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Title: Systematic development of a complex intervention: a theory and evidence-based physiotherapist led group intervention to increase physical activity and reduce sedentary behaviour following bariatric surgery (PARIS).

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Abstract

Objectives To describe the systematic development of a physiotherapist led group behaviour change intervention targeting physical activity and sedentary behaviour in individuals who have undergone bariatric surgery.

Study design Intervention development including evidence synthesis, qualitative research and mapping of intervention components, using the 2008 MRC framework for complex interventions.

Methods We conducted a systematic review to identify the evidence for promising interventions and components to increase physical activity and reduce sedentary behaviour following bariatric surgery. We also conducted primary qualitative research exploring these behaviours with three key stakeholder groups: patients, clinicians and commissioners. We selected two contemporary behaviour change frameworks to inform intervention development and developed a conceptual matrix in which intervention objectives were defined to inform selection of appropriate behaviour change techniques, proposed mechanisms of action(s), and mode of delivery. We also developed two intervention handbooks for participants and facilitators to support delivery and receipt of the intervention.

Results We have developed a behaviour change intervention targeting physical activity and sedentary behaviour in patients following bariatric surgery. Eight intervention objectives were defined and mapped to the Behaviour Change Wheel and Theoretical Domains Framework. We identified what the intervention must be able to do (intervention functions), behaviour change techniques that could be used to achieve this, the proposed mechanism of action, and mode of delivery. This intervention will be subject to a feasibility study, with the intervention delivered online over a six-week period to participants who have had bariatric surgery within the previous five years.

Contribution of the paper

- This paper clearly explains the process involved in developing a theory and evidence-based physiotherapy-led complex behaviour change intervention.
- The full specification of the intervention including proposed mechanism of effect has been provided, which should facilitate faithful intervention delivery and allow it to be comprehensively evaluated in a planned feasibility study.
- This paper aims to enable physiotherapists to develop their own complex interventions, targeting behaviours that are relevant to their patients in their own areas of clinical practice.

Keywords: physical activity, sedentary behaviour, intervention development, behaviour change, bariatric surgery

Introduction

Physiotherapists are increasingly involved in the care of patients with severe obesity, defined as excessive adiposity that may be harmful to health (1). As the prevalence of obesity within the population increases, most areas of physiotherapy practice are likely to be accessed by patients with obesity either as the primary reason for their presentation, or because they have an associated condition e.g musculoskeletal pain.

The aetiology of obesity is complex, with strong interacting genetic and environmental factors leading to increased caloric intake, decreased physical activity [PA] and long term positive energy balance (2, 3). Currently the most effective treatment option for severe obesity is bariatric surgery, which results in substantial weight loss and decreased likelihood of obesity related complications. This is achieved through different mechanisms, most notably via neuro-endocrine changes, which can reduce hunger and increase satiety thereby supporting patients' post-operative dietary behaviours (4). Unfortunately, evidence shows that having bariatric surgery is not associated with change in PA and sedentary behaviour [SB], which may remain unchanged post-surgery (5-7). In turn, this may have a negative impact on long-term post-surgical weight loss maintenance, metabolic outcomes and body-composition (8-10). The influences on individual PA levels are multifactorial including environmental, societal, socio-political, individual and biological (11). Having had bariatric surgery for severe obesity adds to this complexity, and evidence is limited about the most salient factors influencing this group in terms of PA and SB (12). Many clinical interventions are based on 'common sense' approaches rather than theory and evidence, and might be characterised as 'it seemed like a good idea at the time' [ISLAGATT] (13, 14). Thus, ISLAGATT interventions are unlikely to address the key modifiable reasons for (not) performing the target behaviour(s). Interventions developed in this manner are more difficult to evaluate as their rationale(s) and mechanism(s) of action are likely to be unclear. In recognition of PA and SB being influenced by multiple interacting factors and the lack of evidence-based behaviour change strategies, we used the 2008 MRC guidance for complex interventions (15)

to develop the PARIS (Physical Activity and reduce sedentary behaviouR after barIatric Surgery) intervention. The MRC guidance identifies four key stages: development, feasibility/piloting, evaluation and implementation. The first of these, development, is the focus of this paper and thus the aim is to describe the systematic development of a physiotherapist led group behaviour change intervention 'PARIS', using the 2008 MRC` framework for complex interventions (15, 16). Whilst the MRC guidance directs the overall process for intervention development and testing, we selected the Behaviour Change Wheel (BCW) to map evidence from different sources against the COM-B model and identify appropriate intervention functions and BCTs accordingly. We used the Theoretical Domains Framework (TDF) in addition to the COM-B to map the evidence against more fine-grained influences of the target behaviour. Finally, we used the BCCTv1 to select Behaviour Change Techniques, defined as "an observable, replicable and irreducible component of an intervention" (p 4) (17).

To our knowledge, PARIS is the first theory and evidence based complex intervention that will be delivered by physiotherapists to increase levels of PA and reduce SB in patients who have undergone bariatric surgery.

