Effectiveness of Non-pharmacologic Interventions on Device-measured Physical Activity in Adults With Cancer, and Methodology Used for Assessment: A Systematic Review and Meta-analysis

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Effectiveness of non-pharmacological interventions on device-measured physical activity in adults with cancer, and methodology used for assessment: a systematic review and meta-analysis

Objective

To investigate the effectiveness of different types of interventions aimed at enhancing device-measured physical activity (PA), and summarize the devices and methodologies used to measure PA in adults with cancer.

Data Sources

A systematic review was prospectively registered on PROSPERO (CRD42020199466). The search was conducted in PubMed, The Cochrane Library, EMBASE (via Ovid) and PEDro from 2005 onwards.

Study Selection

Prospective interventional studies (randomized controlled trials (RCTs), non-randomized controlled trials and single-group trials), that included adults within 12 months from cancer diagnosis, and device-measured PA before and after commencement of an intervention were included. Studies were excluded if PA was measured at a single time point. Two independent reviewers screened 3,033 records and 30 articles met the inclusion criteria.

Data Extraction

Two reviewers independently extracted the data. PEDro scale and GRADE approach were used to assess methodological quality of RCTs and overall quality of evidence, respectively. A meta-analysis of relevant RCTs was conducted.

Data Synthesis

Thirty studies were identified, mainly including adults with multiple cancer types. Interventions were behavior change interventions (n=15), exercise training (n=13), neuromuscular electrostimulation (n=1) or a nutritional program (n=1). The meta-analysis showed improvements on moderate-to-vigorous intensity PA (MVPA) in the experimental group (eight studies; standardized mean difference (SMD) = 0.23; 95% CI 0.06 to 0.39); with subgroup analysis showing that findings were mainly driven by behavior change interventions (five studies; SMD = 0.23, 95% CI 0.05 to 0.41). An uncertain effect on sedentary behavior, daily steps and light intensity PA was found. PA was measured with medical devices and commercial wearables, quality of the methodology was variable.

Conclusions

Behavior change interventions increased device-derived MVPA in adult cancer patients who underwent the intervention within 12 months of the cancer diagnosis. Various devices and methodologies were used to assess PA, which limits comparisons across the studies.

Keywords

Neoplasms; Exercise; Equipment and Supplies

List of abbreviations

BCT: Behavior change technique; CI: Confidence interval; cpm: Counts per minute; MD: Mean difference; MET: Metabolic equivalent units; MVPA: Moderate-to-vigorous intensity PA; NMES: Neuromuscular electrical stimulation; PA: Physical activity; PAM: Physical activity monitor; RCT: Randomized controlled trial; SMD: Standardized mean difference.

Physical activity (PA) is defined as any bodily movement produced by skeletal muscles that requires energy expenditure[1] and can be classified as light, moderate, or vigorous intensity activity.[2] Current PA guidelines for people with cancer recommend that they perform at least 150 to 300 minutes of moderate intensity PA, or 75 to 150 minutes of vigorous intensity PA per week, combined with a minimum of twice-weekly resistance training.[3]

In adults with cancer, the choice of treatment, which can include surgery, radiotherapy, chemotherapy, immunotherapy, hormonal, and/or targeted therapies, is largely dependent on the cancer type and stage as well as on the patient's functional status.[4] During cancer treatment, patients are prone to develop deconditioning[5-7] and show decreased levels of PA.[8,9] Furthermore, poor PA levels can be present in a proportion of patients before commencement of cancer treatment,[10] with failure of reaching PA guidelines reported in 78% before start of treatment and 72% after start of treatment.[11]

A systematic review including 136 studies has demonstrated that higher levels of PA before or after cancer diagnosis is associated with decreased cancer-specific mortality and all-cause mortality for at least 11 cancer types.[12] Further, the meta-analysis in that review demonstrated that post-diagnosis PA is a prognostic factor distinct from pre-diagnosis levels.[12] Therefore, post-diagnosis PA is an important treatable trait in adults with cancer.

Physical activity is a complex behavior which is influenced by numerous determinants on individual, social, environmental, and policy level.[13] It is therefore challenging to enhance such behavior. Extensive evidence suggests that interventions targeting physical activity (such as behavior change interventions) can improve device-measured PA in long-term cancer survivors,[14,15] but evidence about interventions delivered in the first year after a diagnosis is more scarce and has never been systematically reviewed. Nevertheless, it is important to tackle physical inactivity as soon as possible in the recovery trajectory due to its relationship with poor prognosis in people with cancer.[12]

Objective assessment of PA using validated devices is more accurate than questionnaire based assessment,[16] and should be used in clinical trials aiming to enhance PA levels. Importantly, the quality of reported device-based data depends on the validity of the device (and its placement), protocol wear time, filters applied, criteria used to delete non-wear time, criteria used to define a 'valid day', and data processing algorithms to obtain measures of specific PA intensities. These decisions can affect the findings of the study, and it is of paramount importance that data collection and processing decisions are clearly reported in published studies.[17]

In this systematic review, the following research questions will be addressed: 1) What is the effectiveness of different types of interventions aimed at changing device-measured PA in adults within 12 months from cancer diagnosis? The hypothesis is that any change in PA or sedentary behavior will only be seen with interventions that included a component to increase PA performance and a behavior change component. And 2) Which devices and methodologies have been used to objectively measure PA in adults with cancer?

Methods

This systematic review was prospectively registered on PROSPERO (CRD42020199466) and was conducted in accordance with The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA).[18]

Data sources and database search

We searched PubMed, The Cochrane Library, EMBASE (via Ovid) and PEDro. The search was conducted in February 2022. The following search strategy was used in PubMed and adapted to other databases (online supplement): ((neoplasms [MeSH] OR cancer [Title/Abstract] OR carcinoma [Title/Abstract] OR leukemia [Title/Abstract] OR lymphoma [Title/Abstract] OR mesothelioma [Title/Abstract]) AND (pedometer [tw] OR accelerome*

[tw] OR activity monitor* [tw] OR ambulatory monitor* [tw] OR step counter [tw] OR multi-sensor device [tw] OR ActivPAL [tw] OR ActiGraph* [tw] OR SenseWear [tw] OR DynaPort [tw] OR MiniMod [tw] OR Yamax [tw] OR Omron [tw] OR Actiwatch [tw] OR Actimarker [tw] OR Digiwalker [tw] OR Lifecorder [tw] OR RT-3 [tw] OR Tritrac [tw] OR MOX [tw])).

