% of 511). A higher prevalence of balance impairment was observed among cancer survivors with advanced age, lower socioeconomic status or educational attainment, body mass index <25 kg/m², and an inactive lifestyle. During up to 16.4 years of follow-up (median, 11.3 years; 5088 person-years), 253 cancer survivors had died. Cancer survivors with a balance impairment had a 63% higher risk of death from all causes (hazard ratio, 1.63; 95% confidence interval [CI], 1.12-2.38) after adjusting for sociodemographic factors, comorbidities, and cancer type. Specifically, those with vestibular dysfunctions had approximately 1.54 (95% CI, 1.05-2.27) times the risk of death compared to those without any balance impairment. These associations were stronger in males than in females. **CONCLUSIONS:** In a US nationally representative sample of cancer survivors, balance impairment and vestibular dysfunctions were prevalent and associated with heightened all-cause mortality. **Cancer 2021;0:1-8. © 2021 American Cancer Society.**

**KEYWORDS:** all-cause mortality, balance impairment, cancer survivors, National Health and Nutrition Examination Survey (NHANES), vestibular dysfunction.

**INTRODUCTION**

The population of cancer survivors (ie, any person with a prior cancer diagnosis, from the time of diagnosis until the end of life) in the United States is rapidly growing due to continuous advancements in early detection and treatment of cancer.1 Approximately 15.5 million Americans are currently living with cancer. Coupled with an aging population, this number is projected to increase to 22.1 million by 2030.1 Since 2016, the National Comprehensive Cancer Network established standards for survivorship care that include assessment of late psychosocial, physical, and immunologic effects as well as establishing interventions for the sequela of cancer and its treatment.2 To date, psychological side effects (eg, pain, fatigue, and emotional distress) and cancer-specific side effects (eg, lymphedema, urinary and sexual dysfunctions, and hormonal change) are the most commonly studied outcomes.1,3,4 Accordingly, the American Cancer Society recently noted that population-based information on long-term and late side effects related to physical function problems is limited.1

Cancer treatments induce problems with lower limb strength and balance/walking. Specifically, previous studies reported that 24% and 20% of cancer survivors self-identified as having difficulty with walking and maintaining balance, respectively, which accounted for the most common functional problems.5 Risk factors for balance problems in this unique population include certain chemotherapeutic agents, advanced stages of the disease, brain metastases, and neuropathy.6-9 Patients' cancer-specific symptoms such as fatigue, confusion, and low blood counts contribute to balance problems.10 Additionally, this problem is further exacerbated by the fact that almost 64% of cancer survivors are 65 years of age or older1 and are therefore at a higher risk of age-related balance impairments.
Balance impairments have multiple contributing factors that involve the integration of sensorimotor control systems. Balance incorporates input from vestibular, visual, and proprioceptive systems, integration of sensory inputs by the peripheral nervous system and central nervous system, and response by the musculoskeletal system. Treatment-related neurotoxicity is a well-established problem among cancer survivors. The effects of this neurotoxicity can lead to balance deficiencies that may be due to proprioceptive and/or vestibular deficits. Specifically, chemotherapy-induced peripheral neuropathy (CIPN) not only causes sensory symptoms but also impairs other peripheral nerve function. Past studies have shown that cancer survivors with CIPN symptoms demonstrate balance deficits indicative of somatosensory impairment. In some cases, these symptoms and balance deficits may persist long-term after treatment is completed.

Currently, studies have overwhelmingly focused on studying the relationship between physical function or falls, in general, and mortality in cancer survivors. No study has examined balance impairments in cancer survivors by specific sensory input, specifically, at the population-level. Therefore, the objectives of our study are to describe the patterns and correlates of balance impairment and to evaluate the association between sensory-specific balance impairment and all-cause mortality among a nationally representative sample of cancer survivors in the United States.

MATERIALS AND METHODS

Study Population

Since 1999, the National Center for Health Statistics (NCHS) began to conduct the National Health and Nutrition Examination Survey (NHANES) to monitor the health and nutritional status of the US national, civilian, noninstitutionalized population by using a continuous, complex multistage probability sampling design in 2-year cycles. All NHANES protocols were approved by the NCHS ethics review board. Each participant completed written informed consent, in-person interviews, physical examinations, and laboratory tests in a mobile examination center. Data on sociodemographic, lifestyle factors, and medical conditions were analyzed for adults ≥40 years who reported a cancer diagnosis during the 3 cycles of NHANES from 1999 to 2004 and completed the balance function test.

