A preoperative package of care for osteoarthritis, consisting of weight loss, orthotics, rehabilitation, and topical and oral analgesia (OPPORTUNITY): a two-centre, open-label, randomised controlled feasibility trial

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Summary

Background Osteoarthritis of the knee is a major cause of disability worldwide. Non-operative treatments can reduce the morbidity but adherence is poor. We hypothesised that adherence could be optimised if behavioural change was established in the preoperative period. Therefore, we aimed to assess feasibility, acceptability, and recruitment and retention rates of a preoperative package of non-operative care in patients awaiting knee replacement surgery.

Methods We did an open-label, randomised controlled, feasibility trial in two secondary care centres in the UK. Eligible participants were aged 15–85 years, on the waiting list for a knee arthroplasty for osteoarthritis, and met at least one of the thresholds for one of the four components of the preoperative package of non-operative care intervention (ie, weight loss, exercise therapy, use of insoles, and analgesia adjustment). Participants were randomly assigned (2:1) to either the intervention group or the standard of care (ie, control) group. All four aspects of the intervention were delivered weekly over 12 weeks. Participants in the intervention group were reviewed regularly to assess adherence. The primary outcome was acceptability and feasibility of delivering the intervention, as measured by recruitment rate, retention rate at follow-up review after planned surgery, health-related quality of life, joint-specific scores, and adherence (weight change and qualitative interviews). This study is registered with ISRCTN, ISRCTN96684272.

Findings Between Sept 3 2018, and Aug 30, 2019, we screened 233 patients, of whom 163 (73%) were excluded and 60 (27%) were randomly assigned to either the intervention group (n=40) or the control group (n=20). 34 (57%) of 60 participants were women, 26 (43%) were men, and the mean age was 66·8 years (SD 8·6). Uptake of the specific intervention components varied: 31 (78%) of 40 had exercise therapy, 28 (70%) weight loss, 22 (55%) analgesia adjustment, and insoles (18 [45%]). Overall median adherence was 94% (IQR 79·5–100). At the final review, the intervention group lost a mean of 11·2 kg (SD 5·6) compared with 1·3 kg (3·8) in the control group (estimated difference –9·8 kg [95% CI –13·4 to –6·3]). A clinically significant improvement in health-related quality o life (mean change 0·078 [SD 0·195]) were reported, and joint-specific scores showed greater improvement in the intervention group than in the control group. No adverse events attributable to the intervention occurred.

Interpretation Participants adhered well to the non-operative interventions and their health-related quality of life improved. Participant and health professional feedback were extremely positive. These findings support progression to a full-scale effectiveness trial.

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See Comment page e195

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Introduction

The lifetime risk of hip or knee osteoarthritis is 45%.[1] Osteoarthritis is the fastest growing cause of disability[2] and affects around 595 million people worldwide.[3] Osteoarthritis has a substantial negative impact on the UK economy, costing about £3·2 billion in lost working days alone.[4] At the same time, £43 million was spent on community services and £215 million spent on social services for osteoarthritis.[4] However, patients with osteoarthritis tend to have multiple long-term conditions in which reduced activity, weight gain, and loss of fitness have much wider implications.[5,6] Obesity-related illness is responsible for about 10% of morbidity and mortality in the UK, and costs the UK National Health Service (NHS) more than £11 billion annually.[7] People with hip or knee osteoarthritis have a 30–40% reduction in their health-related quality of life, and up to a third of patients waiting for arthroplasty

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Research in context

Evidence before this study

The evidence for non-surgical treatments of osteoarthritis such as weight loss, exercise therapy, analgesia, and insoles supports the use of these interventions in people with symptomatic knee osteoarthritis; however, adherence with these interventions has been recognised to be poor. Before our study, applying generic preoperative physiotherapy (ie, so-called pre-habilitation) to individuals before knee replacement surgery was hoped to improve clinical outcomes postoperatively. We searched PubMed, the Cochrane Central Register of Controlled Trials, and ClinicalTrials.gov for randomised controlled trials or observational studies evaluating the use of a package of care of non-operative management interventions targeted to patients that stood to benefit from these interventions who were on the waiting list for total knee replacement. We used the following search terms: "osteoarthritis" AND "knee arthroplasty" AND "waiting lists" OR "preadmission" AND "pre-habilitation" OR "rehabilitation" OR "physical therapy" OR "diet" OR "orthotic devices" AND "psychological techniques". We searched the databases from inception to June 1, 2013. We found no trial or cohort study or feasibility report concerning the use of a package of care of non-operative management, underpinned by a behaviour change framework, targeted specifically to patients on the waiting list for surgery. However, a systematic review and meta-analysis of preoperative interventions noted only scant evidence from four small trials in which preoperative exercise reduced pain before knee replacement, with no post-operative effect.

Added value of this study

This feasibility study showed that delivery of non-surgical recommended osteoarthritis treatments specific to patient needs is possible in the preoperative window, and a high rate of adherence was observed in participants receiving the weight loss component of the preoperative package of care, losing a mean of more than 11 kg. The person-centred plan provided the components (ie, weight loss, exercise therapy, insoles, and analgesia adjustment) that were relevant to patients. A medication adjustment plan was developed for participants on the weight loss component, which could be used in the preoperative period without affecting patients for anaesthesia. Participants receiving the intervention commented on learning to change their behaviours.