The search was filtered to only identify studies published from 2005 onwards, because devices validated to measure PA were not available until 2005.

Study selection

After removing duplicates using EndNote, Research Screener (www.test.researchscreener.com) was used to screen the records based on title and abstract. Research Screener is a Web application, designed by researchers from Curtin University (Australia), that applies machine learning techniques to semi-automate research article screening. Thereby, articles were ranked by relevance and the screening process halted when all articles were screened.[19] Records were screened independently by two reviewers (KQ and IG) and the results were compared. In case of disagreement, a third researcher was consulted (CB or VC).

Prospective interventional studies have been included. Question 1 was addressed with randomized controlled trials only. Question 2 was addressed with randomized and non-randomized controlled trials as well as single group studies). We included studies that: 1) included adults (≥ 18 yr) with a mean length of time since cancer diagnosis within 12 months, 2) measured PA using a device before and after commencement of an intervention, and 3) were published in English. Studies were excluded if PA was measured at a single time point. Abstracts from conference presentations, commentaries, study protocols and clinical trials registries were excluded. Relevant reviews were used for reference list screening.

Data extraction and quality assessment

Two reviewers (KQ and IG) independently extracted the data into an MS Excel sheet (Microsoft, Redmond, WA, USA) and then checked for any inconsistencies. Extracted data included: 1) study characteristics: title, authors, journal, date of publication, country, study aim, study design; 2) participant characteristics: age, gender, type of cancer, time since diagnosis, type of treatment, body mass index, comorbidities; 3) intervention characteristics: setting, timing (before, during or after treatment), type, duration; 4) PA evaluation characteristics: type of medical device (requiring a medical-grade CE mark and/or 510(k) approval in the European Union and United States, and providing data integrity, security, and privacy)[20] or non-medical device, specifications related to wear time (instructed wear time, number of instructed days of activity monitoring, definition of a valid day, minimum number of valid days required, inclusion/exclusion weekend days); 5) device-measured outcomes reported.

The methodological quality of the randomized controlled trials (RCTs) was assessed independently by two authors (KQ and IG) using the 11-item PEDro scale,[21] and checked for any inconsistencies. As the first item related to the eligibility criteria is not scored, the total score of the PEDro scale ranges between 0 and 10. To rate the overall quality of evidence of each outcome, the GRADE approach was used.[22] The methodological quality of the non-RCTs and single-group trials were not assessed as they were only included to address research question 2, and not to estimate the effects of an intervention.

In case of unclear or missing information, authors of the papers were contacted for additional information.

Data synthesis and analysis

Data related to interventions delivered in the included studies and devices used to measure PA, have been summarised in a narrative manner.

To address research question one, meta-analyses were performed and forest plots were generated using Review Manager® version 5.4, according to the recommendation of the Cochrane Handbook.[23] Baseline and post-intervention data from RCTs only were used to compare outcomes of people allocated to the experimental groups (interventions delivered within 12 months from diagnosis) with those of people allocated to the control groups. Outcome measures included sedentary behavior, number of daily steps, light intensity PA and moderate-to-vigorous intensity PA (MVPA). Data on PA from studies that reported only moderate or only vigorous intensity PA, were used as MVPA in the current review. Subgroup analyses according to type of intervention (i.e. behavior change and non-behavior change interventions) were conducted. Behavior change interventions consisted of strategies to enhance physical activity behavior using techniques such as feedback and monitoring, goal-setting and planning, and self-belief.[24] Whenever possible, data on within-group change (and their standard deviation; SD) were included in the meta-analyses. If not reported in the included studies, authors were contacted to provide within-group change and SD data. If the contact attempts were unsuccessful, calculation of within-group change was performed by our research team (post-intervention values minus pre-intervention values) and the SD of the pre-intervention value was used in the meta-analyses.

A random effects model was used to calculate summary pooled estimates. If the studies were found not to have substantial heterogeneity, a fixed-effect model was applied. The heterogeneity across the studies was assessed using I^2 statistic. In case of substantial statistical heterogeneity (i.e. I^2 greater than 50%),[23] a sensitivity analysis was performed. Pooled estimates were reported as either mean difference (MD) and its respective 95% confidence intervals (CI) or standardized mean difference (SMD) and its respective 95% CI.

Results

The database search identified a total of 3,033 records. After removing duplicates and clinical trials registries, 2,307 record titles/abstracts were screened. A total of 1,996 records were excluded based on title and abstract, and of the 311 full-texts assessed for eligibility, 281 were excluded. A total of 30 studies met the eligibility criteria and were included in the review (Fig. 1).

Summary of studies

Of the 30 included studies, 19 were RCTs.[10,25-42] The remaining studies were single-group (n=8 studies),[43-50] non-randomized controlled trials (n=2 studies),[51,52] and a non-randomized multiple-group study (n=1 study).[53] The studies were conducted in North America (n=11 studies),[25,26,28,36,40,41,43,44,46-48] Europe (n=12 studies),[29-32,34,35,37-39,42,45,52] Asia (n=4 studies),[33,49-51] and Oceania (n=3 studies).[10,27,53]

A total of 1,682 adults with cancer were included across the 30 studies. The sample size of the included studies ranged between 3 and 430 adults with cancer, with a median age ranging from 32 to 75 years old. Two studies included adults between 30-39 years old,[28,49] three studies between 40-49 years old,[31,33,34] 14 studies between 50-59 years old,[26,30,36,37,39-42,44-47,51,53] 8 studies between 60-69 years old,[10,27,29,32,35,38,48,52] and three studies between 70-79 years old.[25,43,50] The mean time since diagnosis ranged between 37 days to 11 months. Of the 30 included studies, ten included adults with multiple cancer types,[28-30,34,38,39,46,47,50,53] eight included adults with breast cancer,[31,33,36,37,40,44,45,51] and four included adults with lung cancer.[10,27,35,42] The remaining studies included adults with bladder cancer (n=2 studies),[43,48] prostate cancer (n=2 studies),[25,26] colorectal cancer (n=2 studies),[32,41] hematological cancer,[49] and rectal cancer (n=1 study).[52] Cancer stage was not reported in 13 studies.[28-30,37-39,43,45,47,49,51-53] Other studies included stage I-III (n=8 studies),[27,31-34,36,40,44], I-II (n=3 studies),[25,26,48] I-IV (n=3 studies),[10,41,46] III-IV (n=2 studies),[35,50] and III (n=1 study).[42]