Diagnosis of Cancer

The medical condition section of the NHANES interview collected data on the history of cancer diagnosis and cancer type. Participants were asked, “Have you ever been told by a physician or other health professional that you had cancer or a malignancy of any kind?” Individuals who responded “Yes” were defined as cancer survivors. Then, the cancer survivors reported up to 3 types of diagnosed cancer. For the purpose of our study, the most common cancer sites that include lung, breast, colorectal, and prostate were considered, and all other sites were grouped as “Other.” Participants who only reported having skin cancer were excluded.

Assessment of Balance Impairment

Balance function was assessed using the modified Romberg test of standing balance on firm and compliant support surfaces performed by trained health technicians. The modified Romberg test procedure is detailed on the NHANES website and available at https://www.cdc.gov/nchs/data/nhanes/ba.pdf. In brief, to ensure safety, participants who could not stand on their own, had a leg brace, or felt dizzy and/or lightheaded were ineligible for the balance function test. The modified Romberg test examines participants’ ability to stand unassisted under 4 test conditions that increase in difficulty. The test condition 1 allows the participant to stand on a firm-padded surface for 15 seconds using all the sensory inputs that contribute to balance, including the vestibular, visual, and proprioceptive (somatosensory) systems. Test condition 2 tests required the participant to close their eyes to eliminate visual input to stand on a firm-padded surface for 15 seconds. In test condition 3, the participant must have maintained their balance on a foam-padded surface for 30 seconds, which reduces the proprioceptive input, leaving only visual and vestibular cues. Finally, in test condition 4, the participant had to stand on a foam pad for 30 seconds with closed eyes and maintain balance using only the vestibular system. Each participant is eligible for an initial test and one retest to pass a specific test condition.

Overall, balance impairment (no/yes) was defined by whether or not participants passed 4 test conditions (no) or failed at any condition (yes). Sensory-specific balance impairments were further classified as visual/proprioceptive (ending the test at conditions 1-3) and vestibular balance impairment (ending the test at condition 4). The severity of vestibular dysfunction was further defined by condition 4 failure time: 15 to <30 and 0 to <15 seconds.

Ascertainment of Mortality

The NCHS provided the NHANES public-use linked mortality file through December 31, 2015, which was
linked to the National Death Index. The International Classification of Diseases, Tenth Revision was used to record the underlying cause of death. The duration of follow-up was defined as the interval (months) from the date of the balance function testing to the date of death or to December 31, 2015, whichever occurred first, for those who were censored. To reduce the probability of reverse causation, deaths that occurred during the first 12 months of follow-up were excluded.

**Sociodemographic and Health-Related Covariates**

Self-reported sociodemographic characteristics included sex, race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and other), educational attainment (<high school, high school, and >high school), and family income (ratio of family income to the federal poverty level: <1.30, 1.30-3.49, or ≥3.5). Lifestyle factors included leisure-time physical activity (inactive vs active, defined as engaging in no or any moderate to vigorous physical activities over the past 30 days at leisure-time), body mass index (BMI; calculated as measured weight divided by the height squared: underweight [<18 kg/m²], normal weight [18.5-24.9 kg/m²], overweight [25.0-29.9 kg/m²], and obese [≥30.0 kg/m²]), smoking status (never, former <20 pack-years, former ≥20 pack-years, former with unknown pack-year, current <20 pack-years, and current ≥20 pack-years), alcohol consumption (derived from 24-hour dietary recall interviews: 0, 0.1-4.9, 5-14.9, 15-29.9, and ≥30 g/d), and the Healthy Eating Index-2010 (HEI-2010, derived from 24-hour dietary recall interviews). HEI-2010 indicates the overall dietary quality with a score ranged from 0 (worst-quality diet) to 100 (best-quality diet).

