Breast Cancer Research and Treatment (2019) 176:395–400
https://doi.org/10.1007/s10549-019-05263-3

CLINICAL TRIAL

Establishing physical activity in breast cancer: self-report versus activity tracker

Chad W. Wagoner[1] · Seul K. Choi[3] · Allison M. Deal[2] · Jordan T. Lee[1] · William A. Wood[2] · Hyman B. Muss[2] · Kirsten A. Nyrop[2]

Received: 28 March 2019 / Accepted: 26 April 2019 / Published online: 30 April 2019

Abstract

Purpose Establishing accurate estimates of physical activity at baseline is essential for interventions assessing the potential benefits of exercise in adults with cancer. This study compares self-reported physical activity with independent data from activity trackers in women with early breast cancer (BC) recruited into a "walking" intervention during chemotherapy.

Methods Baseline (pre-intervention) questions inquired about self-reported physical activity—number of walking days/week and minutes/day—in women who were initiating chemotherapy for Stage I–III BC. Activity trackers measured steps per day during the first full week of chemotherapy. Weighted Kappa statistic and Pearson correlation coefficients were used to evaluate agreement and association between self-reported and objectively tracked physical activity levels, respectively. Univariate analyses were conducted to identify variables that may influence congruence between the two measures.

Results In a sample of 161 women, 77% were white, with mean age 56 years. Agreement between self-reported and objectively tracked physical activity was "fair" (kappa coefficient = 0.31), with most patients (59%) over-reporting their physical activity levels. There was weak correlation between the two measures ($r = 0.24$); however, correlation was strong in participants who were not married ($r = 0.53$) and/or living alone ($r = 0.69$).

Conclusions Objective methods for assessing physical activity (activity trackers, accelerometers) should be used as a complement to self-reported measures to establish credible activity levels for intervention studies seeking to increase physical activity and/or measure the impact of increased physical activity in women with breast cancer.

Keywords Exercise interventions · Fitbit · Garmin · Oncology · Questionnaire · Walking

Introduction

The importance of physical activity and exercise promotion within oncology has received increased attention over the past several decades. In 2010, the American College of Sports Medicine (ACSM) published exercise guidelines for cancer survivors recommending that patients aim for 150 min of moderate physical activity or 75 min of vigorous physical activity per week [1]. For adults receiving primary cancer treatment (surgery, chemotherapy, radiation treatment), guidelines suggest that the minimum goal should be maintaining pre-treatment physical activity, focusing on individual patient preference and abilities [2].

Most exercise oncology studies to date have been conducted in women diagnosed with breast cancer primarily in the post-treatment setting, producing efficacious outcomes pertaining to quality of life and cancer-related fatigue [3–5], as well as improved overall fitness and patient-reported outcomes including increased physical fitness, less depression, and less anxiety [6–8]. Self-directed, home-based exercise programs have gained particular attention as an alternative to time and resource intensive on-site programs with trained

✉ Chad W. Wagoner
chadwago@live.unc.edu

[1] Exercise Oncology Research Laboratory, Department of Exercise and Sport Science, University of North Carolina at Chapel Hill, Campus Box #8700, Chapel Hill, NC 27599, USA

[2] Division of Hematology Oncology, Department of Medicine, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

[3] Department of Health Behavior, School of Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

personnel, and show outcomes comparable to those of supervised programs [9].

Whether the exercise intervention is supervised or home-based, it is important to establish baseline (pre-intervention) physical activity levels in order to properly evaluate the effectiveness of the exercise intervention itself. Without accurate determination of baseline physical activity levels, quantification of the true impact of an exercise intervention to increase physical activity is substantially hindered. With increased physical activity engagement being the primary endpoint of many exercise intervention studies, this issue warrants significant attention.

Baseline physical activity can be measured by self-report questionnaire or by an accelerometer (activity tracker) that is worn for at least a week; a common length of time that has been utilized in large-scale trials evaluating activity trackers [10]. Self-report questionnaires are quick and easy to administer, and require the patient to recall physical activity habits with regard to duration, type, intensity, and frequency of exercise, within the timeframe of the past 7 days. Well-established studies such as the National Health and Nutrition Survey (NHANES) have a long history of self-reported physical activity [11], but few studies have shown that self-report can provide an accurate measure of physical activity when compared to accelerometers [12, 13]. On the other hand, when compared to accelerometers that provide an objective measure physical activity, subjective self-reports tend to over-report physical activity levels and under-report sedentary time as observed in non-cancer samples [14–19]. The question of self-reported compared to objectively measured baseline physical activity has not been well explored in exercise oncology despite a recent study reporting discrepancies in a sample of mixed cancer diagnoses [20].