Methods

The development phase of the MRC framework requires: identifying the evidence base, identifying/developing a relevant theory, and modelling the process and outcomes (15).

Identifying the evidence base

We conducted a systematic review to identify interventions and their components, that aimed to increase PA and/or reduce SB in patients who were considering or had undergone bariatric surgery.

As the focus was on the post-surgical population only studies that had measured PA and/or SB after bariatric surgery were included. Full details of the review are published (18).

We also conducted primary qualitative research with patients, clinicians and commissioners. Key topics covered influences on patients PA and SB, clinicians' current practice regarding these behaviours and commissioners' experiences of commissioning post-surgical care services. We also explored the requirements of a future clinical intervention that would seek to support behaviour change, from the perspectives of patients, clinicians and commissioners.

We used focus groups and interviews with the three key stakeholder groups: patients (n=3 groups; and n=13 patients in total), clinicians (n=11) and commissioners (n=3). To ensure that there were no misunderstandings of what 'physical activity' referred to, the World Health Organisation's definition of PA was shared with participants at the beginning of each focus group and interview.

Patients who had undergone bariatric surgery were purposively sampled to participate in focus groups and a follow up interview where it was perceived that a deeper qualitative enquiry would be necessary to fully explore the topic. Patients were asked to discuss their experiences of any type of PA, barriers and facilitators of PA and their preferences for a future behaviour change intervention delivered as part of clinical care. Clinicians who had experience of treating patients who had undergone surgery were purposively sampled and asked about their understandings of PA, their current clinical practice and what they think a future intervention should comprise. Commissioners who had currently or previous experience of commissioning bariatric and post-surgical care were sampled and asked about their understandings of PA, if they thought current commissioned services facilitated PA and considerations for a future intervention from their perspective. Clinicians and commissions were interviewed on a one-to-one basis, either face-to -face or via telephone. The qualitative methodological approach was constructivist grounded theory according to Charmaz (2006) (19): transcripts from the focus groups and interviews were reviewed line by line, with small sections

of the text summarised, which helped to identify initial themes and the categories that they constructed via an iterative process.

Identifying/developing appropriate theory

Behaviour change theories and frameworks were considered when identifying the theoretical base on which to develop the intervention. There are a number of theories for PA behaviour, which might be helpful in explaining and predicting future behaviour (20), and when deciding which to use, it is important to be cognisant of the literature in this specific patient group. There are multiple influences on behaviour including biological, environmental and societal as highlighted in the Foresight report and systems map (2). A previous systematic review of interventions to increase physical activity or reduce sedentary behaviour found that interventions are often poorly described in terms of their theoretical basis (21), which made it challenging to select the most appropriate and effective theory or theories to underpin this intervention on the basis of evidence supporting the use of specific theories. Based on our theoretical understanding of influences on our target behaviours we identified BCTs from the Behaviour Change Technique Taxonomy V1 (BCTTv1) as explained under 'modelling processes and outcomes'.

Modelling processes and outcomes

The findings from the systematic review and qualitative research were used to identify key modifiable influences on the two target behaviours, which informed the intervention objectives. This process was iterative; objectives were reviewed and refined to ensure that they took account of the evidence from the different key stakeholder groups, as their focus and priorities differed. The objectives were then mapped against the COM-B model and TDF from which the intervention functions (which are broad categories that can be used to change behaviour e.g education or persuasion) were

determined. Following this, the most appropriate BCTs were chosen, informed by the Theory and Techniques tool which is based on expert consensus and evidence synthesis (22). The proposed mode of action was hypothesised, and from this a mode of delivery i.e how the BCTs would be used to deliver the intervention function (e.g provide education) to meet the objectives of the intervention was outlined.

Mode of delivery was also reviewed according to the 'APEASE' criteria to assess if this would be Affordable, Practicable, Effective/ cost-effective, Acceptable, have any Safety considerations or side effects and if it would be Equitable (14). Following this, the intervention objectives and how these would be addressed was presented to a purposively sampled sub-group of patient participants (n=4) in a focus group held via Zoom. During this meeting, we discussed how these overall objectives might be broken down into weekly objectives, the format for the intervention i.e. groups; how many weeks were required to deliver the intervention and other practical issues such as when the sessions should take place e.g. morning, afternoon or evening. This provided an opportunity to ensure that participants who had been involved in the primary research could confirm if their needs had been met and that the future intervention would be acceptable. This refined intervention was also discussed with the PPI group (who were involved in previous stages of the intervention development) to review what had been discussed with participants and to develop the handbooks that would be used during the intervention by patients and facilitators. The participants' handbook aimed to provide a resource that patients could use in the sessions and refer back to at a later date, whilst the facilitator's handbook would be used by clinicians facilitating the group.

