ARTICLE IN PRESS
JSAMS-02792; No of Pages 10
Journal of Science and Medicine in Sport xxx (xxxx) xxx–xxx
Contents lists available at ScienceDirect
Journal of Science and Medicine in Sport
journal homepage: www.elsevier.com/locate/jsams

Review

Effects of home-based exercise programs on physical fitness in cancer patients undergoing active treatment: A systematic review and meta-analysis of randomized controlled trials

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ARTICLE INFO

Article history:
Received 23 November 2022
Received in revised form 16 February 2023
Accepted 15 March 2023
Available online xxxx

Keywords:
Exercise oncology
Cardiorespiratory fitness
Muscle strength
Body composition

ABSTRACT

Objectives: This systematic review and meta-analysis aimed to investigate the effects of home-based exercise on physical fitness (cardiorespiratory fitness, muscle strength, and body composition) in cancer patients undergoing active treatment.
Design: Systematic review with meta-analysis and Grading Recommendations Assessment, Development, and Evaluation of the evidence.
Methods: A comprehensive search of existing literature was carried out in four electronic databases: PubMed, Web of Science, Scopus, and PEDro. All databases were searched for randomized controlled trials assessing the effects of home-based exercise on physical fitness outcomes in cancer patients during active treatment. Multicomponent interventions (i.e., exercise plus diet/behavioral therapy) were excluded. The methodological quality of each study was assessed using the Revised Cochrane risk-of-bias tool for randomized trials. Meta-analytical procedures were performed when appropriate and standardized mean differences (SMD) were calculated.
Results: Twenty-eight randomized controlled trials (n = 2424 cancer patients) were included. Most of the interventions were conducted in breast cancer patients (n = 13) during the adjuvant treatment period (n = 17); 18 studies included a walking component in their home-based protocol. Home-based exercise was effective at improving the distance of the 6-minute walk test (k = 6; SMD = 0.321, p = 0.010). However, the results were no longer significant when performing sensitivity analysis based on exclusively walking (k = 1) and non-exclusively walking interventions (k = 5; SMD = 0.258; p = 0.072). No effects were found for muscle strength and body composition outcomes ($p > 0.05$).
Conclusions: Regular home-based exercise programs are an effective strategy to improve 6-minutes walk test in cancer patients undergoing active treatment. Conversely, no alterations were found in muscle strength and body composition.

Practical implications

- Home-based exercise improved 6MWT in cancer patients undergoing active therapy
- Body composition outcomes remain preserved following home-based exercise protocols
- Home-based exercise preserves muscle strength in cancer patients undergoing active treatment
- Home-based exercise may be useful to improve or at least preserve physical fitness

1. Introduction

Despite the technological and pharmacological advances, cancer patients often report adverse consequences following anticancer therapies such as nausea, pain, fatigue, and a decline in physical fitness and body composition outcomes,[1] which directly impact their quality of life. Therefore, the development of non-pharmacological prevention

Abbreviations: CRF, Cardiorespiratory fitness; RCT, Randomized controlled trials; 6MWT, 6-min' walk test; SMD, Standardized means of difference; FM, Fat mass; LBM, Lean body mass; BMI, Body mass index; 1RM, 1-maximum repetition (1RM).

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https://doi.org/10.1016/j.jsams.2023.03.009
1440-2440/

strategies as well as innovative treatments with no side-effects is of particular importance.

Exercise has been suggested as an effective tool to be combined with anticancer treatments as it has been shown to have benefits on tumor-intrinsic response and cancer-related symptoms.[2] Moreover, exercise attenuates physical deterioration resulting from therapy, which often implies the loss of independence and mobility, a greater effort to carry out activities of daily living (i.e. fatigue), and reduced quality of life.[2,3] Through improvements in cardiorespiratory fitness (CRF), muscle strength, and body composition, exercise may promote noticeable reductions in the cytotoxic effects of treatments and, for instance, prevent cardiotoxicity, severe sarcopenia, and cachexia leading to better post-treatment and survival outcomes.[2,4,5] Altogether, these benefits make physical fitness a prognostic parameter that might be used to enhance therapeutic management approaches.[6]

Despite the above-mentioned benefits of exercise, the levels of practice tend to decline after diagnosis, while the time spent in sedentary pursuits increases.[7] These behavioral changes may be explained by patients (e.g. fear and lack of time) and organizational barriers (e.g. access to exercise facilities and transport).[8] To overcome these difficulties, home-based exercise approaches have proliferated and emerged as a potential strategy to increase long-term adherence to exercise practice.[3,9,10]

Researchers have demonstrated that home-based exercise programs may improve or, at least, mitigate the harmful effects of anticancer therapies on the multiple components of physical fitness, namely CRF and muscle strength,[11–15] the supervised modality is still considered more effective to improve functional capacity in cancer patients.[16] However, it must be recognized that the body of evidence on the benefits of home-based exercise during active treatment is still scarce, thus more investigations evaluating the impact and effectiveness of this type of program on physical fitness outcomes during this period are warranted.

The purpose of this systematic review with meta-analysis was to understand whether home-based exercise programs are effective in maintaining and/or improving physical fitness components (i.e. CRF, muscle strength, and body composition) in cancer patients during active treatment.

2. Methods

The present systematic review was registered on PROSPERO (CRD42022252246) and performed based on PRISMA guidelines while using four distinct electronic databases: PubMed, Web of Science, Scopus, and PEDro. The online search was conducted on August 16, 2022. Relevant Boolean terms were combined as follows: “home-based”, “exercise”, “physical activity”, and “cancer”. Detailed search strategies for the different databases are presented in Supplementary material 1.

2.1. Eligibility criteria

PICOs' structure was considered to define inclusion and exclusion criteria. **P**: adults (>18 years) diagnosed with cancer undergoing active treatment (neoadjuvant and/or adjuvant chemotherapy, radiotherapy, hormone therapy, and/or immune therapy); investigations conducted on those who had completed therapy were not considered; **I**: randomized controlled trials (RCT) involving home-based exercise interventions of aerobic, resistance, or a combination of both were included; investigations encompassing multiple component interventions (i.e. exercise plus nutritional programs, cognitive therapy, etc.) were excluded; **C**: no comparison was defined; **O**: RCT assessing physical fitness (aerobic fitness, muscle strength, and/or body composition) as an outcome were selected. Moreover, only manuscripts with original full reports written in English were included.