As an ancillary investigation to three larger studies pertaining to the potential benefits of exercise during chemotherapy, we revisit the issue of self-report versus observed physical activity in a sample of women with early-stage breast cancer, using self-report questionnaires and activity tracker data collected in the first full week of chemotherapy. By comparing self-reported with objective measures, we hope to gain a better understanding of how to assess and interpret self-reported physical activity levels in both exercise intervention research and clinical practice.

Methods

Study participants

The patient population for our study was drawn from participants in two recently completed studies (NCT01789983, NCT02167932) and one on-going investigation (NCT02328313) of exercise during chemotherapy. Women aged 21 or older diagnosed with early breast cancer (Stage I–III) and scheduled to start chemotherapy were recruited for these studies. Details regarding the sample have been published elsewhere [21]. Patients were approached in clinic before starting chemotherapy and provided written informed consent to participate. Informed consent was obtained from all individual participants included in the study. The intervention studies were approved by the Protocol Review Committee of the Lineberger Comprehensive Cancer Center and the Institutional Review Board of the University of North Carolina at Chapel Hill.

Physical activity measures

Self-reported walking

Baseline (pre-chemotherapy initiation) self-reported physical activity was assessed through two questions: (1) "On average, how many days a week do you go for a walk for at least 10 min, for any reason, in and around your neighborhood or elsewhere?" and (2) "On average, how much time do you usually spend per day when you go for a walk in and around your neighborhood or elsewhere?" Walking days and minutes were multiplied to compute total walking minutes/week.

Behavioral risk factor surveillance system (BRFSS) health behavior questionnaire (HBQ)

Baseline self-reported vigorous physical activity was assessed using the BRFSS-HBQ [22]. This questionnaire focuses on engagement (frequency and duration) in vigorous physical activity for at least 10 min that is accompanied by heavy sweating or significant increases in heart rate or breathing.

Accelerometer

At baseline, patients were equipped with a Fitbit (Fitbit Inc., San Francisco CA) or Garmin Vivo (Garmin International Inc., Olathe KS) activity tracker to provide an objective measure of step count. Activity tracker email accounts were set up for each patient, and data were uploaded into a research computer during regularly scheduled chemotherapy infusion visits. For the current study, activity tracker steps collected in the first full week of chemotherapy were used for analyses. Total step count for the week was divided by seven to calculate the average daily step count.

Categorizing activity levels

We have previously reported [21] that 6286 steps/day is an approximation of the number of steps required to achieve

the recommended amount of walking 150 min/week [2, 23], walking at a moderate pace (60 steps/min). Accordingly, self-reported walking less than 50 min/week calculated to less than 3000 steps/day, self-reported walking of 50–100 min/week calculated to 3000–6000 steps/day, and self-reported walking of 100 min/week or more calculated to 6000 or more steps/day. For each of these three levels, the corresponding physical activity designation was "Very Low," "Low," and "Moderate," respectively. Women who had "0" recorded steps/week or were averaging fewer than 500 steps/day were excluded from analyses because there was a strong possibility that they were not wearing their activity tracker as directed from the moment they rose in the morning until they went to bed at night. Additionally, patients who did not provide self-reported baseline physical activity were also excluded from the analyses. A flowchart of patient exclusion criteria for the present study is provided in Fig. 1.

Demographic and clinical characteristics

Electronic medical records (Epic@UNC) were reviewed for information regarding breast cancer diagnosis and treatment, height, weight, and body mass index (BMI). Study participants provided demographic information via questionnaire pertaining to age, race, education, marital status, current living situation, and employment status.

Statistical analysis

Descriptive statistics were used to characterize the sample. Pearson correlation coefficients and weighted Kappa statistics were used to evaluate the association and level of agreement between activity tracker physical activity and self-reported physical activity, respectively [24]. A priori cut points for interpreting the Kappa coefficient were < 0.20 = poor agreement, 0.20–0.39 = fair, 0.40–0.59 = moderate, 0.60–0.79 = good, 0.80–0.99 = very good, and 1 = perfect. A priori interpretation of the Pearson correlation coefficient was 0–0.1 none/very weak, 0.1–0.3 weak, 0.4–0.5 moderate, and > 0.5 strong. Subgroup analysis was conducted to identify factors (age, race, education, marital status, living alone, employment, BMI, tumor stage) that might influence the correlation between self-report and activity tracker estimates.

