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# Motivational strategies to improve physical activity adherence in breast cancer survivors: A systematic review and meta-analysis

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## ABSTRACT

Two behavioral change-based strategies for promoting adherence to physical activity (PA) suggested to have the greatest potential are the pedometer and Motivational Interviewing (MI). However, there are no comparisons between these two strategies identifying which one is more effective for improving PA adherence. This systematic review and meta-analysis aimed to determine which PA motivation strategy is more effective for promoting adherence to self-directed PA in female breast cancer survivors. Studies implementing self-directed PA which used step tracker and/or MI for motivation in female breast cancer survivors were identified from the following databases: CENTRAL, PubMed, CINAHL, PsycINFO, and Sportdiscuss at two timepoints in September 2019 and June 2020. Sixteen randomized controlled trials (RCTs) were recruited for data extraction, whereas ten RCTs were included in meta-analysis. Meta-analysis was performed on pooled data to estimate the standardized mean difference and 95% confidence intervals of PA duration and step count. Analysis of the number of participants meeting PA recommendations was also performed. Subgroup analysis was performed for three motivational strategies (pedometer combined with counselling, print material or combining with motivational interviewing). Meta-analysis showed that pedometer combined with another intervention on behavioral change theory has a small effect on step count ( $p = 0.03$ ) and a moderate effect on moderate-vigorous physical activity (MVPA) duration ( $p = <0.0001$ ) compared to controls. Additionally, motivational strategies increase the number of participants who meet PA goal ( $p = 0.005$ ). The findings of this review advocate for the use of step tracker combined with counselling, print material or MI based on behavioral change theory. This approach provided the most consistent positive effect on PA adherence in self-directed PA among breast cancer survivors. Future studies should specifically evaluate the differences between PA adherence measurements in self-directed PA, to identify the best motivation strategy for improving patient adherence and health outcomes.

**Systematic review registration:** PROSPERO Registration number CRD42020148542

*Keywords:* Breast cancer survivors, physical activity, exercise, self-directed, behavioral change strategies, step count tracker, wearable technology, pedometer, accelerometer, motivational interviewing, adherence, compliance

## 1. Introduction

Breast cancer was the leading cause of cancer morbidity and mortality in women across the world in 2018 with 2.1 million females diagnosed and 626,679 deaths [1]. In 2017, the disability-adjusted life-years (DALYs) was 17.7 million [2]. The significant health impacts of breast cancer make a strong argument to develop interventions which reduce the burden on both patients and healthcare systems. Breast cancer survivors are also vulnerable to significant mental distress [3]. There are a number of factors which can cause psychological stress, including their cancer related illness, fear of cancer recurrence, difficult work-life balance, lost feminine body image and dysfunctional intimate relationships with partner [4]. These psychological burdens can reduce coping with daily life issues and affect quality of life (QoL) [5].

A cohort study acknowledged that adherence to regular PA can improve mental health-related quality of life in breast cancer survivors [6]. PA adherence has been defined by an individual's behaviour in meeting exercise recommendations [7]. PA adherence is typically measured by two methods: determining total activity by ratio or percentage of exercise session attendance or physical measures such as step count, exercise duration and intensity [7]. It can be reported by threshold of exercise prescription (e.g., the percentage of participants who perform at least 50% of exercise sessions) [8] or as the percentage of participants meeting a level of exercise goal of duration and intensity [9, 10]. Some studies suggest that adherence can be measured by PA frequency (number of sessions), duration (mean minutes), and intensity (mean RPE) completed per week and report a weekly trend [11]. For the measurement of exercise volume, technology such as activity trackers are commonly used to record participants' exercise intensity and duration [12].

Adherence to PA or exercise programs is known to be associated with positive breast cancer outcomes such as enhancement of QoL, physical and mental health [13]. A year-long supervised home-based exercise program in breast cancer survivors reported that the exercise group adhered to 115 min and 119 min of aerobic exercise weekly on average at six and twelve months, respectively [10]. While only 33 % of the women met exercise recommendations (150 min weekly) in the year-long program, they still increased their aerobic fitness over the follow-up period [10]. PA or exercise programs are typically classified as self-directed if more than 50% of the program is implemented without close supervision (e.g. at a laboratory or clinic) [14]. Self-directed PA programs for cancer survivors often consist of a partially supervised and home-based program, with exercise classes or group support walking [15]. Many trials applying self-directed PA in cancer survivors achieve high levels of adherence to PA [15]. In breast cancer survivors, a one year-self-directed weight training at a clinical setting and at home resulted in high percentage adherence to the program [16].

PA or exercise promotion in breast cancer survivors can be improved by integrating behavioral change theories or models such as Social Cognitive Theory (SCT) [17], Self-determination Theory (SDT) [18], Theory of Planned Behavior (TPB) [19] or the Transtheoretical Model (TTM) [17]. Theory-based PA programs employ strategies such as social or peer support, participative goal-setting, self-efficacy promotion and self-monitoring to promote adherence [20]. More specifically, these behavioral change theory-based strategies have been implemented through PA counselling focused on supportive approach by an exercise coach (in person or by phone) or group session [20]. A systematic review reported that adherence to home-based PA programs was associated with self-motivation and social support, highlighting the importance of these strategies [21].

Motivation is a vital factor in individual behaviour change; for example, people with more intrinsic motivation have more engagement in weight management programs [22]. SDT identifies some factors influencing human motivation such as individual characteristics and their interaction with the social world [23, 24] and represents the significance of autonomous self-regulation [25]. Two most potential strategies used for exercise motivation in clinical research are self-monitoring [26] and Motivational Interviewing (MI) [27]. Step count trackers or pedometers have been used to enhance PA adherence in many research studies [12, 28, 29]. Similarly, MI can increase PA behavior in cancer survivors [30]. MI, a patient-focused interview, aims to empower a person by counselling for behavioral change [31]. A counsellor who provides MI should apply four principles: (1) empathy

expression (2) understanding of individual's current behavior and their goal (3) attention to resistance and (4) self-efficacy promotion [31]. There is evidence that MI through both phone call and in-person counselling can reduce sedentary and increase active behaviors in breast cancer survivors [30]. Phone based MI integrated into a twelve-week diet control and exercise program in breast cancer survivors resulted in 70% of participants to adhere to the program [32].

Self-monitoring, one of the key concepts in Self-regulation Theory, is an individual evaluating their personal performance with reference to their perceptions, beliefs, and emotions [33]. PA promotion through self-monitoring can be made more pragmatic by making use of technological devices [34]. Step trackers can accurately detect PA behavior as daily steps and it can be used for PA motivation [35] in cancer patients and survivors [36, 37]. A previous study found that step trackers helped in PA self-monitoring and resulted in long-term PA adherence in post-menopausal women [12].

This systematic review and meta-analysis examined whether step count tracker and MI are effective motivational strategies to promote adherence to self-directed exercise in breast cancer survivors. We will explore the effectiveness of these motivational strategies in exercise interventions by comparing the adherence rates of participants in participating in self-directed PA.

### **1.1. Objective**

The objective of this systematic review and meta-analysis was to compare PA adherence to self-directed PA in programs applying step tracker and MI in female breast cancer survivors. The study aimed to identify whether either of these behavioral change techniques is more effective in promoting adherence to self-directed PA in breast cancer survivors.

## **2. Methods**

### *2.1. Protocol and Registration*

The protocol was written using the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols (PRISMA-P) 2015 [38]. The protocol of this systematic review was registered with the International Prospective Register of Systematic reviews (PROSPERO) (CRD42020148542).

