

# Returning to Sport: Female Athletes Living With and Beyond Cancer

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**Abstract:** Athletes living with and beyond cancer can continue to train and, in some cases, compete during treatment. Following cancer treatment, athletes can return to competitive sport but need to learn to adapt their physical strength and training to lingering effects of cancer. It is critical for oncology healthcare providers to use the principles of assess, refer and advise to exercise oncology programs that are appropriate for the individual. Managing side effects of treatment is key to being able to train during and immediately following cancer treatment. Keen attention to fatigue is important at any point in the cancer spectrum to avoid overtraining and optimize the effects of training.

**Keywords:** cancer, exercise, athletes, competition, long-term effects, late effects, living with and beyond cancer, cancer survivor

## 1. Introduction

While the incidence of cancer is lower among athletes, athletes get cancer too.<sup>1,2</sup> Many continue to train at some level throughout their treatment. Others take a season or more off to get through treatment, recover and return to a competitive level of fitness and strength. The field of exercise oncology, the study of how physical fitness can enhance the lives of people living with beyond cancer, has grown tremendously over the past decade. Despite the exponential growth in the field, we were only able to identify two studies that focused on athletes living with or beyond cancer. One study was a cross-sectional, descriptive survey of 219 of athletic cancer survivors who continued to exercise throughout their treatment and resumed their sport and competition at the conclusion of treatment.<sup>3</sup> The other study assessed perceptions of treatment-related physical fitness, appearance and identity changes of 22 athletes (18-40yo) who were receiving chemotherapy and participating in a group exercise intervention.<sup>4</sup>

There is a large and convincing body of research demonstrating that exercise is beneficial before, during and after cancer treatment.<sup>5-7</sup> As exercise oncology rehabilitation is slowly becoming standard of care, all cancer patients in treatment should be assess, advised and referred to an exercise program that is appropriate for them: supervised by physical or occupational therapist, community based with an exercise oncology trainer, or home based when a patient is capable of exercising without supervision<sup>6,8,9</sup> An exercise oncology referral should be part of the treatment plan for everyone living with and beyond cancer and exercise oncology prescriptions need to be tailored to each individual.<sup>10</sup> When working with athletes, the exercise prescription needs to be focused on the specific sport(s) the athlete specializes in, along with any limitations from surgery or the cancer treatment (e.g. colostomy, risk for lymphedema). Perhaps the most important consideration for the fitness professional working with an athlete during the immediate post treatment period is to understand the extend of the physical and emotional side effects that cancer has had on the individual and how that affects their ability to exercise and perhaps their need for specialized exercise with a rehabilitation professional.

The American College of Sports Medicine Exercise Guidelines for Cancer Survivors is a recommendation for the minimum amount of exercise to prevent cancer, reduce side effects of treatment and improve survivorship.<sup>5</sup> The recommendation is for at least 30 minutes of aerobic exercise 3-days per week and 2 days a week of resistance exercise. Unless an athlete is extremely compromised by their disease, this amount of exercise will be insufficient to minimize their loss of physical condition. What is key for healthcare practitioners is to assess, advise and refer to appropriate rehabilitation to optimize the athlete's opportunities to return to competition in the best condition possible. This paper will discuss exercise considerations during and after treatment, training and competition considerations.

## 2. General Considerations During Cancer Treatment

During treatment, symptom management, is key to success in exercise training. Many side effects of treatment (e.g. nausea, vomiting) can be well controlled with medications. Patients need to learn to aggressively treat their symptoms pre-emptively or immediately after onset to minimize their severity. Healthcare teams should provide adequate instruction for optimal utilization of prescribed medications and symptom management.

While keeping a patient active is critical, exercise may need to be placed on hold or modified until a surgical wound is healed or altered if an ostomy is required for a period of time. While waiting for the body to heal, muscle weakness and fatigue may become problematic side effects. Working with a trained exercise oncology rehabilitation team is important to retain as much strength and cardiopulmonary fitness as possible and work around physical limitations and treatment side effects.