Results

Identifying the evidence base

The systematic review added to the evidence base for BCTs associated with PA initiation following bariatric surgery; they included demonstration of the behaviour (BCT 6.1), behavioural practice/rehearsal (BCT 8.1) and graded tasks (BCT 8.7) among others. BCTs that were associated with maintenance of PA were action planning (BCT 1.4), instruction on how to perform the behaviour (BCT 4.1), prompts and cues (BCT 7.1), behavioural practice and rehearsal (BCT 8.1), graded tasks (BCT 8.7) and self-reward (BCT 10.9). Thus, these BCTs were incorporated into the intervention as there is evidence for their use to increase PA following bariatric surgery.

Key findings from the qualitative research, relevant to intervention development, was a lack of a shared meaning of PA across participants' groups, although all participants believed that increased levels of PA would improve physical health and well-being. Another key finding was that any future intervention had to be delivered by the 'right' healthcare professional who could adapt the intervention to their needs, as opposed to being given generic advice (if any) by other members of the multi-disciplinary team.

Identifying and developing theory

A review of available frameworks and theories identified that the BCW, which features the COM-B model at its core and was informed by a review of behaviour change frameworks (14), was appropriate to use as the theoretical basis. COM-B specifies Capability, Opportunity and Motivation as key components of the target Behaviour (14). The BCW has been used to inform interventions targeting PA in people living with other complex conditions including stroke (23) and cancer (24); and has been used to target SB in patients who have had a stroke (25), and have chronic obstructive pulmonary disease (26). In addition to the BCW, the TDF, which can be mapped onto the COM-B model, was also chosen as it provides a greater level of detail about theoretical domains related to capability and motivation, particularly psychological capability, and automatic and reflective

motivation (27). Both frameworks were then used as part of the conceptual intervention development, incorporating findings from the systematic review and qualitative research.

Modelling processes and outcomes

We developed eight intervention objectives informed by systematic review (18), qualitative research, and input from the PPI group.

1. Provide an explanation as to the rationale for the intervention and a lay summary of the evidence that underpins the rationale in the context of current care and evidence. The evidence shows that not all patients increase their levels of PA after surgery and many do not meet the recommended guidelines for PA (28).
2. Provide information about PA and SB including their effect on health and how this might be assessed e.g body composition changes are not reflected in weight change. How to pace and increase PA and provide information about delayed onset muscle soreness, its consequences and appropriate management.
3. Discuss the known consequences of increasing PA and reducing SB, explaining and aligning with the evidence for the consequences and outcomes of bariatric surgery (e.g. improved metabolic status).
4. Provide information about the guidelines for PA and SB for different patient groups (29) and ask participants to reflect on this information in relation to themselves and their current PA and SB.
5. Explain and discuss the process of behaviour change, including how to approach 'relapses' or 'blips' using the COM-B model; share the BCTs that have been associated with initiation and maintenance of PA behaviour; and ask participants to relate this information to their previous attempts at behaviour change and consider how they might do things differently in the future.

6. Prompt and encourage goal setting including how to set small achievable goals, formulate action plans and monitor behavioural outcomes (according to what would be expected). Ask participants how they might progress their goals and encourage them to set their own goals throughout the intervention period.
7. Provide information about motivation and discuss how this might impact on the success of their goals; ask participants to use this information to consider their own motivators and desired outcomes.
8. Encourage participants to reflect on and review their levels of PA and SB, comparing their perceptions with the data captured by the activity trackers – Fitbit (provided) to identify any discrepancies and reasons for this.

The outcome of the development process was a conceptual matrix (table 1) that clearly identifies the intervention objectives, sources of evidence that informed the objectives (e.g. systematic review, qualitative research, PPI input), how these map to the BCW and TDF, and the resulting intervention functions. BCTs were chosen for their ability to meet the intervention functions e.g BCT 5.1 "information about health consequences" was chosen as it was able to meet the intervention function "education". Twenty-nine BCTs are directly linked to the intervention and objectives, and we anticipated that social support (unspecified) (BCT 3.1) would likely be facilitated by the facilitator and group environment, but as this relies on group coherence and interaction it is impossible to guarantee.

Two intervention handbooks were developed; their content mapped directly onto the aims and content of the group sessions and was organised into weeks. The participants' handbook was reviewed by the PPI group who suggested minor formatting changes, while the facilitators' handbook was reviewed by two clinicians who did not suggest any changes.

The participants' handbook provided information and prompts for consideration about the target behaviours e.g "can you recall when you successfully increased your activity" with enough space for

participants to write in it. Throughout the handbooks non-stigmatising images of people with obesity being physically active were used (30) (see figure 1 below for an example of the content).