Implications of all the available evidence

This feasibility study supports the progression to a full-scale effectiveness trial to determine whether a person-centred package of non-surgical osteoarthritis treatments can prevent deterioration of people on surgical waiting lists in a cost-effective manner and whether non-surgical osteoarthritis treatments can reduce symptoms enough that some patients chose to cancel their planned joint replacement surgery.

surgery rate their life as being "a state worse than death".[8]

The negative effect of hip and knee osteoarthritis can be improved if pharmacological and non-pharmacological treatments are optimised, as these treatments could result in a reduction of patient symptoms, fewer complications from comorbidities, less need for surgery or strong analgesics, and fewer complications if patients proceed with surgery.[9] From the health service perspective, optimised non-operative treatments could help address lengthy waiting lists for outpatient appointments and surgery.

We therefore developed a theory-informed complex intervention to optimise non-operative osteoarthritis treatment in people with multiple long-term conditions as recommended by the UK National Institute for Health and Care Excellence and postulated that this intervention would lead to the following: reduction in symptoms that might result in patients deferring their surgery, reduction in risk of complications for those who proceed with surgery, and improvements in fitness and health-related quality of life, including benefits for comorbid conditions.[9] In this study, we aimed to test the feasibility of the study methods and intervention delivery, as well as the recruitment and retention rate and acceptability of the intervention in preparation for a fully powered effectiveness trial.

Methods

Study design and participants

We did a two-centre, open-label, randomised controlled, feasibility trial comparing a preoperative package of non-operative care comprising four components (ie, weight loss, exercise therapy, use of insoles, and analgesia adjustment) with standard care before joint replacement, using a built-in process evaluation. This study took place in two secondary care sites in the UK (Edinburgh and Leeds) between September, 2018, to April, 2019. Participant recruitment occurred over 11 months. To assess the effect of the intervention rather than the effects of the surgery, the final follow-up was defined as 1 week before patients' planned surgical date, which was approximately 16 weeks following enrolment. Additionally, in the feasibility study, we monitored for a minimum of 90 days after the planned surgery date for early post-operative complications.

Eligible participants were of any ethnicity or gender, aged 15–85 years, on the waiting list for a knee arthroplasty for osteoarthritis with sufficient time for the intervention to be delivered before the planned date of surgery and for the follow-up appointment to be done after the planned date of surgery, met at least one of the thresholds (ie, eligibility criteria) for one of the four components of the intervention, and were able to consent and willing to comply with the study protocol. Patients were not eligible

if they were undergoing revision knee arthroplasty, fully constrained knee arthroplasty, knee replacement for a diagnosis other than osteoarthritis, or purely for pain relief (such as for those with no walking capacity); had a second contralateral procedure planned within the study timeframe; were involved in another research study containing elements of behaviour change related to diet, physical activity, and other study elements; were currently under active review with a clinician for physiotherapy; were unable to understand verbal explanations or written information given in English; or were pregnant, within 4 months postpartum, or breastfeeding.

Additional exclusion criteria applied to included participants eligible for the weight loss aspect of the intervention were patients who had recently lost a substantial amount of weight (>5 kg in the previous 3 months) or who were already on a specialised diet; and patients with insulin-dependent diabetes, brittle type-2 diabetes that was being managed in secondary care (confirmed by recent glycated haemoglobin measurement if available), or moderate or severe retinopathy.

A post-operative safety review, to determine if any early post-operative complications occurred such as impaired wound healing, was done 90 days after surgery. The study was designed in accordance with the UK Medical Research Council (MRC) Framework for Complex Interventions,[10] which was used primarily as a guide to the evaluation approach in this study. Ethics approval was received from the Southeast Scotland Research Ethics Committee on Jan 18, 2018 (17/SS/0156). The trial was overseen by an independent trial steering committee, who also ensured the safety of the study. In collaboration with the Trial Steering Committee the key barriers and enablers of recruitment, retention, and compliance, were used to decide whether they could be overcome for a full-scale trial and how the design could be optimised. We obtained written informed consent from participants, and eligibility was confirmed by the participant's research nurse.

Randomisation and masking

Eligible participants were randomly assigned (2:1) to either the intervention group or the standard care group. Participants were randomised centrally by the Edinburgh Clinical Trials Unit at the baseline visit, using a secure online system with telephone backup. Following randomisation, both the participant and the investigator were notified of the assigned treatment allocation. Participants were stratified by site and BMI band (<30 kg/m², ≥30 to <35 kg/m², and ≥35 kg/m²) to ensure that we tested the feasibility of recruiting people with a range of BMI values. Stratification was done using randomly generated block sizes of 3 and 6.

Procedures and interventions

Potential participants were approached about the study by a member of the clinical team at the outpatient clinic visit where the decision to proceed to knee surgery had been made. Participants were recruited across two sites to establish that the intervention could be delivered in different contexts—eg, different service delivery models. At their baseline visit, potential participants were seen by a research nurse, who acted as their osteoarthritis case manager, and eligible participants were randomly assigned. Depending on the result of randomisation, within 1 week, participants were asked to follow standard care or the non-operative package of care intervention until their planned date of surgery. All participants were assessed in clinic at the end of the intervention period, just before their planned surgery date and at 90 days after the planned surgery date.