Fatigue is the number one problem experienced by people living with and beyond cancer. It is typically most severe during treatment.<sup>11</sup> A survey of 219 athletic cancer survivors found that they exercised an average of 9 hours per week, but 69% reported fatigue during active treatment and a concomitant decrease in training level during treatment. However, the majority of respondents reported that exercise attenuated their fatigue.<sup>3</sup> There is now a large and convincing body of research that demonstrates that exercise reduces fatigue both during and following cancer treatment.<sup>5,7</sup>

Sun sensitivity is a commonly overlooked side effect that the oncology team needs to discuss as a risk for their athletic cancer patients. Many targeted and immunologic oncology agents (e.g. erlotinib, vemurabinib) can cause significant skin reactions and photosensitivity. Photosensitivity reactions range between 22% to 66% and occur more frequently in the summer.<sup>12</sup> Using broad-spectrum sunscreens with high UVA and wearing sun protective clothing (sunglasses, hat and long sleeves) is important.<sup>13</sup> Alternatively, avoiding the sun and exercising inside whenever possible is probably the safest option to reduce the risk of treatment discontinuation. Even if the sunburn and rashes that are potentiated by the sun do not limit treatment, they can be severe and limit exercise until they are resolved.

Weight change is a disheartening side effect of many cancer regimens. Weight gain increases the risk for recurrence and development of secondary cancers when it is sustained after treatment ends.<sup>14,15</sup> Weight gain is most common in early-stage, non-metastatic, diseases and may impair the success of an athlete when she is able to return to competition. Discussions about changes in body composition (increase fat, decrease lean body mass and bone density) should be disclosed before treatments begin. Early referral to a nutritionist may help to minimize some of these changes along with a well-designed strength training program and psychological support.<sup>16</sup>

### Considerations for Specific Acute, Long-term and Late Effects of Cancer

Cancer and its treatment cause many acute, long-term and late effects that can impair exercise tolerance. Acute side effects occur during treatment and may persist for up to 1-year after the completion of treatment. Unique health concerns may linger for many years after treatment (long-term effects) and new side effects of treatment may develop many years after treatment (late effects). Side effects such as nausea, vomiting and fatigue can be acute and occur during treatment or, in the case of cancer-related fatigue, may linger for many years after treatment and be considered a long-term effect.<sup>11</sup> Late effects include, but are not limited to, hypothyroidism, cardiotoxicities and immune deficiencies. The exercise professional working with a survivor during the immediate post-treatment period needs to understand the potential physical and emotional effects of cancer may affect an athlete's ability to resume exercise training. This is especially true if a treatment regimen was so rigorous that the athlete could not maintain their strength or cardiovascular fitness or is significantly debilitated. Lingering side effects impact each person differently and this must be taken into consideration when developing an exercise prescription.

The following are some of the most common acute, long-term and late effects of treatment:

- Fatigue is the most common side effect both during and following cancer treatment with as many as 90% of patients experiencing fatigue during treatment and 60% of patients having persistent fatigue years after treatment ends.<sup>11</sup> Fatigue that lingers long after treatment ends may be associated with different factors, such as, inactivity, hypothyroidism, cardiac impairment, or depression. Exercise reduces fatigue and fatigue is further reduced when training is for longer than 30 minutes per session.<sup>5,17-19</sup> However, it is unclear what the optimal or maximum duration of training an athlete should engage in, and this will be sport-specific. Athletes often have an above-average awareness of their body and its limitations. Fatigue level is a key indicator in determining how hard or intensely one can train and level of fatigue should be used to modify the training plan.
- Muscle weakness is common and is usually associated with inactivity. Compared to controls, breast cancer survivors who completed chemotherapy had 20-30% less muscle strength.<sup>20</sup> A well-balanced resistance training program can quickly improve and restore the athletes' muscle strength.
- Lymphedema is common after surgery that involves removal of lymph nodes in the axilla or groin. Disruption of the lymphatic system after surgery can cause a build-up of lymph fluid in the affected area and make movement and use of the affected limb difficult and painful. Upper limb lymphedema occurs in 10% to 90% of breast cancer survivors treated with surgery and/or radiation therapy.<sup>21</sup> Resistance exercise needs to be started in a slow methodical manner to systematically progress from very light weights to heavier weights. Resistance exercise can reduce the number and intensity of flares and it is an important part of an exercise prescription.<sup>22</sup>
- Neurotoxicity is associated with chemotherapy agents (e.g. cisplatin, taxanes). These drugs can cause vestibular changes (e.g. vertigo, unsteadiness), ototoxicity, and chemotherapy induced peripheral neuropathy (CIPN). CIPN affects 20-95% of cancer patients and causes numbness and tingling in the hands and/or feet which can be painful and limit functional ability and fine motor skills. CIPN changes can pose significant problems with exercise training and performing fine-motor function, such as descending stairs buttoning a shirt or picking up small items.<sup>23</sup> CIPN may make it difficult to hold exercise equipment and create a challenge to athletes who play racquet sports, volleyball, throwing or kicking sports. Regimens focused on balance training,

