RESEARCH PROTOCOL

Outcomes of a Pre-operative Exercise Regimen for patients undergoing hand-assisted live donor nephrectomy and Transplantation (OPERATe)

Contents

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2) INTRODUCTION

This is a feasibility study to investigate the effectiveness of a prehabilitation programme for live renal transplantation donors and transplant recipients. Participants will undergo a 6 week, at home exercise programme prior to their procedure. This programme of prehabilitation will be monitored using an exercise diary and wearable technology. The data will be utilised, along with participant feedback to assess their compliance and physiological effects of the exercise regimen.

This study will inform the research group on the feasibility of bespoke prehabilitation pathways in transplantation, and how digital technology can inform this. The results of this will inform the grant application of a much larger study into the effects of prehabilitation in transplantation.

3) BACKGROUND

Prehabilitation programmes have been shown to have significant benefits for patients undertaking surgery in cardiothoracic, general and orthopaedic surgical procedures (1). Benefits include reduction in post operative complications, reduced morbidity and mortality, decreased post operative length of stay (LOS), faster recovery and return to work (1–7). These significant benefits have been found in a spectrum of interventions that concentrate on the three key principles of prehabilitation; exercise, nutrition and psychological support. However, there is a paucity of evidence supporting the use, and demonstrating the feasibility of a prehabilitation programme in transplantation (8).

We already have evidence in other populations that decreased anaerobic threshold is a marker for being high risk for post operative complications (9). Therefore, acting within this period to improve physical fitness is perceived to improve post operative outcomes. Prehabilitation works by acting prior to the insult of surgery to improve a patient's baseline characteristics, such as lean body weight, muscle mass and cardiorespiratory reserve.

Live renal transplantation is an example of one of the most profound altruistic acts in our community. Therefore, it is vital that we optimise all stages of this journey, both in terms of preparation and post operative recovery of the recipient, and importantly for the donor. The aim of this would be to increase satisfaction, reduce post operative LOS, reduce time to being back to work (particularly for the donor who has no baseline medical condition prior to the surgery), and reduce post operative complications.

Not all prehabilitation interventions have shown improvement in their study populations. There are multiple reasons for this, including drop out of exercise programs, or that control groups may significantly benefit from interventions that are meant to act as controls rather than intervention. An example of this includes a prehabilitation study in colorectal cancer that showed no difference between walking and cycling group, but the walking intervention control group did see an improvement in their function from baseline as they also increased their physical activity as part of the study (10). There is also the consideration that patients are not prepared appropriately for the intervention. Asking patients prior to surgery to participate in prehabilitation exercises without understanding the benefits they bring leads to poor compliance (10,11). This is particularly relevant to this study population who may experience post dialysis fatigue, deconditioning and baseline poor mobility (12).

By creating an exercise program that is directly suitable to specific populations, studies have demonstrated this can remove some of the barriers to compliance, as well as leading to improved physical fitness and mental wellbeing (13). In the proposed study the use of electronic vital sign monitors with live feedback of results will act to reinforce the achievement that participants experience by engaging in a pre-surgical exercise plan. There is evidence for the use of wearable technology helping to deliver prehabilitation services in other surgical populations in a similar method that we aim to use (14–16).

Ideally the behavioural change introduced by prehabilitation can be transitioned into the regular lives of patients. This would have a longer lasting impact on patients' health and quality of life (17). This study provides an education and application that can be followed simply in participants own homes and fit around other commitments they have. The patients will be directed by the surgical team as to when physical activities can be restarted post-surgery.

This study will provide key information into how the set-up of the trial and delivery of this service will be met. The study is not powered to detect statistically significant differences in outcome of the two groups, although statistical analysis will be performed to determine whether the impact of this intervention on its participants has led to a measurable change in physiological and clinical outcomes. This study provides the opportunity to test the set-up of a new team, and how the wearable technology can be utilised in this cohort of patients.

We will assess 4 key areas (18). First, we will evaluate the recruitment capability though the transplant team at MRI. This determines the ability and expected speed of recruitment of a much larger study. Secondly, this will evaluate and refine our data collection procedure in terms of data extraction, time for data collection and inform the need for future grants for research staff to be allocated time for OPERATe. Thirdly, this will evaluate the acceptability

and suitability of the intervention. As already discussed, exercise interventions for prehabilitation programmes have struggled previously with finding an acceptable method of exercise intervention, particularly one which participants will remain compliant with. Finally, this will provide a preliminary evaluation of participant responses to the intervention, in terms of improved post operative outcomes and patient satisfaction (18,19). Each of these key areas will provide important actionable information that will lead to a more refined and improved larger study, thereby saving time, funding, and limiting wasteful interaction with participants in the future (20).