Results

Demographics

Baseline characteristics for the sample ($N = 161$) are presented in Table 1. Mean age was 56 (range 24–78), 23% were non-white, 14% had a high school education or less, 41% were not married, 20% were living alone, and 63% were not employed more than 32 h per week. BMI was characterized as follows: 1% underweight, 26% normal weight, 38% overweight, and 35% obese.

Physical activity level: self-report compared to activity tracker

The weighted Kappa statistics for self-reported and activity tracker agreement was 0.31, indicating "fair" agreement between the two measures. Percentages for each measure are illustrated in Fig. 2. 59% of study participants self-reported walking a "moderate" amount of 100 min/week at baseline, while activity tracker data for the first week showed that only 33% of participants actually walked the equivalent in terms of step data. "Very low" levels of walking were self-reported by 23% of participants; however, activity tracker data placed 33% of participants in this category.

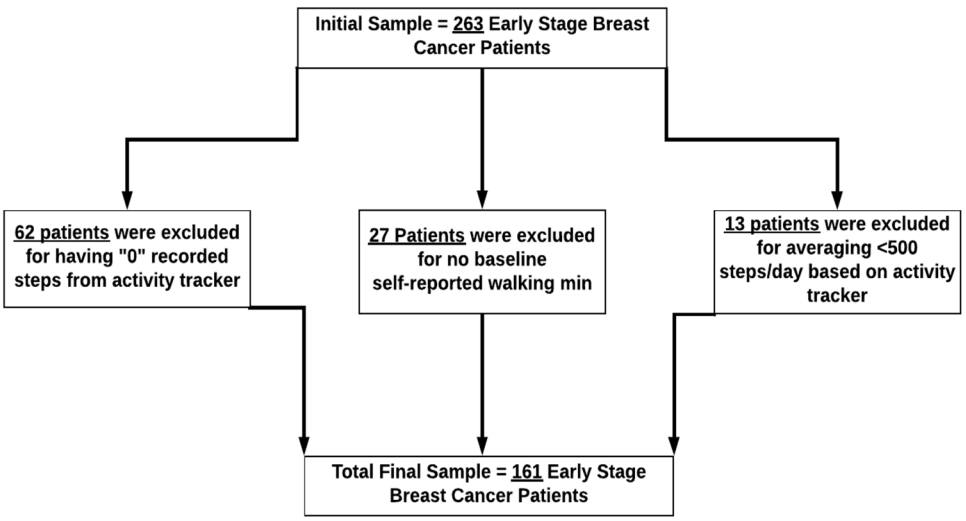

Fig. 1 Study sample exclusion flowchart

Table 1 Study participant characteristics ($N = 161$)

Variable	Mean (standard deviation) or number (percent)
Age	56.3 (12.1)
Race	
White	123 (77.4)
African American or other	36 (22.6)
Education	
High school or less	22 (13.8)
More than high school	137 (86.2)
Married	
No	65 (41.1)
Yes	93 (58.9)
Living alone	
No	125 (80.1)
Yes	31 (19.9)
Employed more than 32 h a week	
No	97 (63.4)
Yes	56 (36.6)
Body mass index (BMI)	
Underweight	2 (1.3)
Normal (18.5–25)	41 (25.8)
Overweight (25–30)	60 (37.7)
Obese I (30–35)	31 (19.5)
Obese II (greater than 35)	25 (15.7)
Health behavior questionnaire (HBQ): vigorous minutes per week	22.9 (24.8)
Total self-reported walking minutes per week for exercise or pleasure	137 (125)
Average daily activity tracker steps	4777 (3119)
Breast cancer stage	
I	38 (24.4)
II	78 (50.0)
III	40 (25.6)

Overall, Pearson correlation between self-report physical activity levels and activity tracker-based physical activity was weak ($r = 0.24$). In Table 2, we present correlation coefficients between the two measures separately for demographic subgroups. Only two demographic characteristics showed large differences in the strength of correlation between subgroups; patients who were not married and lived alone had much stronger correlation between self-reported walking and activity tracker steps compared to those in the other subgroups. No differences in correlation were seen for other demographic subgroups ("Age," "Race," "Education," "Employed more than 32 Hours/Week," "BMI," and "Breast Cancer Stage").

