Safety and tolerability of a skin sensor for glucose and lactate

Full title: Safety and tolerability study of a minimally invasive microneedle sensor for monitoring glucose and lactate

Protocol Version 1.2, 1st May 2026

Research Reference Numbers

IRAS Number:	368419
Sponsor Reference Number:	UoL002031
Funder Reference Number:	MRC IAA Grant - MR/X502765/1

Signature Page

The undersigned confirm that the following protocol has been agreed and accepted and that the Chief Investigator agrees to conduct the study in compliance with the approved protocol and will adhere to the principles outlined in the Declaration of Helsinki, the Sponsor's SOPs, and other regulatory requirement.

I agree to ensure that the confidential information contained in this document will not be used for any other purpose other than the evaluation or conduct of the investigation without the prior written consent of the Sponsor

I also confirm that I will make the findings of the study publicly available through publication or other dissemination tools without any unnecessary delay and that an honest accurate and transparent account of the study will be given; and that any discrepancies from the study as planned in this protocol will be explained.

For and on behalf of the Study Sponsor:

Signature:

.....

Date:
...../...../.....

Name (please print):

Mrs Karen Jennings-Wilding

Position:

Senior Clinical Research Governance Manager

Chief Investigator:

Signature: 

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Date:
21/01/2026

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Sponsor	The University of Liverpool is the research Sponsor for this Study. It is recognised that as an employee of the University the Chief Investigator has been delegated specific duties, as detailed in the Sponsorship Approval letter. For further information regarding the sponsorship conditions, please contact: Mrs Karen Jennings-Wilding Senior Clinical Research Governance Manager Sponsor@liverpool.ac.uk
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Study Summary

Study Title	Safety and tolerability study of a minimally invasive microneedle sensor for monitoring glucose and lactate
Type of study	In-vivo optimisation study
Trial Design	First-in-human
Trial Participants	Healthy volunteers
Planned sample size	15
Follow-up duration	48 hours
Planned Trial Period	April 2026 – December 2026
Primary Objective	Evaluate safety and tolerability
Secondary Objectives	Evaluate accuracy
Primary Endpoint	Safety and tolerability established
Secondary Endpoints	Accuracy assessed
Device Name	Liverpool microneedle glucose and lactate sensor
Manufacturer Name	Smart Sensors Research Group, University of Liverpool
Principle intended use	Research tool and clinical tool for monitoring acute illness, particularly infection

Funding and Support in Kind

FUNDER(S)	FINANCIAL AND NON-FINANCIAL SUPPORT GIVEN
MRC/ CHI-Zone IAA Commercialisation Award (Wood PI, Khoo, Sharma and Michael Co-I) MR/X502765/1	£10,000- match funding from MRC IAA and CHI-Zone programmes In-kind support from CHI-Zone experts valued at approximately £5,000 • Technical support (min. 12 hours per awardee) • Business case coaching • Access to networks, IP advice, and commercialisation pathways
Wellcome Trust 223502/Z/21/Z	£465k fellowship for Dr Greta K Wood on Liverpool Clinical PhD Programme Funds time for Dr Wood to work as Clinical Research Fellow including contributing to this first-in-human study – conceptualisation/ design/delivery/recruitment/analysis

Roles and Responsibilities of Study Management Committees/Groups & Individuals

Study Steering Groups

The study is supported by the Investigators and Centre for Experimental Therapeutics (TherEx) Team. The Study Steering Group meets 1-2 times monthly to guide study delivery.

Patient & Public Innovation Advisory Group

Role in Study Design - Input on proposal from previous PPI Panels

The initial skin sensor was developed with and by the Microprobe Glucose Sensor PPI Advisory Group. The group wanted a small, painless patch, an accessible display, and data readily available. The COVID-19 Clinical Neuroscience Study (COVID-CNS) PPI group raised concerns about late diagnosis of deterioration during infection, motivating development of technology for early recognition. COVID-CNS successfully reached under-represented groups(1,2).