Participants in the intervention group were reviewed regularly to assess adherence. Our person-centred plan optimised non-operative management of osteoarthritis with weight loss, muscle strengthening and increased physical activity (ie, exercise therapy), coupled with an appropriate medicine review of their analgesia, and attention to footwear (ie, the use of insoles or soft heeled shoes).[9] All four aspects of the intervention were delivered weekly (alternating between in-person and telephone sessions) by their case manager, who had received brief standardised training for the components of the package of care. As these patients were on the waiting list for joint replacement, the intervention offered all modalities that were relevant to that individual at the same time rather than sequentially. The duration of intervention was 12 weeks but could be reduced to a minimum of 8 weeks. Each participant received the components they required; therefore, some participants received one component and others received all four.

Participants with a BMI of 30 kg/m² or more received the weight loss component of the intervention. In supervised sessions in primary care, the effectiveness of weight loss for osteoarthritis on pain or physical function, or both, has been demonstrated.[11] The proposed dietary intervention (a formula diet of 810 kcal per day total diet replacement) benefits comorbidities, reduces the need for antihypertensive medication,[11] and improves diabetic control.[12] Total diet replacement interventions have been shown to be free of serious adverse events; side-effects are reported in less than 5% of the studied population, making total diet replacement a safe weight loss method.[12] As patients were awaiting surgery, medications were reviewed and adjusted according to an agreed management plan formulated with the anaesthetic team (appendix pp 17–23).

See Online for appendix

Patients with symptoms of giving way, who were unable to perform a straight leg raise (extensor lag), or get out of a chair, received the exercise therapy component of the intervention.[13,14] The amount of exercise that patients with osteoarthritis attending orthopaedic clinics do is variable; however, evidence suggests that exercise (such as walking, swimming, and cycling) reduces pain and improves physical function in patients with knee

osteoarthritis. The participants in this study were at the stage of listing for knee replacement, and—unlike those with early osteoarthritis for whom Osteoarthritis Research Society International guidelines[15] have been developed—the most efficacious exercise therapy is muscle strengthening, which can enhance functional ability such as climbing stairs.[16] The details of the strengthening intervention as described by the Consensus on Exercise Reporting Template criteria were bodyweight exercises delivered by research nurses (trained by trial physiotherapist) in individual, remote, and unsupervised exercise therapy sessions, employing a behaviour change philosophy and adherence reporting template. The focal intervention was quadriceps muscle strengthening through a graded progression of load and intensity, done at the participants' home. A generic exercise prescription was used, with an individualised dosage and starting level. The fidelity and adherence were evaluated by the case manager.

Patients who were not using shock absorbing insoles or footwear received insoles. Shoes with a shock-absorbing sole are considered suitable for patients with lower limb osteoarthritis. In particular, the use of such shoes for as little as 1 month reduces pain and improves physical function in patients with osteoarthritis.[17]

Patients who were not using or had not tried simple topical or oral analgesia (eg, non-steroidal anti-inflammatory drugs [NSAIDs], paracetamol) received an analgesia review. Many patients are reluctant to take strong pain killers, and compliance with osteoarthritis pharmacological treatment is only around 50%.[18] With education,[19] simple analgesics can be effective with increased compliance rates, and evidence suggests that topical NSAIDs might help relieve pain in knee osteoarthritis, yet many patients have not tried this option.

All participants randomly assigned to the package-of-care intervention received the individual components through a behaviour change methodology. Evidence suggests that capitalising on a secondary care referral or episode could be a teachable moment, thus being an ideal time to change patients' behaviour, especially when linked to possible impending surgery.[20] However, behaviour change is often difficult to achieve and maintenance of change is even more difficult.[21] Our approach incorporated evidence-based behaviour change techniques to enhance the likelihood of change and maintenance of behaviours related to the four components.

Participants in the control group received standard care through the NHS, which did not include any additional treatment before surgery.

Regarding the process evaluation, we used qualitative interviews and quantitative data (case report form data) to explore findings in five key domains:[9] acceptability and feasibility of study and intervention processes (as well as barriers and facilitators to implementation), fidelity, exposure, reach, and contextual influences on intervention impact. Issues around recruitment, retention contamination, and barriers and facilitators to engagement and participation were also explored (appendix pp 2–15). Interviews were done with participants in the intervention group, as well as research nurses and hospital staff across both study sites. All eligible participants were invited to take part in the interviews, which were done by telephone with audio recording and transcription. A descriptive thematic analysis was done using both an inductive and deductive approach to code the data in relation to the domains of the process evaluation framework, as well as to identify relevant themes in the lived experience of participants taking part in the study. 20% of the transcripts were double coded, discrepancies being subsequently checked, and disagreements resolved by discussion. A logic model was developed and tested as part of the process evaluation (appendix p 16).

Outcomes

The primary endpoint was whether the intervention and study protocol were feasible and acceptable, and whether a full-scale effectiveness trial was warranted. The following were measured and used to inform study feasibility: rate of recruitment, rate of retention at follow-up review after planned surgery date, and adherence to the intervention estimated through review questionnaires and weight change (for those receiving the weight loss component of the intervention).

In addition, interviews (with participants, researchers, and clinical staff) exploring acceptability, feasibility, adherence, possible barriers to implementing the intervention, and acceptability of the different outcome measures were assessed qualitatively.