### *2.2. Eligibility criteria*

#### *2.2.1. Participants*

Studies were considered eligible for the review if: 1) they included female breast cancer survivors aged 18 and older diagnosed with stage 0 to III tumors; 2) participants had completed primary treatments (surgery, chemotherapy and radiotherapy) at least three months prior to recruitment and had no evidence of cancer recurrence [39]; and 3) participants were on continuing hormonal therapy (e.g. Tamoxifen) as well as immune targeted therapy (e.g. Herceptin).

Studies were excluded if participants were currently receiving primary treatments of breast cancer and those who were diagnosed with metastatic breast cancer. We also excluded studies that involved male breast cancer survivors, unless the results of females could be separately extracted.

#### *2.2.2. Intervention*

The review included RCTs that evaluated self-directed PA or exercise as defined by the World Health Organization (WHO) compared to usual care [40]. Exercise is deemed a subcategory of PA which is well-organized and aims deliberately to improve physical fitness [40]. RCTs with PA or exercise implementation were considered self-directed and included if more than half of the program duration was independently implemented without strict control or close supervision in a controlled unit [14]. We included partially supervised or non-supervised programs, home-based programs, exercise class sessions that participants choose or group support walking [15]. The interventions were not limited by exercise or PA type, duration or intensity.

### 2.3. Outcome

The primary outcome of this systematic review was PA or exercise adherence. The study included studies which assessed the adherence by using the following criteria:

- Percentage of participants who completed a specified number of sessions (full adherence).
- Percentage of participants who attended at least a defined threshold of exercise sessions (partial adherence).
- Percentage of participants who achieved a given exercise volume recommendation such as weekly duration and intensity.
- The average of repeated measures such as exercise duration, intensity and step count.

PA adherence can be affected by the duration of PA program [41]. Therefore, PA or exercise adherence was reported at the end of the follow-up period of the program.

### 2.4. Report characteristics

The review included peer-reviewed articles with available full-texts. There were no limitations to the language of the publication. However, all eligible studies were reported in English. Literature reviews, conference abstracts, theses and book chapters were excluded from the review.

### 2.5. Information sources

The literature search made use of relevant medical subject headings (MeSH) and terms related to breast cancer, physical activity, self-directed, behavioral change and adherence to developed searching strategies in electronic databases (Appendix 1). The literature search includes studies published up to June 2020 available on the following databases; the Cochrane Breast Cancer Group's Specialized Register, the review identified relevant studies and trials which were outlined at <http://www.mrw.interscience.wiley.com/cochrane/clabout/articles/BREASTCA/frame.html>, Cochrane Central Register of Controlled Trials (CENTRAL) (Appendix 2), PubMed (Appendix 3), Cumulative Index to Nursing and Allied Health Literature (CINAHL) with full text (EBSCOhost) (Appendix 4), PsycINFO (EBSCOhost) (Appendix 5) and Sportdiscuss with full text (EBSCOhost) (Appendix 6).

Searches were performed at two timepoints; firstly, September 2019, and with an update in June 2020 for studies published from September 2019 to June 2020. The literature was limited to human research.

### 2.6. Search Strategy

The search strategy was designed in collaboration with an experienced college librarian, College of Health and Biomedicine, Victoria University. A trial search with key words and related terms was conducted on PubMed (advance search) in May 2019 for feasibility of the number of potential articles. The trial search on PubMed is in Appendix 3.

### 2.7. Study selection

Search results from the five databases were exported to Covidence with following reviews working in the software [42]. The reviewers utilized Covidence screening tools for assessment of articles based on keywords for inclusion and exclusion criteria.

A summary of study inclusion and exclusion at each phase is described in Figure 1. Two reviewers (SP and JF) independently screened the titles and abstracts yielded by electronic key-term searching. Full-texts of the included studies were then uploaded and reviewed in full by the same reviewers independently. During screening any conflicts between reviewers were reviewed finally by a deciding third reviewer (VA).

### 2.8. Data extraction

Data from included studies was extracted manually and entered into a collection tool built in Microsoft Excel developed specifically for the current review. After data was extracted by the first reviewer (SP), the data was independently verified by a second and third reviewer (JF and JT). Where required, study authors were contacted by email for additional clarification regarding PA adherence measurement.

The review extracted the following data: Publication related information (Authors, year, Titles), Type of study or research design, number and age of participants, intervention characteristics (types and period of self-directed physical activity), PA or exercise motivation techniques (pedometer, MI and other behavioral change theory-related interventions) and measurements of PA or exercise adherence.

### *2.9. Risk of bias*

Two reviewers (SP and JF) independently used Cochrane's assessment tool for the risk of bias in the recruited studies [43]. Relevant domains for risk assessment were: Selection bias (random sequence generation and allocate concealment); performance bias (blinding of participants and researchers); detection bias (blinding of outcome assessment); attrition bias (completeness of outcome data including exclusion from analysis); and reporting bias (selective reporting). All decisions were reported as low, high, and unclear risk. Any disagreements were resolved by discussion with the reviewer team and then by consensus. The result of the risk of bias assessment is reported and discussed in the review findings.