Ongoing role of PPI panel

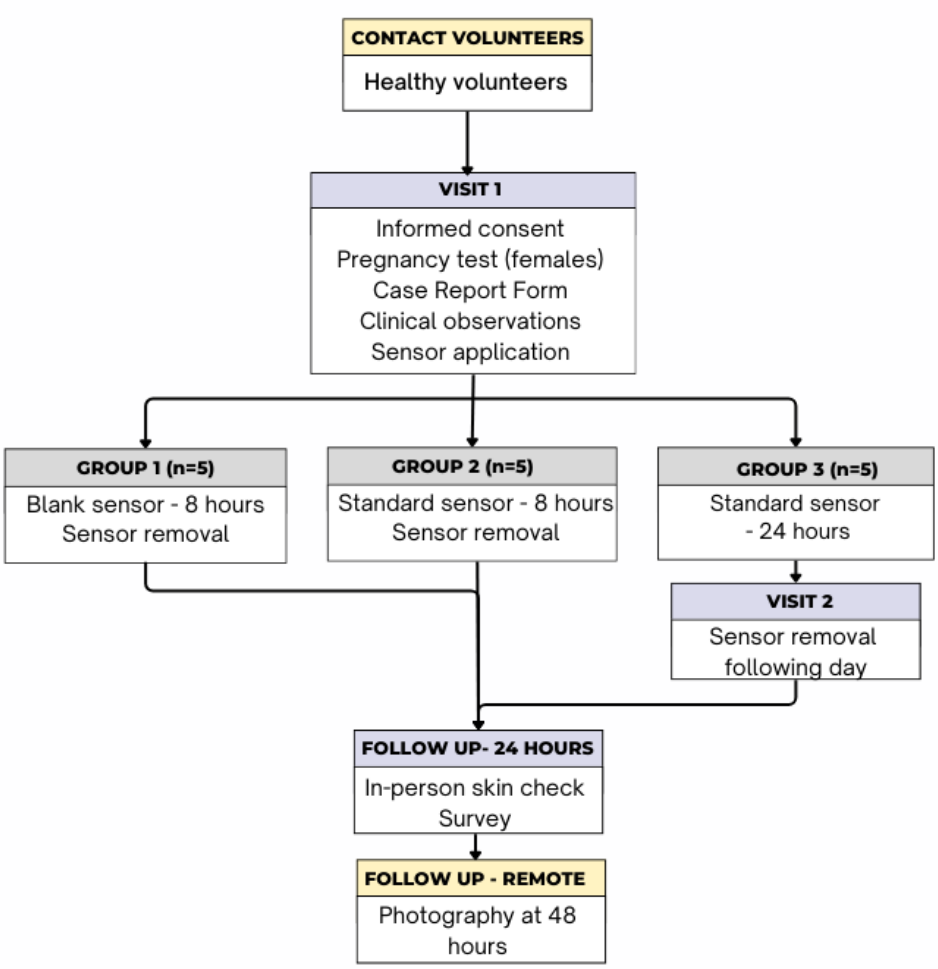
The Patient & Public Innovation Advisory Group has been meeting regularly since February 2025 during in-vitro validation of the sensor. They have indicated that the proposed sensor would be acceptable to them to use during acute illness and for spotting any signs of deterioration during recovery. They advised on design requirements for the sensor and associated monitoring system. They will continue to be consulted during the study and updated on progress.

Health Care Professional Innovation Advisory Group

The Healthcare Professionals group has been active since February 2025. To support equitable access to resulting technology, the group includes professionals in high, middle- and low-income countries. The group has highlighted the need for low-cost, lab-free monitoring techniques that require minimal staff time and training. The group requested visualised trends of biomarkers. They will continue to be consulted during the study and updated on progress.

Key Words:	First-in-human
	Glucose
	Lactate
	Biosensor
	Electrochemistry

Study Flow Chart



Glossary of Abbreviations

HRA	Health Research Authority
REC	Research Ethics Committee
AE	Adverse Event
SAE	Serious Adverse Event
CRF	Case Report Form

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1. INTRODUCTION

This protocol describes “Safety and tolerability study of a minimally invasive microneedle sensor for monitoring glucose and lactate” and provides information about procedures for entering participants, study procedures, safety reporting and governance requirements. Every care was taken in its drafting, but corrections or amendments may be necessary. These will be circulated to investigators in the Study following receipt of required approvals.