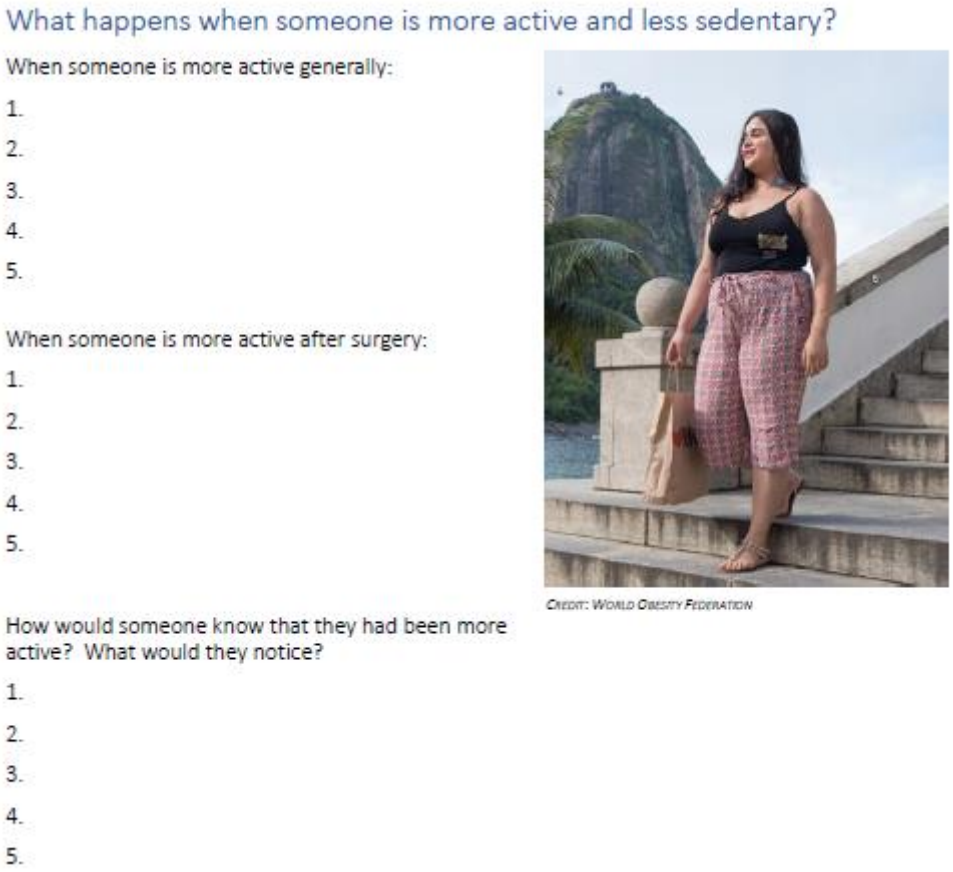

Figure 1 Example of content taken from the participants handbook

All of the information in the participants' handbook was duplicated in the facilitators' handbook with additional details, e.g., the overall intervention objectives, and objectives for each group session. Prompts were included for each section that the facilitator could use to generate discussion during the group sessions (see figure 2). The handbook also contained a glossary of BCTs used in the group sessions and their definitions.

What happens when someone is more active and less sedentary?

Ask participants to discuss the following as a group; "what do you think when ....."

When someone is more active and sits for less generally:

1. *Inverse relationship with PA and premature mortality*
2. *Impact on CVD, hypertension etc*
3. *Metabolic benefits – type 2 diabetes etc*
4. *Function - ADLs*
5. *Cognitive function*

When someone is more active after surgery:

1. *Improved body composition*
2. *Improved health related QOL*
3.
4.
5.

Encourage the discussion towards health domains.

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How would someone know that they had been more active, what would they notice?

1. *Functional – improved shortness of breath on exertion*
2. *Clothes size/ fit – body composition*
3.
4.
5.

Figure 2 Example of prompts used to facilitate discussion taken from facilitator handbook
**CVD cardiovascular disease, ALDs activities of daily living, QOL quality of life*

When the intervention was discussed with participants purposively sampled from the research, they reported that they agreed with the intervention objectives and made helpful suggestions regarding the mode of delivery. They preferred six group sessions rather than eight and mentioned that these should take place in the morning, as this provided the opportunity for them to implement some of the techniques and action plans that had been discussed earlier in the day. Participants from the focus group and the PPI group mentioned that the word 'intervention' had negative connotations, as it was

associated with drug and alcohol abuse. As a result, this was replaced by the word 'programme', which was used in the participants' handbook.

The resulting intervention is a remotely delivered physiotherapist led behaviour change intervention that aims to facilitate increases in PA and reductions in SB in patients who have undergone bariatric and is the culmination of a mixed method, theory and evidence-based approach. Table one shows the intervention objectives, the source of evidence that informed this, how this map onto the COM-B and TDF with the intervention function(s) described. Chosen BCTs with their proposed mode of action, mode of delivery of the intervention and the results of the APEASE assessment is also shown.

Discussion

We have detailed the steps to systematically and iteratively develop a theory and evidence-based intervention to promote physical activity and reduce sedentary behaviour in patients who have had bariatric surgery.