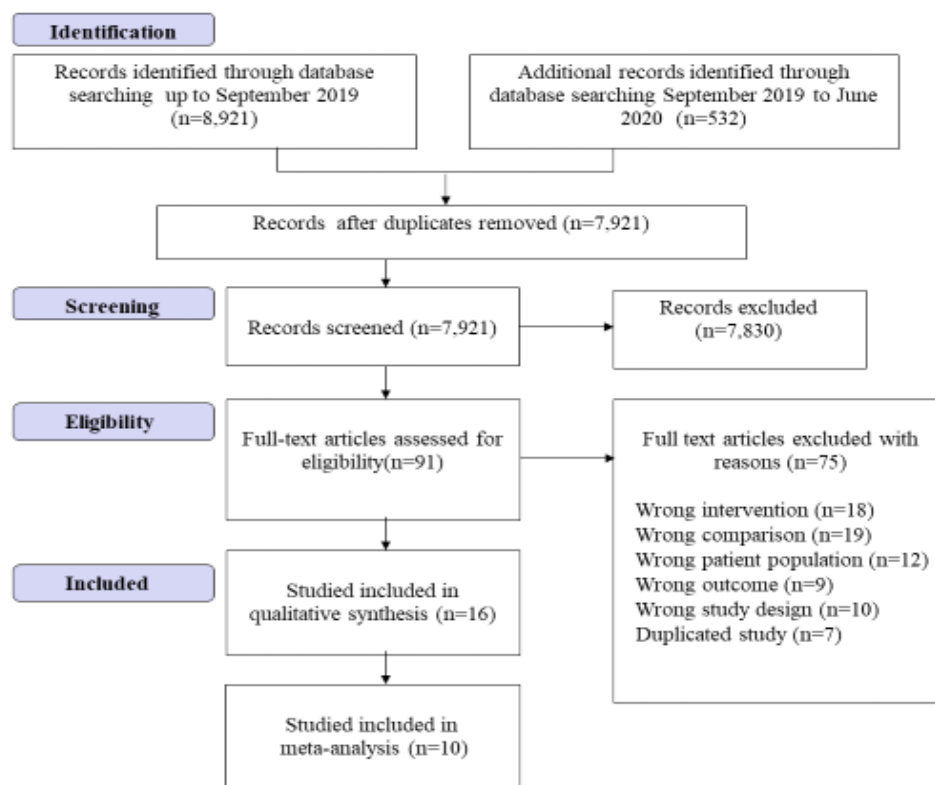
### *2.10. Synthesis of results*

The review reported the outcomes of included studies consisting of repeated measures of PA duration (minutes per week of MVPA) and step count (daily or weekly steps) in standardized mean difference. Additionally, the number of participants who meet PA recommendation was reported by odds ratio (OR). A meta-analysis was performed on pooled data to estimate the standardized mean difference and 95% confidence intervals of PA duration (weekly minutes MVPA) and step count. The pooled difference in number of participants meeting PA recommendations between control and intervention groups was also performed. This analysis method was suitable for the comparison of data from the relevant scales [44]. The primary outcome was exercise or PA adherence in female breast cancer survivors which was reported by dichotomous data (e.g., the number of participants who met and did not meet the exercise/PA targets) and continuous data (e.g., mean of duration attending exercise and mean of daily steps). The outcomes of each study were displayed in forest plots to identify the effect of motivational strategies on PA adherence. The score of standardized mean difference was considered as a small, moderate and large effect with scores of <0.20, between 0.20 and 0.80 and >0.80, respectively [45]. Subgroup effect analyses were conducted for each outcome regarding to the characteristics of PA motivational strategies of each study (e.g., pedometer combining with counselling or pedometer combining with motivational interviewing). The I square ( $I^2$ ) statistic for heterogeneity was also calculated, with a threshold of > 50% was identified as significant. A random-effects model was used to account for heterogeneity and extended variation in the pooled data [45], otherwise fixed-effect models were used [46]. All statistical analyses were conducted by using Review Manager, version 5.3.

## **3. Results**

### *3.1. Study selection*

The database search returned 7,921 articles which underwent abstract screening, with 7,830 excluded for irrelevance to topic. The remaining 91 studies underwent full-text screening, resulting in a final 16 studies included for data extraction. The search and selection of articles are represented in Figure 1.



**Figure 1.** Flow of information through the different phases of a systematic review

### 3.2. Study characteristics

The sixteen included RCTs had a median duration of follow-up of twelve weeks (range: ten weeks to nine months). There was a total of 1,668 participants (953 intervention and 715 control) and the mean age across studies ranged from 49.50 - 61.90 years. Self-directed PA types consisted of home-based PA, walking programs and supervised tapering to home-based PA. The interventions studied could be grouped based on PA motivational strategy by five classifications as following 1) pedometer combining counselling, 2) pedometer combining MI, 3) pedometer combining print material, 4) pedometer combining social media and 5) MI. The first three groups were included in the meta-analysis. Groups 4 and 5 could not be included in the meta-analysis as there was only one trial of the intervention.

There were thirteen trials providing usual care of breast cancer, standard PA recommendation or maintaining usual activity in waiting list as control interventions, while three trials provided standard care with pedometer [47, 48] or accelerometer for daily use [37].

PA adherence was reported as weekly intensity of PA (MET), weekly minutes of MVPA, daily steps (one study reported weekly steps [48], the numbers of participant who met PA goals and percent of participant who met PA recommendations (% PA adherence). The adherence measures of all included studies are illustrated in Table 1.



**Table 1.** Characteristics of included studies

No.	Author, Year	Study site (Country)	PA program	Follow-up	Participant Number and Age	Motivation strategies	Control condition	PA adherence measurement
<b>Pedometer + Counselling</b>								
1	Basen-Engquist et al, 2006	USA	6 months PA at moderate intensity such as walking at home.	6 months	Intervention group N= 35 Age= 55.7± 11.1 Control group N= 25 Age= 54.4± 11.7	Pedometer + 21 sessions lifestyle counselling based on Transtheoretical Model	Receiving Standard care	●S-MVPA (min/week)
2	Pinto et al., 2005	USA	12 weeks home-based moderate intensity PA	12 weeks	Intervention group N= 43 Age= 53.42 ± 9.08 Control group N= 43 Age= 52.86 ± 10.38	Pedometer +PA counselling based on Transtheoretical Model (weekly phone call)	Receiving weekly phone call about Breast cancer care	●S-MVPA (min/week) ● Daily steps ●% PA adherence
3	Pinto et al., 2015	USA	12 weeks MVPA such as brisk walking at home	12 weeks	Intervention group N= 39 Age= 55.64 ± 8.59 Control group N= 37 Age= 55.59 ± 10.59	Pedometer +PA counselling based on Transtheoretical Model (weekly phone call)	Receiving Standard care	●S-MVPA ●O- MVPA (min/week) ●% PA adherence
4	Roger et al., 2015	USA	3 months supervised tapered to 12 weeks home-based PA	24 weeks	Intervention group N= 110 Age= 54.9± 9.3 Control group N= 112 Age= 53.9 ± 7.7	Accelerometer + Counselling based on Social Cognitive Theory (3 Face-to-face sessions)	Accelerometer +Standard PA	●S-MVPA ●O-MVPA (min/week) ●% PA adherence
<b>Pedometer + Motivational Interviewing</b>								
5	Hartman et al., 2018	USA	12 weeks walking with pedometer	12 weeks	Intervention group N= 43 Age= 58.2± 11.37 Control group N= 44 Age= 56.2 ± 9.30	Pedometer + MI (1 time in-person session and 2 phone calls)	Wait listed control	●O-MVPA (min/week, min/day) ●% PA adherence
6	Lynch et al., 2019	Australia	12 weeks wearable technology-based PA	12 weeks	Intervention group N= 40 Age= 61.3± 5.9 Control group N= 40 Age= 61.9 ± 7.0	Pedometer + MI (1 face-to-face session and 5 phone calls)	Wait listed control	●O-MVPA (min/week) ●Daily steps
<b>Pedometer + Print materials</b>								
7	Short et al., 2015	Australia	4 months home-based PA support	4 months	Intervention (SCT) N= 109 Age= 56 (34-74) Intervention (TPB) N= 110 Age= 55 (36-82) Control group N= 111 Age= 55 (33-75)	Pedometer + Print materials (2 groups) based on <ul style="list-style-type: none"> <li>• Social Cognitive Theory</li> <li>• Theory of Planned Behaviour</li> </ul>	Pedometer + Standard PA guideline	●S-MVPA (min/week) ●Daily steps ●% PA Adherence