Queries relating to this Study should be referred, in the first instance, to the Chief Investigator, or Dr Greta Wood, Clinical Research Fellow.

This study will adhere to the principles outlined in the UK Policy Framework for Health and Social Care Research. It will be conducted in compliance with the protocol, the Data Protection Act 2018 and the UK GDPR as amended from time to time and any successor legislation in the UK and any other directly applicable regulation relating to data protection and privacy as well as any other regulatory requirements as appropriate.

2. BACKGROUND

There is an unmet clinical need for longitudinal monitoring and early recognition of deterioration during acute infection. Delayed recognition of deterioration is common worldwide, resulting in avoidable death and disability(3). Globally, each year, over 700 million disability-adjusted life years are associated with 85 different pathogens, disproportionally affected young children and those in low-income settings(4). In the UK in 2017, sepsis was estimated to cost the economy £8-15 billion per year(5). Effective patient monitoring enables early intervention, however, this can be difficult to achieve due to restrictions in human, laboratory, and financial resource(6). These challenges can potentially be addressed by technology advances, especially real-time measurements from low-cost wearable devices, which have revolutionised monitoring in conditions such as diabetes. This study aims to evaluate the safety and tolerability of a low-cost continuous biosensor for glucose and lactate.

Biosensor platform technology

We have developed a low-cost advanced prototype of a skin sensor for personalised healthcare monitoring(7). Almost all biomarkers that are present in blood are also present in skin interstitial fluid(8). Our minimally invasive patch uses functionalised microneedle electrodes, enabling highly sensitive, selective and stable real-time determination of metabolites (lactate, glucose), cytokines (IL-6), and drugs (theophylline, B-lactam antibiotics) (9–12) in interstitial fluid. This has been validated in-vitro and an earlier prototype detecting glucose tested on healthy volunteers and participants with type 1 diabetes (13). An advanced prototype of the platform technology has been developed testing lactate and glucose which is ready for safety and tolerability testing.

Glucose and lactate sensor

Continuous glucose monitoring is now well established in UK clinical practice for the management of diabetes. Commercial devices such as the FreeStyle Libre use electrochemical sensing to detect glucose in interstitial fluid using the glucose oxidase enzyme(14). However, commercially available sensors remain expensive, and do not simultaneously detect other important biomarkers in infection management, such as lactate.

Device description

The microneedle glucose and lactate sensor is a minimally invasive skin sensor comprising seven microneedles 1mm in length. Microneedles sit within the dermis in the skin compartment, detecting glucose and lactate which leaks out from small blood vessels, capillaries, into interstitial fluid (Figure 1).

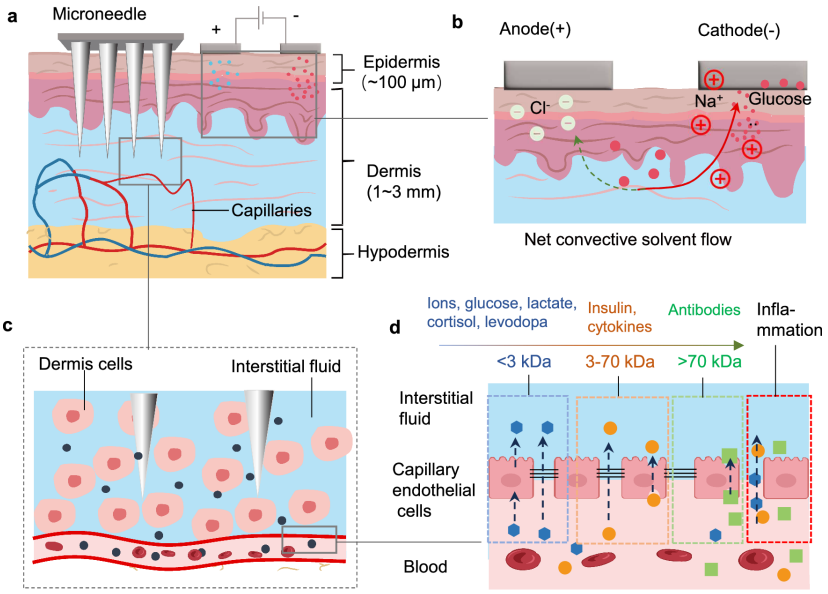

Figure 1: a Schematic illustration of skin structure, ISF bioenvironment, and common ISF accessing approaches. b Schematic illustration of reverse iontophoresis-based ISF sampling approach and bioenvironment. c Schematic illustration of microneedle accessing or sampling approach and bioenvironment. d Transport pathways of biomarkers between blood and ISF (Wu et al, Nature Communications Materials(15))