We have specified the intervention using a comprehensive conceptual matrix that clearly demonstrates how existing evidence has informed the intervention objectives, how objectives were mapped to the BCW (14) and TDF (27), and how these objectives will be addressed by the intervention. Completing these steps means that we are confident that our intervention is based on theory and evidence, rather than 'common sense' or using implicit theories (13), and as a result we can robustly justify our intervention. Additionally, using the BCTTV1 to describe BCTs means that others will be able to identify what we did and evaluate our intervention. Our research will contribute to the evidence base of why interventions are effective or why not (31), how they work, for whom and when (32).

It is important to be transparent about some of the challenges in developing this intervention: the process was time consuming, taking approximately two years. This reflects the work involved, which

was due in part to the lack of evidence for interventions to increase PA and reduce SB in this patient population and necessitated primary qualitative research.

The arrival of the Covid-19 pandemic to the UK also posed challenges as it was inappropriate to hold in person face to face meetings with participants and the PPI group due to their increased risk from Covid-19 as a result of their obesity (33, 34), and so these were moved online and conducted via Zoom. It also meant that the intervention could not be delivered in-person, in a face to face setting. However, the timing of the pandemic relative to the stage of intervention development meant that we could design the intervention to be delivered online from the outset rather than adapting a face to face programme. The acceptability of delivering the intervention in this way is currently unknown and will be explored in post-intervention interviews with participants in the feasibility study (18).

There are a number of strengths to our work. Firstly, the intervention has been developed with evidence from the published literature, our own systematic review and primary qualitative research with three different stakeholder groups, using the 2008 MRC framework (35) to guide this. Secondly, we followed an iterative process of reviewing and refining the intervention as required, engaging with patients and the PPI group to ensure that we have fully understood their preferences for an intervention. Whilst this process was time consuming it helped to ensure that the intervention that we have proposed is able to meet their needs and preferences. Thirdly, we have described the development of our intervention in detail and been transparent in the justification of our decisions. Consequently, other researchers and clinicians will have sufficient information to replicate our intervention and evaluate its effectiveness. They may find our description of the processes that we followed to be a useful template for their own intervention development.

To conclude, we used the 2008 MRC complex intervention guidance to inform intervention development, as this was the most recent guidance when we conducted the study; a new version has been published since (36). We have developed a theory and evidence-based behaviour change

intervention which is underpinned by two contemporary behaviour change frameworks, the BCW and TDF. We have selected BCTs from the BCTTv1 to clearly define the active ingredients of our intervention. By careful development we have included the needs and preferences of key stakeholder groups, which makes it more likely that the resulting intervention is acceptable and feasible and participants will engage in it.

To our knowledge PARIS is the first theory and evidence-based clinical intervention, designed to increase physical activity and reduce sedentary behaviour in individuals who have undergone bariatric surgery. Going forwards, as per the MRC guidance, PARIS will now be evaluated in a single site feasibility study to determine feasibility parameters including rate of recruitment, retention, intervention fidelity, participant engagement, acceptability and generate evidence to inform a future fully-powered evaluation study.

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Conflict of interest: None declared

Table 1: Shows intervention objectives, their source mapped to the COM (capability, opportunity and motivation) and TDF (Theoretical Domains Framework) with the intervention function(s) identified. Chosen BCTs (behaviour change techniques) with their proposed MOA (mode of action), mode of delivery and APEASE (affordability, cost-effectiveness, acceptability, side effects and safety, and equity).

Objective	Source	COM: TDF	Intervention function(s)	Selected BCT(s)	Proposed MOA	Mode of delivery*	Does this meet APEASE criteria?
1.RATIONALE FOR INTERVENTION: Participants will be given an explanation as to the rationale for this intervention and a lay summary of the evidence that underpins this. This will be put in the context of current care and evidence, which shows that following surgery not all patients increase their PA and many do not meet the recommended guideline for PA for good health. (Session 1)	PPI: input during the project stated that participants must understand that the sessions are not support group sessions but are intervention group sessions.	Psychological capability: Knowledge (about the rationale for the intervention)	Education	5.1 Information about health consequences	Knowledge, beliefs about consequences, intention, attitude towards the behaviour, perceived susceptibility/vulnerability	At the first intervention session, information and an explanation of the intervention including the rationale will be discussed with participants as a group (BCT 5.1), with reference to current care requirements. Participants will be given information specifically about observed levels of PA in patients who have had surgery (BCT 5.3), which will be put into the context of levels of PA in the general population (BCT 5.3) with reference to the Chief Medical Officer's (CMO) PA guidelines for good health (BCT 5.1 and 5.6). As a group task, participants will be asked to discuss what they perceive the consequences of this will be, with prompting and information giving only if required (BCT 5.1, 5.6). The handbook will contain information that participants can reference outside of the sessions.	Yes
				5.3 Information about social and environmental consequences	Knowledge, beliefs about consequences, attitudes towards the behaviour		
				5.6 Information about emotional consequences	Beliefs about consequences		