Funding
Funding for consumer wearables has been provided by the Kidney for Life charitable fund.

4) STUDY OBJECTIVES

4.1 Primary Question/Objective:

- Is it feasible for renal transplant patients and live kidney donors to participate in a prehabilitation programme in combination with a piece of wearable technology?

4.2 Secondary Question/Objective:

- Are transplant outcomes improved by prehabilitation regimens delivered by video instruction?
- Are there discernible perioperative digital signatures provided by the wearable that link to outcomes?
- Is the quality of perioperative sleep linked to outcomes?

5) STUDY DESIGN & PROTOCOL

This is a prospective study investigating the impact of prehabilitation in live kidney donors and their recipients.

Duration

Initially, the study will recruit patients over a 9-month period, or until all 10 live donor pairs (20 participants) have been recruited. During this time, participants will wear a wearable smart device (Oura ring, Withings watch or Corsano wristband) for 2 weeks to collect baseline data before engaging with a prehabilitation programme for 6 weeks. The devices will be worn for a further 6 weeks after surgery, leading to participants being involved for a total 14-week period. Finally, a 3-month period will follow the completion of data collection when data analysis and write up will be completed.

5.1 Participants

The study aims to recruit a minimum of 20, maximum of 40 participants, half of whom will be live donors for renal transplantation and hald of whom will be the recipients of the live kidney transplant.

5.2 Study Intervention and/or Procedures

Potential participants will be identified for by the renal transplant team in preoperative outpatient clinic. They will be provided with all information about the study in a participant information sheet and highlighted to the research team following completion of a consent to contact form.

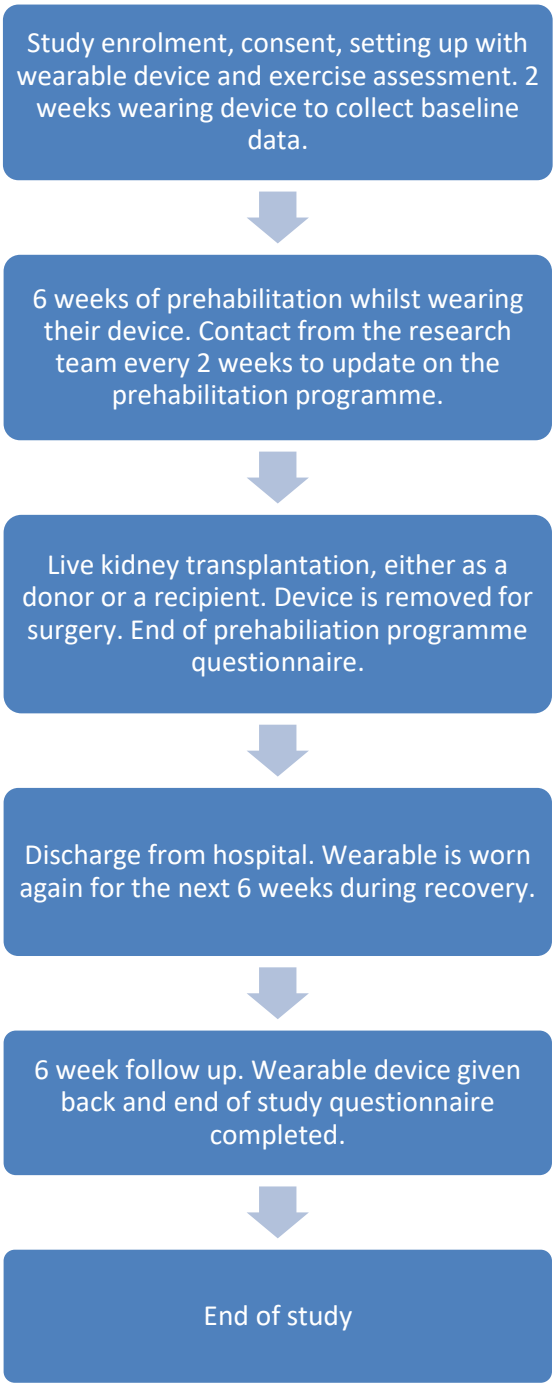
Interested participants will then be contacted by a member of the research team, no sooner than 24 hours later. If the potential participant is deemed suitable following telephone screening, and would like to enrol in the study, they will be invited to a face-to-face meeting with a member of the research team. This meeting will take place in The Wearables Lab, Manchester Royal Infirmary. The participant will complete the consent form. The participant will then need to go through the baseline exercise questionnaire and circadian rhythm questionnaire. The participant will be sized and given a wearable device to use. Sizing, comfort, and stock availability of the different devices will determine which device the participant receives. The participant will be given manufacturer's instructions on the use of the wearable device (instructions in the box), charging it and when it is required to remove the device, for example devices are not MRI compatible. The participant will complete a hand grip strength test, which is a surrogate measurement for sarcopenia and important marker of frailty, measurements will be interpreted using both the International and European guidance on sarcopenia (24–26). They will then be instructed as to which exercise videos they should follow as part of their prehabilitation programme. The participant will be shown how to access the videos, how often they should use the video and given a folder of paper surveys and blank notebook to keep a 'patient journal.'

