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Interventions to improve exercise behaviour in sedentary people living with and beyond cancer: a systematic review

L Bourke*,[1], K E Homer[1], M A Thaha[2], L Steed[1], D J Rosario[3], K A Robb[4], J M Saxton[5] and S J C Taylor[1]

[1]Department of Primary Care and Public Health, Barts and The London School of Medicine and Dentistry, Blizard Institute, Queen Mary University of London, London, UK; [2]Academic Surgical Unit, Centre for Digestive Diseases, Barts and The London School of Medicine and Dentistry, Blizard Institute, Queen Mary University London, London, UK; [3]Academic Urology Unit, Department of Oncology, E Floor, Royal Hallamshire Hospital, University of Sheffield, Glossop Road, Sheffield, UK; [4]Department of Physiotherapy, Bart's Hospital, London, UK and [5]School of Allied Health Professions, University of East Anglia, Norwich, UK

Background: To systematically review the effects of interventions to improve exercise behaviour in sedentary people living with and beyond cancer.

Methods: Only randomised controlled trials (RCTs) that compared an exercise intervention to a usual care comparison in sedentary people with a homogeneous primary cancer diagnosis, over the age of 18 years were eligible. The following electronic databases were searched: Cochrane Central Register of Controlled Trials MEDLINE; EMBASE; AMED; CINAHL; PsycINFO; SportDiscus; PEDro from inception to August 2012.

Results: Fourteen trials were included in this review, involving a total of 648 participants. Just six trials incorporated prescriptions that would meet current recommendations for aerobic exercise. However, none of the trials included in this review reported intervention adherence of 75% or more for a set prescription that would meet current aerobic exercise guidelines. Despite uncertainty around adherence in many of the included trials, the interventions caused improvements in aerobic exercise tolerance at 8–12 weeks (SMD = 0.73, 95% CI = 0.51–0.95) in intervention participants compared with controls. At 6 months, aerobic exercise tolerance is also improved (SMD = 0.70, 95% CI = 0.45–0.94), although four of the five trials had a high risk of bias; hence, caution is warranted in its interpretation.

Conclusion: Expecting the majority of sedentary survivors to achieve the current exercise guidelines is likely to be unrealistic. As with all well-designed exercise programmes, prescriptions should be designed around individual capabilities and frequency, duration and intensity or sets, repetitions, intensity of resistance training should be generated on this basis.

It is estimated that there are now around 29 million people living with or beyond cancer globally (excl. non-melanoma skin cancer) (GLOBOCAN, 2008), and this number will continue to rise as a result of an ageing population, increased detection and improving survival (Maddams et al, 2009). For many cancer survivors, iatrogenic harm caused by primary treatment, and the transition from end of treatment to living beyond cancer, can have an impact on all aspects of life for the individuals and their families (Ferrell et al, 1998).

Europe's largest survey assessing patient-reported outcomes in people living with and beyond cancer reported that <25% meet the current physical activity guidelines, 43% have trouble with fatigue and 45% experience fear of disease recurrence (Department of Health—Quality Health, 2012). Furthermore, around 50% of people with cancer have an existing chronic condition (Elliott et al, 2011) and are at an increased risk of developing new comorbidities such as heart failure, coronary heart disease, osteoporosis and diabetes

during the survivorship period (Khan et al, 2011). For these individuals, the proportion suffering on-going poor health, quality of life and disability may be as high as 25–30% (Elliott et al, 2011).

Exercise interventions for cancer survivors have received increasing attention over the last decade as an effective way to improve health-related quality of life, physical function and reduce fatigue (Fong et al, 2012; Mishra et al, 2012a, b). Associations with the reduced risk of disease recurrence have also come to prominence (Holmes et al, 2005; Meyerhardt et al, 2006, 2009; Kenfield et al, 2011; Richman et al, 2011). The current exercise guidelines indicate that cancer survivors should achieve 150 min per week of aerobic exercise and twice weekly resistance (strength) training (Rock et al, 2012). However, as few individuals achieve such physical activity levels, a comprehensive review of behaviour-change effectiveness including which interventions meet the current guidelines is crucial. The aim of this study was to systematically review the effects of exercise interventions on exercise behaviour in sedentary people living with and beyond cancer.

MATERIALS AND METHODS

Search strategy. Full details of the MEDLINE search (which was adapted accordingly for separate databases) can be seen in the parallel publication of Bourke et al (2013). Briefly, the following electronic databases were searched: Cochrane Central Register of Controlled Trials MEDLINE; EMBASE; AMED; CINAHL; PsycINFO; SportDiscus; PEDro from inception to August 2012. To supplement this evidence, grey literature was evaluated, leading experts in the field and charities were written to and reference lists of other recent systematic reviews were screened for potential trials.

Eligible studies. Only randomised controlled trials (RCTs) involving adults (18 years or over) that aimed to improve exercise behaviour compared with a usual care comparison group with a sedentary lifestyle (i.e., not undertaking 30 min or more of the structured exercise of at least a moderate intensity, 3 days per week) were included. Participants were required to have been histologically or clinically diagnosed with cancer regardless of sex, tumour site, tumour type, tumour stage and type of anticancer treatment received. Only interventions that detailed the frequency, duration and intensity of aerobic exercise behaviour, or the frequency, intensity, type, sets, repetitions of resistance exercise behaviour were included. The exercise programmes could be individual or group, professionally led or not, and home, community, primary care or exercise facility based. Eligible RCTs must have included at least 6 weeks of follow-up.