endurance and strength training have been shown to reduce symptoms compared to non-trained groups.<sup>24</sup> Balance training appears to have to greatest effect on symptom reduction.<sup>25</sup>

- Cardiac and pulmonary dysfunction (declines in left ventricular function, congestive heart failure, arrhythmias, arterial stenosis, valvular disease, pulmonary fibrosis, bronchiectasis) are reported after treatment with anthracycline (e.g. doxorubicin), taxanes (e.g. paclitaxel) or bleomycin chemotherapy and mediastinal radiation.<sup>26,27</sup> There is a 5-fold increase in cardiotoxicity among patients treated with anthracycline-based chemotherapy for breast or ovarian cancer, lymphoma, myeloma or sarcoma.<sup>28</sup> Some athletes will benefit from clinically supervised exercise and others may be able to obtain medical clearance for community-based exercise program. Cardiopulmonary dysfunction poses a significant threat to the athlete's ability to resume competition at a high level. A case study of a multisport female athlete diagnosed with breast cancer describes the effect of exercise training in reversing the declines in cardiorespiratory fitness that occurred during treatment.<sup>29</sup>
- Endocrine changes can be disrupted by many different cancer treatments. Chemotherapy and radiation therapy can lead to hypothyroidism, infertility, diabetes mellitus, premature menopause and changes in body composition.<sup>30-32</sup> Anti-estrogen drugs (e.g. anastrozole, fluvestrant) can cause arthralgias and bone loss. Immunotherapy drugs (e.g. sunitinib) and checkpoint inhibitors (e.g. ipilimumab) can cause profound endocrine dysregulation including adrenal insufficiency, diabetes, thyroid and pituitary dysfunction. Fatigue can be a manifestation of endocrine dysfunction. Exercise may mitigate some of the arthralgias, declines in bone density and negative changes in body composition.
- Early-onset osteopenia and osteoporosis are common and significant consequences of many treatments including steroids (e.g. dexamethasone), chemotherapy (e.g. doxorubicin) and anti-estrogen (e.g. anastrozole, fluvestrant) drugs. These drugs can waste bone and promote the early onset of osteopenia and osteoporosis. While weight-bearing exercise is important for maintaining bone density, if a woman has clinically-significant decreased bone mass, interventions that have been most effective have followed the ACSM recommendations to preserve bone health in the general population.<sup>32,33</sup> These exercises should produce moderate to high bone loading forces and include aerobic exercise 3 to 5 days per week and 2 to 3 days a week of resistance exercise. Exercises that cause hyperflexion or hyperextension of the trunk and dynamic twisting are contraindicated in women with osteoporosis.<sup>31</sup>
- Impaired immune function may present as a late effect of treatment after bone marrow transplant and B-cell lymphoma. Radiation and immunotherapy drugs (e.g. rituximab) are associated with immunodeficiency disorders.<sup>34,35</sup> Bone marrow transplant and maintenance therapy can lead to late effect impaired immune functions. A literature review of 7 studies examining exercise and immune environment in hematologic malignancies suggests exercise favorably influences the immune system by enhancing cellular functions to decrease inflammation but does not prevent impaired immune function.<sup>36</sup>

### 3. Training Considerations

When developing a training plan for an athlete, the basic principles of exercise training should be considered to develop the optimal program for complete recovery and success. Periodicity, intensity and specificity should be built into each training cycle. Awareness of changes in physical function due to deconditioning or cancer must be considered when developing training programs. The athlete with

cancer may need more days of active rest than their healthy counterparts without cancer. In this population of athletes, it is paramount to maintain a keen awareness of signs of overtraining to guide the athlete and/or coach in modifying training expectations.