Hypertension was defined as those participants who have received a prior diagnosis from a health professional or have an NHANES measured the blood pressure of ≥130 mm Hg systolic or ≥80 mm Hg diastolic. Hypercholesterolemia was defined by receiving a diagnosis from a health professional or NHANES measured total cholesterol level of ≥6.2 mmol/L (240 mg/dL). Medical history of chronic diseases (heart disease, stroke, and diabetes) was defined by participants receiving these diagnoses from health professionals or if participants were instructed to take prescribed medications for these conditions.

**Statistical Analysis**

All statistical analyses were conducted following the NHANES analysis guideline. Survey analysis procedures were used to account for sample weights to take into account the nationally representative estimates. Sample sizes, weighted percentage of balance impairment, and 95% confidence intervals (CIs) were estimated overall and according to participants’ sociodemographic characteristics, lifestyle factors, and cancer type. Hazard ratios (HRs) and 95% CIs were estimated using multivariable Cox proportional hazards regression to examine the associations between overall and sensory-specific balance impairment and all-cause survival. Three-stage additive multivariable models were adjusted for age, sex, race/ethnicity, educational attainment, family poverty ratio in the first stage; additionally, leisure-time physical activity, alcohol consumption, BMI, smoking status/intensity, diagnosis of hypertension, hypercholesterolemia, diabetes, cardiovascular disease (CVD), and/or cancer and family history of diabetes and/or CVD in the second stage; finally, cancer type in the third stage. Analyses were conducted for all patients overall and partitioned by females and males. Statistical analyses were done using Stata, version 15.1 (StataCorp, Texas). Statistical tests were two-sided and statistical significance was set at P < .05. Survival curves were produced using R software to illustrate the association between balance impairment and all-cause survival.

**RESULTS**

**Baseline Characteristics**

A total of 511 cancer survivors were included in the analyzed cohort; 282 (48.3%) had a balance impairment, which was predominantly attributed to vestibular dysfunction (251; 89.0% of 282 and 44.5% of 511). Several sociodemographic disparities were observed in the prevalence of balance impairment among cancer survivors (Supporting Table 1). Although there was no difference in the prevalence of balance impairment between females and males, cancer survivors ≥65 years old (67.6%) had a higher prevalence of balance impairment than those adults aged 50 to 64 years (35.2%) and 40 to 49 years (20.9%). A higher prevalence of balance impairment was observed among Hispanics (59.8%) than non-Hispanic Whites (47.8%) and Blacks (38.7%). Balance impairment was also more common among cancer survivors with lower socioeconomic status and educational attainment as well as those with a BMI <25 kg/m² and an inactive lifestyle. With respect to cancer sites, prostate cancer survivors (61.8%) had a considerably higher prevalence of balance impairment than other cancer types. Similar prevalence patterns were seen for vestibular dysfunction overall (Supporting Table 1) and by sex (Supporting Tables 2 and 3).
Balance Impairment and Survival

Table 1 shows the results of survival analyses using the multivariable Cox regressions. During up to 16.4 years of follow-up (median, 11.3 years; 5088 person-years), 253 cancer survivors had died from any causes. Among all cancer survivors, those with a balance impairment had a 63% higher risk of death from all causes (HR, 1.63; 95% CI, 1.12-2.38) (Fig. 1) than those without...
a balance impairment after adjusting for sociodemographic characteristics, lifestyle factors, chronic conditions, and cancer type. Specific to sensory inputs, those with vestibular and visual/proprrioceptive dysfunctions had approximately 1.54 (95% CI, 1.05-2.27) and 2.65 (95% CI, 1.49-4.69) times, respectively, the risk of death compared to those without any balance impairment (Table 1). The results remained after additional adjustment for walking difficulties (Supporting Table 4) and when modeling for cancer-specific and noncancer mortality, respectively (Supporting Tables 5 and 6). Within those with vestibular dysfunction, cancer survivors with the highest severity (ie, the modified Romberg test condition 4 failure time of 0 to <15 seconds) had a higher risk of death (HR, 1.68; 95% CI, 1.11-2.55) in comparison to those without vestibular dysfunction.

Overall, survival differences were noted between females and males (Table 1). Of the 276 females, there were 141 deaths at the end of follow-up, and for the 235 males, 112 deaths were noted. Among male cancer survivors, those with a balance impairment were almost 3.4 times more likely to die from any cause (HR, 3.36; 95% CI, 1.94-5.81) than those without a balance impairment after multivariable adjustment. In addition, dose-response associations were found between failure time at the fourth testing point (specific to vestibular balance dysfunction) and survival ($P_{trend} < .001$).