In an effort to attempt to understand how different interventions might be relevant to each type of cancer and its specific treatment methods, we did not include studies of heterogeneous cancer cohorts (i.e., patients with different primary cancer sites). Studies in 'at risk' populations that are addressing primary prevention research questions were not included. Trials directed specifically at end-of-life-care pathways or hospital in-patients were also excluded.

Study quality. Risk of bias and methodological quality were assessed in accordance with the Cochrane Collaboration's tool for assessing risk of bias (Higgins and Green, 2011). Two review authors (LB and KH) applied the risk of bias tool independently, and any differences were resolved by discussion with a third review author (ST or DR).

Outcomes. Primary outcomes were aerobic exercise behaviour (frequency, duration and intensity) and resistance exercise behaviour (sets, repetitions and intensity). Interventions were judged as successful in achieving their exercise goals as identified in the study methods if they reported at least 75% adherence over the given follow-up period (Martin and Sinden, 2001). We also assessed which interventions were designed to achieve the American Cancer Society's guidelines for exercise in people living with and beyond cancer – that is aerobic exercise of at least 150 min per week – with at least 2 days per week of strength training (Rock et al, 2012). Secondary outcomes were change in aerobic fitness or exercise tolerance, change in skeletal muscle strength and endurance, adverse events and intervention attrition rate.

Screening and data extraction. All titles and abstracts were screened to identify studies that might meet the inclusion criteria or that could not safely be excluded without full-text assessment (e.g., where there is no abstract available) by two of the authors working independently (LB and KH). Full texts were retrieved for these articles. All eligible papers were formally abstracted by at least two members of the group working independently (LB and KH) using the data collection form and the risk of bias tool (Higgins and Green, 2011). Any disagreements were resolved by discussion with one more review author (ST or DJR).

Data synthesis. Data on adherence were quantified in terms of number of prescribed exercise sessions attended as a proportion of those prescribed. Interventions were categorised in terms of the behaviour-change techniques (BCTs) used according to the 'Coventry, Aberdeen & London—Refined' (CALO-RE) taxonomy by a health psychologist trained in using this taxonomy (LS) and checked by LB (Michie et al, 2011). Where possible, and if appropriate, meta-analyses of review outcomes were performed. A fixed-effect model was used if there was no significant statistical heterogeneity ($I^2 \geqslant 50\%$). For continuous outcomes (e.g., fitness or exercise tolerance), the standardised mean difference between treatment arms was estimated by extracting the final value and standard deviation of the outcome of interest with the number of participants assessed at follow-up. The Cochrane group RevMan version 5.2 statistical analysis software was used to carry out meta-analyses (Cochrane IMS, 2013).

RESULTS

We identified 5559 unique records from research database records from grey literature and 'snowballing' techniques, which included reference checking from recent large systematic reviews (see Figure 1, PRISMA flow chart). Given that the detail of prescribed exercise is rarely reported in manuscript abstracts (e.g., frequency, intensity and duration of exercise prescription), this led to a large number of manuscripts being evaluated at the full-text stage ($n = 402$). After consensus agreement between study authors, 14 RCTs were included in this review (McKenzie and Kalda, 2003; Pinto et al, 2003, 2005, 2013; Drouin et al, 2005; Kim et al, 2006; Daley et al, 2007; Cadmus et al, 2009; Hayes et al, 2009; Perna et al, 2010; Kaltsatou et al, 2011; Bourke et al, 2011a, b; Musanti, 2012). A total of 648 participants were randomised in these trials. A total of 377 reports were excluded; reasons for exclusion were: non RCTs – for example, reviews or comment/editorial articles; mixed cancer cohorts or cohorts that included non-cancer populations; trials that failed to describe essential metrics of exercise prescription used in the intervention; trials involving active participants at baseline; trials involving hospital in-patients; interventions that were <6 weeks in follow-up; trials involving participants <18 years of age; not able to translate into English.