2.2. Study selection and data extraction

Two authors (IRC and VC) independently assessed eligible studies according to inclusion and exclusion criteria by evaluating the titles and abstracts of each paper after removing duplicate entries. Then, a full-text version of the studies was obtained and screened for eligibility. Any disagreements were decided by dialog with a third reviewer (CC). Reference lists of eligible articles were manually checked for additional papers. Information was extracted from each eligible article, including article identification, type of cancer, sample size, treatment, exercise intervention and duration, results obtained for the outcomes of interest (within and between-group results), and other outcomes included in the manuscript.

2.3. Quality assessment

The methodological quality of each included article was assessed by the Revised Cochrane risk-of-bias tool for randomized trials (RoB2). This tool is structured into five domains through which bias might be introduced into the result, namely: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in measurement of the outcome, and bias in selection of the reported outcome. Each intervention was classified as having a low risk of bias, some concerns, or a high risk of bias. Two independent assessors performed the assessment.

2.4. Data analysis

Meta-analyses were separately conducted for each outcome (peak of oxygen consumption (VO_{2peak}) measured in L/min, and ml/kg/min; peak power measured in watts; 6-minute walk test distance (6MWT, meters), 30-second chair stand test (times), handgrip (kg), percentage of fat mass (FM), and lean body mass (LBM); FM and LBM expressed in kg; weight (kg), and body mass index (BMI)) using the Comprehensive Meta-Analysis (CMA) Software version 3.0 (Biostat, Inc., Englewood, NJ, USA). Meta-analyses were performed using fixed-effects or random effects when $k < 6$ or $k \geq 6$, respectively. Standardized mean difference (SMD) was used to summarize the effect size based on sample size, standard mean differences (i.e., differences between pre- to post-intervention time points of both intervention and control groups), effects direction, and interpreted according to Cohen's specifications (i.e., values of 0.2, 0.5, and 0.8 for small, medium, and large SMD, respectively).[17–19] Because pre- to post-test correlation coefficients were not reported in the studies, a conservative value of 0.7 was assumed as proposed by Rosenthal.[20] The 95 % confidence interval and corresponding p-values were considered to verify the significance of the effect. Since not all studies provide sufficient data to determine SMD, the number of studies included in the qualitative review was different from those included in the quantitative synthesis.

Heterogeneity was tested using: (i) Cochran's Q statistic, in which a p-value <0.05 demonstrates that investigations do not share a common SMD and, therefore, there is heterogeneity[21]; (ii) I^2 statistic that ranges from 0 to 100 % and in which a value of 0 %, 25 %, 50 %, and 75 % reflects no observed, low, medium, and high observed heterogeneity, respectively.[22]

Sensitivity analyses were performed to explore whether the effects of home-based exercise differed from exclusively walking interventions and non-exclusively walking interventions while using fixed-effect models.

2.5. Grading the certainty of evidence for major comparisons and outcomes

We graded the certainty of evidence of relevant outcomes using GRADE (Grading of Recommendations Assessment, Development and Evaluation) guidance.[23] Five domains were used to complete this assessment: risk of bias, inconsistency, indirectness, imprecision, and other considerations. Moreover, SMDs calculated during the meta-analysis were used. We used GradePro to summarize the findings.

3. Results

3.1. Study selection

The database search retrieved 6720 articles published in PubMed (n = 231), Web of Science (n = 685), Scopus (n = 5745), and PEDro (n = 59). All articles were checked for duplicates. After duplicate removal (n = 794), 5926 articles were initially screened for inclusion and exclusion criteria by title. This number was reduced to 681 articles (excluded n = 5245) that were subjected to a full-text review, resulting in the additional exclusion of 655 articles. Finally, 26 articles remained from the initial search, while 2 additional articles were manually added after checking reference lists. Hence, 28 articles were considered eligible and were included in the present systematic review (Fig. 1).

3.2. Study characteristics

The characteristics of the included studies are described in Supplementary material 2.

The majority of home-based exercise protocols were applied to breast cancer patients (n = 13), followed by prostate (n = 5), colon (n = 2), and pancreatic (n = 1) cancer. The remaining 7 interventions included mixed samples, i.e. patients with different types of cancer (breast, colon, prostate, head and neck, and upper gastrointestinal tract disease). More than half of the interventions were implemented during the adjuvant period (n = 17) and almost 86 % (n = 24) included participants undergoing chemotherapy or radiotherapy. Four interventions were performed in patients treated with hormone therapy alone. As far as study design is concerned, 18 out of the 28 intervention protocols compared a home-based exercise group, namely combined training and/or walking activity, vs. a usual care control group (i.e. 2-arm RCT). Additionally, 10 studies presented a 3-arm design, of which 8 included a supervised exercise group. Also, 18 studies incorporated a walking component either alone or in combination with another exercise stimulus such as strength training into their home-based protocol. Sample sizes ranged from 23 to 300 participants (a total of 2424 subjects were included), while the intervention length varied from 4-weeks to 12-months. Furthermore, adverse events were only reported in 14 (i.e. 50 %) of the 28 studies included. Of them, 7 mentioned that no adverse events were observed during the exercise intervention.

3.3. Quality assessment

The methodological quality assessment details of each criterion are presented in Supplementary material 3. Overall, 10 (~36 %) studies were classified as having "high risk of bias", 14 as having "some concerns" (~50 %), and only 4 were considered as having "low risk of bias" (~14 %).

3.4. Effects of home-based exercise on physical fitness outcomes

3.4.1. Aerobic fitness

Regarding the assessment of CRF, 22 of the 28 studies included in this systematic review evaluated the effects of home-based training on this component of physical fitness. Cardiopulmonary exercise test measuring gas exchange (n = 10), 6MWT (n = 8), 12-minute walk test (12MWT, n = 3), 3-minute step test (n = 1), or the Modified Shuttle Run Test (n = 1) were used alone or in combination to estimate CRF. From a within-group analysis perspective, 13 studies (i.e. ~59 %) found improvements in CRF levels as a result of a home-based exercise intervention, while 2 and 3 investigations reported decreases and no changes in this fitness parameter, respectively.