Furthermore, a process evaluation was done to explore in detail the way in which the intervention operated to produce outcomes. The evaluation was done based on the MRC guidelines for process evaluations of complex interventions and examined the following elements: context, fidelity of the intervention, exposure to the intervention, reach, recruitment and retention, contamination, the control group, and the mechanisms of impact (appendix pp 2–15).[9]

Secondary endpoints were assessment of knee-specific function, health-related quality of life, the Timed Up and Go (TUG) test, arthritis-specific self-efficacy (ie, the ability to cope with the consequences of arthritis), pain, eating behaviours, and adverse events. The long-term outcome scores will be obtained and evaluated in a subsequent effectiveness trial.

The Western Ontario and McMaster Universities Arthritis Index (WOMAC)[22] and the Oxford knee score[23] (OKS) were used to assess knee-specific function in both non-operatively and operatively treated patients with osteoarthritis. The WOMAC was reported as a total score and for the three separate subscales of pain, physical function, and stiffness from 0 being the worst to 100 being the best. The OKS was reported as a total score from 0 being the worst to 48 being the best.

The EuroQoL (EQ) questionnaire was used to assess health-related quality of life, which assesses five dimensions (5D): mobility, self-care, usual activities, pain or discomfort, and anxiety or depression.[24] The 5-level (5L) version of the EuroQoL questionnaire was used and the five-digit code was used to assign a single summary index that were specific to the UK population and are based on a time trade-off technique.[24] This index is on a scale of –0·594 to 1, in which 1 represents perfect health and 0 represents death.

The TUG test was done to assess functional mobility and is a standardised test to minimise bias; the participant was timed from commencing to rise from an armchair (approximate seat height of 46 cm), walk at a comfortable and safe pace to a line on the floor 3 m away, turn and walk back to the chair, and sit down again.[25]

The arthritis self-efficacy questionnaire (ASEQ) was used to assess the participants' arthritis-specific self-efficacy, or their beliefs that they could do specific tasks or behaviours to cope with the consequences of arthritis.[26] Scores ranged from 0 to 10, in which a higher score indicates a greater confidence of self-efficacy than a lower score.

Pain self-efficacy was assessed using the Pain Self-Efficacy Questionnaire (PSEQ), which is a ten-item questionnaire that rates patients' confidence in performing activities while in pain from 0 points (not at all confident) to 6 points (completely confident).[27] A total score was calculated by summing the individual items with a range from 0 points (less self-efficacy) to 60 points (more self-efficacy).[27]

The Eating Self-Efficacy Scale score was collected in participants on the dietary component and used to rate the likelihood of having difficulty controlling overeating in a range of situations. Scores ranged from 25 (no problems controlling eating) to 175 (difficulty controlling eating).[28]

Finally, adverse events were documented by the case manager using standard definitions (appendix pp 76–79).

Statistical analysis

The primary endpoint was to assess the feasibility of the trial design and the acceptability of the intervention. Therefore, a formal sample size calculation was not undertaken, and statistical analyses were descriptive in nature. 60 participants were recruited a priori (according to protocol) and randomly assigned, with 40 in the intervention group. This number was considered sufficient to address the research questions and assess the feasibility and acceptability of the intervention. The sample size of 60 will provide sufficient precision in the variance to design a study with 90% power and two-sided significance level for an effect size of 0·20.[29]

Descriptive statistical analysis, including estimation of the effect size and 95% CI between the intervention group and control group for clinical outcomes were done using SPSS (version 17). The intraclass correlation coefficient of patients in the intervention group across the two sites was estimated from WOMAC scores, making use of the repeated nature of this outcome for each participant.

This study is registered with ISRCTN, ISRCTN96684272.

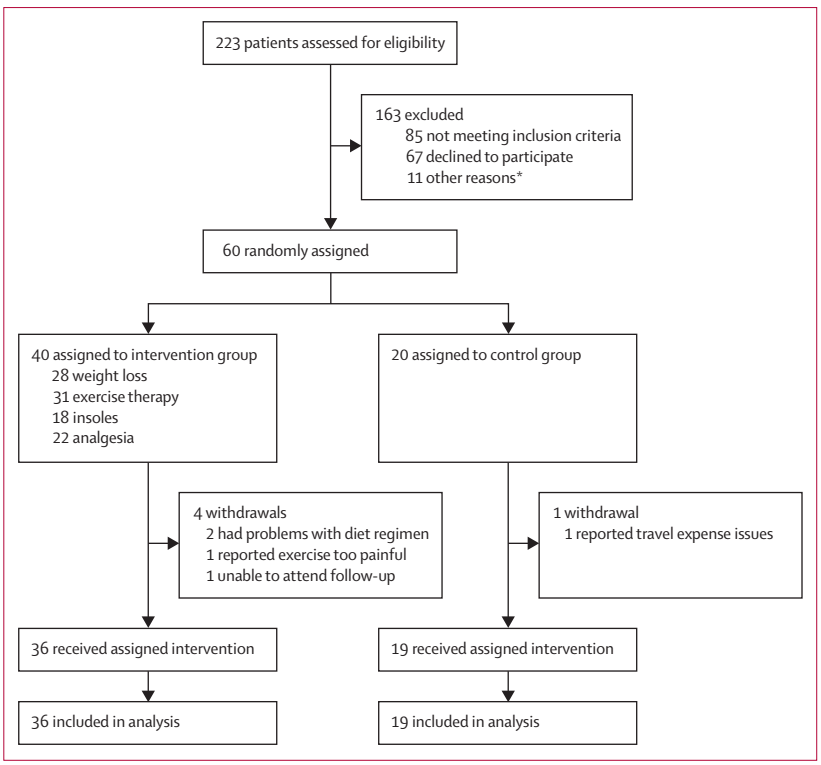

Figure 1: **Trial profile**
*The appendix (p 27) shows a summary of the other reasons for exclusion.