The majority of trials were conducted in breast cancer survivors with only two trials in colorectal (Bourke et al, 2011b; Pinto et al, 2013) and one trial in prostate cancer (Bourke et al, 2011a). A summary of study characteristics can be seen in Table 1. We only found one study that reported data from patients with metastatic disease (Bourke et al, 2011a) and two studies that were conducted
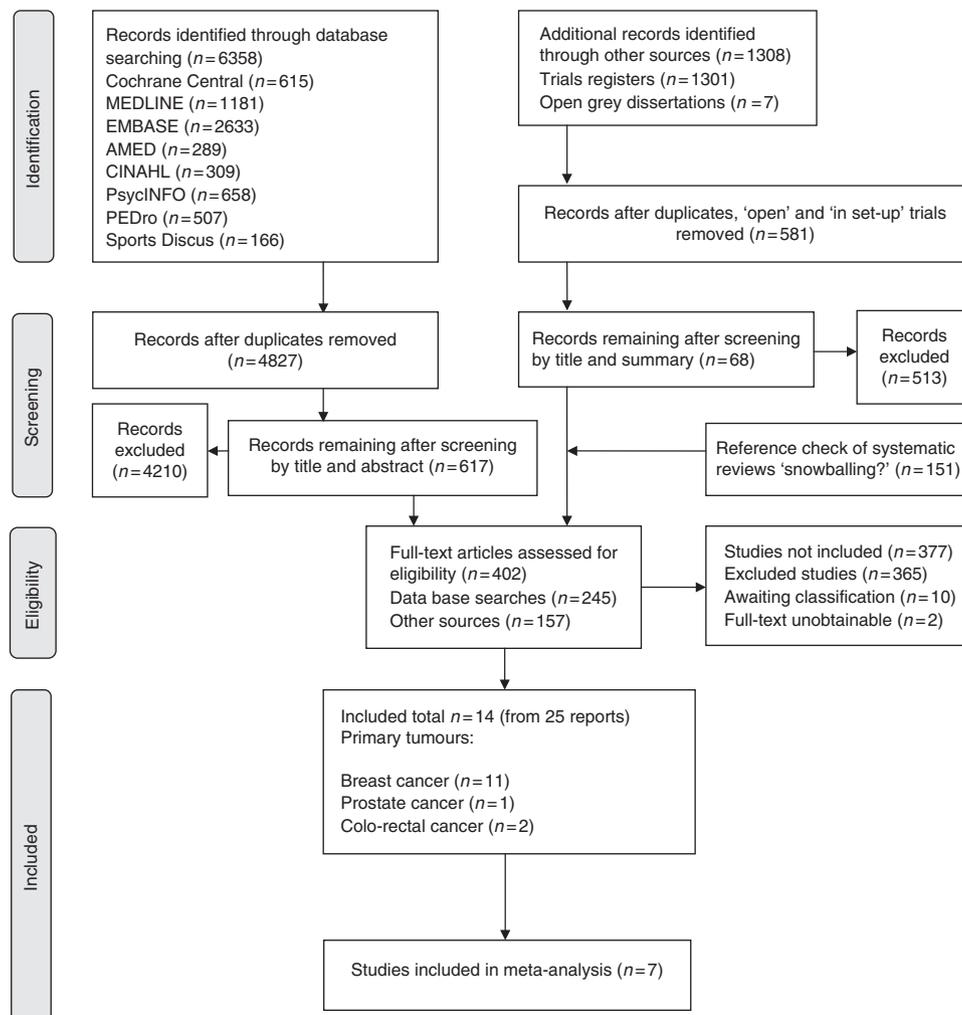
Figure 1. PRISMA flow diagram of included and excluded studies.

in obese cohorts (Drouin *et al*, 2005; Cadmus *et al*, 2009). The overwhelming proportions of participants were White, with only one study reporting data from an ethnically diverse sample (Perna *et al*, 2010). Comorbidities at baseline were largely unclear or unreported, with only two studies (Daley *et al*, 2007; Hayes *et al*, 2009) reporting on proportion with lymphedema, and one trial reporting on proportion with clinically relevant depression scores (Perna *et al*, 2010).

Seven trials used a combination of supervised and non-supervised exercises (Pinto *et al*, 2003; Kim *et al*, 2006; Cadmus *et al*, 2009; Hayes *et al*, 2009; Perna *et al*, 2010; Bourke *et al*, 2011a, b); four trials were exclusively home-based (Drouin *et al*, 2005; Pinto *et al*, 2005, 2013; Musanti, 2012); and just three were exclusively supervised trials (McKenzie and Kalda, 2003; Daley *et al*, 2007; Kaltsatou *et al*, 2011). Contact with exercise professionals or study researchers ranged from 20 times over 12 weeks (Hayes *et al*, 2009) to weekly phone calls after an initial one-to-one exercise consultation (Pinto *et al*, 2005, 2013). Just six trials incorporated prescriptions that would meet the Rock *et al* (2012) recommendations for aerobic exercise, that is, 150 min per week (Cadmus *et al*, 2009; Pinto *et al*, 2013) or resistance exercise, that is, strength training exercises at least 2 days per week (Perna *et al*, 2010; Bourke *et al*, 2011a, b; Musanti, 2012). Only three trials were identified that attempted to objectively validate independent exercise behaviour with accelerometers or heart rate monitoring (Pinto *et al*, 2005, 2013; Cadmus *et al*, 2009). A summary of included studies can be seen in Table 2.

Quality of studies. Three trials were judged not to include a high risk of bias (Drouin *et al*, 2005; Cadmus *et al*, 2009; Bourke *et al*, 2011b). The majority of uncertainty in judging trial bias came from a lack of clarity around randomisation procedures and blinding of study outcome assessors (McKenzie and Kalda, 2003; Pinto *et al*, 2003, 2005, 2013; Kaltsatou *et al*, 2011). The majority of trials in the review were judged to include at least one element indicating a high risk of non-standard bias. These included adherence data missing or not clear (McKenzie and Kalda, 2003; Hayes *et al*, 2009; Kaltsatou *et al*, 2011; Musanti, 2012); high attrition at follow-up (Pinto *et al*, 2003; Bourke *et al*, 2011a); significant differences in those participants excluded from trial analysis/dropouts (Pinto *et al*, 2003; Kim *et al*, 2006; Musanti, 2012); numbers randomised to trial arms and trial completion rate are unclear (Perna *et al*, 2010); significant differences in cohorts at baseline (Pinto *et al*, 2003, 2005; Musanti, 2012); inconsistencies between objective and subjective measures of exercise behaviour (Pinto *et al*, 2005, 2013).