8	Singh et al., 2020	Australia	12 weeks follow-up pedometer and guideline-based PA after 12 weeks supervised exercise	12 weeks	Intervention group N= 26 Age= 49.5 ± 8.6 Control group N= 26 Age= 52.8 ± 9.5	Pedometer + Booklet based on Theory of Planned Behaviour	Standard PA guideline	<ul style="list-style-type: none"> <li>●S-MVPA</li> <li>●O-MVPA (min/week)</li> <li>●Daily steps</li> <li>●% PA adherence</li> </ul>
No.	Author, year	Study site (Country)	PA program	Follow-up	Participant Number and age	Motivation strategies	Control condition	PA adherence measurement
9	Vallance et al., 2007	Canada	12 weeks step tracker and guideline-based PA	12 weeks	Intervention (pedometer + booklet) N= 93 Age= 58 (38-86) Intervention (pedometer + PA advice) N= 94 Age= 58 (34-75) Control group N= 96 Age= 57 (37-90)	Pedometer + Booklet based on Theory of Planned Behaviour	PA recommendation	<ul style="list-style-type: none"> <li>●S-MVPA (min/week)</li> <li>●Daily steps</li> </ul>
10	Hirschey et al., 2018	USA	12 weeks home-based PA	12 weeks	Intervention group N= 29 Age= 59 ± 10.0 Control group N= 29 Age= 57 ± 12.0	Pedometer + Booklet based on Social Cognitive Theory (self-efficacy and expected outcome)	Pedometer +Booklet based on diet	<ul style="list-style-type: none"> <li>●Weekly steps</li> </ul>
Pedometer + Counselling								
11	Baruth et al, 2015	USA	12 weeks home-based walking program	12 weeks	Intervention group N= 20 Age= 57.4 ± 6.1 Control group N= 12 Age= 54.9 ± 6.5	Pedometer + Counselling based on Social Cognitive Theory (goal setting, social support and reward) (1 in-person session and 5 phone calls)	Maintain usual activity.	<ul style="list-style-type: none"> <li>●MET (hr/week)</li> </ul>
12	Pinto et al., 2013	USA	12 months PA at least at moderate intensity (received in person advice)	12 months	Intervention group N= 106 Age= 56.1 ± 9.9 Control group N= 86 Age= 55.9 ± 9.9	Pedometer + PA counselling based on Transtheoretical Model and Social Cognitive Theory (8 phone calls)	8 phone call about Breast cancer symptoms	<ul style="list-style-type: none"> <li>●S-MVPA (min/week)</li> </ul>
13	Pinto et al., 2008	USA	Follow-up 6 and 9 months after 12 weeks home-based PA	6 and 9 months	Intervention group N= 43 Age= 53.42 ± 9.08 Control group N= 43 Age= 52.86 ± 10.38	Pedometer + PA counselling based on Transtheoretical Model (weekly Phone call for first 3 months and then monthly phone calls for 3 months and then last 3 months they were asked to maintain PA by themselves)	Receiving phone call about Breast cancer symptoms	<ul style="list-style-type: none"> <li>●S-MVPA (min/week)</li> </ul>
Pedometer + Social support								
14	Vallance et al., 2008	Canada	6 months follow-up after 3 months step tracker and print material guideline-based PA	6 months	Intervention (pedometer + booklet) N= 93 Age= 58 (38-86) Intervention (pedometer + PA advice) N= 94 Age= 58 (34-75) Control group	Pedometer + Booklet based on Theory of Planned Behaviour	PA recommendation	<ul style="list-style-type: none"> <li>●S-MVPA (min/week)</li> </ul>

					N= 96 Age= 57 (37-90)			
15	Pope et al., 2018	USA	10 weeks home-based PA	10 weeks	Intervention group N= 16 Age= 50.6 ± 7.4 Control group N= 14 Age= 54.9 ± 11.0	Pedometer + Social media: Facebook Based on Social Cognitive Theory	Separated, content identical Facebook	<ul style="list-style-type: none"> <li>●O-MVPA (min/day)</li> <li>●Daily steps</li> </ul>
<b>No.</b>	<b>Author, Year</b>	<b>Study site (Country)</b>	<b>PA program</b>	<b>Follow-up</b>	<b>Participant Number and Age</b>	<b>Motivation strategies</b>	<b>Control condition</b>	<b>PA adherence measurement</b>
<b>Motivational Interviewing</b>								
16	Lahart et al., 2016	UK	6 months moderate intensity of home-based PA program	6 months	Intervention group N= 40 Age= 52.4± 10.3 Control group N= 40 Age= 54.7 ± 8.3	MI (1 face-to-face session + 3 phone calls)	Standard PA guideline	<ul style="list-style-type: none"> <li>●MET (min/week)</li> </ul>

**Abbreviations:** USA: United States of America, UK: United Kingdom, N: the numbers of participant, Age: reported in years (mean ± standard deviation or mean and range), PA: Physical activity, S-MVPA: Subjective (self-report) moderate vigorous physical activity, O-MVPA: Objective moderate vigorous physical activity, min/week: Minutes per week, MET: Metabolic equivalent of task, MI: Motivational Interviewing

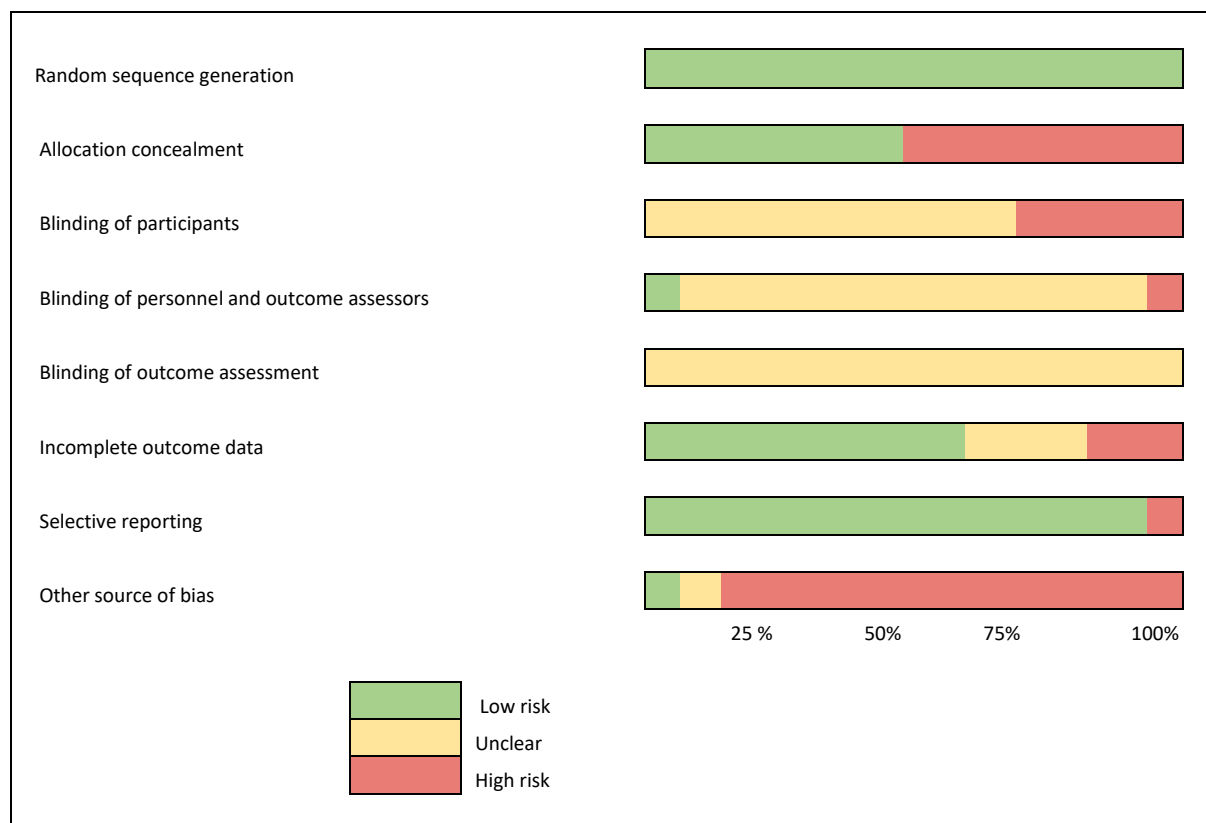
### 3.3. Risk of bias within the studies

All included studies indicated randomization of participants into study groups but only 50% declared allocation concealment [37, 47, 49-54]. There were no trials which blinded participants, assessors, and outcomes assessment. One trial reasoned that they did not blind participants and staff due to the nature of intervention [53]. Ten of sixteen trials [37, 47, 49, 51, 52, 54-58] reported low risk of attrition bias (presenting the methods to deal with missing data). One of sixteen trials [55] had high risk of reporting bias as they did not report all outcomes stated in the protocol; the frequency, duration of walking and MET were not reported at the follow-up. Most of studies reported the potential of other sources of bias which may affect the results as they had the limitation in generalization of participants, small sample size, and type 1 error control. Most of participants were willing to participate in an exercise program that may result in the positive effects of intervention. The review could not assess non-reporting bias across included trials by evaluating the symmetry of funnel plot and Egger's test because there were not more 10 trails included in meta-analysis for each PA adherence outcome [59]. However, the review implemented comprehensive searching from 5 databases and included studies with peer review publication. Risk of bias is summarized in Figure 2 and Figure 3.