It is critical that return to sport considers the safety, functional capacity and functional and physical requirements of the athlete's sport.<sup>37</sup> Anatomical and functional health status must be considered with strength programs devised to focus on muscle strength to areas of weakness. Rehabilitation professionals should be involved in the care of athletes at this stage to ensure that muscular balance is achieved and full range of motion is attained. The goal of rehabilitation should be to restore normal function as much as possible if there is surgical compromise (e.g. lymphedema, large surgical excision). The athlete may be able to continue training with these physical limitations, but should not be involved in team/contact sports until released from rehabilitation and given instruction that it is safe to return to a contact sport. Individual athletes can return to sport as it is deemed safe by their rehabilitation team.

A well-developed individualized training plan will incorporate active rest into the program to accommodate treatment cycles and the physical and emotional stress that comes with building back to a competitive level. The exercise dose may need to be modified for women with significant debilitation, i.e. start low and go slow. Exercise prescription adaptations should be based on side effects and symptoms not only related to cancer treatment but with attention to the interplay of other co-morbidities. Gradual progression of aerobic and resistance exercise is key to success in optimizing recovery of physical functioning to a level that enables the athlete to fully engage in sport and competition.

#### **4. Competition Considerations**

Issues related to returning to competition must consider the individual athlete's physical and emotional condition, along with effects of cancer treatment and the disease itself. While some athletes may return to competition at the level they were at before cancer, others may not be at the same level. These athletes may need support in determining reasonable goals for competition. Readiness for competition is a decision that should be made by the athlete, coach and care team. Realistic expectations should be set for competition so that success is reached and the athlete is not defeated by not attaining previous goals, which can be psychologically destructive.

If an athlete wants to *compete during cancer treatment* special considerations need to be made regarding safety. An athlete in consultation with their coach and cancer care team should discuss the goals of the athlete. From an oncology perspective, a complete blood count (CBC) and a metabolic panel should be reviewed to ascertain the patient's infection risk, bleeding risk, oxygen carrying capacity and electrolyte status. Depending on the level of athlete, data to accurately determine muscle strength and cardiopulmonary condition may help mitigate risk of injury or psychological damage.

*Competition after cancer treatment* is complete poses fewer risks from an oncology perspective. The athlete, coach and care team should review the current physical and emotional state, fitness, strength and mental readiness for competition. There are far fewer reasons to hold an athlete back from competition once they have completed treatment.

#### **4. Resources**

*Cancer Exercise* is an app developed to help athletes exercise during and following cancer. It is tailored to the athlete's current state (on/off treatment, type of treatment and daily fatigue level, etc). *Cancer Exercise* was developed following the principles of exercise physiology, the American College of Sports Medicine exercise guidelines for cancer survivors,<sup>5</sup> the extensive body of research in exercise oncology and clinical

experience. Dynamic algorithms in the *Cancer Exercise* app create an exercise program that is individualized according to the daily condition of the user.

*Moving Through Cancer* is an initiative of the American College of Sports Medicine. It provides resources for fitness and healthcare professionals and people living with and beyond cancer. There are easy to use clinical forms to provide an exercise prescription or referral to an exercise oncology program, patient handouts about the benefits of exercise, a list of exercise oncology certified trainers, and a registry of exercise oncology programs around the world. The website, [www.exerciseismedicine.org/support\\_page.php/moving-through-cancer/](http://www.exerciseismedicine.org/support_page.php/moving-through-cancer/) is regularly updated.