The device compromises a round printed circuit board (PCB) with modified sterile stainless steel acupuncture needles (Suzhou Tianxie Acupuncture Instruments Co) (Figure 2A). The central needle is a reference electrode which provides a stable reference point against which to measure (Figure 2B). Adjacent to this are two working electrodes, which are used to measure biomarker concentrations. In the functionalised advanced prototype, the surfaces of the working electrodes are modified in layers

to enable enzymatic sensing of glucose (WE1) and lactate (WE2) (Figure 2B). The four counter electrodes in the outer ring allow a stable relationship between the working and reference electrodes, enabling reliable interpretation of measurements. When glucose or lactate come into contact with the microneedles, a signal is generated which can be recorded by an attached CE-marked potentiostat device.

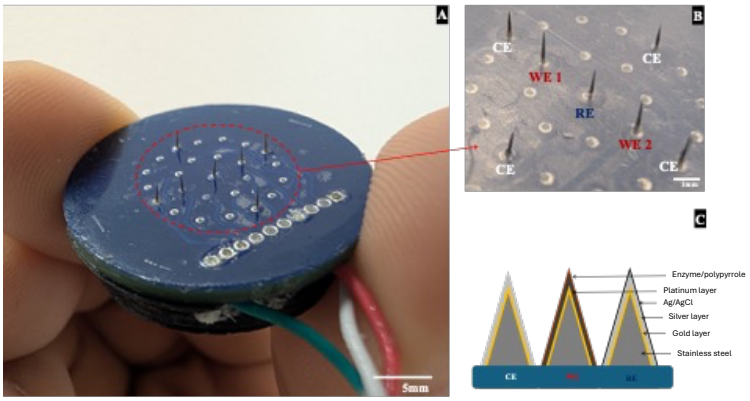

Figure 2: A. Photograph of sensor prototype with microneedles visible. B. Photograph of microneedles indicating the reference electrode (RE) centrally, one working electrodes (WE) detecting glucose and a second working electrode detecting lactate, and four counter electrodes (CE). C. Layered surface modification demonstrating stainless steel with strike gold plating followed by layers specific to each type of electrode.

Surface modification

The surfaces of the microneedles are modified using Standard Operating Procedures in the Smart Sensors Research Group, William Henry Duncan Building, University of Liverpool (Figure 2C). All electrodes are strike plated with gold using chronopotentiometry (Gold Strike Xtra Brush plating solution). The counter electrode and reference electrodes are then soldered to the PCB and silver plated with silver brush plating solution using multistep potentiometry. This step is then quality controlled. The working electrodes are then soldered to the PCB and platinum plated with platinum brush plating solution using chronopotentiometry. Platinum quality control is then performed. The reference electrode surface is modified to form a standard silver/ silver chloride reference electrode. Working electrode 1 (WE1) is then coated with a solution of glucose oxidase and pyrrole which is electrochemically polymerised using cyclic voltammetry. This enables the needle to sense glucose. Working electrode 2 (WE2) is coated with a solution of lactate oxidase and pyrrole and electropolymerized using cyclic voltammetry, enabling the needle to sense lactate.

Quality Management System

Devices are quality controlled according to Standard Operating Procedures at each stage of fabrication including:

- Microscopy of needles following gold strike plating to ensure coverage
- Silver plating QC on counter and reference electrode
- Platinum plating QC on working electrode

Each device is marked with a unique identifier to enable record keeping throughout the device lifecycle. All operators are appropriately trained to follow Standard Operating Procedures.

Biocompatibility of patient contacting materials

The materials the device potentially brings into contact with skin are platinum, silver, glucose oxidase enzyme and polypyrrole. In case of damage to the needles, the underling gold and stainless steel could also be exposed.