	Random sequence generation	Allocation concealment	Blinding of participants	Blinding of personnel and outcome assessors	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other source of bias
Basen-Engquist et al, 2006	√	?	?	?	?	√	√	?
Pinto et al., 2005	√	?	?	?	?	?	√	X
Pinto et al., 2015	√	√	X	?	?	?	√	X
Roger et al., 2015	√	√	?	?	?	√	√	√
Hartman et al.,2018	√	?	?	?	?	√	√	X
Lynch et al., 2019	√	√	X	X	?	x	√	X
Short et al., 2015	√	√	?	?	?	√	√	√
Singh et al., 2020	√	?	?	?	?	√	√	X
Vallance et al.,2007	√	√	X	?	?	√	√	X
Hirschev et al., 2018	√	?	?	?	?	x	√	X
Baruth et al 2015	√	?	?	?	?	√	x	X
Pinto et al., 2013	√	√	x	√	?	√	√	X
Pinto et al., 2008	√	?	?	?	?	?	√	x
Vallance et al., 2008	√	√	x	?	?	√	√	x
Pope et al., 2018	√	?	?	?	?	?	√	x
Lahart et al., 2016	√	√	?	?	?	√	√	x

√ = low risk  
 X = high risk  
 ? = unclear

**Figure 2.** Risk of bias summary



**Figure 3.** Risk of bias graph

### 3.4. Synthesis of results

Ten studies with eleven intervention arms (one study had two parallel intervention arms [47]) were included in the meta-analysis [37, 47, 48, 50, 51, 53, 56-58, 60]. Overall, intervention group involved in meta-analysis can be categorized into three groups consisting of 1) pedometer + counselling, 2) pedometer + MI, and 3) pedometer + print material.

#### 3.4.1. MVPA duration

Nine trials [37, 47, 50, 51, 53, 56-58, 60] were included in meta-analysis of MVPA duration (minutes per week). There was significant heterogeneity between studies ( $I^2 = 77\%$ ). When a random effects analysis was applied, the intervention group achieved a moderate improvement in MVPA duration compared with the usual care group (SMD=0.55, 95% CI 0.30,0.79). Results were consistent in the three subgroup analyses (Figure 4).

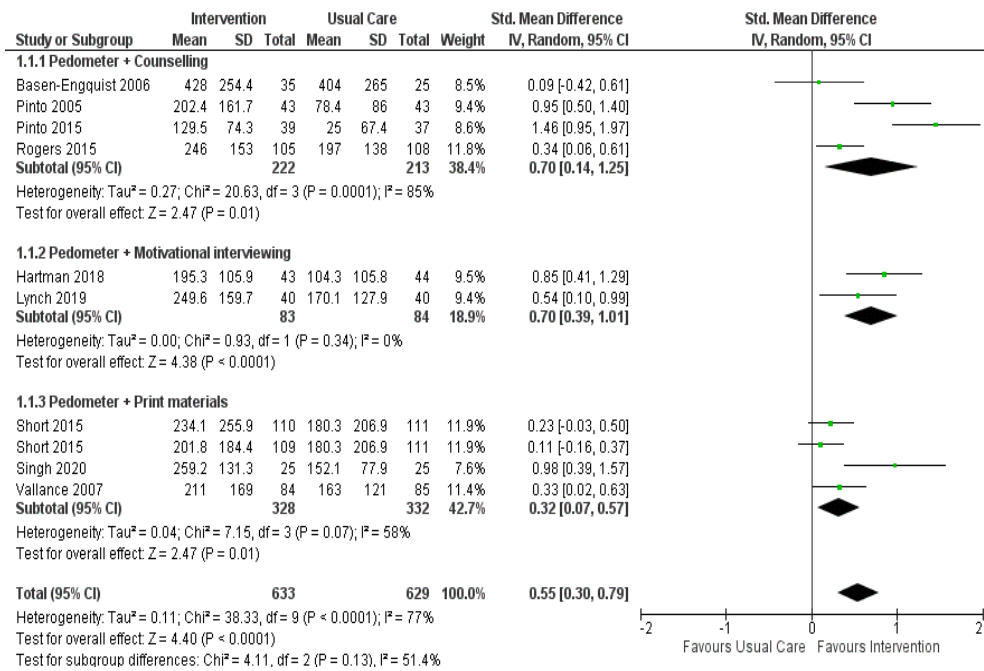
#### 3.4.2. Step count

Five studies were included in meta-analysis of step count; four studies [47, 51, 53, 57] reported in daily steps but one study [48] reported in weekly steps. There was no heterogeneity between studies ( $I^2 = 0\%$ ). Overall, a small effect of the intervention was detected compared to the control groups (SMD= 0.16, 95% CI 0.02, 0.29; Figure 5). There were two subgroups meta-analysis of step count; 1) the intervention group applying pedometer and print material [47, 48, 51, 57] showed a

small effect in improvement of step count; SMD 0.15, 95% CI 0.01, 0.30,  $p = 0.04$ ,  $I^2=0\%$ , 2) the intervention group applying pedometer and motivational interviewing [53] shown small effect; SMD 0.19, 95% CI -0.26, 0.64,  $p = 0.40$  (Figure 5).

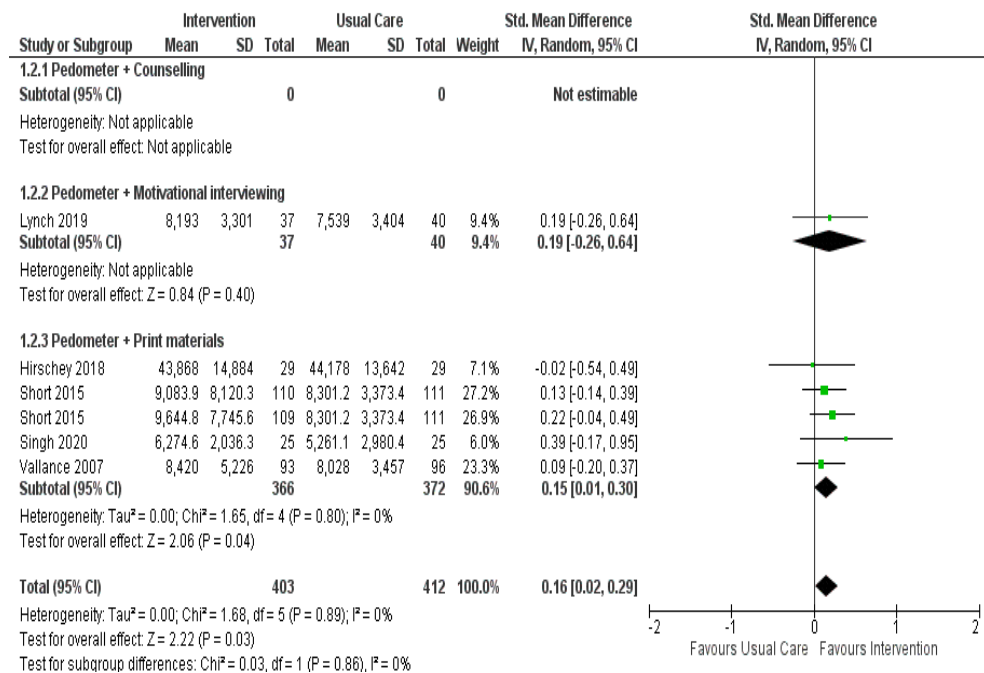
#### *3.4.3. The number of participants who meet physical activity recommendation.*