Quality assessment

The PEDro score of the 19 included RCTs ranged between 3 and 10 (Mean ± SD: 6 ± 2) (Table 1). Overall, eligibility criteria were specified in 84% of the RCTs. Random allocation was adequate in all RCTs, but concealed allocation was problematic in 47% of them. Baseline comparability was reported in most RCTs (95%). Subjects and therapist were only blinded in one RCT, assessors were blinded in seven (37%). In 68% of the trials, measures were obtained from more than 85% of the subjects. Intention-to-treat analysis was done in 58% and the results of between-group statistical comparison was reported in 79% of the RCTs. All RCTs provided both point estimates measured and measured of variability for at least one key outcome.

Types of intervention

Information about the interventions are presented in Table 2. In the majority of the 30 included studies, interventions were delivered either during cancer treatment (n=14 studies)[10,25,28,33,39-43,45-47,50,51] or after cancer treatment (n=9 studies)[27,30-32,34-37,44] only. The other studies delivered interventions before treatment,[26] before and after treatment,[48,52] before and during treatment,[49] and during and/or after treatment.[29,38,53] In 19 of the 30 included studies, PA data were collected on two different time points,[26-30,32,35-37,39-41,44-47,49,51,53] in eight studies PA data were collected on three time points,[10,25,31,34,38,42,48,50] and in one study PA data were collected across four time points.[52]

In 12 of the 19 included RCTs, the experimental group received a behavior change program, including behavior change techniques (BCTs). Physical activity was a primary outcome in seven studies.[28,29,32,33,36,39,40] Program components are defined according to the Behavior Change Technique Taxonomy[24] and included goal-setting and planning,[10,28,29,32-34,36,40] feedback and monitoring,[29,33,34,36,38,41] social support,[36,39] comparison of behaviour,[29] and self-management.[30]

The program was compared to usual care,[10,29,30,34,36,38] an exercise brochure,[28] a booklet about staying healthy after cancer,[32] a booklet about PA,[41] standard public health PA recommendations,[40] BCT (goal-setting and planning, and feedback and monitoring) without the use of a wearable[33] or stress-management.[39]

A non-behavior change intervention was offered in seven out of 19 included RCTs. In two studies, PA was a primary outcome.[25,37] Exercise training was included in four studies, and consisted of aerobic exercises[31,37] or a combination of aerobic and resistance exercises[26,27] and was compared to usual care. One RCT offered a combination of aerobic, resistance and flexibility exercises and compared 3 groups (center-based personal training center-based group training, individual home-based training).[25] In one RCT, neuromuscular electrical stimulation (NMES) was delivered and compared to usual care.[35] In another RCT, participants were randomly allocated to either receive a protein- and energy-dense oral nutritional supplement containing n-3 polyunsaturated fatty acids or an isocaloric control oral nutritional supplement.[42]

Detailed information of the 11 non-RCTs can be found in Table 2.

Effectiveness of the interventions

Results of interventions on PA outcomes are displayed in Table 2. An overview of the certainty of evidence, assessed with GRADE, are presented in Table 3. Overall, the quality of evidence across the RCTs was graded as low to moderate. Risk of bias and imprecision were the main causes to downgrade the score for the quality of evidence.

Results meta-analyses

Three studies used sedentary behavior as an outcome.[27,31,34] An uncertain effect of the interventions on sedentary behavior was found (SMD 0.48, 95% CI -0.05 to 1.01; $I^2 = 0\%$, 3

studies, 60 participants, low-certainty evidence) (Fig. 2a), with no difference between subgroups.

Daily steps was reported in eight studies.[10,27,28,30,35,37,40,41] An uncertain effect of the interventions on daily steps was found (MD 141.43, 95% CI -102.40 to 385.26; I^2 = 26%, 8 studies, 379 participants, low-certainty evidence) (Fig. 2b), with no difference between subgroups.

Light intensity PA was measured in five studies.[27,28,31,41,42] An uncertain effect of the interventions on light intensity PA was found (SMD -0.34, 95% CI -0.68 to 0.01; I^2 = 0%, 5 studies, 135 participants, low-certainty evidence) (Fig. 2c). Subgroup analysis demonstrated that in the non-behavior change intervention subgroup, time spent in light intensity PA increased more in the control group when compared to the experimental group (SMD -0.54, 95% CI -1.05 to -0.04; I^2 = 0%, 3 studies, 67 participants).

Eight studies reported results on MVPA.[27-29,31,32,34,41,42] When compared to the control group, time spent in MVPA increased more in the experimental group (SMD 0.23, 95% CI 0.06 to 0.39; I^2 = 29%, 8 studies, 556 participants, moderate evidence) (Fig. 2d). Subgroup analysis demonstrated that this between-group difference was driven by the results from the behavior change intervention subgroup. That is, in the behavior change intervention subgroup only, time spent in MVPA increased more in the experimental group when compared to the control group (SMD 0.23, 95% CI 0.05 to 0.41; I^2 = 0%, 5 studies, 522 participants). The five studies that offered behavior change interventions included participants with multiple cancer types,[28] colorectal and prostate cancer,[29] colorectal cancer,[32,41] and breast and endometrial cancer.[34]

Reasons for RCTs not be included in the meta-analyses were: no response from the authors about sample sizes in each group, results of the control group and SD of each group,[36,38,39] other PA outcomes[25,26] and only PA results of the experimental group.[33]

Physical activity devices

Table 4 presents the PA devices and methodology used in the included studies. In 18 of the 30 studies, the PA device used was a medical device.[10,25-29,31,32,34-36,38,39,41,44,46,47,52] In the twelve remaining studies, a non-medical device, such as a step counter or an activity tracker was used.[30,33,37,40,42,43,45,48-51,53] The most commonly used medical devices were the Actigraph (n=8 studies)[25,28,29,32,34,36,39,41] and the SenseWear armband (n=4 studies).[10,27,38,46] The placement of the PA device was reported in 18 studies: in eight studies the PA device was worn on the hip,[28,29,32,34,36,42,44,49] in six studies the PA device was worn on the wrist,[10,26,27,30,41,45] in two on the thigh,[35,47] and in two on the triceps muscle.[38,52]