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

Between Sept 3, 2018, and Aug 30, 2019, 223 patients who were being placed on a waiting list for a knee replacement were screened, of whom 163 (73%) were excluded and 60 (27%) were randomly assigned to either the intervention group (n=40) or the control group (n=20; figure 1). The most common reason for declining to participate was the increased number of study visits and was not related to the treatment regimen. Of the 60 participants, five (8%) withdrew from the study (four in the intervention group and one in the control group). All but one participant were happy to provide follow-up data.

In the intervention group, reasons for discontinuing treatment were inability to attend clinic appointments (one [25%] of four), finding exercise uncomfortable (one [25%]), and difficulty with the diet regimen (two [50%]). The participant who withdrew in the control group had problems with travel expenses for the study. 52 (87%) of 60 participants attended their final review

	Intervention group (n=40)	Control group (n=20)
Sex		
Male	15 (38%)	11 (55%)
Female	25 (63%)	9 (45%)
Age (years)	67·3 (8·7)	65·9 (8·5)
BMI (kg/m²)	36·0 (8·2)	35·1 (6·7)
<30	12 (30%)	5 (25%)
≥30 to <35	8 (20%)	5 (25%)
≥35	20 (50%)	10 (50%)
Current smoker	3 (8%)	0
Diabetes	10 (25%)	1 (5%)
Blood pressure (mm Hg)		
Systolic	139·1 (17·8)	149·3 (20·6)
Diastolic	79·8 (8·5)	83·3 (7·6)

Data are n (%) or mean (SD).

Table 1: **Baseline characteristics of all participants**

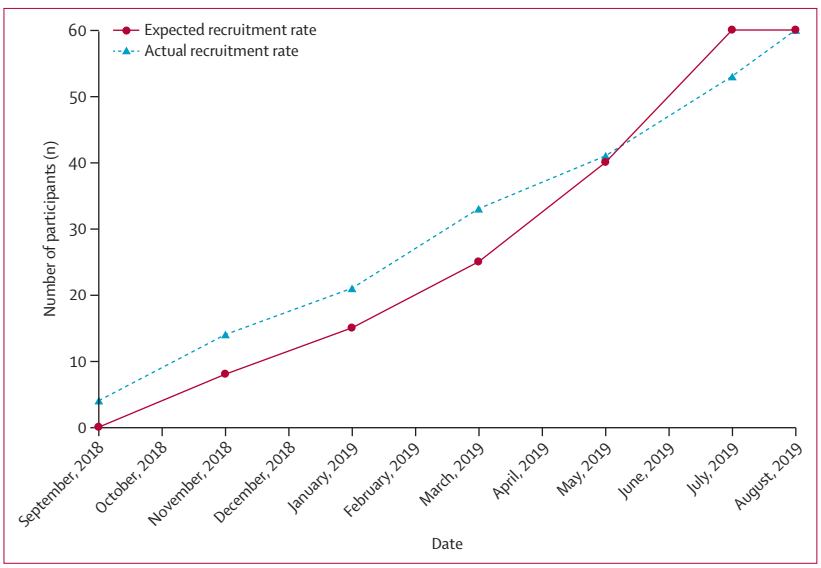

Figure 2: **Recruitment rate**

	Participation status			Total (n=40)
	Active	Discontinued	Withdrawal	
Weight loss	22/28 (79%)	3/28 (11%)	3/28 (11%)	28 (70%)
Exercise therapy	24/31 (77%)	3/31 (10%)	4/31 (13%)	31 (78%)
Insoles	13/18 (72%)	2/18 (11%)	3/18 (17%)	18 (45%)
Analgesia	17/22 (77%)	2/22 (9%)	3/22 (14%)	22 (55%)

Data are n/N (%) or n (%). Each participant received the components they required.

Table 2: **Participation in the different components of the intervention**

(after intervention and before surgery) and 55 (92%) attended their postoperative review (90 days after surgery).

Of the 60 participants in the study cohort, 34 (57%) were women, 26 (43%) were men, and the mean age was 66·8 years (SD 8·6). 43 (72%) of 60 participants had a BMI of 30 kg/m² or greater. Other common long-term conditions were hypertension (32 [53%] of 60), back pain (20 [33%]), diabetes (11 [18%]), lung disease (eight [13%]), and depression (eight [13%]). At baseline, no differences in age or BMI were observed between the intervention and control groups (table 1). 44 (73%) of 60 participants were taking analgesics for their knee pain; of whom, 27 (61%) were taking them regularly; analgesics included paracetamol (24 [55%] of 44), NSAIDs (21 [48%]), weak opioids (six [14%]), fixed-dose combined (15 [34%]), and strong opioids (one [2%]).