The participant will wear their chosen device for 2 weeks before starting the prehabilitation programme to allow for the collection of baseline data. On starting their programme, the participant will be asked to complete their exercise videos at least four times a week. After each time, the participant will complete a short paper-based survey of how they feel and their interaction with the video. Participants are encouraged to keep a patient journal on their thoughts/feeling during this study. Every 2 weeks a member of the research team will contact the participant by phone. This is to provide encouragement for their interaction with the study and any feedback from their device data. The participant may be instructed at this point to use a higher or lower intensity exercise video.

On admission for surgery, a member of the research team will visit the patient pre-operatively on the ward. Participants will submit their paper post-exercise surveys at this time. The participant will repeat the hand grip strength test and complete an end of prehabilitation questionnaire. The participant will remove their device during their inpatient stay.

On discharge from hospital the patient will reapply their wearable device until their 6 week follow up appointment. At this point they will return their device, any outstanding surveys, and complete the final questionnaire.

Study Overview:



5.3 Prehabilitation exercise program

Oura Ring

The Oura ring is a commercially available wearable device. On enrolment to the study the research team will size and provide details on the ring to the participant. This includes how to use the ring and incidences when it should be removed. The participant will be asked to download the OURA ring app to their smart device so that the ring is able to upload its information.

Withings Watch

The Withings watch is a commercially available wearable device. On enrolment to the study the research team will provide details on the watch to the participant. This includes how to use it and incidences when it should be removed. The participant will be asked to download the Withings Health Mate app to their smart device so that the watch is able to upload its information.

Corsano Wristband

The Corsano wristband is an FDA approved; CE marked wearable wrist device. On enrolment to the study the research team will provide details on the wristband to the participant. This includes how to use it and incidences when it should be removed. The participant will be asked to download the Corsano Research app to their smart device so that the wristband is able to upload its information.

Data from all device applications is uploaded to the Cloud via Wi-Fi. Biometric data (heart rate, heart rate variability, respiratory rate, blood pressure, SpO2, core body temperature), activity data (step and workout count) and sleep data from the wearable devices will be extracted from the Cloud by a member of the research team. This will be stored on encrypted NHS Trust computers. Some of the information is available to participants through the relevant app. Should any of this be of concern to the participant they will be able to share this with their primary care team. A letter will be sent to each participant's primary care physician on enrolment to the study.

5.5 End of study

The end of the study will be when the final participant has completed their 6-week post-transplant review. Participants will complete their final questionnaire and be asked to return their wearable device and journal. This can take place during their scheduled outpatient appointment to prevent repeated returns to hospital for the participant. Following return, devices will be passed to the research team for cleaning and returned to factory status. Participants will not be entitled to keep their wearable device.

An end of study notification will be submitted to the HRA within 90 days of the end of the study.

6) STUDY PARTICIPANTS

Study participants must meet all inclusion criteria. Meeting any of the exclusion criteria means that they would be unable to participate in the trial. Should any of the exclusion criteria take place after enrolment then the participant will be removed from the study.