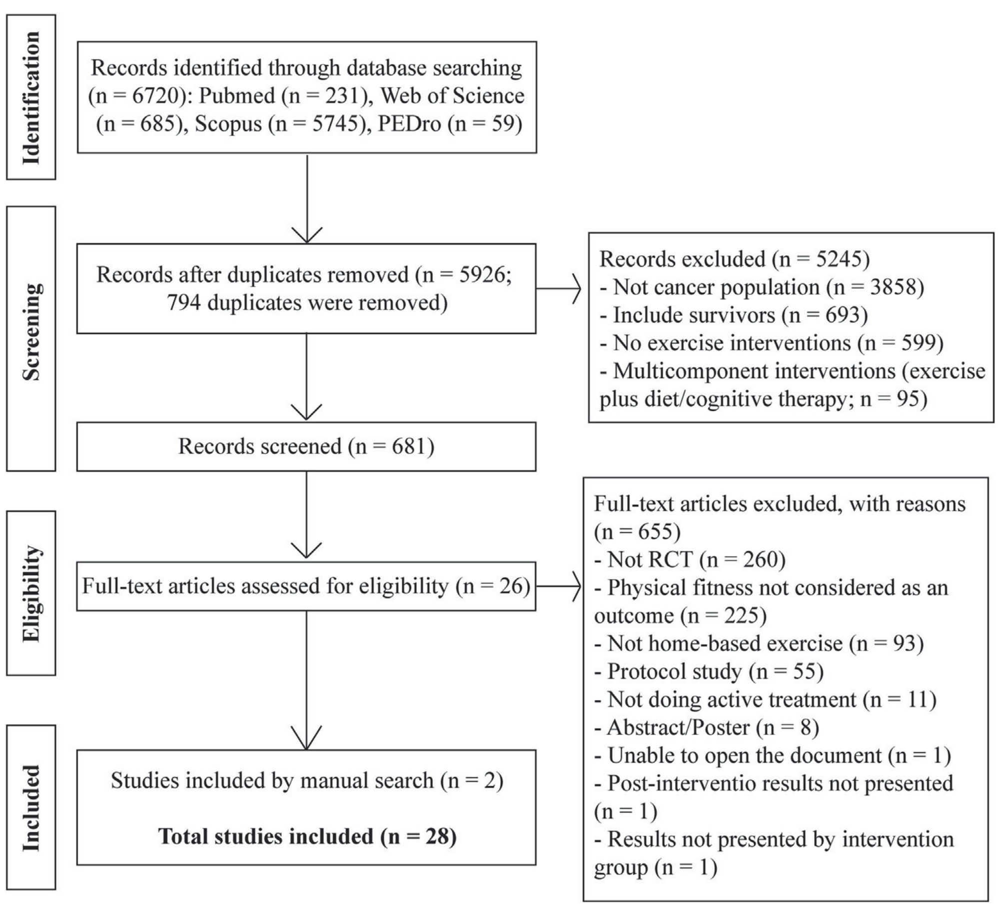

Fig. 1. Flow chart of the methodology for the identification and inclusion of studies.

Meta-analytic results are presented in Fig. 2 with a positive significant effect of home-based exercise on 6MWT (k = 6; SMD = 0.321, p = 0.010; Q = 4.329, p = 0.503; $I^2 < 0.001$ %). This pooled estimate was no longer significant with non-walking interventions only (k = 5; SMD = 0.258, p = 0.072; Q = 3.493, p = 0.479; $I^2 < 0.001$ %) (Table 1). Since there was only 1 walking study assessing 6MWT, no

Outcome: VO2peak (ml/kg/min)

Study name	SMD	SE	95%LL	95%UL	p
Cornette (2016)	0.848	0.381	0.101	1.595	0.026
Moller (2015a)	-0.385	0.451	-1.270	0.499	0.393
Moller (2015b)	1.420	1.119	-0.773	3.613	0.204
Pooled estimate	**0.403**	**0.282**	**-0.149**	**0.956**	**0.153**

Heterogeneity
Q-value = 5.239, df = 2 (p = 0.073), I-squared = 61.824%

Outcome: VO2peak (L/min)

Study name	SMD	SE	95%LL	95%UL	p
Moller (2015a)	-0.000	0.447	-0.877	0.880	1.000
Moller (2015b)	-2.111	1.248	-0.334	4.560	0.091
Wiskemann (2019)	0.485	0.382	-0.265	1.230	0.205
Pooled estimate	**0.374**	**0.283**	**-0.180**	**0.930**	**0.186**

Heterogeneity
Q-value = 2.722, df = 2 (p = 0.256), I-squared = 26.522%

Outcome: peak power (watts)

Study name	SMD	SE	95%LL	95%UL	p
Moller (2015a)	-0.034	0.447	-0.911	0.840	0.939
Moller (2015b)	-1.183	1.084	-0.941	3.310	0.275
van Waart (2015)	-0.161	0.171	-0.496	0.170	0.344
van Waart (2018)	-0.193	0.579	-1.327	0.940	0.739
Wiskemann (2019)	0.023	0.377	-0.716	0.760	0.951
Cornette (2016)	0.601	0.373	-0.131	1.330	0.108
Pooled estimate	**-0.014**	**0.132**	**-0.273**	**0.240**	**0.915**

Heterogeneity
Q-value = 4.785, df = 5 (p = 0.443), I-squared < 0.001%

Outcome: 6-minute walk test (meters)

Study name	SMD	SE	95%LL	95%UL	p
Cornette (2016)	0.689	0.376	-0.048	1.425	0.067
Wang (2011)	0.528	0.259	0.021	1.034	0.041
Mustian (2009)	0.348	0.327	-0.293	0.989	0.287
Husebo (2014)	-0.054	0.258	-0.560	0.452	0.834
Villumsen (2019)	0.464	0.317	-0.157	1.084	0.143
Wiskemann (2019)	0.085	0.365	-0.631	0.801	0.815
Pooled estimate	**0.321**	**0.125**	**0.076**	**0.566**	**0.010***