*Athletes Fighting Cancer* uses the power of sport to fight cancer. AFC uses peer navigation in an online forum so athletes can encourage and advise each other in real-time. AFC uses the core values of sport - such as teamwork, mental toughness and understanding your body - to improve lives affected by cancer. AFC believes that anyone who moves their mind and body is an athlete. The organization provides an education center that shares evidence-based information and resources to safely integrate sport into cancer management and survivorship.

*MyVictory* is an at-home exercise and community platform for cancer patients, survivors, and caregivers. MyVictory offers live-streamed and on-demand classes and helps users achieve their goals, reduce risk of recurrence and live healthier, more active lives through exercise.

## 5. Conclusion

Continuing or returning to sport and competition during or following cancer treatment is possible for any athlete and many athletes successfully compete during treatment. Key to success in training and competition is mastering symptom management and developing an understanding of the athlete's body to predict how the athlete will feel after treatment. Even when treatment ends, training may need to be attenuated according to the impact of long-term and late effects of treatment. Special attention to the mental and emotional health of the athlete is essential to optimize performance. Success in the balancing act of training load and symptom management to prevent overtraining is challenging, but maintaining ongoing communication and a healthy relationship between the athlete, coach and care team will provide the foundation for the athlete to excel.

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## References

1. Sormunen J, Bäckmand HM, Sarna S, Kujala UM, Kaprio J, Dyba T, Pukkala E. Lifetime physical activity and cancer incidence—a cohort study of male former elite athletes in Finland. *J Sci Med Sport*. 2014 Sep;17(5):479-84. doi: 10.1016/j.jsams.2013.10.239. Epub 2013 Oct 26. PMID: 24239090.