In the majority of the included studies (n=20 studies), participants were asked to wear the PA device for seven days.[10,25-29,31-39,41,44,47-50] In three studies participants were instructed to wear the PA device for three days,[40,46,52] and in seven studies, participants were instructed to wear the PA device during the entire intervention period.[33,45,47,48,50,51,53]

Sixteen studies reported on minimum wear time that would be considered a valid day[10,25-29,32,34,36,38,39,41,44,46,49,50] and 12 studies reported on minimum number of valid days required for the data to be included in the analyses.[10,25,27-29,32,34,38,39,41,42,44] A valid day ranged between 8 and 20 hours of wear time and the minimum number of valid days required, ranged between 1 and 5 days. The most commonly reported criterion of a valid measurement was a minimum of 4 days with at least 10 hours of wear time per day (n=7 studies). Two studies reported the PA device had to be worn for a minimum of one weekend day to be considered valid.[27,34] Only eight studies included a definition of non-wear period. Non-wear period was defined as zero activity for 60 consecutive minutes,[25,26,32,34,41] zero activity for 90 consecutive minutes,[29] zero activity for 20 consecutive minutes[36] and, zero daily steps.[33]

Physical activity outcomes

Most common PA variables reported included number of daily steps (n=20 studies),[10,27,28,30,33,35-37,40,41,43,45-53] MVPA (n=11 studies),[25,27,29,32,34,36,38,39,44,49,50] light intensity PA (n=7 studies),[27,28,31,41,42,47,49] moderate intensity PA (n=6 studies),[28,31,34,41,42,46] vigorous intensity PA (n=5studies),[28,31,34,41,46] and time spent in sedentary behavior (n=4 studies).[27,31,34,49] Other outcomes included total PA,[28,46,52] bouts of steps,[10] bouts of moderate intensity PA,[41] days of ≥30min spent in PA,[29], active energy expenditure,[52] TEE,[47,52] time spent lying down,[52] inactive time,[36] MET,[52] counts per minute (cpm),[47] and physical activity monitor (PAM) activity score.[42]

The cut-off values for PA intensity were reported in 14 of the 18 studies that reported PA intensity. Eight studies used cut-off values based on cpm,[25,26,28,29,32,36,39,41] five studies used cut-off values based on metabolic equivalent units (MET),[27,38,46,49,50] and one study used mean amplitude deviation.[34]

Discussion

This systematic review summarizes the interventions that were used to modify physical activity in 1,682 adults within 12 months from a cancer diagnosis. Most studies delivered a behavior change program including goal-setting and planning, and feedback and monitoring. Our hypothesis was that any change in PA or sedentary behavior would only have been seen with interventions that included a component to increase PA performance and a behavior change component. A larger increase in MVPA was found in the experimental group compared to the control group after a behavior change intervention, but not after an exercise intervention. In contrast, evidence showed an uncertain effect of the interventions on sedentary behavior, daily steps and light intensity PA. This is does not support our hypothesis. In most studies, physical activity was measured with a medical device, the other studies used a non-medical device. The results on effectiveness of the interventions must be interpreted with caution due to different methodology used to measure PA across the RCTs. Further, the methodological quality of RCTs included in the meta-analyses is low to moderate.

The most commonly used intervention to modify PA in the included studies was a behavior change intervention. In these studies, device-measured PA was most frequently used as the primary outcome. Primary outcomes of the other studies included exercise capacity, fatigue, self-reported PA, cancer-related stress or adherence. Overall, the behavior change interventions utilised a combination of instructions for home-based exercises with elements of BCTs. Previous literature also found that goal-setting and planning were the most used BCTs to enhance PA in adolescents and young adults with chronic cardiorespiratory conditions.[54] In addition, a review found that goal-setting and social support were the most common used techniques among physiotherapists while promoting PA. Interestingly, interventions that proved effectiveness to enhance PA used more BCTs.[55]

There are a few indications that some techniques are more effective than others. A meta-analysis from Michie et al.[56] suggests that self-monitoring combined with at least one other BCT is likely to enhance the effectiveness of interventions designed to promote PA in adults. Several studies included in our review supplied non-medical devices to participants, which is a strategy to provide feedback on PA and allow self-monitoring, goal-setting, and record and review data,[57] and are effective for increasing PA in clinical populations.[58] However, individual differences on attitudes towards PA devices may have an influence on the effectiveness of these interventions.[59]

The optimal dose and timing of activity for adults with cancer remains questionable.[12] A review including quantitative and qualitative research showed that this patient group prefers moderate intensity PA, walking and home-based programs.[60] It is important to increase participation and adherence to interventions by tailoring programs to their preferences as these interventions can reduce cancer-related mortality and all-cause mortality, and may improve functional status and quality of life during cancer treatment.[61]

This review provides moderate evidence that an increase in MVPA was found in favor of the experimental group after a behavior change intervention (i.e. moderate level of certainty of the evidence based on the GRADE evaluation). A previous review including behavior change interventions in cancer survivors also found an increase in (self-reported) MVPA after the intervention which resulted in an increase of 40 min per week.[62] This is an important fact as any amount in PA shows a decrease in total mortality risk in adults with cancer.[63]

Studies including exercise programs without BCTs lacked improvements in PA while exercise capacity increased. Exercise training is a successful intervention to improve exercise capacity but this does not automatically translate into enhanced PA behavior. In patients with chronic obstructive pulmonary disease, a "can do" versus "do do" model has been proposed in which patients are subdivided in quadrants, based on both exercise capacity ("can do" versus "can't do") and physical activity ("do do" vs "don't do").[64] This concept may be useful for stratification of patients to different non-pharmalogic interventions for optimizing exercise capacity and PA (e.g. rehabilitation, PA counseling, or a combination).[65] Moreover, it is essential to embed BCTs within an exercise training intervention because it has been shown that specific instructions regarding the execution of this health behavior (by goal-setting and planning) rather than just participation in an exercise program is needed to optimize the success of an intervention.[54]

Low-certainty evidence showed an uncertain effect of interventions on sedentary behavior, daily steps and light intensity PA in the experimental group. A Cochrane review, comparing different interventions in older adults, also found an uncertain effect on sedentary behavior.[66] It has been suggested that a reduction in sedentary behavior is more likely when the intervention is designed with the aim to reduce sedentary time rather than increase PA,[67] which was not the aim in the studies included in our review. In addition, light intensity PA has a strong negative correlation with sedentary behavior,[68] and because exercise training did not

reduce sedentary behavior, it also may not increase light intensity PA. Furthermore, sedentary behavior and light intensity PA are best measured with inclinometers worn on the thigh.[69] Some papers included in this analysis wore the device on the wrist which may cause imprecision on this outcome and affect the results.