6.1 Inclusion Criteria:

- Aged 18 years and over
- Live kidney donor or transplant recipient

6.2 Exclusion Criteria:

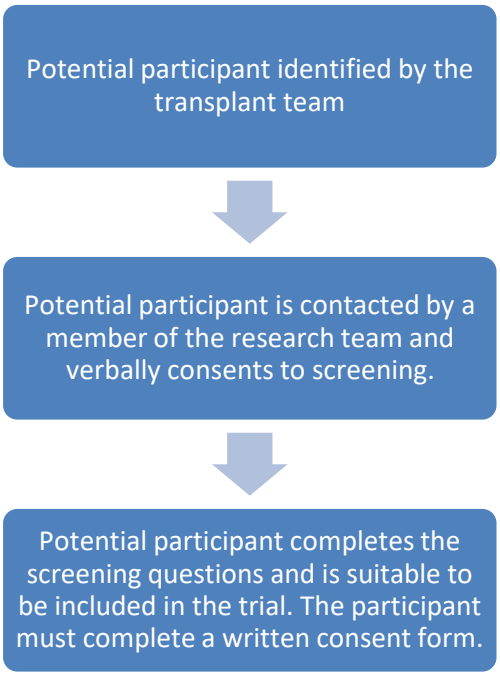
- Deceased donor transplant recipient
- Patients unable to wear or tolerate the wearable device
- Unstable angina pectoralis, recent myocardial infarction, recent cerebrovascular accident, or new arrhythmia
- Patient declines or is unable to participate in the exercise programme
- Patient lacks capacity to give informed consent to participate in the trial
- Non-English language
- Patient has no access to a smart device to download the OURA/Withings Health Mate/Corsano Research Trials app

6.3 Recruitment:

Participants will be recruited at Manchester Royal Infirmary through the transplant team. The transplant team will identify candidates for recruitment from their outpatient work when reviewing potential donors and recipients for live kidney transplantation. At the time of identification potential participants will be provided with a participant information sheet to read about the study at a time convenient for them and complete a consent to contact form. Interested participants will then be contacted via a phone call after a minimum of 24 hours has passed. The potential participant will verbally consent to be screened for whether they would be suitable for the trial.

If a potential participant is deemed suitable for enrolment after telephone screening, they will be invited to an in-person meeting where they will be required to sign a consent form to be involved in the study. This meeting will take place in The Wearables Lab, Manchester Royal Infirmary. After completion of the consent form the participant will complete a paper-based baseline exercise and circadian rhythm questionnaire and be allocated their device. The participant will be shown the prehabilitation exercise videos and instructed as to which video(s) they should be using as part of their initial prehabilitation. Participants will also

receive a folder of paper-based post exercise surveys and a blank notebook to keep an informal patient journal.



6.4 Participants who withdraw consent [or lose capacity to consent]:

Participants can withdraw consent at any time without giving any reason, as participation in the research is voluntary, without their care or legal rights being affected. There is no change to their usual management based on their participation, or withdrawal, from this study.

Participants will be asked whether any pseudonymised data collected so far, can be used as part of the analysis of the study. Data would include wearable data (biometric, activity, sleep) and paper surveys linked to their study ID only. Links between their study ID and any identifiable data would be permanently erased at the time of consent withdrawal.

Once full data collection has been completed, all data will be anonymised and no longer linked to a study ID. It would not be possible to remove individual participant data from the analysis of this trial after the point of anonymisation.

Participants will continue to be involved with data collection after discharge from hospital, therefore any loss of capacity to consent during anaesthesia and/or whilst a patient on intensive care will be resolved at discharge. For any patient that may die during their

admission, however unlikely, will also be included in analysis as this is an extremely important adverse outcome of surgery.

Withdrawal from study

The reasons why participants will be withdrawn from the study are as follows:

- Participant's decision to withdraw from the study
- Investigator decision
- Safety reasons
- Severe non-compliance to protocol as judged by the investigator (participating in less than 50% of exercise sessions as monitored by their diary and wearable technology).

If a participant decides to withdraw:

- Monitoring with the wearable device will cease.
- Participants will continue with the normal standard of care.

6.5 Special circumstances

The study team will counsel participants on safe use of their wearable device in accordance with the manufacturer's instructions. This will include circumstances when the device should be removed and any side effects the participant may experience. Participants will be provided with contact details for the study team so that they can contact the team if they have questions. This will be an email address and phone number through which the research team will be contactable 09:00-17:00 Monday to Friday.

6.6 Training and support for participants

Participants will be given detailed instructions on their wearable device and initial troubleshooting will be provided. Participants will be provided with a telephone number and study email address should they have any difficulties using their device or interacting with the software.

There is a small possibility that the participant may become concerned when reviewing their own vital sign data on their smart device. In this case the participants will be encouraged to contact the research team via telephone and/or email address. Participants will then be signposted to the appropriate service if necessary. In some cases, participants will be able to show their device data on their smart phone to their primary care physician, if required.

7) OUTCOME MEASURES

This is a feasibility study, the results of which will inform the development and planning of a much larger clinical study into prehabilitation in live renal transplant patients and the use of wearable technology to augment this. The hypothesis is that prehabilitation may have a significant positive impact on the outcomes for recipients and donors in live kidney transplants.