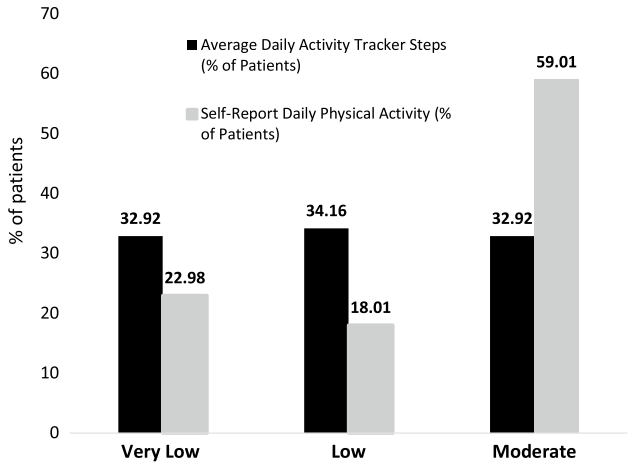

Fig. 2 Activity Tracker versus self-report physical activity levels. Activity tracker and self-reported physical activity were compared within three different categories. Patients were grouped based on the following activity tracker step criteria: Very Low ≤ 3000 steps/day; Low = 3000–6000 steps/day; Moderate ≥ 6000 steps/day. The same patients were then allocated to the different physical activity level groups based on their self-reported walking data: Very Low ≤ 50 min/week; Low = 50–100 min/week; Moderate ≥ 100 min/week

Discussion

To our knowledge, this is the first study in a large sample of women with early-stage breast cancer starting chemotherapy that compared self-reported with activity tracker data prior to the initiation of an exercise intervention. We found only modest kappa agreement between the two measures of physical activity when categorized into three levels (very low, low, and moderate) and low correlation between the two measures as continuous variables. Interestingly, participants who were living alone and/or not married were the most accurate in self-reporting their physical activity levels.

Our findings are in line with the previous studies in the non-oncology setting suggesting that older adults, adolescents, and certain clinical populations (COPD patients, gastric bypass patients, fibromyalgia patients) over-report their physical activity levels when compared to activity tracker-derived measures of physical activity [14, 17, 18, 25, 26]. Our finding of over-reporting in self-reported data also concurs with findings in a study of adults with colon cancer [27], as well as a mixed sample of adults with cancer (~53% breast cancer) [20]. It should be noted that that the final sample in the present study includes patients that wore two different activity trackers (Fitbit Zip or Garmin Vivo) that, to our knowledge, have not been validated against each other. However, both brands have been validated with research-grade accelerometers (Actigraph) in their ability to track step count when worn on the wrist or hip [28, 29]. Further, we did not adjust our analysis for wear-time based

Table 2 Correlation between self-reported and activity tracker steps/day, unadjusted analysis, demographic variables

Variable	Correlation coefficient
Age	
≥ 65	0.34
< 65	0.23
Race	
White	0.23
African American or other	0.42
Education	
High school or less	0.07
More than high school	0.24
Married	
No	0.53[a]
Yes	0.07
Living alone	
No	0.16
Yes	0.69[a]
Employed more than 32 h a week	
No	0.24
Yes	0.23
Body mass index (BMI)	
Normal/overweight	0.32
Obese I/II	0.11
Breast cancer stage	
I/II	0.30
III	0.09

[a]Denotes a significant correlation coefficient indicating a high congruence between self-reported physical activity and activity tracker based physical activity

on hourly data, as our chosen activity trackers did not allow for this type of deeper analysis.

The seeming disconnect between self-reported and objectively measured activity data is of concern for establishing a true baseline for assessing the effectiveness of exercise interventions. A common endpoint of exercise interventions in cancer populations is assessing whether physical activity increased or decreased in response to the intervention. Self-reported physical activity assessments that do not mirror reality can result in imprecise characterizations of the sample population at baseline (e.g., over-estimation of baseline physical activity levels), lead to erroneous claims that the intervention actually "changed behavior" (e.g., increased the sample's physical activity), and/or undermine conclusions that the exercise intervention did or did not impact other study outcomes. It is also possible that individualized exercise programs prescribed based on self-reported physical activity could elicit inappropriate training volume, thus not allowing for proper progression of exercise throughout the intervention.