A previous review found that a combination of goal-setting and exercises can improve daily steps in cancer survivors.[15] This is in contrast with our findings where no differences in daily steps were found after the same form of intervention. Suggesting that these types of interventions seem to work in patient on long term follow-up and further needs to be explored whether this is also feasible and effective in our patient population.

As shown in this review, intervention studies using device-measured PA as an outcome in patients with cancer are scarce and the used methodology to assess PA is very heterogeneous. While the majority of studies used well-validated medical devices, several studies used non-medical devices with less clear accuracy.[70] The decision on which device to use is not only dependent on the validity and reliability of devices but also affordability, product reliability, monitor size, technical support and comparability with other studies needs to be taken into account.[71] In adults with cancer, there is no recommendation on the minimum number of days of monitoring but it should be long enough to reflect the habitual level of activity and should not cause a high burden for the participant.[72] Previous work showed that the device wear time, and the interaction of the device wear time and the device type moderates the estimate of sedentary behavior.[69] That is, the longer the wear time of the device with an inclinometer, the more accurate estimation of sedentary behavior. For daily steps and various PA intensities, it is recommended to use a minimum proposed to use a minimum of 12 hours of wear time as less would give an underestimation of the results.[73] It has been suggested to include both weekdays and weekend days in the analysis, although it is not clear if variability exists between these days in adults with cancer.[72,74]

Strengths of this review include the broad search in four different databases to screen for articles. Two independent researchers determined study inclusion and risk of bias of the included studies, and assessed their agreement. In case of disagreement, another researcher was contacted.

Study limitations

Limitations of this review are firstly, the heterogeneous group of adults with cancer included, with interventions delivered to various cancer types, cancer stages and different timings. Secondly, despite the numerous attempts to contact authors in case of unclear or missing data, we did not receive a reply from all the authors, which can possible cause a selection bias.

Conclusion and future directions

In adults within 12 months from cancer diagnosis, exercise programs with or without a behavior component were delivered to assess device-measured PA. A significant increase in MVPA was found following a behavior change intervention in the experimental group. In contrast, an uncertain effect was found on sedentary behavior, daily steps, and light intensity PA. A wide range of devices and methodologies were used to assess PA, which limits comparability between studies. For future studies it is essential to embed BCTs within an exercise training intervention and choose the device according to the type of activity being studies. Given the fast evolution in wearables and physical activity monitors, a detailed reporting of methodology is crucial. Additionally, as cancer often exist in combination with other chronic conditions, studies should also focus if the presence of multi-morbidity influenced physical activity. In the included trials, patients with comorbidities (such as neuromuscular, psychiatric and cognitive disorders) were frequently excluded. Furthermore, it is not clear to what extent vulnerable populations were represented in the study samples. These issues negatively impact on the external validity of the findings.

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Availability of data and materials

The datasets generated and analysed during the current review are from the corresponding author on reasonable request.

References

1. Mathiowetz V, Weber K, Volland G, Kashman N. Reliability and validity of grip and pinch strength evaluations. *J Hand Surg Am*. Mar 1984;9(2):222-6. doi:10.1016/s0363-5023(84)80146-x
2. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc*. Sep 2000;32(9 Suppl):S498-504. doi:10.1097/00005768-200009001-00009
3. Patel AV, Friedenreich CM, Moore SC, et al. American College of Sports Medicine Roundtable Report on Physical Activity, Sedentary Behavior, and Cancer Prevention and Control. *Med Sci Sports Exerc*. Nov 2019;51(11):2391-2402. doi:10.1249/mss.0000000000002117
4. Duffy MJ, Crown J. A personalized approach to cancer treatment: how biomarkers can help. *Clin Chem*. Nov 2008;54(11):1770-9. doi:10.1373/clinchem.2008.110056
5. Brown JC, Winters-Stone K, Lee A, Schmitz KH. Cancer, physical activity, and exercise. *Compr Physiol*. Oct 2012;2(4):2775-809. doi:10.1002/cphy.c120005
6. Heywood R, McCarthy AL, Skinner TL. Efficacy of Exercise Interventions in Patients With Advanced Cancer: A Systematic Review. *Arch Phys Med Rehabil*. Dec 2018;99(12):2595-2620. doi:10.1016/j.apmr.2018.04.008
7. Velthuis MJ, Agasi-Idenburg SC, Aufdemkampe G, Wittink HM. The effect of physical exercise on cancer-related fatigue during cancer treatment: a meta-analysis of randomised controlled trials. *Clin Oncol (R Coll Radiol)*. Apr 2010;22(3):208-21. doi:10.1016/j.clon.2009.12.005
8. Granger CL, McDonald CF, Irving L, et al. Low physical activity levels and functional decline in individuals with lung cancer. *Lung Cancer*. Feb 2014;83(2):292-9. doi:10.1016/j.lungcan.2013.11.014
9. Zhou W, Webster KE, Smith EL, et al. Physical activity in surgical lung cancer patients: a systematic review. *Support Care Cancer*. Apr 6 2022;doi:10.1007/s00520-022-07018-1
10. Edbrooke L, Granger CL, Clark RA, Denehy L. Physical Activity Levels Are Low in Inoperable Lung Cancer: Exploratory Analyses from a Randomised Controlled Trial. *Journal of Clinical Medicine*. 2019;8(9):1288.
11. Timmerman JGJ, Dekker-van Weering M, Wouters M, Stuiver MMM, de Kanter WW, Vollenbroek-Hutten M. Physical behavior and associations with health outcomes in operable NSCLC patients: A prospective study. *Lung Cancer*. May 2018;119:91-98. doi:10.1016/j.lungcan.2018.03.006
12. Friedenreich CM, Stone CR, Cheung WY, Hayes SC. Physical Activity and Mortality in Cancer Survivors: A Systematic Review and Meta-Analysis. *JNCI Cancer Spectr*. Feb 2020;4(1):pkz080. doi:10.1093/jncics/pkz080
13. Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJF, Martin BW. Correlates of physical activity: why are some people physically active and others not? *The Lancet*. 2012/07/21/ 2012;380(9838):258-271. doi:https://doi.org/10.1016/S0140-6736(12)60735-1
14. Rogers LQ, Courneya KS, Anton PM, et al. Effects of the BEAT Cancer physical activity behavior change intervention on physical activity, aerobic fitness, and quality of life in breast cancer survivors: a multicenter randomized controlled trial. *Breast Cancer Research and Treatment*. 2015/01/01 2015;149(1):109-119. doi:10.1007/s10549-014-3216-z
15. Knols RH, de Bruin ED, Shirato K, Uebelhart D, Aaronson NK. Physical activity interventions to improve daily walking activity in cancer survivors. *BMC Cancer*. 2010/08/04 2010;10(1):406. doi:10.1186/1471-2407-10-406
16. Troiano RP, McClain JJ, Brychta RJ, Chen KY. Evolution of accelerometer methods for physical activity research. *Br J Sports Med*. 2014;48(13):1019-1023. doi:10.1136/bjsports-2014-093546
17. Peddle-McIntyre CJ, Cavalheri V, Boyle T, et al. A Review of Accelerometer-based Activity Monitoring in Cancer Survivorship Research. *Med Sci Sports Exerc*. Sep 2018;50(9):1790-1801. doi:10.1249/mss.0000000000001644
18. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. doi:10.1136/bmj.n71
19. Chai KEK, Lines RLJ, Gucciardi DF, Ng L. Research Screener: a machine learning tool to semi-automate abstract screening for systematic reviews. *Syst Rev*. Apr 1 2021;10(1):93. doi:10.1186/s13643-021-01635-3