Heterogeneity
Q-value = 4.329, df = 5 (p = 0.503), I-squared < 0.001%

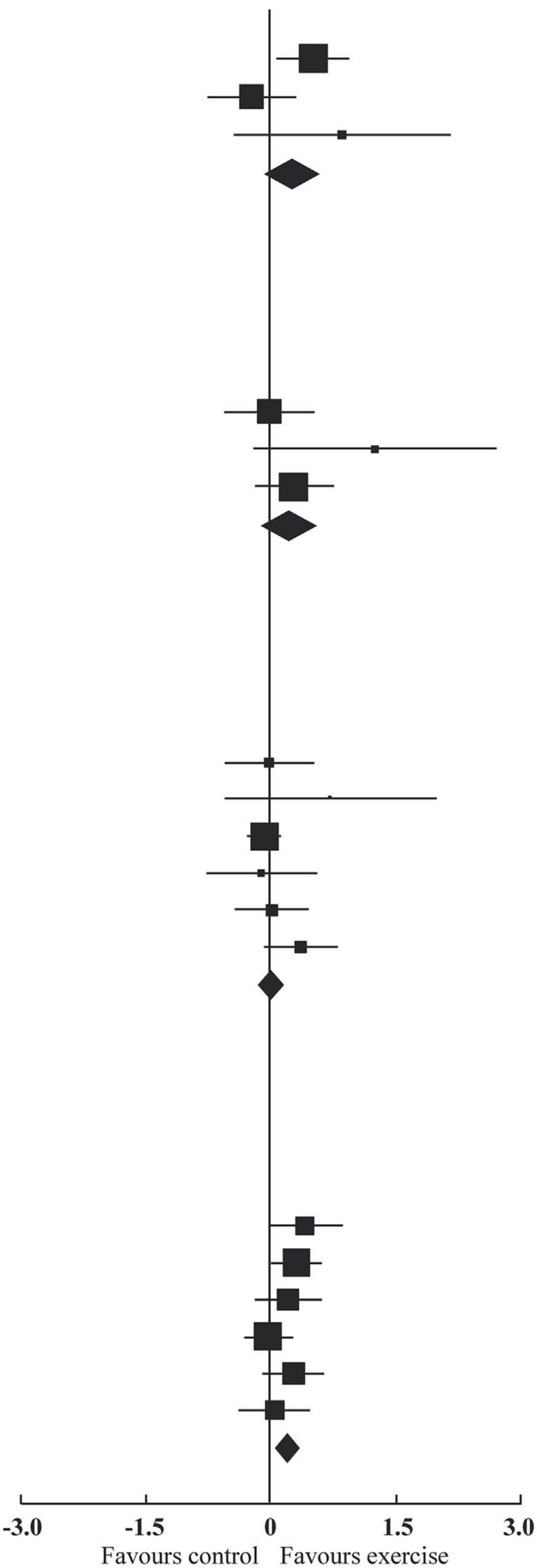

Fig. 2. Meta-analysis on cardiorespiratory fitness (forest plot). * p-value <0.05.

Table 1
Meta-analytic results for the effects of exclusively walking and non-exclusively walking home-based interventions on physical fitness outcomes.

						Heterogeneity		
Outcome	k	SMD	CI lower[a]	CI upper[a]	p	Q-value	p	I^2
Peak power (Watts)								
Walking	4	−0.122	−0.420	0.176	0.421	1.556	0.669	<0.001
Non-walking	2	0.315	−0.205	0.835	0.235	1.186	0.276	15.663
VO_{2peak} (L/min)								
Walking	2	0.240	−0.585	1.065	0.568	2.537	0.111	60.583
Non-walking	1	–	–	–	–	–	–	–
VO_{2peak} (ml/kg/min)								
Walking	2	−0.133	−0.953	0.688	0.751	2.239	0.135	55.245
Non-walking	1	–	–	–	–	–	–	–
6MWT (m)								
Walking	1	–	–	–	–	–	–	–
Non-walking	5	0.258	−0.023	0.538	0.072	3.493	0.479	<0.001
30-s chair stand (times)								
Walking	2	0.213	−0.111	0.538	0.198	0.663	0.415	<0.001
Non-walking	1	–	–	–	–	–	–	–
Handgrip (kg)								
Walking	2	−0.023	−0.347	0.300	0.889	0.186	0.666	<0.001
Non-walking	2	−0.059	−0.574	0.455	0.821	0.006	0.938	<0.001
FM (%)								
Walking	2	0.150	−0.660	0.959	0.717	0.938	0.333	<0.001
Non-walking	3	0.247	−0.102	0.597	0.165	8.227	0.016	75.691
FM (kg)								
Walking	2	0.031	−0.775	0.837	0.941	0.687	0.407	<0.001
Non-walking	1	–	–	–	–	–	–	–
LBM (%)								
Walking	2	0.162	−0.643	0.966	0.694	0.381	0.537	<0.001
Non-walking	2	−0.227	−0.747	0.293	0.393	7.501	0.006	86.668
LBM (kg)								
Walking	2	0.261	−0.543	1.066	0.525	0.125	0.723	<0.001
Non-walking	2	0.026	−0.391	0.443	0.904	3.039	0.081	67.100
Weight (kg)								
Walking	2	−0.253	−0.600	0.095	0.154	3.048	0.081	67.192
Non-walking	2	−0.050	−0.463	0.364	0.814	0.161	0.688	<0.001
BMI (kg/m^2)								
Walking	3	0.033	−0.378	0.444	0.877	0.022	0.989	<0.001
Non-walking	1	–	–	–	–	–	–	–

Abbreviations: VO_{2peak}, peak of oxygen consumptions; 6MWT, 6-minute walk test; FM, fat mass; LBM, lean body mass; BMI, body mass index; k, number of studies; SMD, standardized mean difference; CI, confidence interval; I^2, I-squared; p, p-value.
[a] 95 %.

meta-analysis was run for this subgroup. A non-significant SMD for absolute (k = 3; SMD = 0.374, p = 0.186; Q = 2.722, p = 0.256; I^2 = 26.522 %) and relative (k = 3; SMD = 0.403, p = 0.153; Q = 5.239, p = 0.073; I^2 = 61.824 %) VO_{2peak}, as well as peak power (k = 6; SMD = −0.014, p = 0.915; Q = 4.785, p = 0.443; I^2 < 0.001 %) were found (Fig. 2). The results remained non-significant when sensitivity analyses were performed (Table 1).