Recruitment occurred within the expected time period (figure 2). 60 participants were recruited at a rate of about four per month. Exercise therapy (31 [78%] of 40) was the component of the intervention for which patients were most commonly eligible, followed by weight loss (28 [70%]), analgesia review (22 [55%]), and insoles (18 [45%]; table 2).

Adherence to the intervention was estimated at each follow-up visit through review questionnaires, administered by the research nurses, and weight change (for those receiving the weight loss component of the intervention). Of the 40 participants in the intervention group, six (15%) participants received one intervention component, 15 (38%) received two intervention components, 13 (33%) received three intervention components, and six (15%) received all four intervention components. Four (10%) participants discontinued the intervention; two (5%) stated they had problems with the diet regimen, and one (2·5%) was not able to complete the exercise therapy regimen.

The overall median adherence with the intervention was 94% (IQR 79·5–100). The median adherences for each component were 100% (IQR 80–100) for weight loss, 92% (75–100) for exercise therapy, 100% for insoles (91·7–100), and 100% for analgesia (0–100).

Concerning the weight loss component, 28 (65%) of 43 participants who were obese (BMI ≥30 kg/m²) were randomly assigned to the intervention group and received the weight loss component. At the final review, the intervention group lost a mean of 11·2 kg (SD 5·6), most of which was maintained at the postoperative review following surgery, when the mean weight loss was 9·7 kg (6·5) compared with 1·3 kg (3·8) at the final review and 1·7 kg (4·9) at the postoperative review in the control group (appendix p 24). This finding equates to an estimated difference of –9·8kg (95% CI –13·4 to –6·3) at final review and –8·0 kg (–12·3 to –3·6) at postoperative review. The mean weight loss of 11·2 kg in the intervention group, whose initial mean weight was 108·2 kg represents a 10·4% loss in bodyweight compared with 1·2% in the control group (1·3 kg of 107·8 kg).

Overall, 36 (90%) of 40 participants stated they were satisfied or very satisfied with the intervention. A

clinically significant improvement[30] in the health-related quality of life (EQ-5D-5L utility index) was observed at the final follow-up compared with the baseline in the intervention group (mean change 0·078 [SD 0·195]), which was not seen in the control group (mean change 0·006 [0·185]; table 3; appendix p 24). Regarding the knee-specific outcomes, WOMAC and OKS both showed a greater improvement at the final preoperative follow-up in the intervention group than in the control group (table 3; appendix p 25). No variability in outcome was noted between study sites (intraclass correlation coefficient of 0); however, this finding was for only two centres. At 90 days after the planned date of surgery, the results were confounded by the fact that four participants did not proceed with surgery. A greater improvement in the TUG test was observed in the intervention group than in the control group at the final follow-up (–2·2 s [SD 4·6] *vs* –0·2 s [1·9]) and following surgery (–2·9 s [4·3] *vs* –2·7 s [4·1]; table 3). Qualitative interviews were done in 15 participants in the intervention group, as well as six research nurses and hospital staff; details about the interviews are summarised in the appendix (pp 2–14).

Participants on the weight loss component of the intervention were specifically asked about previously reported side-effects of their diet. These issues were reported in more than a quarter of participants. Their frequency within all of the reviews attended were 47% for hunger, 44% for bad breath, 35% for feeling cold, 35% for thirst, and 28% for constipation. The Eating Self-Efficacy Scale showed improved control of eating at the final follow-up with a decrease of 5·8 points (SD 23·2), and further improvement at the postoperative review with a decrease of 14·8 points (25·2) from the mean baseline score of 60·7 points (28·5).

Five (8%) of 60 participants cancelled their surgery; four (10%) of 40 in the intervention group cancelled because of improved symptoms and one (5%) of 20 in the control group cancelled for medical reasons.

Fidelity data were collected on case report forms. Only data for face-to-face sessions were recorded on these forms (approximately 50% of all sessions). Nurses delivering the intervention did not note any major problems in delivery and only 13 (7%) of 198 reported deviating from normal intervention delivery as per the manual. Overall, the data indicated that the weight loss, insoles, and analgesia components of the intervention were delivered with fidelity. With regards to the behaviour change techniques, the percentage of sessions in which different behaviour change techniques were covered ranged from 20% to 100%. Mostly, these techniques were felt to be too repetitive if the participant was not receiving the weight loss component, therefore a responsive and flexible approach was taken by research nurses to reduce participant fatigue.

No adverse events attributable to the intervention occurred. 21 (53%) of 40 participants in the intervention group and five (25%) of 20 in the control group had adverse events. Three (6%) of 54 adverse events in the intervention group and one (13%) of eight in the control group were serious adverse events (appendix p 30). Similar proportions of wound healing problems were