2. PA AND SB: Information will be given about PA and SB, this will include: what it is, the consequences of it (including how to assess the outcomes of this), how to pace and how to progress it. Information will also be given about delayed onset muscle soreness [DOMS], what it is, the consequences of it and how to manage it. (Session 1 and 2)	Qualitative research: identified slight misunderstandings about what PA is amongst participants in all participant groups (patient, clinician and commissioner). Also identified that patients might not be knowledgeable about progressing activity and might sustain soft tissue injuries. Literature: suggests that SB might be a realistic target behaviour for this patient group and so this is explored in the intervention	Psychological capability: knowledge, skills.	Education	4.1 Instruction on how to perform a behaviour	Knowledge, skills and beliefs about capabilities	Participants will be asked to discuss what they understand by the term PA, examples of PA and SB, and how PA is different to exercise will be explained (BCT 4.1). There will be a group task which will ask participants to discuss their understandings of the consequences of increased PA (BCT 5.1 and 5.6), generally and specifically after surgery. The session leader will facilitate the discussion towards health rather than weight domains (BCT 13.2), but will provide this information if this is not generated (BCT 4.1). Another group task will be to discuss how the outcomes of PA (BCT 5.1 and 5.6) might be practically assessed or measured (BCT 4.1). Participants will also be given information about Delayed Onset Muscle Soreness (DOMS), its causes, and a group task will be set in which participants will be asked to consider the consequences of DOMS (BCT 5.3) and how they would manage this- pacing and appropriate progression of activities - providing this information if it is not generated by group discussion (BCT 4.1).	Yes
				5.1 Information about health consequences	Knowledge, beliefs about consequences, intention, attitude towards the behaviour, perceived susceptibility/ vulnerability		
				5.3 Information about social and environmental consequences	Knowledge, beliefs about consequences, attitudes towards the behaviour		
				5.6 Information about emotional consequences	Beliefs about consequences		
		Reflective motivation: beliefs about capabilities and consequences	Persuasion	13.2 Framing/ reframing.	Attitudes towards the behaviour		
3. ALIGNING PA AND SB WITH SURGERY: The known consequences of increased	Literature: identifies the benefits of increased PA and	Psychological capability: knowledge.	Education	4.1 Information on how to perform a behaviour	Knowledge, skills and believes about capabilities	Participants will be asked to discuss the consequences of increased PA aligning these with	

PA and reduced SB will be explained and aligned with the evidence for consequences and outcomes of bariatric surgery. (Session 1)	reduced SB will not be quantified on the scales. Qualitative research: identified the strong and ongoing influence of the scales and weight post-surgery. It is important to ensure participants understand that the consequences of increased PA and reduced SB will not be captured by the scales.			5.1 Information about health consequences	Knowledge, beliefs about consequences, intention, attitude towards the behaviour, perceived susceptibility/ vulnerability	the consequences of bariatric surgery (BCT 5.3), with information provided (BCT 4.1) if this does not generate the consequences for which there is evidence (BCT 5.1 and 5.6). The focus on outcomes will be framed (BCT 13.2) towards health rather than weight domains.	Yes
				5.3 Information about social and environmental consequences	Knowledge, beliefs about consequences, attitudes towards the behaviour.		
				5.6 Information about emotional consequences	Beliefs about consequences		
		Reflective Motivation: Beliefs about capabilities, beliefs about consequences	Persuasion	13.2 Framing/ reframing.	Attitudes towards the behaviour		
4. GUIDELINES FOR DIFFERENT PATIENT GROUPS: Information will be given to participants about the guidelines for SB and PA for different patient groups. (Session 5)	Qualitative research: identified that patients are unaware of the guidelines for health but would find this helpful, particularly in terms of progressing activity after the intervention. Literature: guidelines for health are evidence based, and evidence suggests that this patient group are	Psychological capability: Behavioural regulation.	Enablement	1.4 Action planning	Goals	The PA guidelines for good health (according to the CMO for England) will be discussed with attention to the consequences of attaining these (BCT 5.1, 5.3 and 5.6) and participants will be asked to consider what strategies they might use to work towards these guidelines in the future (BCT 1.4). This information will be represented with infographics which will be included in the handbook, with the internet address / hyperlink included.	Yes
		Psychological capability: Knowledge	Education	5.1 Information about health consequences	Knowledge, beliefs about consequences, intention, attitude towards the behaviour, perceived susceptibility/ vulnerability		
				5.3 Information about social and environmental consequences	Knowledge, beliefs about consequences, attitudes towards the behaviour		