2. McTiernan A, Friedenreich CM, Katzmarzyk PT, Powell KE, Macko R, Buchner D, Pescatello LS, Bloodgood B, Tennant B, Vaux-Bjerke A, George SM, Troiano RP, Piercy KL; 2018 PHYSICAL ACTIVITY GUIDELINES ADVISORY COMMITTEE\*. Physical Activity in Cancer Prevention and Survival: A Systematic Review. *Med Sci Sports Exerc.* 2019 Jun;51(6):1252-1261. doi: 10.1249/MSS.0000000000001937. PMID: 31095082; PMCID: PMC6527123.
3. Schwartz AL. Patterns of exercise and fatigue in physically active cancer survivors. *Oncology Nursing Forum.* 1998 Apr;25(3):485-491.
4. Adamsen L, Andersen C, Midtgaard J, Møller T, Quist M, Rørth M. Struggling with cancer and treatment: young athletes recapture body control and identity through exercise: qualitative findings from a supervised group exercise program in cancer patients of mixed gender undergoing chemotherapy. *Scand J Med Sci Sports.* 2009;19(1):55-66. doi: 10.1111/j.1600-0838.2007.00767.x. PMID: 18266788.
5. Campbell KL, Winters-Stone KM, Wiskemann J, May AM, Schwartz AL, Courneya KS, Zucker DS, Matthews CE, Ligibel JA, Gerber LH, Morris GS, Patel AV, Hue TF, Perna FM, Schmitz KH. Exercise Guidelines for Cancer Survivors: Consensus Statement from International Multidisciplinary Roundtable. *Med Sci Sports Exerc.* 2019 Nov;51(11):2375-2390. doi: 10.1249/MSS.0000000000002116. PMID: 31626055.
6. Schmitz KH, Campbell AM, Stuiver MM, Pinto BM, Schwartz AL, Morris GS, Ligibel JA, Chevile A, Galvão DA, Alfano CM, Patel AV, Hue T, Gerber LH, Sallis R, Gusani NJ, Stout NL, Chan L, Flowers F, Doyle C, Helmrich S, Bain W, Sokolof J, Winters-Stone KM, Campbell KL, Matthews CE. Exercise is medicine in oncology: Engaging clinicians to help patients move through cancer. *CA Cancer J Clin.* 2019 Nov;69(6):468-484. doi: 10.3322/caac.21579. Epub 2019 Oct 16. PMID: 31617590; PMCID: PMC7896280.
7. Schwartz AL. Fatigue mediates the effects of exercise on quality of life. *Qual Life Res.* 1999 Sep;8(6):529-38. doi: 10.1023/a:1008978611274. PMID: 10548868.
8. Schmitz, KH, Stout, NL, Maitin-Shepard, M, Campbell, A, Schwartz, AL, Grimmert, C, Meyerhardt, J, Sokolof, JM. Moving through cancer: Setting the agenda to make exercise standard in oncology practice. *Cancer.* 2021 Feb 1;127(3):476-484. Doi:10.1002/cncr.33245. Epub 2020 October. PMID: 33090477.
9. Stout, NL, Brown, JC, Schwartz, AL, Marshall, TF, Campbell, AM, Nekhlyudov, L, Zucker, DC, Basen-Enquist, KM, Campbell, G., Meyerhardt, J, Chevile, AL, Covington, KR, Ligibel, JA, Sokolof, JM, Schmitz, KH, Alfano, CM. An exercise oncology clinical pathway: screening and referral for personalized interventions. *Cancer.* 2020 June 15;126(12):2750-2758. PMID: 32212338
10. Silver JK, Baima J, Mayer RS. Impairment-driven cancer rehabilitation: an essential component of quality care and survivorship. *CA Cancer J Clin.* 2013 Sep;63(5):295-317. doi: 10.3322/caac.21186. Epub 2013 Jul 15. PMID: 23856764.
11. Weis J. Cancer-related fatigue: prevalence, assessment and treatment strategies. *Expert Rev Pharmacoecon Outcomes Res.* 2011 Aug;11(4):441-6. doi: 10.1586/erp.11.44. PMID: 21831025.
12. Sanlorenzo M, Choudhry A, Vujic I, Posch C, Chong K, Johnston K, Meier M, Osella-Abate S, Quagliano P, Daud A, Algazi A, Rappersberger K, Ortiz-Urda S. Comparative profile of cutaneous adverse events: BRAF/MEK inhibitor combination therapy versus BRAF monotherapy in melanoma. *J Am Acad Dermatol.* 2014 Dec;71(6):1102-1109.e1. doi: 10.1016/j.jaad.2014.09.002. Epub 2014 Oct 16. PMID: 25440439; PMCID: PMC4254519.
13. Lacouture ME, Anadkat MJ, Bensadoun RJ, Bryce J, Chan A, Epstein JB, Eaby-Sandy B, Murphy BA; MASCC Skin Toxicity Study Group. Clinical practice guidelines for the prevention and treatment of EGFR inhibitor-associated dermatologic toxicities. *Support Care Cancer.* 2011 Aug;19(8):1079-95. doi: 10.1007/s00520-011-1197-6. Epub 2011 Jun 1. PMID: 21630130; PMCID: PMC3128700.