**DISCUSSION**

In this US nationally representative cohort of cancer survivors, balance impairment affects nearly 50% of the population in both sexes. Notably, the vast majority (89.0%) of balance impairments can be attributed to vestibular dysfunctions. A higher prevalence of balance impairment was observed for older individuals, those of Hispanic ethnicity, those with lower socioeconomic status, and those with a prostate cancer diagnosis. Overall, having a balance impairment as well as having vestibular dysfunction was associated with a 63% and 54%, respectively, higher risk of all-cause death among all cancer survivors over 16 years follow-up after adjusting for sociodemographic and lifestyle factors as well as comorbid conditions. Furthermore, there were notable differences in the observed associations according to sex given that the relationship found between balance impairment and all-cause mortality among males was not present among females.

The present study demonstrated a notable prevalence of balance and vestibular dysfunctions among
cancer survivors. Previous research has shown that 43.0% of the general US population ≥65 years suffers from poor balance function. Therefore, in comparison to this previous report, a higher prevalence (67.6%) of balance impairments was found among the present population of cancer survivors ≥65 years. Additionally, the finding that balance impairments were more prevalent among cancer survivors who were Hispanics or had lower levels of economic status is parallel to the patterns seen among adults of the general US population. These results may be attributed to the racial/ethnic and socioeconomic disparities in the prevalence and management of risk factors and comorbidities, such as hypertension and diabetes, that may impact balance impairments.

In cancer survivors, the malignancy and treatment can cause neurologic, musculoskeletal, and systemic effects that can affect overall balance. These side effects are most common in patients with breast, lung, colon, prostate, and head and neck tumors. In the present study, we analyzed the visual, somatosensory, and vestibular components of postural balance. In terms of impairments to the visual system, optic neuropathy related to chemotherapeutic agents or radiotherapy can be manifested through optic nerve edema, optic neuritis, or in some rare cases, optic atrophy. Agents associated with optic neuropathy include the tyrosine kinase inhibitor imatinib, taxanes, cisplatin, and methotrexate. The somatosensory system may be further aggravated by peripheral neuropathies, CIPN, that develop from nerve damage due to neurotoxic anticancer agents such as taxanes, vinca alkaloids, and platinum compounds. Peripheral neuropathy can cause numbness, weakness, and discomfort or pain to the hands and/or feet. Additionally, there is evidence of vestibular toxicities associated with platinum-based chemotherapy, particularly cisplatin. Sensory hair cell damage and as well as insult to the neurons in the cochlea and vestibular system have been documented with the use of cisplatin. Together, all of these can contribute to the development of balance impairments in cancer survivors. In our study, among all cancer survivors, there was a stronger association between the visual and/or somatosensory input than vestibular dysfunction with all-cause mortality. Therefore, our findings add to the growing evidence that suggests that peripheral neuropathy is an important contributor of balance impairments in cancer patients.

To our knowledge, this analysis is the first comprehensive study that focuses on balance impairment in a nationally representative sample of cancer survivors that identified its association with a higher risk of all-cause mortality. Cao et al previously used data from the same NHANES cycles and demonstrated that the general US adults population with balance impairments had a 44% higher risk of death compared to those without a balance impairment. Meanwhile, in our study, cancer survivors with a balance impairment had a 63% greater likelihood of death than those without a balance impairment. There is an established relationship between physical functioning, in general, and all-cause mortality of cancer survivors in the literature. In previous studies with elderly colorectal and breast cancer patients, the presence of functional limitations was associated with increased all-cause mortality. Functional impairment is independently related to lower use of cancer screening for early detection, changes in initially proposed cancer treatment options, reduced likelihood of undergoing surgery and/or chemotherapy, and poor treatment tolerance. Furthermore, balance problems are recognized as a major risk factor for falls. However, there is currently limited evidence regarding the relationship between falls and overall survival among adults with cancer. The higher prevalence of balance impairment in cancer survivors in comparison to the general US population appears to parallel past findings that have observed that older adults with cancer are more likely to fall than those without. Nevertheless, data in the literature found no association between falls and survival among older adults with multiple myeloma. Because of the overall limited nature of the literature and subset of patients included in studies, future cancer survivorship research is needed to fully understand the relationship between balance impairments and mortality as well as the contributing biological mechanisms.