Effects of the interventions. None of the trials included in this review reported an adherence of 75% or more, to a prescription that would meet the Rock *et al* (2012) aerobic exercise guidelines. Only three trials reported an adherence of 75% or more to a lower aerobic exercise goal (Cadmus *et al*, 2009; Bourke *et al*, 2011a, b). Notably, all three incorporated both a supervised and independent exercise component as part of their intervention and none placed restrictions on the control group in terms of their exercise behaviour. Cadmus *et al* (2009) appeared to be the most successful

Table 1. Characteristics of included studies

Study	N and primary cancer	Current treatment	Exercise prescription components	Method of measuring exercise behaviour	Instructions to controls
Cadmus et al, 2009	37, 38 (Intervention vs control): BCa	Completed adjuvant treatment (with the exception of hormonal therapy) at least 6 months before enrolment. 57% vs 70% on hormone therapy in the intervention group vs controls; 30% on tamoxifen in both arms; 27 vs 40% vs control on aromatase inhibitors	**Aerobic exercise.** Frequency: three sessions per week supervised, two sessions per week at home or at a health club: total 5 days a week. Duration: participants were asked to perform three 15 min sessions during week 1, building to five 30 min moderate-intensity sessions by week 5. Intensity: 60–80% of maximal heart rate reserve	Heart rate monitors, physical activity questionnaire, a 7 day physical activity log, and a 7 day pedometer log. Adherence to the intervention among exercise group participants was assessed with 7 day physical activity logs weekly	Can exercise on their own if they chose
Daley et al, 2007	34;36;38 (Intervention; sham; control, respectively): BCa	73.5%, 69.4%, 76.3% On hormone therapy in the intervention, sham, and usual care groups, respectively	**Aerobic exercise.** Frequency: three sessions per week. Duration: 27 min of exercise on average per session. Intensity: 65% to 85% of age-adjusted heart rate maximum and RPE of 12–13	Adherence was calculated from session attendance and the amount (duration, RPE, heart rate) of exercise achieved by participants during sessions was calculated by extraction from physical activity logs	Continue with lives as usual
Drouin et al, 2005	13 Intervention, 8 placebo stretching controls: BCa	External beam radiation on 5 days per week for 7 weeks. The affected breast and regional lymph nodes received a 4500 to 5000 cGy dose in 200 cGy fractions with a boost of 1000–1600 cGy delivered to the primary tumour bed	**Aerobic exercise.** Frequency: three to five times per week. Duration: 20–45 min. Intensity: 50–70% of the maximal heart rate achieved by the participant during a symptom-limited graded exercise test	Participants were provided with a training diary to record. Participants in the intervention group wore heart rate monitors to record training time and time spent in the training heart rate range to improve reporting of data on exercise compliance, training intensity and training duration	Not to begin any new exercise activity other than a general flexibility programme they were given
Kaltsatou et al, 2011	14,13 (Intervention vs control): BCa	Treatment completed	**Aerobic exercise.** Frequency: three times per week. Duration: the aerobic training phase lasted 25 min and included learning and practising Greek traditional dances. Intensity: between 65 and 80% of maximum heart rate or 13–14 on the Borg scale. **Resistance exercise** sets, reps and intensity unclear	Unclear	Refrain from any form of recreational activity during the study period
Kim et al, 2006	22,19 (Intervention vs control): BCa	Chemotherapy was the most common type of adjuvant therapy (48.8%), followed by radiotherapy (34.1%) and a combination of chemotherapy and radiotherapy (17.1%)	**Aerobic exercise.** Frequency: three days per week. Duration: 30 min of aerobic exercise and five minutes for warm-up or cool-down. Intensity: moderate intensity to produce an heart rate corresponding to 60–70% of the individual's heart rate reserve and/or VO_2 peak achieved on a graded exercise test at baseline	Polar heart rate monitors and a 7 day physical activity log	Not to start any regular or structured exercise programme while participating in the study
Pinto et al, 2003	12,12 (Intervention vs control): BCa	Treatment completed	**Aerobic exercise.** Frequency: three times per week. Duration: up to 30 min. Intensity: 60–70% of peak heart rate by the end of the 12-week intervention	Attendance at supervised exercise sessions	Not to change their current level of physical activity
Pinto et al, 2005	43, 43 (Intervention vs control): BCa	49% of intervention and 74% of controls on hormone therapy	**Aerobic exercise.** Frequency: 2–5 days per week. Duration: 10–30 min. Intensity: 55–65% of maximum heart rate	The 7 day physical activity recall questionnaire and accelerometer data providing $kcal\,h^{-1}$	Not to change their current level of activity during the first 12 weeks

Table 1. (Continued)