20. Demeyer H, Mohan D, Burtin C, et al. Objectively Measured Physical Activity in Patients with COPD: Recommendations from an International Task Force on Physical Activity. *Chronic Obstr Pulm Dis*. Oct 28 2021;8(4):528-550. doi:10.15326/jcopdf.2021.0213
21. Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M. Reliability of the PEDro scale for rating quality of randomized controlled trials. *Phys Ther*. Aug 2003;83(8):713-21.
22. Guyatt GH, Oxman AD, Vist GE, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. *BMJ*. 2008;336(7650):924-926. doi:10.1136/bmj.39489.470347.AD
23. Higgins JPT TJ, Chandler J, Cumpston M, Li T, Page MJ, Welch VA Cochrane Handbook for Systematic Reviews of Interventions version 6.3. https://training.cochrane.org/handbook
24. Michie S, Richardson M, Johnston M, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Ann Behav Med*. Aug 2013;46(1):81-95. doi:10.1007/s12160-013-9486-6
25. Alibhai SMH, Santa Mina D, Ritvo P, et al. A phase II randomized controlled trial of three exercise delivery methods in men with prostate cancer on androgen deprivation therapy. *BMC Cancer*. 2019/01/03 2019;19(1):2. doi:10.1186/s12885-018-5189-5
26. Au D, Matthew AG, Lopez P, et al. Prehabilitation and acute postoperative physical activity in patients undergoing radical prostatectomy: a secondary analysis from an RCT. *Sports Med Open*. May 22 2019;5(1):18. doi:10.1186/s40798-019-0191-2
27. Cavalheri V, Jenkins S, Cecins N, et al. Exercise training for people following curative intent treatment for non-small cell lung cancer: a randomized controlled trial. *Braz J Phys Ther*. Jan-Feb 2017;21(1):58-68. doi:10.1016/j.bjpt.2016.12.005
28. Erickson JM, Tokarek N, Ke W, Swartz A. A Randomized Controlled Trial of a Physical Activity Intervention for Self-management of Fatigue in Adolescents and Young Adults With Cancer. *Cancer Nurs*. Jul-Aug 01 2021;44(4):263-271. doi:10.1097/ncc.0000000000000834
29. Golsteijn RHJ, Bolman C, Volders E, Peels DA, de Vries H, Lechner L. Short-term efficacy of a computer-tailored physical activity intervention for prostate and colorectal cancer patients and survivors: a randomized controlled trial. *Int J Behav Nutr Phys Act*. Oct 30 2018;15(1):106. doi:10.1186/s12966-018-0734-9
30. Grégoire C, Faymonville ME, Vanhaudenhuyse A, et al. Effects of an intervention combining self-care and self-hypnosis on fatigue and associated symptoms in post-treatment cancer patients: A randomized-controlled trial. *Psychooncology*. Jul 2020;29(7):1165-1173. doi:10.1002/pon.5395
31. Guinan E, Hussey J, Broderick JM, et al. The effect of aerobic exercise on metabolic and inflammatory markers in breast cancer survivors--a pilot study. *Support Care Cancer*. Jul 2013;21(7):1983-92. doi:10.1007/s00520-013-1743-5
32. Hubbard G, O'Carroll R, Munro J, et al. The feasibility and acceptability of trial procedures for a pragmatic randomised controlled trial of a structured physical activity intervention for people diagnosed with colorectal cancer: findings from a pilot trial of cardiac rehabilitation versus usual care (no rehabilitation) with an embedded qualitative study. *Pilot Feasibility Stud*. 2016;2:51. doi:10.1186/s40814-016-0090-y
33. Kong S, Lee JK, Kang D, et al. Comparing the Effectiveness of a Wearable Activity Tracker in Addition to Counseling and Counseling Only to Reinforce Leisure-Time Physical Activity among Breast Cancer Patients: A Randomized Controlled Trial. *Cancers (Basel)*. May 30 2021;13(11)doi:10.3390/cancers13112692
34. Lion A, Backes A, Duhem C, et al. Motivational Interviewing to Increase Physical Activity Behavior in Cancer Patients: A Pilot Randomized Controlled Trials. *Integr Cancer Ther*. Jan-Dec 2020;19:1534735420914973-1534735420914973. doi:10.1177/1534735420914973
35. Maddocks M, Lewis M, Chauhan A, Manderson C, Hocknell J, Wilcock A. Randomized controlled pilot study of neuromuscular electrical stimulation of the quadriceps in patients with non-small cell lung cancer. *J Pain Symptom Manage*. Dec 2009;38(6):950-6. doi:10.1016/j.jpainsymman.2009.05.011