The statistically significant association of balance and vestibular dysfunction with all-cause mortality among male cancer survivors was not observed for females. This sex difference may be partially explained by the fact that this seems to be an even more prevalent problem among prostate cancer survivors who had the highest prevalence of balance impairment. Men undergoing treatment for prostate cancer have increased functional limitations that may lead to balance problems. Androgen-deprivation therapy, in particular, has been associated with long-term functional decline and an increase in falls. Most importantly, a greater proportion of prostate cancer survivors are older than 65 years than for other common sites such as breast, colorectal, and lung cancer and therefore could partly account for the findings in our study.
From the clinical and public health perspectives, our findings can inform the current understanding of balance impairment risk profile among cancer survivors. Currently, the Centers for Disease Control and Prevention has implemented STEADI (Stopping Elderly Accidents, Deaths, and Injuries), a program that helps health care providers screen elderly patients for fall risk.\(^\text{43}\) The goal is to not only screen patients but also to assess the modifiable risk factors and intervene. The current algorithm takes into consideration gait, strength, and balance problems. Using electronic health records, there has been success in implementing this tool throughout health systems in the United States. However, the target population is limited to older adults, in general. In the oncology setting, the importance of this topic has been historically recognized given the emphasis on performance scales created over 50 years ago such as the Karnofsky performance status and Eastern Cooperative Oncology Group performance status.\(^\text{44,45}\) Nonetheless, traditional functional status scales such as these mainly focus on the assessment of daily living activities but do not take into consideration balance impairments and the contributing sensory input. A major strength of this study is the use of NHANES that includes a nationally representative sample of cancer survivors with detailed exposure and disease obtained data from interviews and examinations. However, some limitations must be noted. Balance testing was conducted using the modified Romberg test rather than a clinical diagnostically instrument such as computerized dynamic posturography that is used to assess vestibular dysfunction. Nevertheless, the Romberg test is a validated screening tool in clinical and research settings.\(^\text{19}\) We also did not have sample size to isolate the contributions from the visual and somatosensory system which are also involved in balance impairments. Furthermore, we could not assess cause-specific survival or by the cancer type. There was a lack of data on tumor- and therapy-related characteristics such as the stage of diagnosis, histology type, and treatment modality. However, to minimize the potential effects of confounding factors, we adjusted for potential predictors of balance and vestibular dysfunction and comorbidities such as age, race/ethnicity, sex, physical activity, alcohol intake, BMI, smoking status, hypertension, hypercholesterolemia, family history of diabetes, family history of CVD, history of diabetes, history of CVD, and cancer type. Finally, NHANES did not collect data on the incidence of falls and disability that could be within the pathway between balance problem and mortality. Nevertheless, our findings remained in sensitivity analyses that additionally adjusted for walking difficulty as a proxy of disability.

Our study suggests that balance impairments may be an important addition to screening for physical functional status among cancer survivors. Screening for poor balance function may be of particular interest among vulnerable minority populations such as Hispanics, as well as individuals with lower socioeconomic status and educational attainment. In our sample of US nationally representative cancer survivors, the impairments of balance and vestibular dysfunction was not only a prevalent issue but was also associated with all-cause mortality. To provide comprehensive survivorship care, future efforts should focus on examining balance impairments in this unique population. By incorporating individualized cancer-specific factors such as cancer type, stage at diagnosis, and treatment, it is possible to prevent, treat, and assess the underlying causes of this cause of morbidity and mortality.

**FUNDING SUPPORT**

Lin Yang was supported by Canadian Cancer Society #707046.

**CONFLICT OF INTEREST DISCLOSURES**

The authors made no disclosures.

**AUTHOR CONTRIBUTIONS**

Heidy N. Medina: Investigation, methodology, study oversight, writing—original draft, and writing—review and editing. Qirnan Liu: Investigation, methodology, writing—original draft, and writing—review and editing. Chao Cao: Design of the present analysis, conceptual ion, data curation, formal analysis, and writing (review and editing). Lin Yang: Design of the present analysis, conceptual ion, data curation, formal analysis, writing (review and editing), supervision, and primary responsibility of the study and the integrity of the content contained herein.