This study will examine the interaction between participants and the prehabilitation exercise videos, the set up for this additional service within the transplantation team and test the methods of data extraction.

This study will perform data analysis which may show benefit of prehabilitation for kidney transplant recipients and live donors, although this is not powered.

8) DATA COLLECTION, SOURCE DATA AND CONFIDENTIALITY

8.1 Recruitment

Consent to contact, screening proformas, consent forms, all questionnaires and patient journals will be retained in the study documentation. A copy of consent form will also be uploaded to their electronic patient records.

8.2 Questionnaires

Questionnaires will be completed in writing. Questionnaires will then be stored with the study information by the PI in a locked cabinet. After completion of the questionnaire these will be given to the PI at the earliest opportunity. Answers from the questionnaire will be transcribed into pseudonymised data collection tools.

8.3 Data Extraction

Demographics, current and past medical history, social status, planned operation date, medications, GP information and operation notes will be accessed through electronic patient records with their informed consent. This data will be pseudonymised and linked to their assigned study ID only. At the end of the study, when full data collection is complete study IDs will be removed, and data fully anonymised prior to analysis.

8.4 Oura ring/Withings watch/Corsano wristband

Only relevant data from the participant's wearable device will be accessed from the Cloud by a member of the research team with their informed consent. Relevant data includes

biometric (heart rate, heart rate variability, respiratory rate, blood pressure, SpO2, core body temperature), activity (step and workout count) and sleep data.

8.5 Data Management

- Participants will be assigned a study ID at the time of informed consent taking, only known to the research team. A key linking personalised details (name and NHS number) to the study ID will be stored as an encrypted file on NHS Trust platform, only available to those in the research team.
- Data will be pseudonymised via the individual ID whilst data collection for this study is being conducted
- Data will be fully anonymised after data collection has been completed and the ID key permanently deleted.
- Anonymised data from this study will be held by the principal investigator for 5 years after the completion of this study.
- Data will be held under password protected files on password protected NHS trust computers.
- Only data pertinent to this study (mentioned above) will be extracted from the wearable devices via the Cloud.
- Following return of devices at the end of participant involvement, they will be restored to factory settings.
- No hard or soft data copies will be transferred to University of Manchester (UoM).
- Study data and materials may be looked at by UoM individuals, from regulatory authorities or the NHS trust for monitoring and auditing purposes.

9) STATISTICAL CONSIDERATIONS

9.1 Statistical Analysis

9.11 Study analysis

All variables will be explored descriptively with graphs and summary statistics. Key characteristics, such as overall recruitment, compliance with the prehabilitation programme and qualitative analysis of responses to open questions will be used to assess the primary research question.

Description analysis will be performed on all appropriate variables, within the limits of an unpowered study. This will include number (%), mean, median, maximum and minimum values, standard deviation and interquartile range.

The number of potential participants screened, the number enrolled, withdrawals and completion of study will all be listed outcomes.

Qualitative values, such as post operative complications will be listed.

9.12 Thematic Analysis

Where possible, depending on the quality and quantity of responses, anonymised free text answers to questionnaires or direct quotes from patient journals will be analysed through thematic analysis. The framework method will be used to examine for themes within participants responses (27). This involves the researcher immersing themselves in the data to familiarise themselves. Next themes and codes will be drawn from the data before charting and summarising the data. A matrix will be used to summarise the data before interpretations are drawn from this. This analysis will then be included in the write up with anonymised quotations, where suitable.

9.2 Sample Size:

This is a feasibility study to assess the role and interaction between prehabilitation services prior to transplantation and the use of wearable technology to augment this. Therefore, a power equation has not been used. The results of this study and its feasibility will indicate the need and success of a successive powered study. A provisional sample size of 10 donors and 10 recipients of live renal transplantation has been deemed suitable to determine the success of a successive trial. This is in part limited by the availability of wearable devices to run this study.

10) MONITORING AND QUALITY ASSURANCE

The responsibility for monitoring the study and its quality assurance is the chief investigator (CI) Dr Gareth Kitchen. Vital sign data will be monitored and commented upon at two-week intervals as per the study protocol. Each participant will be closely monitored by the transplant team, as per their usual standard of care. The research team will meet every 3 months to monitor the study for recruitment and discussion of any adverse events.