36. Matthews CE, Wilcox S, Hanby CL, et al. Evaluation of a 12-week home-based walking intervention for breast cancer survivors. *Support Care Cancer*. Feb 2007;15(2):203-11. doi:10.1007/s00520-006-0122-x
37. Nikander R, Sievänen H, Ojala K, Oivanen T, Kellokumpu-Lehtinen PL, Saarto T. Effect of a vigorous aerobic regimen on physical performance in breast cancer patients - a randomized controlled pilot trial. *Acta Oncol*. 2007;46(2):181-6. doi:10.1080/02841860600833145
38. Nilsson M, Arving C, Thormodsen I, Assmus J, Berntsen S, Nordin K. Moderate-to-vigorous intensity physical activity is associated with modified fatigue during and after cancer treatment. *Support Care Cancer*. Jul 2020;28(7):3343-3350. doi:10.1007/s00520-019-05176-3
39. Ungar N, Sieverding M, Weidner G, Ulrich CM, Wiskemann J. A self-regulation-based intervention to increase physical activity in cancer patients. *Psychol Health Med*. 2016;21(2):163-75. doi:10.1080/13548506.2015.1081255
40. Vallance JK, Friedenreich CM, Lavallee CM, et al. Exploring the Feasibility of a Broad-Reach Physical Activity Behavior Change Intervention for Women Receiving Chemotherapy for Breast Cancer: A Randomized Trial. *Cancer Epidemiol Biomarkers Prev*. Feb 2016;25(2):391-8. doi:10.1158/1055-9965.Epi-15-0812
41. Van Blarigan EL, Dhruva A, Atreya CE, et al. Feasibility and Acceptability of a Physical Activity Tracker and Text Messages to Promote Physical Activity During Chemotherapy for Colorectal Cancer: Pilot Randomized Controlled Trial (Smart Pace II). *JMIR Cancer*. Jan 11 2022;8(1):e31576. doi:10.2196/31576
42. van der Meij BS, Langius JA, Spreeuwenberg MD, et al. Oral nutritional supplements containing n-3 polyunsaturated fatty acids affect quality of life and functional status in lung cancer patients during multimodality treatment: an RCT. *Eur J Clin Nutr*. Mar 2012;66(3):399-404. doi:10.1038/ejcn.2011.214
43. Chestnut C, Smelser W, Dum T, et al. Glycemic impact of a diet and lifestyle intervention on diabetics and prediabetics during treatment for non-muscle invasive bladder cancer. *Nutr Cancer*. 2020;72(7):1219-1224. doi:10.1080/01635581.2019.1672761
44. De Jesus S, Fitzgeorge L, Unsworth K, et al. Feasibility of an exercise intervention for fatigued breast cancer patients at a community-based cardiac rehabilitation program. *Cancer Manag Res*. 2017;9:29-39. doi:10.2147/CMAR.S117703
45. Delrieu L, Pialoux V, Pérol O, et al. Feasibility and Health Benefits of an Individualized Physical Activity Intervention in Women With Metastatic Breast Cancer: Intervention Study. *JMIR Mhealth Uhealth*. Jan 28 2020;8(1):e12306. doi:10.2196/12306
46. Javaheri PA, Nekolaichuk C, Haennel R, Parliament MB, McNeely ML. Feasibility of a pedometer-based walking program for survivors of breast and head and neck cancer undergoing radiation therapy. *Physiother Can*. Spring 2015;67(2):205-13. doi:10.3138/ptc.2014-24O
47. Lowe SS, Watanabe SM, Baracos VE, Courneya KS. Home-based functional walking program for advanced cancer patients receiving palliative care: a case series. *BMC Palliat Care*. 2013;12:22-22. doi:10.1186/1472-684X-12-22
48. Metcalf M, Glazyrine V, Glavin K, et al. The Feasibility of a Health Care Application in the Treatment of Patients Undergoing Radical Cystectomy. *J Urol*. May 2019;201(5):902-908. doi:10.1097/ju.0000000000000050
49. Morishita S, Kaida K, Yamauchi S, et al. Relationship of physical activity with physical function and health-related quality of life in patients having undergone allogeneic haematopoietic stem-cell transplantation. *Eur J Cancer Care (Engl)*. Jul 2017;26(4)doi:10.1111/ecc.12669
50. Naito T, Mitsunaga S, Miura S, et al. Feasibility of early multimodal interventions for elderly patients with advanced pancreatic and non-small-cell lung cancer. *J Cachexia Sarcopenia Muscle*. Feb 2019;10(1):73-83. doi:10.1002/jcsm.12351
51. Gandhi A, Samuel SR, Kumar KV, Saxena PP, Mithra P. Effect of a Pedometer-based Exercise Program on Cancer Related Fatigue and Quality of Life amongst Patients with Breast Cancer Receiving Chemotherapy. *Asian Pac J Cancer Prev*. 2020;21(6):1813-1818. doi:10.31557/APJCP.2020.21.6.1813