Study	N and primary cancer	Current treatment	Exercise prescription components	Method of measuring exercise behaviour	Instructions to controls
Pinto et al, 2013	20, 26 (Intervention vs control): CRCa	Treatment completed	**Aerobic exercise.** Frequency: two to five times per week. Duration: 10–30 min. Intensity: 64–76% of estimated maximum heart rate	The 7-day physical activity recall questionnaire; community healthy activities model programme for seniors questionnaire; stage of motivational readiness for physical activity. Accelerometer data	Not to change their usual level of activity
Bourke et al, 2011a	9, 9 (Intervention vs control): CRCa	Treatment completed	**Aerobic exercise.** Frequency: three times or more per week. Duration: 30 min per session or more. Intensity: 55–85% of age-predicted maximum heart rate/11–15 Borg scale. **Resistance exercise.** Frequency: three times per week. Sets: between two and four sets. Reps: eight to 12 reps. Resistance exercise intensity: 60% of one rep max	Attendance at supervised session with heart rate monitors, exercise diaries and Godin leisure score index questionnaire	Continue current exercise/ dietary behaviours as normal
Bourke et al, 2011b	25, 25 (Intervention vs control): PCa	Undergoing androgen suppression therapy for a minimum of 6 months prior	**Aerobic exercise.** Frequency: three times per week. Duration: 30 min per session or more. Intensity: 55–85% of age-predicted maximum heart rate/11–15 Borg scale. **Resistance exercise.** Frequency: three times per week. Sets: between two and four sets. Reps: eight to 12 reps. Intensity: 60% of 1 rep max	Attendance at supervised session with heart rate monitors, exercise diaries and Godin leisure score index questionnaire	Continue current exercise/ dietary behaviours as normal
Hayes et al, 2009	16, 16 (Intervention vs control): BCa	Treatment completed	**Aerobic exercise.** Frequency: three to four or more times per week. Duration: 20–45 + min. Intensity: three to seven on a modified Borg scale. **Resistance exercise** sets unclear	Exercise adherence rates and qualitative comments were used to provide insight into the acceptability of the programme	Continue habitual activities
McKenzie and Kalda, 2003	7,7 (Intervention vs control): BCa	Treatment completed	**Aerobic exercise.** Frequency: 3 days per week (initiated after week 2). Duration: 5–20 min. Intensity: arm cycling at a resistance of 8.3–25 W. Intensity was also assessed with Polar HR monitors. A target heart rate was 60–80% of maximum predicted by age. **Resistance exercise** intensity unclear	Work in kJ was calculated for each session for every subject, and this was used to calculate cumulative work performed over the course of the programme	Not to initiate any new activity
Musanti, 2012	Flexibility group (n = 13); aerobic group (n = 12) resistance group (n = 17), aerobic and resistance group (n = 13): BCa	Hormonal therapy could be on-going: 56% on hormone therapy	**Aerobic exercise.** Frequency: three to five times per week. Duration: 15–30 min. Intensity: 40–65% of the calculated maximum heart rate. **Resistance exercise.** Frequency: 2/3 times per week reps: 10–12. Resistance exercise sets: one. Intensity: rating of perceived exertion of three to eight, on a scale of one to 10	Adherence to the exercise prescription was calculated as a proportion of completed sessions over the total possible number of sessions in their assigned exercise programme	All participants were prescribed flexibility exercise and received a written guidebook that included general information about exercise participation, an individualised exercise prescription, exercise instructions and an exercise log sheet

Table 1. (Continued)

Study	N and primary cancer	Current treatment	Exercise prescription components	Method of measuring exercise behaviour	Instructions to controls
Perna et al, 2010	51 Participants in total. Numbers randomised to each arm are unclear: BCa	The majority (52.9%) of women had stage I breast cancer and received lumpectomy surgery (74.1%). Many (44.1%) women received both radiation and chemotherapy, 26.5% received radiation only, 8.8% received chemotherapy only, and 20.6% received no adjuvant therapy	**Aerobic exercise.** Frequency: three or more times per week. Duration: 15–45 min. Intensity: 50–85% of maximum predicted heart rate or 11–16 on the Borg scale. **Resistance exercise.** Frequency: three times per week. Sets: one to two sets. Resistance exercise reps: 12–15. Participant body weight was used for lower body exercises	Participants were provided with monthly calendars to record their exercise activity and were contacted weekly by telephone or electronic mail according to patient preference. Godin leisure score index and the leisure time exercise questionnaire self-report instrument surveys were also used	Women in the information control group received a 45 min session covering their fitness, strength and flexibility assessment results and an informational brochure

Abbreviations: BCa = breast cancer; CRCa = colorectal cancer; PCa = prostate cancer; Reps = repetitions; RPE = rate of perceived exertion.

study regarding the promotion of aerobic exercise behaviour, with 75% of the intervention group reporting between 90 and 119 min per week of moderate intensity exercise, at an average heart rate of 76% of predicted maximum, for 6 months. However, of these three trials, only two (Bourke *et al*, 2011a, b) met the Rock *et al* (2012) exercise guidelines: specifically, two to four sets of resistance exercise at 60% of one rep maximum, for eight to 12 reps, was carried out twice per week, for just 6 weeks. These three trials shared the following BCTs: goal setting, self-monitoring of behaviour and prompting practice, which were common to most of the interventions, included in the review; however, additionally these three studies included generalisation of a target behaviour – that is, getting people to engage in exercise outside of the immediate intervention environment.

These trials did not explicitly state a theoretical basis. Other studies such as Daley *et al* (2007) or Perna *et al* (2010) were much more comprehensive in their reporting of BCTs and were based on recognised behaviour-change theory. Full details of intervention coding according to the CALO-RE taxonomy (Michie *et al*, 2011) of exercise BCTs can be seen in Table 3. Several trials might have achieved an adherence of 75% or more; however, because of unclear reporting it was not possible to make a judgement on whether this criterion had been fulfilled.

A meta-analysis of change in aerobic exercise tolerance was carried out on seven trials that reported these outcomes. Aerobic exercise tolerance was significantly better after 8–12 weeks of follow-up in intervention *vs* control in 330 participants (SMD = 0.73, 95% CI = 0.51–0.95) and at 6 months of follow-up in intervention *vs* control in 271 participants (SMD = 0.70, 95% CI = 0.45, 0.94; see Figure 2). The 6-month data should be viewed with caution as four of the five trials were judged to have a high risk of bias. Limb strength was significantly better in intervention *vs* controls in 91 participants (SMD = 0.51, 95% CI = 0.09–0.93). After removing one trial for a high risk of bias (Musanti, 2012), in 68 participants the moderate effect size was still apparent but was no longer significant (SMD = 0.47, 95% CI = − 0.01, 0.96).

Attrition rates during the intervention from the included trials ranged from 25% (Pinto *et al*, 2003) to 0% (Drouin *et al*, 2005) (median 6%), with five trials not clearly reporting attrition in the intervention arm. Eight trials reported adverse events that ranged from minor – for example, muscular–skeletal problems (Musanti, 2012) to major events – for example, death (Kim *et al*, 2006). However, only one study was explicit as to which of these adverse events were caused by participating in the intervention group (two instances of plantar fasciitis; Cadmus *et al*, 2009).