We rated the certainty of evidence as moderate for VO_{2peak} (relative), and as high for VO_{2peak} (absolute), power watts, and 6MWT (Supplementary material 4).

3.4.2. Muscular fitness

Thirteen studies included in this review investigated the effects of home-based training on muscular strength evaluated through isometric methods (n = 8), such as handgrip, isometric machines with strain gauges, or isometric handheld dynamometers, chair-stand test (n = 4), isokinetic dynamometers (n = 2), or using the 1-maximum repetition (1RM) approach (n = 2). Further, in one study an incremental strength protocol was performed combining upright row and shoulder press using hand weights, while in another, leg extensor muscle power was assessed. Muscular fitness improvements, namely isometric knee extension, and upper-body strength, observed in home-based exercise groups were only reported in 2 studies (i.e. ~15 %). Indeed, the majority of the investigations (n = 7) found no significant differences in any muscle strength outcome resulting from home-based exercise interventions.

As shown in Fig. 3, no home-based exercise effects were found for handgrip strength (k = 4; SMD = −0.033, p = 0.811; Q = 0.206, p = 0.977; I^2 < 0.001 %) and 30-second chair stand test (k = 3; SMD = 0.034, p = 0.832; Q = 13.873, p = 0.001; I^2 = 85.687 %). Similar results were found when analyzing walking and non-walking subgroups (Table 1), except in terms of heterogeneity that was no longer observed for the 30-second chair test when considering walking studies (k = 2; Q = 0.663, p = 0.415; I^2 < 0.001 %).

We rated the certainty of evidence as moderate for 30-second chair stand and high for handgrip (Supplementary material 4).

3.4.3. Body composition

Fourteen studies presented data for the effects of home-based exercise on body composition-related outcomes, such as body weight (n = 6), BMI (n = 5), FM (n = 6), LBM (n = 8), bone mineral content (n = 2), and bone mineral density (n = 3). Three of these studies reported improvements in body composition variables, namely LBM and FM, while only one found an increase in body weight and BMI following a 10-week home-based walking intervention. Nine investigations (i.e. ~64 %) reported no significant changes in body composition when comparing pre- to post- home-based exercise protocol time points.

Similar to the aforementioned results, no home-based exercise effects were observed for body composition outcomes (Fig. 4a and b). Indeed, a non-significant SMD for FM (%: k = 5; SMD = 0.232, p = 0.157; Q = 9.213, p = 0.056; I^2 = 56.583 %; kilograms: k = 3; SMD = 0.300, p = 0.327; Q = 1.651, p = 0.438; I^2 = <0.001 %) and LBM (%: k = 4; SMD = −0.112, p = 0.614; Q = 8.514, p = 0.037; I^2 = 64.764 %; kilograms: k = 4; SMD = 0.076, p = 0.689; Q = 3.424, p = 0.331; I^2 = 12.389 %) (Fig. 4a) was observed. Heterogeneity was no longer significant when running walking subgroups analysis for the percentage of LBM (Table 1). Also, no effects were obtained for weight (k = 4; SMD = −0.169, p = 0.214; Q = 3.751, p = 0.290; I^2 = 20.027 %) and BMI (k = 4; SMD = 0.069, p = 0.704; Q = 0.145, p = 0.986; I^2 < 0.001 %) (Fig. 4b). Sensitivity analysis revealed similar findings (Table 1).

We rated the certainty of evidence as high for all outcome measures (Supplementary material 4).

3.4.4. Other outcomes

Investigations evaluating the effects of exercise on physical functioning outcomes measured through questionnaires, such as the MOS Short Form Health Survey 36 (MOS SF-36, n = 4) and Patient-reported outcomes measurement information system (PROMIS, n = 1) were also included. The results derived from the application of MOS SF-36 are controversial since both increases and decreases were found for home-based exercise groups; improvements in PROMIS score were found in the only study that used this tool. Furthermore, 4 studies using physical batteries to assess physical performance were also considered (Short Physical Performance Battery (SPPB), n = 3; Time Up and Go Test, n = 1). Shoulder function was measured in 2 studies using the Disabilities of the Arm, Should, and Hand scale (DASH, n = 1) and a goniometer (n = 1) with both studies reporting substantial improvements in upper-body function.

4. Discussion

To the best of our knowledge, this is the first systematic review with meta-analysis that aimed to comprehensively examine the effects of home-based exercise on the physical fitness components of CRF, muscle strength, and body composition in cancer patients undergoing active

Outcome: 30-seconds chair stand (times)

Study name	SMD	SE	95%LL	95%UL	p
van Waart (2015)	0.174	0.173	-0.164	0.510	0.313
van Waart (2018)	0.678	0.594	-0.486	1.840	0.254
Lam (2020)	-1.818	0.532	-2.860	-0.780	0.001
Pooled estimate	**0.034**	**0.158**	**-0.276**	**0.340**	**0.832**

Heterogeneity
Q-value = 13.973, df = 2 (p = 0.001), I-squared = 85.687%

Outcome: handgrip (kg)

Study name	SMD	SE	95%LL	95%UL	p
van Waart (2015)	-0.044	0.172	-0.382	0.290	0.797
Mustian (2009)	-0.045	0.324	-0.681	0.590	0.891
van Waart (2018)	0.216	0.579	-0.919	1.350	0.709
Lam (2020)	-0.088	0.447	-0.965	0.790	0.844
Pooled estimate	**-0.033**	**0.140**	**-0.307**	**0.240**	**0.811**