Overall, six studies [37, 47, 50, 57, 58, 60] were included in the meta-analysis measuring participants meeting PA recommendations. There was significant heterogeneity between studies ( $I^2 = 77\%$ ). When a random effects analysis was applied, the intervention group had a significantly higher odds of meeting physical activity recommendations compared with the usual care group (OR=2.66, 95%CI 1.34, 5.27. This was consistent in all subgroup evaluations (Figure 6).



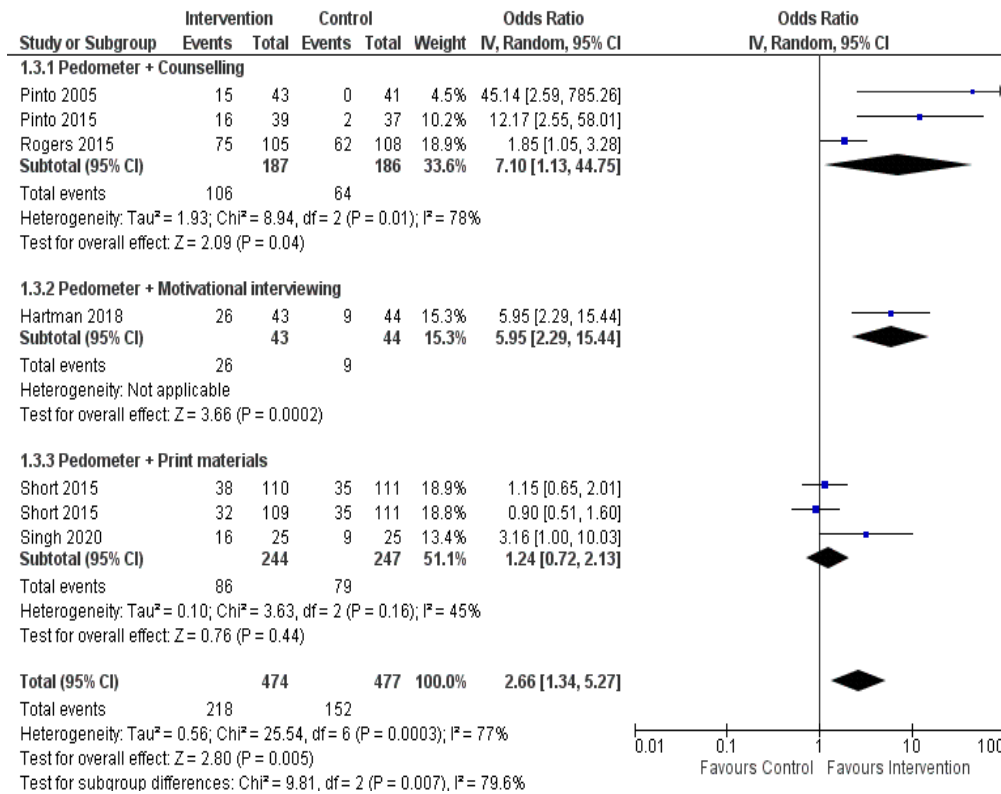
**Figure 4.** Meta-analysis of MVPA duration

**Abbreviations:** IV: inverse variance, Std: standardized, Total: number of participants in the study group



**Figure 5.** Meta-analysis of daily steps

**Abbreviations:** IV: inverse variance, Std: standardized, Total: number of participants in the study group



**Figure 6.** Meta-analysis of meeting PA recommendation (Odds Ratio)

**Abbreviations:** IV: inverse variance, Std: standardized, Total: number of participants in the study group

## 4. Discussion

### 4.1. Summary of evidence

This review and meta-analysis provides new evidence of improved adherence to self-directed PA in breast cancer survivors through application of two motivational strategies; pedometer (step tracker) and MI. Overall, pedometer combined with another motivational strategy based on behavioral change theory provides small to moderate effect on step count and MVPA duration when compared to control receiving standard PA recommendation or usual care. Additionally, motivational strategies increased the number of participants who meet PA goal. Though there was significant heterogeneity among trials, the improvements of PA adherence were mostly consistent across the subgroups of motivational strategy.

Among sixteen included trials, there were a number of commonalities in the application of pedometer (step tracker) and/or MI for PA motivation. Fifteen of the studies used step tracker (fourteen trials used pedometer [47-53, 55-58, 60-62] and one trial [37] used accelerometer for weekly self-monitoring over the trial duration. No trial utilized step tracker alone, with all fifteen trials combining them with another behavioral change theory informed strategy such as counselling, print material, social media, and MI.

Three trials used MI for PA motivation; two combining MI with pedometer [53, 58], and trial applying MI alone [54]. Additionally, there were a variety of behavioral change theories applied to interventions including Social Cognitive Theory (SCT), Transtheoretical Model (TTM) and Theory of Planned Behavior (TPB). However, among the ten studies included in meta-analysis, the review could not analyze these subgroups due to the small number of trials using a particular theoretical framework.



There was also heterogeneity of PA duration among the included studies. A twelve-week self-directed PA regimen was the most widely used program, with durations ranging from ten weeks to nine months. Subgroup analyses on programs of different durations could not be conducted due to low numbers. There was also heterogeneity in the methods used to assess MVPA between the included studies. The review included six studies [47, 50, 51, 56, 57, 60] assessing MVPA by self-reported questionnaire and three studies using objective measurements obtained by accelerometer [37, 53, 58]. Of the studies using self-reported PA questionnaires; three [50, 56, 60] applied the Seven Day Physical Activity Recall Questionnaire (7 Day PAR), two [47, 51] used the Godin Leisure-Time Exercise Questionnaire, and one study used The Active Australia Survey [57].

Among the sixteen included trials of self-directed PA and motivational strategy there were two principal measurements of PA adherence, which have been identified in previous work [7]. The first was percentage of participants who met PA recommendations and the other was the average of repeated measure such as PA intensity, duration and step count. Six trials [37, 47, 50, 57, 58, 60] reported the number and percentage of participants who met PA recommendations. All six of these used a benchmark of at least weekly 150 min of MVPA as a minimum recommendation, in line with common guidelines for breast cancer survivors. The remaining ten trials did not report a percentage of PA adherence, instead reporting the average of repeated measure such as intensity (MET), duration (weekly minutes of MVPA) and step count described above. The corresponding authors of these trials were contacted by email for percentage of PA adherence data, if available, however no additional data was acquired through this despite several responses from the authors. PA adherence was determined to be an individual's behavior in responding to PA goals in accordance with previous definitions [7].