DISCUSSION

The review findings indicate that currently there is a lack of convincing evidence to suggest that existing exercise interventions are useful for achieving the Rock *et al* (2012) guidelines of 150 min per week of aerobic exercise and twice per week of resistance exercise, in sedentary cancer cohorts. Adherence to exercise interventions, which is crucial for understanding treatment dose, is frequently poorly reported. Importantly, the fundamental metrics of exercise behaviour, that is, frequency, intensity and duration, or repetitions, sets and intensity of resistance training, although easy to devise and report, are seldom included in published clinical trials. Attempting to reproduce any exercise prescription without detailing these metrics is fraught with problems, and most likely not possible. The extent of exclusion at the full-text screening stage (377 publications excluded from 402) provided the first indication of problems associated with quality of reporting in this research field.

The supportive evidence that we have narratively synthesised suggests that interventions that combine the supervision of exercise training in tandem with a requirement of independent exercise are likely to promote better adherence. Use of generalisation of behaviour was also a common and relatively unique feature of interventions, which reported better adherence.

Despite the uncertainty around adherence in many of the included trials, the interventions caused improvements in aerobic exercise tolerance at 8–12 weeks and 6 months of follow-up.

Such improvements could be interpreted as reassuring: some of the doubts around adherence might only extend to reporting issues rather than real problems with fidelity. Alternatively, this result could have arisen from the rapid, relatively large early gains in function expected in sedentary participants from exercise training, which could mask smaller changes in non-adherers. Further, aerobic exercise tolerance should not be considered as definitive evidence of changes in aerobic fitness (with the accompanying spectrum of underlying physiological adaptation). It could simply reflect individuals becoming accustomed to the feeling of exertion from exercise testing and a better tolerance towards perceptions of fatigue.

To the authors' knowledge, this is the first comprehensive review to evaluate RCTs with respect to their success in improving exercise behaviour in sedentary cancer cohorts against state of the art recommendations for these patients. The large majority of these trials included women with breast cancer, the remaining three were in people with prostate and colorectal cancer. Furthermore, the

Table 2. Summary of study exercise behaviour

Study	Exercise components	Meets Rock *et al* guidelines?	Adherence summary	At least 75% adherence?	High risk of bias?	Change in AET reported?	Adverse event rate
Cadmus *et al*, 2009	Aerobic	33% Reported 150 min per week of moderate intensity aerobic exercise at an average of 76% Hr, for 6 months	75% Of women were doing between 90 and 119 min of moderate-intensity aerobic activity per week at 6 months	Yes: for up to 119 min per week	No	No	Five of the 37 women randomised to exercise experienced an adverse event; 2 events were related to the study (plantar fasciitis)
Daley *et al*, 2007	Aerobic	No	77% Of the exercise therapy attended 70% (at least 17 of 24 sessions) or more of sessions	Unclear	Yes: outcome assessors were not blinded to participants' group allocation	Yes	Three withdrawals in the intervention group: unclear as to why this was. Some withdrawals due to medical complications in placebo and control arms but unclear if study related
Drouin *et al*, 2005	Aerobic	Unclear	Participants in the intervention group averaged 3.6 days per week of aerobic exercise over an 8-week period	Unclear	No	Yes	None reported
Kaltsatou *et al*, 2011	Aerobic	Unclear	Not reported	Not reported	Yes: method of measuring exercise and adherence not reported	No	None reported
Kim *et al*, 2006	Aerobic	No	The average weekly frequency of exercise was 2.4 ± 0.6 sessions and the average duration of exercise within prescribed target Hr was 27.8 ± 8.1 min per session. The overall adherence was $78.3 \pm 20.1\%$	Yes	Yes: data missing for 45% of the cohort	Yes	Reasons for withdrawal included personal problems ($n = 2$), problems at home ($n = 2$), problems related to chemotherapy ($n = 3$), thrombophlebitis in the lower leg ($n = 2$), non-exercise-related injuries ($n = 1$), or death ($n = 1$). Unclear which arm of the trial these date relate to
Pinto *et al*, 2003	Aerobic	Unclear	Subjects attended a mean of 88% of the 36 session supervised exercise programme	Yes	Yes: 38% lost to follow-up. Exercise tolerance test performed but no control group comparison data were reported	Yes	Not reported. It is unclear why the six controls dropped out
Pinto *et al*, 2005	Aerobic	Unclear	At week 12, intervention participants reported a mean of 128.53 min per week of moderate intensity exercise. However, no changes were reported in the accelerometer data in the intervention group (change score $= -0.33$ kcal h^{-1})	Less than 75% of the intervention group were meeting the prescribed goal after week 4	Yes: significantly more control group participants were on hormone treatment. Accelerometer data do not support the self-reported physical activity behaviour	Yes	Not clear if chest pain was related to exercise in drop out whose participation was terminated
Pinto *et al*, 2013	Aerobic	3-Day PAR questionnaire indicates that 64.7% of the intervention group and 40.9% of controls were achieving the guidelines at 3 months	Correlation between self-reported moderate intensity exercise and accelerometer data at the 3 months follow-up, where the only significant between group change is reported: $r = 0.32$	No	Yes: accelerometer data not reported: also cited correlation was weak (0.32). Further, there was substantial contamination in the control group	Yes	One cancer recurrence in the control group at 3 months