Heterogeneity
Q-value = 0.206, df = 3 (p = 0.977), I-squared < 0.001%

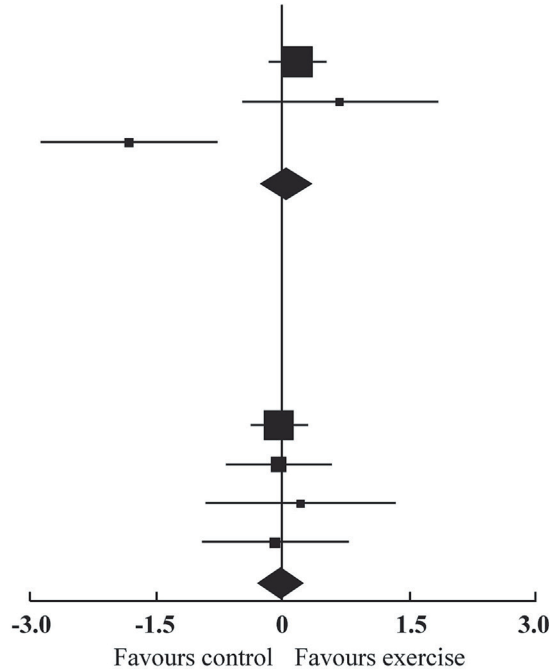

Fig. 3. Meta-analysis on muscle strength (forest plot).

treatment. Twenty-eight investigations were included. Our meta-analysis results indicated that home-based exercise did not impact physical fitness outcomes, except for aerobic fitness when assessed by 6MWT. Overall, the presence or not of adverse events were reported in only 14 of the included interventions (i.e. 50 %). Of these, adverse events were found in only 7 interventions (musculoskeletal injuries, i.e. myalgia, tendinitis or arthralgia, foot, back, or knee pain, swelling, syncope, dizziness, anemia, and non-heat related chest pain), suggesting that overall home-based exercise interventions are safe.

We suggest that home-based exercise may be considered a viable and effective strategy to improve 6MWT distance in cancer patients undergoing active treatment. This finding is in line with the existing literature[11,14,24,25] as well as when considering patients scheduled for surgery but not undertaking other systemic or local treatments.[26] Conversely, a 52-day home-based walking intervention conducted in colon patients did not find any changes in 6MWT.[27] Similarly, researchers did not observe substantial improvements in 6MWT after a 4-week walking intervention implemented in breast and prostate cancer patients.[28] Given that it takes about 8–12 weeks to detect noticeable improvements in CRF,[29] the short duration of these two protocols likely explains the lack of results.

Interestingly, through our sensitivity analysis, we observed that when non-walking studies were considered, the effects of home-based exercise on 6MWT were no longer significant. Therefore, it seems that the significance of the 6MWT results was somehow being driven by the walking intervention.[24] One possible reason for this finding may rely on the biomechanical and physiological specific adaptations that occur after a walking intervention and potentially increase the capacity to walk[30,31] and, consequently, improve the distance covered on 6MWT. However, this hypothesis is merely speculative, and considering that there are only a few available investigations within this research scope, precautions should be taken when interpreting these results. Even so, the prognostic value of 6MWT cannot be neglected. Thus, these initial promising results of home-based exercise interventions on aerobic fitness should be taken into account and considered when prescribing exercise programs for cancer patients.

Only 13 and 14 (i.e. ~50 %) of the 28 investigations included in this review aimed to investigate the effects of home-based protocols on muscle strength and body composition, respectively. This relative scarcity of studies investigating these two physical fitness parameters is somewhat surprising, since they have a noticeable impact on treatment efficacy, symptoms, quality of life, as well as cancer survival and mortality, and have a high prognostic value.[5,32] According to our meta-analytic results, no changes were observed for FM, LBM, weight, and BMI after home-based exercise. Our results corroborate those available in the existing literature that found no changes in body composition parameters after a home-based exercise intervention in cancer patients undergoing active treatment.[11,12,14,28,33–37] Considering that diet combined with exercise is more effective at promoting beneficial weight and FM changes than either method alone,[38] one possible explanation for the lack of findings in the included studies may rely on the absence of a diet component that could induce substantial alterations on body composition parameters. Further, the home-based nature of these interventions may also explain the relative stability of body composition outcomes, which might be linked to the lack of control of the dose of exercise performed in the home setting. For instance, it has been proposed that supervised strength training, namely that performed in a supervised and structured setting with a variety of available equipment, is more conducive to participants exercising at a higher intensity and, thus, provides superior body composition benefits (e.g. on LBM) when compared to home-based approaches.[39,40]

Due to their antiproliferative action and the presence of cytotoxic agents, anticancer therapies reduce LBM and increase FM and body weight,[41] leading to sarcopenia/severe cachexia and raises the risk for therapy-toxicity, which ultimately impairs physical functioning, quality of life, and survival.[5] As recently proposed by Pin and colleagues,[5] interventions aiming to increase or even preserve LBM are an auspicious strategy to reduce the toxic effects of therapies and improve survival. Therefore, the absence of results reported in the studies included in this systematic review/meta-analysis should not be disregarded, since home-based exercise interventions appear to be sufficiently effective to prevent LBM decreases and FM increases, thus potentially protecting patients from therapy-related toxicity.[5] Nonetheless, more experimental studies are warranted to further clarify this mechanistic hypothesis.

Regarding muscle strength assessment and due to the high heterogeneity between methods (i.e. isometric, isokinetic, and 1RM tests) and the different units used to present the results between the multiple studies, it was only possible to conduct the meta-analysis for the handgrip strength and the 30-second chair stand test. According to our meta-analytic results, no differences were observed for both outcomes throughout the home-based exercise interventions. It is noteworthy, however, that 2 studies comparing supervised- vs. home-based training showed a superior effect of supervised exercise directed by a qualified professional[42,43] on muscle strength in cancer patients, reinforcing the premise that more structured and intense loads performed at an exercise facility under supervision are necessary to improve physical fitness

a

Outcome: fat mass (%)

Study name	SMD	SE	95%LL	95%UL	p
deNysschen (2011)	0.250	0.240	-0.221	0.721	0.298
Moller (2015a)	-0.017	0.447	-0.894	0.860	0.970
Moller (2015b)	1.110	1.074	-0.995	3.216	0.301
Lam (2020)	1.472	0.504	0.484	2.460	0.004
Villumsen (2019)	-0.231	0.313	-0.845	0.384	0.461
Pooled estimate	**0.232**	**0.164**	**-0.089**	**0.553**	**0.157**