11) SAFETY CONSIDERATIONS AND ADVERSE EVENTS

Adverse events (AEs) will be recorded by investigators during any face-to-face interactions and during the fortnightly telephone reviews. These events will be documented on the CRF and reported to the CI. Participants will be requested to contact the research team via

phone or email to highlight any AEs that arise between interactions. The research team will meet to discuss AEs every 3 months, or sooner should any urgent safety measures arise.

Possible adverse events (as per separate risk assessment):

- Localised skin irritation or dermatitis
- Injury, exacerbation of underlying medical condition, slip or fall
- Inappropriate fit, catching environment/clothing
- Minor electric shock

Any new underlying pathology that is identified through this study will be highlighted to the transplant team that is primarily involved in the patients care.

Participants will be advised that they should stop exercising if they begin to feel unwell, that they let someone know and take usual medications as appropriate (such as salbutamol inhaler or GTN spray if they are already prescribed them), and to call 999 if none of the above help. This is the same as a participant would do if exerting themselves during their normal activities.

The CI is responsible for:

1. Receiving and assessing AEs and adverse reactions, noted by the research or clinical teams
2. Reporting AEs and urgent safety measures to the sponsor and REC as per the requirements of the Research Ethics Service
3. Maintaining a log of AEs occurring during the study and making this available to the sponsor on request.

Cutoff date for recording of SAEs will be at the participant 6-week post-operative follow up outpatient appointment when wearable devices will be removed and returned to the clinical team.

12) PEER REVIEW

Input for the design of this study has been taken from the prehab for cancer (P4C) team from their varied experience in setting up prehabilitation services for patients awaiting cancer related surgery in the Northwest, whilst wearing Oura ring and Withings watches.

13) ETHICAL and REGULATORY CONSIDERATIONS

13.1 Approvals

NHS REC and HRA approval will be obtained before commencing research. The study will be conducted in full conformance with all relevant legal requirements and the principles of the

Declaration of Helsinki, Good Clinical Practice (GCP) and the UK Policy Framework for Health and Social Care Research 2017.

13.2 Risks

13.21 Risk related to exercise

Risks to participants will be minimised by careful selection criteria. Those at risk of cardiac ischaemia or arrhythmia are excluded from this study as participants will be undertaking unsupervised exercise. Each participant will complete an initial questionnaire to assess their baseline fitness and decide on the level of prehabilitation exercise video they should follow. Participants will be given information of when they should stop exercise (such as chest pain and excessive shortness of breath) and when to call for help.

13.22 Oura Ring, Withings Watch, Corsano Wristband

The Oura ring and Withings watch are commercially available non-medical vital sign monitor. The devices will not be used outside of their marketed function. Corsano wristband is an FDA approved medical bracelet. Participants will receive verbal instruction on how to use and charge their device. It does require connection to a smart phone. Full manufacturer instructions are included in all device boxes. There is a separate risk assessment form available. Information from the devices will not be used to guide clinical care.

The risk of pressure injuries or dermatitis in the conscious participant is low, as conscious participants can notice and react to discomfort from the device prior to injury. Devices are removed on admission to hospital.

14) STATEMENT OF INDEMNITY

The University has insurance available in respect of research involving human subjects that provides cover for legal liabilities arising from its actions or those of its staff or supervised students. The University also has insurance available that provides compensation for non-negligent harm to research subjects occasioned in circumstances that are under the control of the University.

15) FUNDING and RESOURCES

Funding has been provided by the charity Kidneys for Life to allow for the purchase of wearable devices, which are required to run this study.

16) PUBLICATION POLICY

The outcomes of this study will be published, with anonymised data used, through internal education and research meetings at Manchester Royal Infirmary and the University of Manchester, external academic conference presentations, media publications and academic journal publications. Social media may be used to advertise the publications, such as journal articles.

Appendix 1 - Scheme for Participants Contact

Contact 1: Screening

Participants will be screened by one of the research team members. This will either be over the phone or in person using the Screening proforma.

Contact 2: Consent and set-up

Patients will be formally consented to participate in the trial. They will complete baseline questionnaires and be set up with their wearable device. Participants will undergo a non-invasive hand grip strength test. Participants will be instructed as to which video(s) to use at home for their prehabilitation programme, which they will start after 2 weeks of baseline data collection. Participants will be contacted by telephone to remind them of their prehabilitation start date.

Contact 3: Prehabilitation programme review 1

Participants will be contacted approximately 2 weeks after starting their prehabilitation programme. This will discuss any difficulties they have experienced and confirm the plan for the video(s) to follow for the next 2 weeks of prehabilitation.