	insufficiently active to gain the benefits of PA.			5.6 Information about emotional consequences	Beliefs about consequences		
5. BEHAVIOUR CHANGE: Participants will be given basic information about behaviour change (including the occurrence of 'relapses' or blips). The COM-B model has been chosen as the specific framework, and will be referenced throughout the intervention. Participants will also be given information about the BCTs that have been associated with success at post intervention and follow up; these will be explained using appropriate lay language [Post intervention: "Biofeedback (BCT 2.6)," "Demonstration of the behavior (BCT 6.1)," "Behaviour practice/rehearsal (BCT 8.1)," and "Graded tasks (BCT 8.7). Follow up: "Action planning (BCT 1.4)", "Instruction on how to perform the behavior (BCT 4.1)", "Prompts/cues (BCT 7.1)", "Behavior practice/rehearsal (BCT 8.1)", "Graded tasks (BCT 8.7)", and "Self-reward (BCT	Qualitative research: patients discussed their experiences of starting their PA/ exercise but not maintaining it. Literature: has identified that different BCTs are associated with the initiation and maintenance of behaviour change with regard to PA.	Psychological capability: knowledge, skills, and behavioural regulation	Enablement	1.2 Problem solving	Behavioural regulation, beliefs about capabilities	Participants will be given basic information about behaviour change, the COM-B model will be explained to participants (BCT 4.1). As part of this, it will be made clear that relapses are a common occurrence when trying to change a behaviour (BCT 4.1). A group task will be set, where they will be asked to discuss a case study example of someone who has been unsuccessful in achieving their goal and consider why this might have happened (using the COM-B model) (BCT 8.1) and how they could problem solve this (BCT 1.2). Participants will then be asked to recall and discuss when they have successfully implemented a PA behaviour change (BCT 15.3), which will be reviewed and analysed using the BCW and they will be asked to recall the consequences of this (BCT 5.3). The BCTs that can help to initiate and maintain PA behaviour will be discussed with participants and they will be asked to consider how they might use the information and discussion from the session to become more PA in the future (BCT 1.2).	Yes
			Education	4.1 Instruction on how to perform a behaviour	Knowledge, skills and beliefs about capabilities		
				5.3 Information about social and environmental consequences	Knowledge, beliefs about consequences, attitudes towards the behaviour		
			Training	8.1 Behavioural practice/ rehearsal	Skills, beliefs about capabilities		
		Reflective motivation: Beliefs about capabilities	Persuasion	15.3 Focus on past successes	Beliefs about capabilities		

10.9)"]. Participants will then be asked to relate this information to their previous attempts to change PA behaviour and to identify how they could do things differently in the future (BCT 1.2). (Sessions 1, 2 and 4).							
6. GOALS: Participants will be given information about goal setting: this will include how to set small achievable goals, develop implementation plans, evaluate outcomes according to the expected outcomes (examples will be used to illustrate this) and progress goals. Participants will then be encouraged to set their own goals which will be reviewed throughout the intervention to help with ongoing behaviour change. (Throughout)	Qualitative research: patients discussed their experiences of starting their PA/ exercise and how they tended to be dichotomous in their approach - all or nothing, this was echoed by clinician participants.	Psychological capability: knowledge and skills	Education	2.2 Feedback on behaviour	Motivation, feedback processes	Participants will be given information on how to set goals using the SMART acronym (BCT 4.1), develop implementation plans and appropriately evaluate attempts to meet these goals. Group tasks will be set, where a case study is presented and participants asked to work together to discuss and set appropriate goals (BCT 1.1 and 1.3 as appropriate) and assessments of these (BCT 1.5 and 1.7 as appropriate) (BCT 8.1), what they would do next on successful/ unsuccessful attainment of these goals (BCT 1.2) and what they think the consequences of attaining/ not attaining these goals would be (BCT 5.3). Information will also be given on how to progress goals whilst still ensuring that they are realistic and achievable (BCT 8.7). Participants will be encouraged to recall their previous past successes (BCT 15.3). In addition examples of successful	Yes
				2.7 Feedback on outcome(s) of behaviour	Feedback processes		
				4.1 Instruction on how to perform a behaviour	Knowledge, skills and beliefs about capabilities		
				5.3 Information about social and environmental consequences	Beliefs about consequences		
			Training	8.1 Behavioural practice/ rehearsal	Skills, beliefs about capabilities,		
				8.7 Graded tasks	Skills, beliefs about capabilities		
		Reflective motivation: Beliefs about capabilities, beliefs about consequences.	Persuasion	15.1 Verbal persuasion about capability	Beliefs about capabilities		
			Modelling	6.1 Demonstration of the behaviour	Beliefs about capabilities		
			Enablement	1.1 Goal setting (behaviour)	Intention, goals		
				1.2 Problem solving	Behavioural regulation, beliefs about capabilities		