The findings of this review highlight the potential role of incorporating self-directed PA in the treatment of breast cancer survivors by using an affordable step tracker for PA self-monitoring at their home or in the community. Additionally, combining the use of a pedometer with another PA motivational strategy based on behavioral change theories such as counselling, MI, or print materials (handout or brochure) will likely enhance PA adherence in this population.

Given the noticeable heterogeneity of PA adherence outcome assessment in self-directed PA in breast cancer survivors, the review would suggest that the appropriateness of PA adherence outcome measurements in self-directed PA needs to be standardized in trials to provide accurate reporting standards and allow for effective comparison between trials. This will allow for identification of optimal interventions to improve PA adherence in this patient cohort, and so improve health outcomes.

#### **4.2. Limitation**

The recommendations of this meta-analysis are limited by the significant heterogeneity of the trials included in this review. Firstly, there were a variety of PA motivation strategies and behavioral change theories that informed them, making it difficult to recommend a single intervention over another. There was also significant variability in the duration of the self-directed PA regimens. This is important, as participant adherence is strongly impacted by program duration [41]. The included trials in this review all show the potential risk of bias. The nature of the intervention led to unavoidable issues with blinding participants, exposing the trials to risks of bias.

#### **5. Conclusions**

This review found that step tracker combining with counselling, print material or MI based on behavioral change theory provided a consistent positive effect on adherence to self-directed PA among breast cancer survivors. This emphasizes the importance of applying motivational improvement strategies in this cohort to improve their health outcomes over time. While there was heterogeneity in the application of step tracker and/or MI among included trials, the improvements were consistent across studies, so while confidence can be received in the results, no single intervention could be identified as having an optimal outcome. The review highlights opportunities

for health care professionals to improve patient outcomes through the application of motivational strategies to increase PA adherence. Future studies should assess and report PA adherence outcomes consistently, to allow for more effective examination of motivational interventions.

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## Conflict of interest

The authors have no conflict of interest to declare

## Ethical approval

No ethics was required for this article

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## Appendices

### Appendix 1. MeSH terms

#### 1. Breast cancer

Tumors or cancer of the human breast

Entry Terms:

- Breast Neoplasm
- Neoplasm, Breast
- Breast Tumors
- Breast Tumor
- Tumor, Breast
- Tumors, Breast
- Neoplasms, Breast
- Breast Carcinoma
- Breast Carcinomas
- Carcinoma, Breast
- Carcinomas, Breast
- Mammary Neoplasms, Human
- Human Mammary Neoplasm
- Human Mammary Neoplasms
- Neoplasm, Human Mammary
- Neoplasms, Human Mammary
- Mammary Neoplasm, Human
- Breast Cancer
- Cancer, Breast
- Mammary Cancer
- Cancer, Mammary
- Cancers, Mammary
- Mammary Cancers
- Malignant Neoplasm of Breast
- Breast Malignant Neoplasm
- Breast Malignant Neoplasms
- Malignant Tumor of Breast
- Breast Malignant Tumor
- Breast Malignant Tumors
- Cancer of Breast
- Cancer of the Breast

#### 2. Physical activity

Physical activity which is usually regular and done with the intention of improving or maintaining PHYSICAL FITNESS or HEALTH. Contrast with PHYSICAL EXERTION which is concerned largely with the physiologic and metabolic response to energy expenditure.

Entry Terms:

- Exercises
- Physical Activity
- Activities, Physical
- Activity, Physical
- Physical Activities
- Exercise, Physical
- Exercises, Physical



Physical Exercise  
Physical Exercises  
Acute Exercise  
Acute Exercises  
Exercise, Acute  
Exercises, Acute  
Exercise, Isometric  
Exercises, Isometric  
Isometric Exercises  
Isometric Exercise  
Exercise, Aerobic  
Aerobic Exercise  
Aerobic Exercises  
Exercises, Aerobic  
Exercise Training  
Exercise Trainings  
Training, Exercise  
Trainings, Exercise

### **3. Motivational Interviewing**

It is a client-centered, directive method for eliciting intrinsic motivation to change using open-ended questions, reflective listening, and decisional balancing. This nonjudgmental, non-confrontational interviewing style is designed to minimize a patient's resistance to change by creating an interaction that supports open discussion of risky or problem behavior.

Entry Terms:

Interviewing, Motivational

### **4. Fitness tracker**

Devices used for measuring physical activity as an indication of HEALTH STATUS.

Entry Terms:

Fitness Tracker  
Tracker, Fitness  
Trackers, Fitness  
Physical Fitness Trackers  
Fitness Tracker, Physical  
Fitness Trackers, Physical  
Physical Fitness Tracker  
Tracker, Physical Fitness  
Trackers, Physical Fitness  
Activity Trackers  
Activity Tracker  
Tracker, Activity  
Trackers, Activity  
Personal Fitness Trackers  
Fitness Tracker, Personal  
Fitness Trackers, Personal  
Personal Fitness Tracker  
Tracker, Personal Fitness  
Trackers, Personal Fitness

### **5. Wearable Electronic Devices**

Electronic implements worn on the body as an implant or as an accessory. Examples include wearable diagnostic devices, wearable ACTIVITY TRACKERS, wearable INFUSION PUMPS, wearable computing devices, SENSORY AIDS, and electronic pest repellents.

Entry Terms:

- Device, Wearable Electronic
- Devices, Wearable Electronic
- Electronic Device, Wearable
- Electronic Devices, Wearable
- Wearable Electronic Device
- Wearable Technology
- Technologies, Wearable
- Technology, Wearable
- Wearable Technologies
- Wearable Devices
- Device, Wearable
- Devices, Wearable
- Wearable Device
- Electronic Skin
- Skin, Electronic

## **6. Adherence**

Patient Compliance

Voluntary cooperation of the patient in following a prescribed regimen.

Entry Terms:

- Compliance, Patient
- Patient Adherence
- Adherence, Patient
- Patient Cooperation
- Cooperation, Patient
- Treatment Compliance
- Compliance, Treatment
- Treatment Compliances
- Therapeutic Compliance
- Compliance, Therapeutic
- Compliances, Therapeutic
- Therapeutic Compliances

## Appendix 2. Draft CENTRAL search

- #1 MeSH descriptor: [Breast Neoplasms] explode all trees
- #2 breast near cancer
- #3 (breast near cancer) OR (breast near neoplasm) OR (breast near carcinoma)
- #4 MeSH descriptor: [Exercise] explode all trees
- #5 physical next activity\*
- #6 ("physical activity")
- #7 (physical next activity\*)
- #8 (physical next activity\*) OR exercise OR sport
- #9 ("self directed") OR ("home based") OR ("community based") OR ("non supervised")  
OR ("partial supervised") OR ("low supervised")
- #10 ("behavioral change") OR (motivation) OR ("self monitoring") OR ("fitness next  
tracker\*") OR (pedometer) OR (accelerometer) OR ("step count tracker") OR ("step  
next tracker\*")  
OR ("wearable device") OR ("digital device") OR ("wearable technology")
- #11 ("motivational interviewing")
- # 12 MeSH descriptor: [Motivational Interviewing] explode all trees
- # 13 MeSH descriptor: [Treatment Adherence and Compliance] explode all trees
- # 14 adherence
- # 15 (adherence) OR (compliance) OR (engagement) OR (participation)
- # 16 #8 OR #9 OR #10 OR #11
- # 17 #3 AND #16 AND #15