Contact 4: Prehabilitation programme review 2

Participants will be contacted approximately 4 weeks after starting their prehabilitation programme. This will discuss any difficulties they have experienced and confirm the plan for the video(s) to follow for the next 2 weeks of prehabilitation.

Contact 5: Completion of prehabilitation programme

On admission to hospital the participants will repeat the hand grip strength test and complete a questionnaire on how they feel the prehabilitation programme has gone. Wearable devices will be removed during their inpatient stay and reapplied on discharge for a further 6 weeks of monitoring.

Contact 6: End of study

Participants will be contacted at their 6 week follow up point after surgery, to complete the end questionnaire and return their wearable device and patient journal.

17) REFERENCES

1. Banugo P, Fcai B, Amoako D, Frca M. Prehabilitation. [cited 2023 Mar 14]; Available from: https://academic.oup.com/bjaed/article/17/12/401/4083340

2. Nielsen PR, Andreasen J, Asmussen M, Tønnesen H. Costs and quality of life for prehabilitation and early rehabilitation after surgery of the lumbar spine. BMC Health Serv Res [Internet]. 2008 Oct 9 [cited 2023 Mar 14];8(1):1–7. Available from: https://bmchealthservres.biomedcentral.com/articles/10.1186/1472-6963-8-209

3. Santa Mina D, Hilton WJ, Matthew AG, Awasthi R, Bousquet-Dion G, Alibhai SMH, et al. Prehabilitation for radical prostatectomy: A multicentre randomized controlled trial. Surg Oncol [Internet]. 2018 Jun 1 [cited 2023 Mar 14];27(2):289–98. Available from: https://pubmed.ncbi.nlm.nih.gov/29937184/

4. Minnella EM, Awasthi R, Loiselle SE, Agnihotram R V., Ferri LE, Carli F. Effect of Exercise and Nutrition Prehabilitation on Functional Capacity in Esophagogastric Cancer Surgery: A Randomized Clinical Trial. JAMA Surg [Internet]. 2018 Dec 1 [cited 2023 Mar 14];153(12):1081–9. Available from: https://pubmed.ncbi.nlm.nih.gov/30193337/

5. Nakajima H, Yokoyama Y, Inoue T, Nagaya M, Mizuno Y, Kadono I, et al. Clinical Benefit of Preoperative Exercise and Nutritional Therapy for Patients Undergoing Hepato-Pancreato-Biliary Surgeries for Malignancy. Ann Surg Oncol [Internet]. 2019 Jan 15 [cited 2023 Mar 14];26(1):264–72. Available from: https://pubmed.ncbi.nlm.nih.gov/30367303/

6. Mohan R, Huey CWT, Junnarkar S, Low JK, Shelat VG. Prehabilitation in elderly patients scheduled for liver resection and protocol for Recovery Of Surgery in Elderly. Hepatoma Res. 2020 Mar 26;2020.

7. Valkenet K, Van De Port IGL, Dronkers JJ, De Vries WR, Lindeman E, Backx FJG. The effects of preoperative exercise therapy on postoperative outcome: a systematic review. Clin Rehabil [Internet]. 2011 Feb [cited 2023 Mar 14];25(2):99–111. Available from: https://pubmed.ncbi.nlm.nih.gov/21059667/

8. Maring H, Haanstra A, Annema C. Evidence based interventions suitable for prehabilitation to improve physical functioning in kidney transplant candidates: a scoping review protocol.

9. Wilson RJT, Davies S, Yates D, Redman J, Stone M. Impaired functional capacity is associated with all-cause mortality after major elective intra-abdominal surgery. Br J Anaesth [Internet]. 2010 [cited 2023 Mar 14];105(3):297–303. Available from: https://pubmed.ncbi.nlm.nih.gov/20573634/

10. Feldman LS, Zavorsky GS, Kim DJ, Scott S, Carli F, Charlebois P, et al. Randomized clinical trial of prehabilitation in colorectal surgery. Br J Surg Article in British Journal of Surgery [Internet]. 2010 [cited 2023 Mar 14]; Available from: www.bjs.co.uk

11. Scheede-Bergdahl C, Minnella EM, Carli F. Multi-modal prehabilitation: addressing the why, when, what, how, who and where next? Anaesthesia. 2019 Jan 1;74:20–6.

12. Artom M, Moss-Morris R, Caskey F, Chilcot J. Fatigue in advanced kidney disease. Kidney Int. 2014 Sep 1;86(3):497–505.