Heterogeneity
Q-value = 9.213, df = 4 (p = 0.056), I-squared = 56.583%

Outcome: fat mass (kg)

Study name	SMD	SE	95%LL	95%UL	
Moller (2015a)	-0.116	0.448	-0.993	0.761	0.796
Moller (2015b)	0.824	1.042	-1.218	2.865	0.429
Lam (2020)	0.635	0.458	-0.263	1.533	0.166
Pooled estimate	0.300	**0.306**	**-0.300**	**0.900**	**0.327**

Heterogeneity
Q-value = 1.651, df = 3 (p = 0.438), I-squared < 0.001%

Outcome: lean body mass (%)

Study name	SMD	SE	95%LL	95%UL	p
Moller (2015a)	0.052	0.447	-0.825	0.929	0.907
Moller (2015b)	0.748	1.034	-1.279	2.775	0.470
Lam (2020)	-1.380	0.498	-2.355	-0.405	0.006
Villumsen (2019)	0.231	0.313	-0.384	0.845	0.461
Pooled estimate	**-0.112**	**0.223**	**-0.549**	**0.324**	**0.614**

Heterogeneity
Q-value = 8.514, df = 4 (p = 0.037), I-squared = 64.764%

Outcome: lean body mass (kg)

Study name	SMD	SE	95%LL	95%UL	p
deNysschen (2011)	0.219	0.240	-0.251	0.689	0.361
Moller (2015a)	0.197	0.448	-0.681	1.076	0.660
Moller (2015b)	0.592	1.022	-1.410	2.595	0.562
Lam (2020)	-0.686	0.460	-1.588	0.216	0.136
Pooled estimate	**0.076**	**0.189**	**-0.295**	**0.446**	**0.689**

Heterogeneity
Q-value = 3.424, df = 3 (p = 0.331), I-squared = 12.389%

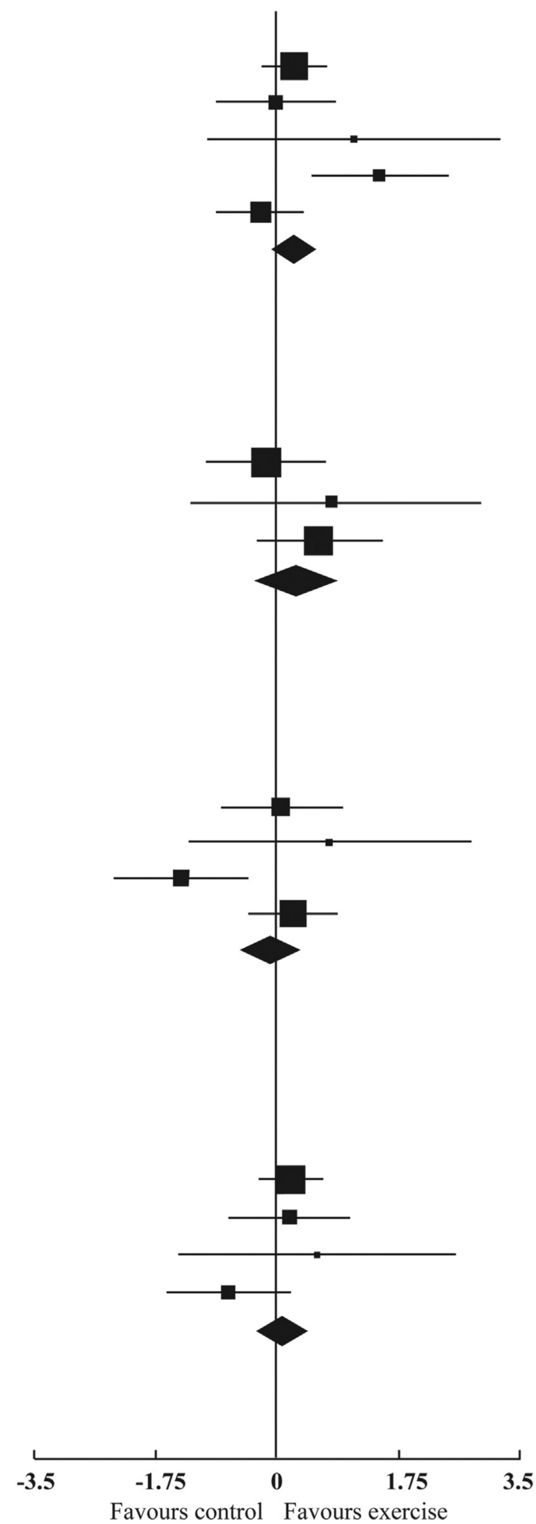

Fig. 4. Meta-analysis on body composition outcomes for fat mass and lean body mass (A) and body mass index and weight (B) (forest plot).

b

Outcome: weight (kg)

Study name	SMD	SE	95%LL	95%UL	p
deNysschen (2011)	-0.095	0.239	-0.564	0.374	0.691
Windsor (2004)	-0.579	0.257	-1.083	-0.074	0.025
Backman (2014)	0.041	0.244	-0.438	0.520	0.867
Lam (2020)	0.109	0.448	-0.769	0.986	0.808
Pooled estimate	-0.169	**0.136**	**-0.435**	**0.097**	**0.214**

Heterogeneity
Q-value = 3.751, df = 3 (p = 0.290), I-squared = 20.027%

Outcome: body mass index (kg/m2)

Study name	SMD	SE	95%LL	95%UL	p
Cornette (2016)	0.180	0.366	-0.537	0.897	0.623
Moller (2015a)	0.000	0.447	-0.877	0.877	1.000
Moller (2015b)	0.162	1.002	-1.801	2.125	0.871
Backman (2014)	0.035	0.244	-0.444	0.514	0.887
Pooled estimate	0.069	**0.182**	**-0.288**	**0.426**	**0.704**