Table 2. (Continued)							
Study	Exercise components	Meets Rock *et al* guidelines?	Adherence summary	At least 75% adherence?	High risk of bias?	Change in AET reported?	Adverse event rate
Bourke *et al*, 2011a	Aerobic and resistance	6 Weeks of resistance exercise at twice a week	90% Attendance at the supervised sessions. 94% of the independent exercise sessions were completed	Yes	No	Yes	One stroke in the intervention group, unrelated to the exercise programme
Bourke *et al*, 2011b	Aerobic and resistance	6 Weeks of resistance exercise at twice a week.	95% Attendance at the supervised exercise sessions. Compliance to the self-directed exercise aspect of the lifestyle intervention was 87%	Yes	Yes: high dropout rate at the post intervention 6 month follow-up assessment	Yes	Two men in the intervention arm were discontinued due to cardiac complications before the 12 week assessments. Two more reported muscular–skeletal complaints before the 6 month assessment. Five men reported various health problems in the control group prohibiting them attending the 6 month assessment
Hayes *et al*, 2009	Aerobic and resistance	Unclear	The majority of women (88%) allocated to the intervention group participated in 70% or more of scheduled supervised exercise sessions	Unclear	Yes: adherence data on unsupervised aspect of the intervention is not clear	No	None reported
McKenzie and Kalda, 2003	Aerobic and resistance	No	Unclear	Unclear	Yes: adherence to exercise not reported	No	None reported
Musanti 2012	Aerobic and resistance	12 Weeks of resistance exercise at twice or three times per week	Mean percentage adherence were as follows: flexibility = 85%, aerobic = 81%, resistance = 91%, and aerobic plus resistance = 86%	Unclear	Yes: a significant number of the dropouts belonged to the resistance exercise group ($n = 8/13$). Only 50% of activity logs returned	Yes	There were adverse events reported in two women during the study. In both cases, the women developed tendinitis: one in the shoulder and the other in the foot. Both had histories of tendonitis, and both received standard treatment
Perna *et al*, 2010	Aerobic and resistance	Three months of resistance exercise at three times per week	Women assigned to the structured intervention completed an average of 83% of their scheduled hospital-based exercise sessions, (only 4 weeks in duration) and 76.9% completed all 12 sessions. Home-based component (8 weeks in duration not clear)	Unclear	Yes: numbers randomised to intervention and control groups are unclear as are numbers completing in each arm	No	Unclear

Abbreviations: AET = aerobic exercise tolerance, Hr = heart rate, PAR = physical activity recall.

overwhelming majority of participants were White, with only one trial made up of an ethnically diverse population. As such, other ethnicities are substantially under-represented. Thirteen of the 14 included trials were conducted in North America or Western Europe, with one trial from Australia. All were in high-income nations. No evidence was found from low- or middle-income countries, and it is uncertain whether the featured interventions would be deliverable in these parts of the world.

Another recent systematic review that examined predictors of adherence to exercise in people living with and beyond cancer

(Husebo *et al*, 2013) found that the transtheoretical model of behaviour change and the theory of planned behaviour were significantly associated with better exercise adherence. The current review does not explicitly support such conclusions. It should be noted that there are key differences in each review methodology, with the present review only including RCTs and people who were sedentary at baseline. Other recent systematic reviews have focused on the potential health-related outcomes of exercise interventions for people living with and beyond cancer. In this respect, Fong *et al* (2012) similarly reported improvements in aerobic exercise

Table 3. CALO-RE taxonomy of behaviour-change techniques

Behaviour change technique	Bourke et al, 2011a	Bourke et al, 2011b	Cadmus et al, 2009	Daley et al, 2007	Drouin et al, 2005	Hayes et al, 2009	Kaltsatou et al, 2011	McKenzie and Kalda, 2003	Musanti, 2012	Perna et al, 2010	Kim et al, 2006	Pinto et al, 2003	Pinto et al, 2005	Pinto et al, 2013
Theory				TTM					EXSEM	TTM			TTM	TTM SCT
Provide Info on consequences of behaviour *in general*			X	X						X	X			
Provide Info on consequences of behaviour *to the individual*														
Provide Info about others approval														
Provide normative info about others behaviour														
Programme set goal	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Goal-setting (behaviour)			X	X						X		X	X	X
Goal setting (outcome)														
Action planning														
Barrier identification/problem solving		X	X	X						X			X	X
Set graded tasks			X	X		X	X	X	X	X		X		X
Prompt review of behavioural goals				X						X				
Prompt review of outcome goals														
Prompt rewards contingent on effort or progress towards goal										X			X	X
Provide rewards contingent on successful behaviour				X										
Shaping														
Prompting generalisation of a target behaviour	X	X	X							X	X			
Prompt self-monitoring of behaviour	X	X	X	X	X				X	X		X	X	X
Prompt self-monitoring of behavioural outcome			X	X	X				X				X	X
Prompting focus on past success				X										
Provide feedback on performance			X							X			X	X
Provide information on *where and when* to perform behaviour				X						X				
Provide instruction on how to perform the behaviour		X	X	X	X		X		X	X	X	X		X
Model/demonstrate the behaviour							X		X	X				
Teach to use prompts/cues				X						X				X
Environmental restructuring										X				X
Agree behavioural contract										X				
Prompt practice	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Use of follow-up prompts	X	X												
Facilitate social comparison														
Plan social support/social change			X	X						X				
Prompt identification as role model/position advocate														
Prompt anticipated regret														
Fear arousal														
Prompt self-talk														

Table 3. (Continued)