13. Greenwood S, Lindup H, Taylor K, Koufaki P, Rush R, MacDougall I, et al. Evaluation of a pragmatic exercise rehabilitation programme in chronic kidney disease. Nephrol Dial Transplant. 2012;27(Suppl 3):iii126–34.

14. Waller E, Sutton P, Rahman S, Allen J, Saxton J, Aziz O. Prehabilitation with wearables versus standard of care before major abdominal cancer surgery: a randomised controlled pilot study (trial registration: NCT04047524). Surg Endosc [Internet]. 2022 Feb 1 [cited 2023 Mar 14];36(2):1008–17. Available from: https://link.springer.com/article/10.1007/s00464-021-08365-6

15. Zhu H, Moffa ZJ, Gui X, Carroll JM. Prehabilitation: Care Challenges and Technological Opportunities. Conference on Human Factors in Computing Systems - Proceedings [Internet]. 2020 Apr 21 [cited 2023 Mar 14]; Available from: https://dl.acm.org/doi/10.1145/3313831.3376594

16. Moorthy K, Halliday LJ, Noor N, Peters CJ, Wynter-Blyth V, Urch CE. Feasibility of Implementation and the Impact of a Digital Prehabilitation Service in Patients Undergoing Treatment for Oesophago-Gastric Cancer. Current Oncology 2023, Vol 30, Pages 1673-1682 [Internet]. 2023 Jan 30 [cited 2023 Mar 14];30(2):1673–82. Available from: https://www.mdpi.com/1718-7729/30/2/128/htm

17. Levett DZH, Grimmett C. Psychological factors, prehabilitation and surgical outcomes: evidence and future directions. Anaesthesia. 2019 Jan 1;74:36–42.

18. Orsmond GI, Cohn ES. The Distinctive Features of a Feasibility Study: Objectives and Guiding Questions. 2009;

19. Bhatia C, Kayser B. Preoperative high-intensity interval training is effective and safe in deconditioned patients with lung cancer: A randomized clinical trial. J Rehabil Med [Internet]. 2019 [cited 2023 Mar 14];51(9):712–8. Available from: https://pubmed.ncbi.nlm.nih.gov/31468059/

20. Morgan B, Hejdenberg J, Hinrichs-Krapels S, Armstrong D. Do feasibility studies contribute to, or avoid, waste in research? PLoS One [Internet]. 2018 Apr 1 [cited 2023 Mar 14];13(4):e0195951. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0195951

21. Ma X, Zhang Z, Peng M, Yao B, Jiang H, Ji X, et al. Face-to-Face Mentoring, Remotely Supervised Home Exercise Prehabilitation to Improve Physical Function in Patients Awaiting Kidney Transplantation: A Randomized Clinical Trial. Front Psychol. 2022 Jun 16;13.

22. McAdams-DeMarco MA, Ying H, Van Pilsum Rasmussen S, Schrack J, Haugen CE, Chu NM, et al. Prehabilitation prior to kidney transplantation: Results from a pilot study. Clin Transplant. 2019 Jan 1;33(1).

23. Hughes MJ, Hackney RJ, Lamb PJ, Wigmore SJ, Christopher Deans DA, Skipworth RJE. Prehabilitation Before Major Abdominal Surgery: A Systematic Review and Meta-analysis. World J Surg [Internet]. 2019 Jul 15 [cited 2023 Mar 14];43(7):1661–8. Available from: https://link.springer.com/article/10.1007/s00268-019-04950-y

24. Wilson D, Jackson T, Sapey E, Lord JM. Frailty and sarcopenia: The potential role of an aged immune system. Ageing Res Rev. 2017 Jul 1;36:1–10.

25. Ha YC, Hwang SC, Song SY, Lee CH, Park KS, Yoo J Il. Hand grip strength measurement in different epidemiologic studies using various methods for diagnosis of sarcopenia: a systematic review. Vol. 9, European Geriatric Medicine. Springer International Publishing; 2018. p. 277–88.

26. Bahat G, Tufan A, Tufan F, Kilic C, Akpinar TS, Kose M, et al. Cut-off points to identify sarcopenia according to European Working Group on Sarcopenia in Older People (EWGSOP) definition. Clinical Nutrition. 2016 Dec 1;35(6):1557–63.

28. Gale NK, Heath G, Cameron E, Rashid S, Redwood S. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. BMC Med Res Methodol [Internet]. 2013 Sep 18 [cited 2023 Mar 15];13(1):1–8. Available from: https://bmcmedresmethodol.biomedcentral.com/articles/10.1186/1471-2288-13-117