**REFERENCES**

9. Ward PR, Wong MD, Moore R, Naeim A. Fall-related injuries in eld-
nerly cancer patients treated with neurotoxic chemotherapy: a re-
November 2, 2020. https://www.cancer.org/treatment/treatments-
-and-side-effects/physical-side-effects/falls.html#references
11. National Institute on Deafness and Other Communication Disorders.
health/balance-disorders
associated with falls in postmenopausal breast cancer survivors: a mul-
13. Monfort SM, Pan X, Loprinzi CL, Lustberg MB, Chaudhari AMW.
Impaired postural control and altered sensory organization during
quiet stance following neurotoxic chemotherapy: a preliminary study.
Integr Cancer Ther. 2019;18:1534735419828823.
14. Argyriou AA, Kyritsis AP, Makatoris T, Kalofonos HP. Chemotherapy-
induced peripheral neuropathy in adults: a comprehensive update of
15. Winters-Stone KM, Horak F, Jacobs PG, et al. Falls, functioning,
and disability among women with persistent symptoms of chemother-
Matthews CE. Ambulatory function and mortality among cancer sur-
vivors in the NIH-AARP Diet and Health Study. Cancer Epidemiol
17. Clough-Gorr KM, Stuck AE, Thwin SS, Silliman RA. Older breast
cancer survivors: geriatric assessment domains are associated with poor
tolerance of treatment adverse effects and predict mortality over 7 years
18. Brown JC, Harhay MO, Harhay MN. Physical function as a prognosti-
Association of balance function with all-cause and cause-specific
2021;147:460-468.
modified Romberg Balance Test: normative data in U.S. adults. Otol
Traumatol. 2012;77:73-76.
24. Liu CY, Francis JH, Pulido JS, Abramson DH. Ocular side effects of
systemically administered chemotherapy. UpToDate. Updated April 5,
ocular-side-effects-of-systemically-administered-chemotherapy
25. Toft Hansen C, Overcash J, Kip K. Falls in persons with chemotherapy-
reported outcomes during taxane-based chemotherapy in early-stage
27. Winters-Stone KM, Horak F, Jacobs PG, et al. Falls, function-
ing, and disability among women with persistent symptoms of chemother-
physical-side-effects/peripheral-neuropathy/what-is-peripheral-neu-
opathy.html#references
ated with platinum-based chemotherapy in survivors of cancer: a scop-
ing review. Front Oncol. 2018;8:363.
30. Black FO, Myers EN, Schramm VL, et al. Cisplatin vestibular oto-
31. Travis LB, Fossa SD, Sesso HD, et al. Chemotherapy-induced periph-
eral neurotoxicity and otoxicity: new paradigms for translational ge-
32. Koroukian SM, Xu F, Bakaki PM, Diaz-Insua M, Towe TP, Owusu C.
Comorbidities, functional limitations, and geriatric syndromes in
relation to treatment and survival patterns among elders with colorectal
33. Iezzoni LJ, McCarthy EP, Davis RB, Siebens H. Mobility impairments
assessment in the decision-making process in elderly patients with can-
experience in an outpatient geriatric oncology service. Crit Rev Oncol
36. Ganz DA, Latham NK. Prevention of falls in community-dwelling
37. Spoelstra SL, Givin BA, Schutte DL, Sikorskii A, You M, Given
CW. Do older adults with cancer fall more often? A comparative
38. Wildes TM, Fiala MA. Falls in older adults with multiple myeloma. Eur
J Haematol. 2018;100:273-278.
deprivation therapy on physical function and quality of life in men
deficits in older patients with prostate cancer undergoing androgen
41. Hussain S, Breunis H, Timishina N, Alibhai SMH. Falls in men on
androgen deprivation therapy for prostate cancer. J Geriatr Oncol.
42. Miller KD, Nogueira L, Mariotto AB, et al. Cancer treatment and sur-
43. Oken MM, Creech RH, Tormey DC, et al. Toxicity and response cri-
44. Centers for Disease Control and Prevention. STEADI-older adult fall
steadi/index.html
45. Karnofsky DA, Burchenal JH. The clinical evaluation of chemo-
therapeutic agents in cancer. In: Macleod CM, ed. Evaluation of