### Appendix 3. Draft PubMed search

- 53 Search (((((breast cancer) OR breast neoplasm) OR breast carcinoma)) AND (((((((((physical activity) OR physical activities) OR exercise) OR exercises) OR sport) OR sports)) OR ((((((self-directed program) OR home-based program) OR community-based program) OR non-supervised program) OR partial supervised program) OR low-supervised program)) OR (((((((((((((((behavioral\* change strategy) OR behavioral\* change strategies) OR physical activity motivation) OR exercise motivation) OR self-monitoring) OR fitness tracker) OR pedometer) OR accelerometer) OR step count trackers) OR step count tracker) OR step counter) OR step counters) OR wearable device) OR wearable devices) OR digital device) OR digital devices) OR wearable technology)) OR motivational interviewing))) AND (((adherence) OR compliance) OR engagement) OR participation)
- 52 Search (((((((((physical activity) OR physical activities) OR exercise) OR exercises) OR sport) OR sports)) OR ((((((self-directed program) OR home-based program) OR community-based program) OR non-supervised program) OR partial supervised program) OR low-supervised program)) OR (((((((((((((((behavioral\* change strategy) OR behavioral\* change strategies) OR physical activity motivation) OR exercise motivation) OR self-monitoring) OR fitness tracker) OR pedometer) OR accelerometer) OR step count trackers) OR step count tracker) OR step counter) OR step counters) OR wearable device) OR wearable devices) OR digital device) OR digital devices) OR wearable technology)) OR motivational interviewing)
- 51 Search (((((((((((((((behavioral\* change strategy) OR behavioral\* change strategies) OR physical activity motivation) OR exercise motivation) OR self-monitoring) OR fitness tracker) OR pedometer) OR accelerometer) OR step count trackers) OR step count tracker) OR step counter) OR step counters) OR wearable device) OR wearable devices) OR digital device) OR digital devices) OR wearable technology)) OR motivational interviewing
- 50 Search (((adherence) OR compliance) OR engagement) OR participation
- 49 Search (((((((((((((((behavioral\* change strategy) OR behavioral\* change strategies) OR physical activity motivation) OR exercise motivation) OR self-monitoring) OR fitness tracker) OR pedometer) OR accelerometer) OR step count trackers) OR step count tracker) OR step counter) OR step counters) OR wearable device) OR wearable devices) OR digital device) OR digital devices) OR wearable technology
- 48 Search ((((((self-directed program) OR home-based program) OR community-based program) OR non-supervised program) OR partial supervised program) OR low-supervised program
- 47 Search (((((physical activity) OR physical activities) OR exercise) OR exercises) OR sport) OR sports
- 46 Search participation
- 45 Search engagement
- 44 Search compliance
- 43 Search adherence
- 42 Search motivational interviewing
- 41 Search wearable technology

40	Search digital devices
39	Search digital device
38	Search wearable devices
37	Search wearable device
36	Search step counters
35	Search step counter
34	Search step count trackers
33	Search step count tracker
32	Search accelerometer
31	Search pedometer
30	Search fitness tracker
29	Search self-monitoring
28	Search exercise motivation
27	Search physical activity motivation
26	Search behavioral* change strategies
25	Search behavioral* change strategy
24	Search low-supervised program
23	Search partial supervised program
22	Search non-supervised program
21	Search community-based program
20	Search home-based program
19	Search self-directed program
18	Search (sport) OR sports
17	Search sports
16	Search sport
15	Search (exercises) OR exercise
14	Search exercises
13	Search exercise
12	Search (physical activities) OR physical activity
11	Search physical activities
10	Search physical activity[MeSH Terms]
9	Search physical activity
7	Search breast cancer[MeSH Terms]
8	Search breast neoplasm[MeSH Subheading]
6	Search ((breast cancer) OR breast neoplasm) OR breast carcinoma
5	Search breast carcinoma
2	Search (breast cancer) OR breast neoplasm
4	Search (breast cancer) AND breast neoplasm
3	Search breast neoplasm
1	Search breast cancer

#### Appendix 4. CINAHL with full text (EBSCOhost)

- S1 (MH "Breast Neoplasms+")
- S2 breast cancer
- S3 breast neoplasm
- S4 breast carcinoma
- S5 S2 OR S3 OR S4
- S6 (MM "Physical Activity")
- S7 physical activity
- S8 physical activity OR exercise OR sport
- S9 self-directed OR home based OR community based OR non-supervised OR partial supervised OR low supervised
- S10 behavioral change OR motivation OR self-monitoring OR (fitness tracker or activity tracker or sport tracker) OR pedometer OR accelerometer OR step count tracker OR step tracker OR wearable devices OR digital devices
- S11 (MM "Motivational Interviewing")
- S12 motivational interviewing
- S13 adherence OR compliance OR engagement OR participation
- S14 S8 OR S9 OR S10 OR S12
- S15 S5 AND S13 AND S14

## Appendix 5. PsycINFO (EBSCOhost)

- S1 breast cancer
- S2 MM "Breast Neoplasms"
- S3 breast neoplasms
- S4 breast carcinoma
- S5 S1 OR S3 OR S4
- S6 MM "Exercise" OR MM "Aerobic Exercise" OR MM Weightlifting"  
OR MM "Yoga" OR MM "Physical Activity" OR MM "Actigraphy" OR MM "Exercise"
- S7 exercise
- S8 MM "Physical Activity" OR MM "Actigraphy" OR MM "Exercise"
- S9 physical activity
- S10 sport
- S11 MM "Sport Psychology"
- S12 S7 OR S9 OR S10
- S13 self-directed OR home based exercise OR community based OR non supervised  
OR partial supervised OR low supervised
- S14 behavioral change OR motivation OR self-monitoring  
OR (fitness tracker or activity tracker or sport tracker) OR (pedometer or activity monitor or daily steps)  
OR (accelerometer or accelerometry or actigraphy) OR step tracker OR step count tracker OR  
(wearable devices or wearable technology) OR digital devices
- S15 motivational interviewing
- S16 MM "Motivational Interviewing"
- S17 S12 OR S13 OR S14 OR S15
- S18 MM "Treatment Compliance"
- S19 adherence
- S20 adherence OR compliance OR (engagement or involvement or participation )
- S21 S5 AND S17 AND S20

## Appendix 6. SPORTDiscus with full text (EBSCOhost)

- S1 DE "BREAST cancer"
- S2 breast cancer OR breast carcinoma OR breast neoplasms
- S3 DE "PHYSICAL activity" OR DE "EXERCISE"
- S4 (DE "PHYSICAL activity" OR DE "EXERCISE" ) OR sports
- S5 DE "SPORT for all"
- S6 S3 OR S5
- S7 physical activity OR exercise OR sports
- S8 self-directed OR home based exercise OR community based OR non supervised OR partial supervised OR low supervised
- S9 behavioral change OR motivation OR self-monitoring OR (fitness tracker or activity tracker or sport tracker) OR (pedometer or activity monitor or daily steps) OR accelerometer OR step tracker OR step counter OR (wearable technology or wearable devices) OR digital devices
- S10 motivational interviewing or mi or motivational interview
- S11 DE "MOTIVATIONAL interviewing"
- S12 (adherence or compliance) OR engagement OR (participation or engagement or involvement)
- S13 DE "PHYSICIAN adherence" OR DE "EXERCISE adherence"
- S14 S7 OR S8 OR S9 OR S10
- S15 S2 AND S12 AND S14