14. Kushi LH, Doyle C, McCullough M, Rock CL, Demark-Wahnefried W, Bandera EV, Gapstur S, Patel AV, Andrews K, Gansler T; American Cancer Society 2010 Nutrition and Physical Activity Guidelines Advisory Committee. American Cancer Society Guidelines on nutrition and physical activity for cancer prevention: reducing the risk of cancer with healthy food choices and physical activity. *CA Cancer J Clin.* 2012 Jan-Feb;62(1):30-67. doi: 10.3322/caac.20140. PMID: 22237782.
15. Rock CL, Doyle C, Demark-Wahnefried W, Meyerhardt J, Courneya KS, Schwartz AL, Bandera EV, Hamilton KK, Grant B, McCullough M, Byers T, Gansler T. Nutrition and physical activity guidelines for cancer survivors. *CA Cancer J Clin.* 2012 Jul-Aug;62(4):243-74. doi: 10.3322/caac.21142. Epub 2012 Apr 26. Erratum in: *CA Cancer J Clin.* 2013 May;63(3):215. PMID: 22539238.
16. Bea JW, De Heer HD, Schwartz AL. Symptom Management: Weight Gain. In: Alberts D, Lluria-Prevatt M, Kha S, Weihs K, editors. *Supportive Cancer Care.* Cham: Springer International Publishing; 2016. p. 241-69.
17. Kelley GA, Kelley KS. Exercise and cancer-related fatigue in adults: a systematic review of previous systematic reviews with meta-analyses. *BMC Cancer.* 2017 Oct 23;17(1):693. doi: 10.1186/s12885-017-3687-5. PMID: 29058631; PMCID: PMC5651567.
18. McNeely ML, Courneya KS. Exercise programs for cancer-related fatigue: evidence and clinical guidelines. *J Natl Compr Canc Netw.* 2010 Aug;8(8):945-53. doi: 10.6004/jnccn.2010.0069. PMID: 20870638.
19. Meneses-Echávez JF, González-Jiménez E, Ramírez-Vélez R. Effects of Supervised Multimodal Exercise Interventions on Cancer-Related Fatigue: Systematic Review and Meta-Analysis of Randomized Controlled Trials. *Biomed Res Int.* 2015;2015:328636. doi: 10.1155/2015/328636. Epub 2015 Jun 17. PMID: 26167483; PMCID: PMC4488083.
20. Harrington S, Padua D, Battaglini C, Michener LA, Giuliani C, Myers J, Groff D. Comparison of shoulder flexibility, strength, and function between breast cancer survivors and healthy participants. *J Cancer Surviv.* 2011 Jun;5(2):167-74. doi: 10.1007/s11764-010-0168-0. Epub 2011 Jan 12. PMID: 21225372.
21. Hayes SC, Johansson K, Stout NL, Prosnitz R, Armer JM, Gabram S, Schmitz KH. Upper-body morbidity after breast cancer: incidence and evidence for evaluation, prevention, and management within a prospective surveillance model of care. *Cancer.* 2012 Apr 15;118(8 Suppl):2237-49. doi: 10.1002/cncr.27467. PMID: 22488698.
22. Schmitz KH, Ahmed RL, Troxel A, Cheville A, Smith R, Lewis-Grant L, Bryan CJ, Williams-Smith CT, Greene QP. Weight lifting in women with breast-cancer-related lymphedema. *N Engl J Med.* 2009 Aug 13;361(7):664-73. doi: 10.1056/NEJMoa0810118. PMID: 19675330.
23. Holz SC, Wininger YD, Cooper C, Smith SR. Managing Neuropathy After Chemotherapy in Patients With Cancer. *Arch Phys Med Rehabil.* 2017 Mar;98(3):605-607. doi: 10.1016/j.apmr.2016.08.461. PMID: 28232002.
24. Kleckner I, Kamen CS, Peppone LJ, et al. A URCC NCORP nationwide randomized controlled trial investigating the effect of exercise on chemotherapy-induced peripheral neuropathy in 314 cancer patients. *J Clin Oncol.* 2016;34(15\_Suppl). doi: 10.1200/JCO.2016.34.15\_suppl.10000
25. Lin WL, Wang RH, Chou FH, Feng JJ, Fang CJ, Wang HH. The effects of exercise on chemotherapy-induced peripheral neuropathy symptoms in cancer patients: a systematic review and meta-analysis. *Support Care Cancer.* 2021 Mar 4. doi: 10.1007/s00520-021-06082-3. Epub ahead of print. PMID: 33660078.
26. Carver JR, Shapiro CL, Ng A, Jacobs L, Schwartz C, Virgo KS, Hagerty KL, Somerfield MR, Vaughn DJ; ASCO Cancer Survivorship Expert Panel. American Society of Clinical Oncology clinical evidence review on the ongoing care of adult cancer survivors: cardiac and pulmonary late effects. *J Clin Oncol.* 2007 Sep 1;25(25):3991-4008. doi: 10.1200/JCO.2007.10.9777. Epub 2007 Jun 18. PMID: 17577017.