Although self-reported physical activity can provide valuable insights into what the study participants perceive as physical activity, our findings suggest that activity trackers that objectively assess physical activity should be used in conjunction for a more comprehensive characterization of physical activity in exercise oncology research. Commercially available activity trackers are now relatively inexpensive and allow for direct uploads of individual tracker data into research computers. Certain activity trackers can also provide information regarding exercise intensity by measuring heart rate, which is often disregarded by physical activity questionnaires that simply provide information on frequency and duration of self-perceived moderate intensity physical activity. For example, for two different patients who record similar step count averages, an activity tracker can provide useful information about the intensity of the activities that make-up the total step count (i.e., jogging vs. walking; running errands vs. lifting weights). This information can then be used to decipher the degree of physical activity (moderate to high physical activity) and who is sedentary prior to starting treatment. Self-reported physical activity remains an important and feasible source of data, especially for population-based studies; however, intervention studies testing the benefits of self-directed exercise require independent measures of physical activity to provide the best possible measure of intervention fidelity and, hence, impact on primary outcomes.

Acknowledgements We thank Tucker Brenizer, Erin O'Hare, Nicole Markowski, and Amy Garrett for their efforts and commitment to the present study. We appreciate the continued support from breast oncology providers and the willingness of breast cancer patients to participate in our studies.

Funding This study was supported by the Breast Cancer Research Foundation (New York), Kay Yow Foundation (Raleigh NC), and UNC Lineberger Comprehensive Cancer Center/University Cancer Research Fund (Chapel Hill NC).

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Research involving human participants and/or animals All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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

References

1. Schmitz KH, Courneya KS, Matthews C et al (2010) American College of Sports Medicine roundtable on exercise guidelines for