	Number of participants in intervention group *vs* control group	Intervention group	Control group	Mean difference (95% CI)
EQ				
5D-5L utility index				
Final follow up	34 *vs* 16	0·078 (0·195)	0·006 (0·185)	0·071 (–0·045 to 0·188)
After surgery	33 *vs* 19	0·230 (0·224)	0·222 (0·201)	0·062 (–0·116 to 0·133)
VAS				
Final follow up	34 *vs* 14	3·4 (17·3)	–0·9 (21·8)	4·2 (–7·7 to 16·1)
After surgery	33 *vs* 17	9·2 (17·2)	15·6 (13·8)	–6·4 (–16·1 to 3·3)
WOMAC				
Overall				
Final follow up	30 *vs* 15	–7·6 (12·0)	–2·0 (16·1)	–5·6 (–14·1 to 2·9)
After surgery	29 *vs* 18	–23·6 (18·4)	–33·8 (20·0)	10·3 (–1·2 to 21·8)
Physical				
Final follow up	34 *vs* 16	–7·3 (13·0)	–3·2 (15·3)	–4·1 (–12·5 to 4·3)
After surgery	33 *vs* 19	–24·4 (19·2)	–37·5 (21·5)	13·1 (–1·0 to 25·1)
Pain				
Final follow up	33 *vs* 16	–4·2 (14·2)	0·9 (19·7)	–5·2 (–15·1 to 4·7)
After surgery	33 *vs* 19	–23·0 (19·7)	–31·8 (20·6)	8·8 (–2·8 to 20·4)
Stiffness				
Final follow up	34 *vs* 16	–10·7 (20·2)	2·3 (29·3)	–13·0 (–27·3 to 1·3)
After surgery	33 *vs* 19	–23·9 (25·1)	–30·9 (19·2)	7·1 (–6·4 to 20·5)
OKS				
Final follow up	34 *vs* 16	2·2 (7·2)	–0·3 (5·4)	2·5 (–1·5 to 6·6)
After surgery	33 *vs* 19	9·7 (8·3)	12·5 (8·1)	–2·8 (–7·5 to 1·9)
TUG				
Final follow up	34 *vs* 14	–2·2 (4·6)	–0·2 (1·9)	–2·0 (–4·6 to 0·6)
After surgery	34 *vs* 15	–2·9 (4·3)	–2·7 (4·1)	–0·2 (–2·8 to 2·5)
ASEQ				
Pain				
Final follow up	34 *vs* 16	0·3 (1·9)	0·5 (1·7)	–0·2 (–1·4 to 0·9)
After surgery	33 *vs* 19	2·0 (1·9)	3·5 (2·9)	–1·5 (–2·9 to –0·2)
Function				
Final follow up	12 *vs* 7	1·0 (1·3)	0·4 (1·1)	0·5 (–0·7 to 1·8)
After surgery	11 *vs* 7	1·8 (1·7)	2·1 (1·5)	–0·3 (–2·0 to 1·3)
Other				
Final follow up	34 *vs* 14	0·9 (2·2)	–0·1 (1·3)	1·0 (–0·3 to 2·3)
After surgery	32 *vs* 17	1·7 (1·5)	3·5 (2·7)	–1·8 (–3·0 to 0·6)
PSEQ				
Final follow up	33 *vs* 15	4·0 (12·0)	1·0 (15·9)	3·0 (–5·4 to 11·3)
After surgery	30 *vs* 15	9·8 (14·8)	14·9 (15·0)	–5·2 (–14·6 to 4·3)

Data are mean (SD), unless otherwise stated. 5D=five dimensions. ASEQ=Arthritis Self-Efficacy Questionnaire. EQ=EuroQoL. OKS=Oxford Knee Score. PSEQ=Pain Self Efficacy Questionnaire. TUG=Timed Up and Go. VAS=Visual Analogue Scale. WOMAC=Western Ontario and McMaster Universities Arthritis Index.

Table 3: **Change in quality of life and knee-specific outcomes from baseline to final follow-up or after surgery in the intention-to-treat population**

seen in both groups (three [10%] of 31 in the intervention group and two [11%] of 18 in the control group), although a higher proportion of wound leakage problems was observed in the control group than in the intervention group (five [28%] of 18 *vs* four [13%] of 31). Of the 49 participants who had undergone their joint replacement at the time of review, five (10%) reported wound problems and sought treatment from their General Practitioner and three (6%) returned to the hospital for treatment. Two (3%) of 60 participants reported deep vein thromboses, both of which were in the intervention group.

Discussion

This feasibility study showed that delivery of a complex, non-operative package of care to individuals with severe osteoarthritis and multiple long-term conditions waiting for knee replacement surgery is possible. The findings also showed that patients will enrol in a randomised study, adhere well to the intervention, and remain in the study until completion. Overall, participants found the intervention acceptable and beneficial.

67 (49%) of 138 eligible participants screened declined to take part; we learnt that an excessive number of face-to-face visits was a barrier to involvement in the study and that these visits could be replaced by virtual or telephone follow-ups. In addition, participants highlighted to us the key role of the case manager in bringing about behavioural change and, therefore, the need to include details of the case manager in the trial database to allow for the effect of clustering by the therapist or case manager. In each centre, the case managers were research nurses with similar expertise, who had received standardised training in the components of the interventional package of care. In the future trial database, we would also record the ethnicity, although we would expect the study findings to be independent of ethnicity.