27. Koelwyn GJ, Khouri M, Mackey JR, Douglas PS, Jones LW. Running on empty: cardiovascular reserve capacity and late effects of therapy in cancer survivorship. *J Clin Oncol*. 2012 Dec 20;30(36):4458-61. doi: 10.1200/JCO.2012.44.0891. Epub 2012 Oct 8. PMID: 23045598; PMCID: PMC3518726.
28. Smith LA, Cornelius VR, Plummer CJ, Levitt G, Verrill M, Canney P, Jones A. Cardiotoxicity of anthracycline agents for the treatment of cancer: systematic review and meta-analysis of randomised controlled trials. *BMC Cancer*. 2010 Jun 29;10:337. doi: 10.1186/1471-2407-10-337. PMID: 20587042; PMCID: PMC2907344.
29. Savage PD, Dittus K, Lakoski SG. Fitness during Breast Cancer Treatment and Recovery in an Athlete: A Case Study. *Med Sci Sports Exerc*. 2016 Oct;48(10):1893-7. doi: 10.1249/MSS.0000000000000987. PMID: 27187100.
30. Gebauer J, Higham C, Langer T, Denzer C, Brabant G. Long-Term Endocrine and Metabolic Consequences of Cancer Treatment: A Systematic Review. *Endocr Rev*. 2019 Jun 1;40(3):711-767. doi: 10.1210/er.2018-00092. PMID: 30476004.
31. Winters-Stone KM, Schwartz AL, Hayes SC, Fabian CJ, Campbell KL. A prospective model of care for breast cancer rehabilitation: bone health and arthralgias. *Cancer*. 2012 Apr 15;118(8 Suppl):2288-99. doi: 10.1002/cncr.27465. PMID: 22488703.
32. Toriola AT, Liu J, Ganz PA, Colditz GA, Yang L, Izadi S, Naughton MJ, Schwartz AL, Wolin KY. Effect of weight loss on bone health in overweight/obese postmenopausal breast cancer survivors. *Breast Cancer Res Treat*. 2015 Aug;152(3):637-43. doi: 10.1007/s10549-015-3496-y. Epub 2015 Jul 15. PMID: 26175059; PMCID: PMC4521978.
33. Kohrt WM, Bloomfield SA, Little KD, Nelson ME, Yingling VR; American College of Sports Medicine. American College of Sports Medicine Position Stand: physical activity and bone health. *Med Sci Sports Exerc*. 2004 Nov;36(11):1985-96. doi: 10.1249/01.mss.0000142662.21767.58. PMID: 15514517.
34. Kaplan B, Kopyltsova Y, Khokhar A, Lam F, Bonagura V. Rituximab and immune deficiency: case series and review of the literature. *J Allergy Clin Immunol Pract*. 2014 Sep-Oct;2(5):594-600. doi: 10.1016/j.jaip.2014.06.003. Epub 2014 Aug 7. PMID: 25213054.
35. Odnoletkova I, Kindle G, Quinti I, Grimbacher B, Knerr V, Gathmann B, Ehl S, Mahlaoui N, Van Wilder P, Bogaerts K, de Vries E; Plasma Protein Therapeutics Association (PPTA) Taskforce. The burden of common variable immunodeficiency disorders: a retrospective analysis of the European Society for Immunodeficiency (ESID) registry data. *Orphanet J Rare Dis*. 2018 Nov 12;13(1):201. doi: 10.1186/s13023-018-0941-0. PMID: 30419968; PMCID: PMC6233554.
36. Sitlinger A, Brander DM, Bartlett DB. Impact of exercise on the immune system and outcomes in hematologic malignancies. *Blood Adv*. 2020 Apr 28;4(8):1801-1811. doi: 10.1182/bloodadvances.2019001317. PMID: 32343800; PMCID: PMC7189285.
37. Metz J, McElheny K, Robinson JN, Scott DA, Sutton KM, Toresdahl BG. Considerations for Return to Exercise Following Mild-to-Moderate COVID-19 in the Recreational Athlete. *HSS J*. 2020 Aug 10;16(Suppl 1):1-6. doi: 10.1007/s11420-020-09777-1. Epub ahead of print. PMID: 32837412; PMCID: PMC7416806.