cancer survivors. Med Sci Sport Exerc 42:1409–1426. https://doi.org/10.1249/MSS.0b013e3181e0c112
2. Rock CL, Doyle C, Demark-Wahnefried W et al (2012) Nutrition and physical activity guidelines for cancer survivors. CA Cancer J Clin 62:243–274. https://doi.org/10.3322/caac.21142
3. Zhang X, Li Y, Liu D (2018) Effects of exercise on the quality of life in breast cancer patients: a systematic review of randomized controlled trials. Support Care Cancer. https://doi.org/10.1007/s00520-018-4363-2
4. Lahart IM, Metsios GS, Nevill AM, Carmichael AR (2018) Physical activity for women with breast cancer after adjuvant therapy. Cochrane Database Syst Rev 1:CD011292. https://doi.org/10.1002/14651858.CD011292.pub2
5. Kessels E, Husson O, van der Feltz-Cornelis CM (2018) The effect of exercise on cancer-related fatigue in cancer survivors: a systematic review and meta-analysis. Neuropsychiatr Dis Treat 14:479–494. https://doi.org/10.2147/NDT.S150464
6. Courneya KS, Segal RJ, Mackey JR et al (2007) Effects of aerobic and resistance exercise in breast cancer patients receiving adjuvant chemotherapy: a multicenter randomized controlled trial. J Clin Oncol 25:4396–4404. https://doi.org/10.1200/JCO.2006.08.2024
7. Furmaniak AC, Menig M, Markes MH (2016) Exercise for women receiving adjuvant therapy for breast cancer. Cochrane Database Syst Rev 9:CD005001. https://doi.org/10.1002/14651858.CD005001.pub3
8. Van Dijck S, Nelissen P, Verbelen H et al (2016) The effects of physical self-management on quality of life in breast cancer patients: a systematic review. Breast 28:20–28. https://doi.org/10.1016/j.breast.2016.04.010
9. van Waart H, Stuiver MM, van Harten WH et al (2015) Effect of low-intensity physical activity and moderate- to high-intensity physical exercise during adjuvant chemotherapy on physical fitness, fatigue, and chemotherapy completion rates: results of the PACES randomized clinical trial. J Clin Oncol 33:1918–1927. https://doi.org/10.1200/jco.2014.59.1081
10. Loprinzi PD, Lee H, Cardinal BJ et al (2012) The relationship of actigraph accelerometer cut-points for estimating physical activity with selected health outcomes: results from NHANES 2003–2006. Res Q Exerc Sport. https://doi.org/10.1080/02701367.2012.10599877
11. Centers for Disease Control and Prevention (CDC) and National Center for Health Statistics (NCHS) (2018) National health and nutrition examination survey data
12. Jovanovic JL, Hughes DC, Baum GP et al (2011) Accelerometry and self-report in sedentary populations. Am J Health Behav 35:71–80
13. Milton K, Clemes S, Bull F (2013) Can a single question provide an accurate measure of physical activity? Br J Sports Med 47:44–48. https://doi.org/10.1136/bjsports-2011-090899
14. Herbolsheimer F, Riepe MW, Peter R (2018) Cognitive function and the agreement between self-reported and accelerometer-accessed physical activity. BMC Geriatr 18:56. https://doi.org/10.1186/s12877-018-0747-x
15. Shadyab AH, Macera CA, Shaffer RA et al (2017) Associations of accelerometer-measured and self-reported sedentary time with leukocyte telomere length in older women. Am J Epidemiol 185:172–184. https://doi.org/10.1093/aje/kww196
16. Neil-Sztramko SE, Ghayyur A, Edwards J, Campbell KL (2017) Physical activity levels of physiotherapists across practice settings: a cross-sectional comparison using self-report questionnaire and accelerometer measures. Physiother Can 69:152–160. https://doi.org/10.3138/ptc.2015-64
17. Sievi NA, Brack T, Brutsche MH et al (2017) Accelerometer- versus questionnaire-based assessment of physical activity and their changes over time in patients with COPD. Int J Chron Obstruct Pulm Dis 12:1113–1118. https://doi.org/10.2147/COPD.S130195
18. Berglind D, Willmer M, Tynelius P et al (2016) Accelerometer-measured versus self-reported physical activity levels and sedentary behavior in women before and 9 months after roux-en-Y gastric bypass. Obes Surg 26:1463–1470. https://doi.org/10.1007/s11695-015-1971-5
19. James P, Weissman J, Wolf J et al (2016) Comparing GPS, log, survey, and accelerometry to measure physical activity. Am J Health Behav 40:123–131. https://doi.org/10.5993/AJHB.40.1.14
20. Vassbakk-Brovold K, Kersten C, Fegran L et al (2016) Cancer patients participating in a lifestyle intervention during chemotherapy greatly over-report their physical activity level: a validation study. BMC Sport Sci Med Rehabil 8:10. https://doi.org/10.1186/s13102-016-0035-z
21. Nyrop KA, Deal AM, Choi SK et al (2018) Measuring and understanding adherence in a home-based exercise intervention during chemotherapy for early breast cancer. Breast Cancer Res Treat 168:43–55. https://doi.org/10.1007/s10549-017-4565-1
22. Centers for Disease Control and Prevention (CDC) (2011) Behaviorial risk factor surveillance system survey data
23. Doyle C, Kushi LH, Byers T et al (2006) Nutrition and physical activity during and after cancer treatment: an American Cancer Society guide for informed choices. CA Cancer J Clin 56:323–353
24. Altman DG (2006) Practical statistics for medical research. Chapman & Hall/CRC Press, Boca Raton
25. Downs A, Van Hoomissen J, Lafrenz A, Julka DL (2014) Accelerometer-measured versus self-reported physical activity in college students: implications for research and practice. J Am Coll Health 62:204–212. https://doi.org/10.1080/07448481.2013.877018
26. Benitez-Porres J, Delgado M, Ruiz JR (2013) Comparison of physical activity estimates using international physical activity questionnaire (IPAQ) and accelerometry in fibromyalgia patients: the Al-Andalus study. J Sports Sci 31:1741–1752. https://doi.org/10.1080/02640414.2013.803594
27. Boyle T, Lynch BM, Courneya KS, Vallance JK (2015) Agreement between accelerometer-assessed and self-reported physical activity and sedentary time in colon cancer survivors. Support Care Cancer 23:1121–1126. https://doi.org/10.1007/s00520-014-2453-3
28. Reid RER, Insogna JA, Carver TE et al (2017) Validity and reliability of Fitbit activity monitors compared to ActiGraph GT3X+ with female adults in a free-living environment. J Sci Med Sport 20:578–582. https://doi.org/10.1016/j.jsams.2016.10.015
29. Hochsmann C, Knaier R, Eymann J et al (2018) Validity of activity trackers, smartphones, and phone applications to measure steps in various walking conditions. Scand J Med Sci Sports 28:1818–1827. https://doi.org/10.1111/sms.13074