Heterogeneity
Q-value = 0.145, df = 3 (p = 0.986), I-squared < 0.001%

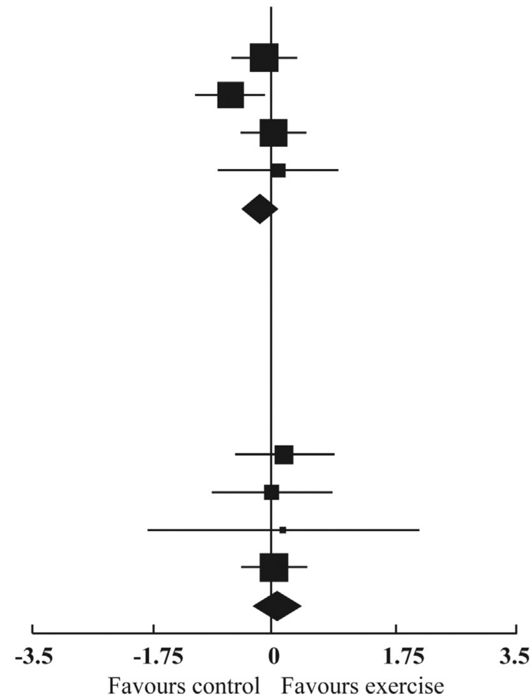

Fig. 4 (*continued*).

outcomes in this population. Given the low number of investigations as well as disparities in study population (i.e., different types of cancer and treatments), samples size (range from 23 to 230), intervention length (4-weeks up to 12-months), and exercise characteristics (type and frequency), it is hard to draw conclusive results on the impact of home-training on muscle strength outcomes, and thus more investigations are warranted.

Breast, prostate, colon, and lung cancer are the most prevalent cancer worldwide[44] and, for all of them, there is a protective evidence-based effect of exercise on the prevention of cancer and disease recurrence.[45] However, concerning the available literature, it is clear that most of the evidence of the effects of home-based training stems from studies carried out in patients with breast cancer, with little evidence in prostate cancer and, above all, in colon and lung populations. One possible reason for such a lack of studies might be the age of these patients who are usually older when compared to patients with breast cancer.[44] Therefore, in addition to the disease-related complication, those patients may also have physical (e.g. frailty) and emotional (e.g. fear of falling) limitations derived from their geriatric condition, which may potentially increase their resistance to partaking in physical exercise.[46,47]

A major strength of our work was the inclusion of RCT studies having only an exercise component, which removes the influence of other widely used approaches, for instance, diet or behavioral interventions. However, this study is not without limitations. First, only a few studies with small and non-representative sample sizes provided sufficient data to be included in the meta-analysis, which limits the statistical power and prevents us from establishing robust conclusions. Furthermore, almost 86 % of the included interventions were classified as having high-risk of bias or, at least, raising some concerns on this issue. Additionally, although most meta-analytic results did not show significant heterogeneity, we cannot exclude its existence given the small number of studies included. Moreover, due to ethical issues, some investigations incorporated a control group with some sort of exercise component/counseling, which makes it difficult to analyze the isolated effect of the intervention. Future studies are needed to further explore the effects of this exercise modality (i.e. home-based exercise). Likewise, some recommendations should be given to researchers planning future investigations: (i) extend the research to other types of cancer such as colon, lung, and gastric cancer, given that most of the current evidence stems from studies carried out in patients with breast cancer; (ii) ensure that studies have a proper power analysis to decrease the risk of bias; (iii) whenever possible, implement outcome assessments that are blinded to intervention assignment.; (iv) standardize muscle strength assessment methods, making it possible to obtain comparable findings between studies; (v) report adverse events to correctly assess the safety of the exercise interventions. Moreover, in future publications, authors should: (i) clearly define what anticancer treatment is being given to the participants (i.e., type, duration, whether is adjuvant or neoadjuvant); (ii) elucidate the readers about the time-points of different assessments; (iii) present, at least, pre- and post-data means and standards deviations of the included variables and, whenever possible, effect sizes as well as within- and-between group statistical comparisons.

5. Conclusion

Regular home-based exercise programs promoted substantial improvements in aerobic function measured by 6MWT, while having no changes on body composition (i.e. weight, LBM, and FM) and muscle strength outcomes in cancer patients despite them undergoing active treatment. Thus, home-based exercise interventions may be useful to improve or at least preserve physical fitness components during cancer treatment. These results are of interest for clinicians and patients, since those undergoing cancer treatment are often affected by toxicities and side-effects that could potentially impact physical fitness attributes. Nevertheless, superior benefits can be observed by adding structured supervised exercise. More experimental investigations are needed to further clarify the potential benefits of home-based exercise in this clinical population.

All authors contributed to the manuscript conception and writing. Here we describe the role of each author. All these authors are members of the NEO project, a research project in breast cancer patients.

Funding information

This work was conducted at the Interdisciplinary Center for the Study of Human Performance (CIPER), unit I&D 447 (UIDB/00447/2020), Faculty of Human Kinetics of the University of Lisbon, and supported by the Portuguese Foundation for Science and Technology, the Portuguese Ministry of Science. IRC and GBR are supported by the Portuguese Foundation for Science and Technology (IRC: SFRH/BD/149394/2019; GBR: 2020.07856.BD).

Confirmation of ethical compliance

Since this is a systematic review with meta-analysis no ethical considerations are applicable.

CRediT authorship contribution statement

Inês Ramos Correia: Conceptualization, Methodology, Formal analysis, Writing – original draft. **Vasco Cardoso:** Conceptualization, Methodology, Writing – original draft. **Catarina Cargaleiro:** Methodology. **João P. Magalhães:** Formal analysis, Writing – review & editing. **Megan Hetherington-Rauth:** Formal analysis, Writing – review & editing. **Gil B. Rosa:** Methodology, Writing – review & editing. **Carla Malveiro:** Methodology, Writing – review & editing. **Leonor Vasconcelos de Matos:** Writing – review & editing. **Maria João Cardoso:** Supervision, Writing – review & editing. **Luís B. Sardinha:** Conceptualization, Supervision, Writing – review & editing.

Declaration of interest statement

None.

Acknowledgments

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsams.2023.03.009.

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