				1.3 Goal setting (outcome)	Goals	goal setting will be provided and discussed and participants will then be asked to use these principles and example to set their own goals (BCT 1.1, 1.4 and 8.1), which will then be reviewed (BCT 1.5, 1.7 as appropriate) with feedback and assistance given as required (BCT 2.2 and 2.7) at each subsequent session. At the end of every session, the topics that have been discussed will be summarised and participants given positive reinforcement (BCT 15.1) for their participation in the sessions and goals that they have set. The handbook will also contain goal setting information which participants will be able to use as a reference, and will feature pictures of people with obesity being physically active as a way of demonstrating the behaviour (BCT 6.1). Images will be sourced from the World Obesity Federation.	
				1.4 Action planning	Goals		
				1.5 Review behavioural goals	Goals, motivation		
				1.7 Review outcome goals	Goals		
			Persuasion	15.1 Verbal persuasion about capability	Beliefs about capabilities		
				15.3 Focus on past successes	Beliefs about capabilities		
7. MOTIVATION: Participants will be given basic information about motivation and how origin of the motivation (autonomous - v - external) can influence how successful they are at achieving their goals.	Qualitative research: Identified from patient participants that activities had to be intrinsically motivating and enjoyable otherwise they would not maintain them.	Psychological capability: knowledge and skills	Education	4.1 Instruction on how to perform a behaviour	Knowledge, skills and beliefs about capabilities	Participants will be given information about the different types of motivation (BCT 4.1), after which a group task will be set where they will be asked to discuss if they feel the origin of the motivation will affect its success and what the consequences of this	Yes
				5.3 Information about social and environmental consequences	Beliefs about consequences		
			Incentivisation	10.7 Self-incentive	?Motivation - inconclusive		

Participants will then be asked to consider their motivators and desired outcomes, which will be discussed with reference to the expected outcomes from PA. (Session 3)	Even with encouragement from others, if they did not enjoy the activity this would not be helpful and could actually be off putting in the future.	Reflective motivation: Intentions, beliefs about consequences and beliefs about capabilities	Persuasion	9.2 Pros and cons	Beliefs about consequences, attitudes towards the behaviour, motivation, general attitudes/ beliefs	could be if successful/ unsuccessful (BCT 5.3). Participants will be asked if they have any examples they would be willing to share and discuss their experience of being motivated and successfully achieving something (BCT 15.3). They will then be set an individual task to consider their own motivators for PA are and as a group the expected consequences of increased this (BCT 5.3). Incentives (BCT 10.7) and rewards (BCT 10.9) as BCTs will also be presented to participants and they will be asked whether or not these might be helpful with reference to achieving their goals. Participants will be asked to assess the pros and cons of being physically active (9.2) and visualise being PA in the future (BCT 13.1), the consequences of this (16.2) and encouraged to see themselves with this as a part of their identity (BCT 13.5, 15.1). To close with instilling confidence in participants that they have come up with some good ideas in the session.	
				13.1 Identification of self as a role model	Self-image		
				13.5 Identity associated with change behaviour	? Social/ professional role and identity, ? motivation, ? values		
				15.1 Verbal persuasion about capability	Beliefs about capabilities		
				15.3 Focus on past successes	Beliefs about capabilities		
		Automatic motivation: reinforcement	Incentivisation	10.9 Self-reward	? Skill, reinforcement - inconclusive		
				16.2 Imaginary reward	No MOA's identified as yet		

8. BUSY VERSUS ACTIVE: Participants will be encouraged to reflect on their PA and SB and to compare this with the data from activity trackers. Participants will then be asked to see if they can identify reasons for any discrepancies and use this when problem solving. (Throughout)	Qualitative research: identified that patients sometimes get confused between being busy and active and this leads to patient's self-reporting higher levels of PA. There is evidence for this overestimation of PA in the literature also.	Physical opportunity: Environmental context and resources.	Environmental restructuring	12.5 adding objects to the environment	Environmental context and behavioural cueing	Activity monitors (BCT 12.5) and logs will be provided to participants. The will be instructed on how to use these (BCT 4.1) and to record their perceived and objectively measured PA and SB (BCT 2.3) and to compare these, noticing if there are any differences and if so what the reasons for these differences are (BCT 1.2).	**
		Psychological capability: Behavioural regulation.	Enablement	1.2 Problem solving	Beliefs about capabilities, behavioural regulation		
			Education	2.3 Self- monitoring of behaviour	Behavioural regulation, feedback processes		
				4.1 Instruction on how to perform a behaviour	Knowledge, skills and beliefs about capabilities		

** All of the sessions will be delivered by a specialist physiotherapist as a matter of course. This in itself is a BCT (9.1) credible source but was also identified in the development work as 'the right healthcare' professional to deliver the intervention. This BCT is appropriate when the intervention function is persuasion. We anticipate that the groups will facilitate BCT (3.1) social support, but are unable to predict if individuals in the group will provide this. We acknowledge that being in a group does not guarantee this.*

*** It is likely that this will meet the APEASE criteria but it may require some adaptation depending upon the commissioning budget in a future clinical intervention. Activity trackers can be expensive, however most mobile phones have them inbuilt and so it might not be necessary to buy separate trackers and patients could be asked to use the activity apps on their mobile phones if this was implemented in clinical practice.*

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M Goodall: Methodology, formal analysis, writing reviewing and editing, supervision. J Wilding: writing reviewing and editing, supervision.

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