Behaviour change technique	Bourke et al, 2011a	Bourke et al, 2011b	Cadmus et al, 2009	Daley et al, 2007	Drouin et al, 2005	Hayes et al, 2009	Kaltsatou et al, 2011	McKenzie and Kalda, 2003	Musanti, 2012	Perna et al, 2010	Kim et al, 2006	Pinto et al, 2003	Pinto et al, 2005	Pinto et al, 2013
Theory				TTM					EXSEM	TTM			TTM	TTM SCT
Prompt use of imagery														
Relapse prevention/coping planning				X							X			
Stress management/ emotional control training											X			
Motivational interviewing														
Time management														
General communication skills training														
Stimulate anticipation of future rewards														

Abbreviations: EXSEM = Exercise Self-Esteem Model; SCT = Social cognitive theory; TTM = Transtheoretical model.
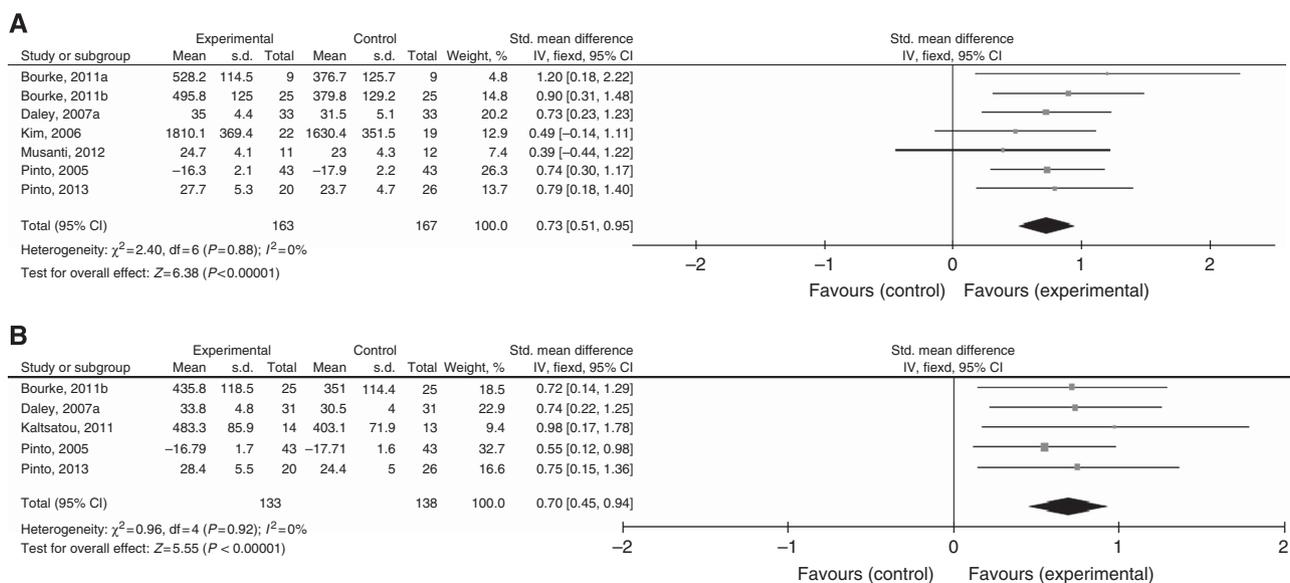

Figure 2. Meta-analysis of (**A**) aerobic exercise tolerance at 8–12 weeks of follow-up and (**B**) aerobic exercise tolerance at 6 months of follow-up. Note, in all meta-analysis data from Pinto et al (2005) has been multiplied by -1 to control for direction of effect (that is, lower values in a timed test indicate a better outcome). Data were extracted from the combined aerobic and resistance training arm of Musanti (2012).

tolerance and muscle strength. One substantial difference in the methodology of the present review when compared with other Cochrane reviews in the area (Mishra et al, 2012a, b) is that we only included studies where the essential metrics of exercise behaviour are reported.

There are limitations to this review, namely the large majority of these trials included women with breast cancer. One trial involved men with advanced prostate cancer and two trials involved colorectal cancer survivors. Although these three primary cancers make up the majority of the population living with and beyond cancer, other common cancers such as lymphoma and lung cancer do not appear at all in this review. Less common cancers are also not represented in the evidence base. Furthermore, the overwhelming majority of participants were White, with only one trial made up of an ethnically diverse population.

Recently, in the largest survey of cancer survivors (covering multiple cancer types) to be conducted in Europe ($N = 3300$), the UK Department of Health reported that <25% of people living

with and beyond cancer are achieving 30 min of exercise on 5 or more days per week. (Department of Health—Quality Health, 2012) This is a clear indicator that the overwhelming majority of cancer survivors are not active. It is therefore of critical importance that future research is designed to improve exercise behaviour in sedentary individuals living with or beyond cancer, particularly in under-represented groups. All trials should report as standard, frequency, intensity and duration of aerobic exercise, as well as reps, sets and intensity of resistance exercise used in intervention prescriptions. Using these essential metrics of exercise prescription will not only help to achieve a balance between safe yet effective exercise but will also ensure that meaningful re-evaluation over time can be undertaken, as adaptation or disease progression dictates.

Reporting of adherence as a single proportion of the cohort who attended/performed exercise according to the set prescription and reporting of BCTs (e.g., using the CALO-RE taxonomy) needs to be standardised. By achieving these standardisations, oncology

scientists and clinicians will help to bring the discipline up to the level of acceptable rigour that will help to elucidate dose response of exercise interventions for given health outcomes. This should afford an opportunity to communicate achievable exercise recommendations for sedentary people living with and beyond cancer.

DISCLAIMER

This review received no external funding.

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