This package of care intervention is important for an array of reasons. First, because life expectancy has increased, an increasing number of people have osteoarthritis. As many people now live longer than the longevity of their joint replacement, delaying joint replacement for as long as possible is beneficial. In some patients, this approach might avoid joint replacement completely, in others it might prevent the need for a revision joint replacement. Second, because many patients with joint replacement have multiple comorbidities, avoiding surgery and managing their arthritis non-operatively might be a safer option. Third, recent studies reported that the health-related quality of life of many patients with osteoarthritis in secondary care deteriorates while waiting for treatment.[31] Thus, a full-scale study determining whether this intervention can prevent this deterioration in health-related quality of life, or even whether it could potentially improve health-related quality of life, would be valuable. Fourth, as a consequence of COVID-19, waiting lists have increased not only in numbers waiting but also in duration,[32] hence a study examining the benefit of this intervention would be particularly timely, as the package of care could empower patients to make use of the time they are waiting to get into an optimum state of fitness. Finally, as four (10%) of 40 patients in the intervention group decided not to proceed with surgery as their symptoms had abated, the intervention has the potential to help address the large waiting lists, as the screening data from this feasibility study suggests that just over half (57%) of these patients could benefit from this package of care.

One aspect of the non-operative package of care that was not addressed in this feasibility study was the potential cost-effectiveness of the intervention. The improvement in the EQ-5D-5L index of 0·078 (SD 0·195; with no change in the control group) at the final follow-up is greater than the minimum clinically important difference.[30] Any improvement in health-related quality of life for the intervention group could be used to derive an incremental cost-effectiveness ratio. Although this improvement was only observed over a short period (16 weeks before surgery), this study was done before the effect of COVID-19 on health-care services, and the waiting times now are more than 1 year.[31] A full-scale study would be able to determine if the improvement in the health-related quality of life for the intervention group persisted for a year while patients were awaiting surgery and also the number of patients wanting to cancel surgery. The full-scale study, as well as exploring whether savings from reduced numbers of operations are possible, would also be able to explore whether reduced costs and decreased morbidity exist from perioperative complications associated with obesity, such as deep infection of knee arthroplasty. Furthermore, recent work from Scotland indicates that a 10% change in the numbers waiting could reduce the time needed to recover to pre-pandemic waiting times by a third.[32]

This study has limitations. First, this study was underpowered for effectiveness and was not powered to show differences in joint-specific function or deep infection. However, although assessing effectiveness was not the aim of the study, a trend towards a greater improvement was observed in the patient-reported outcome measures and the objective functional measures in the intervention group. A larger-scale study is needed to assess the effect of the intervention on joint-specific function and long-term complications after total knee arthroplasty, as well as its cost-effectiveness.

In conclusion, the findings of this feasibility study support doing a full-scale multicentre randomised trial with a longer follow-up. This package of care has the potential to provide a cost-effective intervention for patients and—with the growing orthopaedic waiting lists for knee arthroplasty surgery—is a timely intervention to help and support patients while they are waiting.

Contributors

AHRWS, NDC, SAS, and SS drafted the initial manuscript. AHRWS, SAS, PGC, ARL, HP, SRK, PC, CRH, DH, DR, JN, and EK designed the trial and study protocol. CB, SS, AM, and SRK collected and analysed the data. CK and NDC directly accessed and verified the underlying data reported in the manuscript and did the statistical analysis. All authors contributed to data interpretation and critical review and revision of the manuscript. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Declaration of interests

AHRWS is the Data Monitoring Board Chair of ORIF (National Institute for Health and Care Research [NIHR]-funded multicentre study); Steering Committee Chair of PART (NIHR-funded multicentre study); Editor-in-Chief of *Bone & Joint Research*; and an Editorial Board Member of *Bone & Joint Journal*. NDC is an Editorial Board Member of *Bone & Joint Research* and *Bone & Joint Journal*. SAS is a member of the NIHR Policy Research Panel, Chief Scientist Office (CSO) HIPS Committee, and NIHR/HTA; and has received funding support from the UK Medical Research Council (MRC) and Scottish CSO core funding as part of the MRC/CSO Social and Public Health Sciences Unit Complexity in Health Improvement programme (MC_UU_12017/14, MC_UU_00022/1, SPHSU14, SPHSU16). HP has received grants from NIHR, Zimmer Biomet, DePuy Synthes, Invibio, Allay Therapeutics, and Paradigm Pharma; consulting fees from Medacta International, MicroPort, MAT Ortho, JRI, Smith and Nephew, Invibio, Teleflex, Depuy Synthes, Invibio, Allay Therapeutics, and Paradigm Pharma; expert witness payment for Kennedy's Law; support for travel from Medacta International and Zimmer Biomet; has patents with University of Leeds; is on the Data Safety Monitoring Board for the University of Leeds; and has received equipment or supplies from Pacira Pharmaceuticals. ARL chairs the European industry group: TDMR Europe (the generic industry body that monitors EU legislation and The European Food Safety Authority guidance in relation to total diet replacement food products across Europe). PGC and SRK are supported in part through the NIHR Leeds Biomedical Research Centre. DH has received paid honoraria from Stryker. PC has received core funding from the UK MRC and the Scottish Government CSO for the Informing Healthy Public Policy and Inequalities in Health programmes at the MRC/CSO Social and Public Health Sciences Unit (SPHSU15, SPHSU17, MC_UU_12015/15, MC_UU00022/2). AB-H is an employee and shareholder of Counterweight. JN has received an NIHR/HTA grant to The University of Edinburgh. All other authors declare no competing interests.

Data sharing

The Edinburgh Clinical Trials Unit has a data access request policy and process to enable data sharing, which involves completion of a short application by the external party, which is subsequently reviewed by an internal panel.

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