52. Loughney L, West MA, Dimitrov BD, Kemp GJ, Grocott MP, Jack S. Physical activity levels in locally advanced rectal cancer patients following neoadjuvant chemoradiotherapy and an exercise training programme before surgery: a pilot study. *Perioper Med (Lond)*. 2017;6:3-3. doi:10.1186/s13741-017-0058-3
53. Marthick M, Dhillon HM, Alison JA, Cheema BS, Shaw T. An Interactive Web Portal for Tracking Oncology Patient Physical Activity and Symptoms: Prospective Cohort Study. *JMIR Cancer*. Dec 21 2018;4(2):e11978. doi:10.2196/11978
54. Sawyer A, Lewthwaite H, Gucciardi DF, Hill K, Jenkins S, Cavalheri V. Behaviour change techniques to optimise participation in physical activity or exercise in adolescents and young adults with chronic cardiorespiratory conditions: a systematic review. *Intern Med J*. Oct 2019;49(10):1209-1220. doi:10.1111/imj.14141
55. Kunstler BE, Cook JL, Freene N, et al. Physiotherapists use a small number of behaviour change techniques when promoting physical activity: A systematic review comparing experimental and observational studies. *Journal of Science and Medicine in Sport*. 2018/06/01/ 2018;21(6):609-615. doi:https://doi.org/10.1016/j.jsams.2017.10.027
56. Michie S, Abraham C, Whittington C, McAteer J, Gupta S. Effective techniques in healthy eating and physical activity interventions: a meta-regression. *Health Psychol*. Nov 2009;28(6):690-701. doi:10.1037/a0016136
57. Singh B, Zopf EM, Howden EJ. Effect and feasibility of wearable physical activity trackers and pedometers for increasing physical activity and improving health outcomes in cancer survivors: A systematic review and meta-analysis. *Journal of Sport and Health Science*. 2022/03/01/ 2022;11(2):184-193. doi:https://doi.org/10.1016/j.jshs.2021.07.008
58. J SO, Sherrington C, E RYZ, Franco MR, Tiedemann A. Effect of interventions using physical activity trackers on physical activity in people aged 60 years and over: a systematic review and meta-analysis. *Br J Sports Med*. Oct 2020;54(20):1188-1194. doi:10.1136/bjsports-2018-100324
59. Rupp MA, Michaelis JR, McConnell DS, Smither JA. The role of individual differences on perceptions of wearable fitness device trust, usability, and motivational impact. *Applied Ergonomics*. 2018/07/01/ 2018;70:77-87. doi:https://doi.org/10.1016/j.apergo.2018.02.005
60. Wong JN, McAuley E, Trinh L. Physical activity programming and counseling preferences among cancer survivors: a systematic review. *Int J Behav Nutr Phys Act*. Jun 7 2018;15(1):48. doi:10.1186/s12966-018-0680-6
61. Lugo D, Pulido AL, Mihos CG, et al. The effects of physical activity on cancer prevention, treatment and prognosis: A review of the literature. *Complementary Therapies in Medicine*. 2019/06/01/ 2019;44:9-13. doi:https://doi.org/10.1016/j.ctim.2019.03.013
62. Roberts AL, Fisher A, Smith L, Heinrich M, Potts HWW. Digital health behaviour change interventions targeting physical activity and diet in cancer survivors: a systematic review and meta-analysis. *Journal of cancer survivorship : research and practice*. 2017;11(6):704-719. doi:10.1007/s11764-017-0632-1
63. Schmid D, Leitzmann MF. Association between physical activity and mortality among breast cancer and colorectal cancer survivors: a systematic review and meta-analysis. *Annals of Oncology*. 2014/07/01/ 2014;25(7):1293-1311. doi:https://doi.org/10.1093/annonc/mdu012
64. Koolen EH, van Hees HW, van Lummel RC, et al. "Can do" versus "do do": A Novel Concept to Better Understand Physical Functioning in Patients with Chronic Obstructive Pulmonary Disease. *J Clin Med*. Mar 11 2019;8(3)doi:10.3390/jcm8030340
65. Vaes AW, Spruit MA, Koolen EH, et al. “Can Do, Do Do” Quadrants and 6-Year All-Cause Mortality in Patients With COPD. *Chest*. 2022/06/01/ 2022;161(6):1494-1504. doi:https://doi.org/10.1016/j.chest.2021.12.657
66. Chastin S, Gardiner PA, Harvey JA, et al. Interventions for reducing sedentary behaviour in community-dwelling older adults. *Cochrane Database of Systematic Reviews*. 2021;(6)doi:10.1002/14651858.CD012784.pub2

67. Gardner B, Smith L, Lorencatto F, Hamer M, Biddle SJ. How to reduce sitting time? A review of behaviour change strategies used in sedentary behaviour reduction interventions among adults. *Health Psychol Rev*. 2016;10(1):89-112. doi:10.1080/17437199.2015.1082146
68. Spittaels H, Van Cauwenberghe E, Verbestel V, et al. Objectively measured sedentary time and physical activity time across the lifespan: a cross-sectional study in four age groups. *International Journal of Behavioral Nutrition and Physical Activity*. 2012/12/18 2012;9(1):149. doi:10.1186/1479-5868-9-149
69. Coll F, Cavalheri V, Gucciardi DF, Wulff S, Hill K. Quantifying the Effect of Monitor Wear Time and Monitor Type on the Estimate of Sedentary Time in People with COPD: Systematic Review and Meta-Analysis. *J Clin Med*. Apr 1 2022;11(7)doi:10.3390/jcm11071980
70. Degroote L, De Bourdeaudhuij I, Verloigne M, Poppe L, Crombez G. The Accuracy of Smart Devices for Measuring Physical Activity in Daily Life: Validation Study. *JMIR Mhealth Uhealth*. Dec 13 2018;6(12):e10972. doi:10.2196/10972
71. TROST SG, MCIVER KL, PATE RR. Conducting Accelerometer-Based Activity Assessments in Field-Based Research. *Medicine & Science in Sports & Exercise*. 2005;37(11):S531-S543. doi:10.1249/01.mss.0000185657.86065.98
72. Broderick JM, Ryan J, O'Donnell DM, Hussey J. A guide to assessing physical activity using accelerometry in cancer patients. *Support Care Cancer*. Apr 2014;22(4):1121-30. doi:10.1007/s00520-013-2102-2
73. Herrmann SD, Barreira TV, Kang M, Ainsworth BE. Impact of accelerometer wear time on physical activity data: a NHANES semisimulation data approach. *Br J Sports Med*. Feb 2014;48(3):278-82. doi:10.1136/bjsports-2012-091410
74. GRETEBECK RJ, MONTOYE HJ. Variability of some objective measures of physical activity. *Medicine & Science in Sports & Exercise*. 1992;24(10):1167-1172.

Figure legends

Fig. 1. Flowchart of study selection.

Fig. 2. Forest plot.

Forest plot of comparison: experimental group versus control group on **a)** sedentary behavior; **b)** daily steps (every unit represents a 1000 steps); **c)** light intensity PA; **d)** moderate-to-vigorous PA.