Platinum, stainless steel and gold are considered biocompatible(16–18). Polypyrrole is a natural product and is listed as an inactive ingredient for drug products. Glucose oxidase is routinely used in other commercially available CE-marked devices including the widely-used FreeStyle Libre device(14,19). Silver/silver chloride is an established reference electrode in biomedical applications including commercial continuous glucose monitors(14). The underlying stainless steel acupuncture needle is CE-marked and designed for skin puncture.

Safety data for prior prototype

A prior prototype was tested on eight healthy volunteers and ten participants with type 1 diabetes, demonstrating that the sensor was highly acceptable, safe and well tolerated(13).

Pre-clinical data for the current sensor

<u>Insertion studies</u>

Insertion studies have demonstrated no fracture of the microneedles.

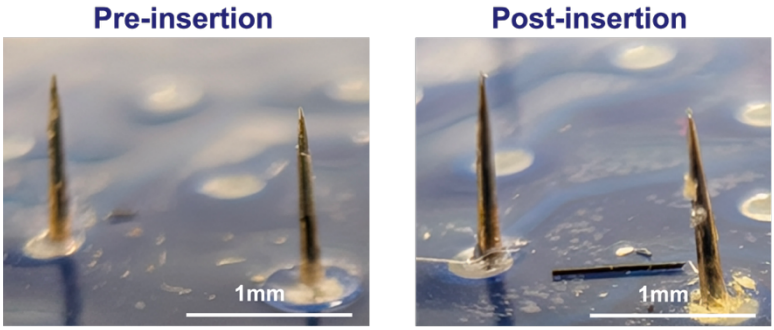

Figure 2: Acupuncture needles on the sensor surface before and after insertion.

Tolerability studies

Animal skin tolerability studies have demonstrated at least equivalent tolerability to a Freestyle Libre 2 by degree of visible skin inflammation.

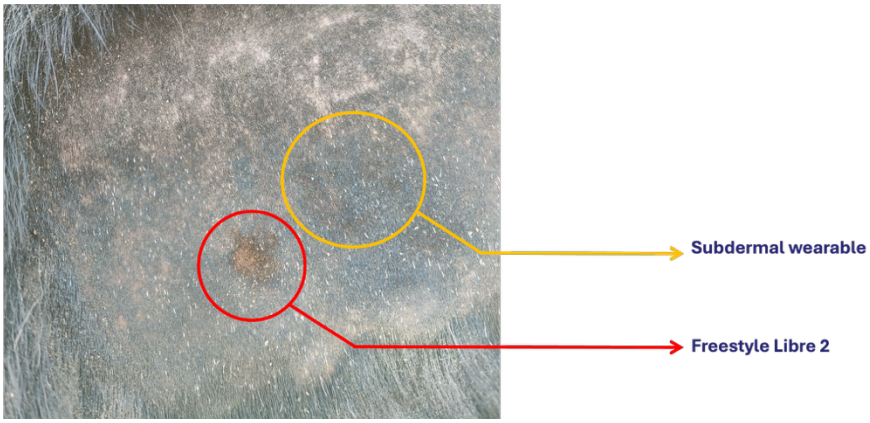

Figure 3: Skin of a beef cow following application of the current sensor, compared to the FreeStyle Libre 2 sensor.

Sterilisation

The sensors will be sterilised with 25kGy of 60Co radiation (TCM Associates) following determination of bioburden levels. This approach has been safely applied in prior studies and is in accordance with ISO 11137-2:2012, Sterilisation of Health Care Products-Radiation(13,20).

3. RATIONALE FOR CURRENT STUDY

How this project represents progress

This project provides crucial safety and tolerability data for our advanced prototype, enabling future use evaluation in acutely unwell participants. This is the next stage in development, having validated the current prototype in-vitro. The prototype design has advanced significantly since previous assessment in healthy volunteers and participants with type 1 diabetes, necessitating further safety data.

Next stage of development following this study

The next stages of development for this sensor are (1) evaluation in a disease cohort, for example diabetes or acute infection and (2) expanded multianalyte sensing of further biomarkers.

Potential long-term impact

In the long-term, real-time monitoring has the potential to transform infection management by addressing key challenges such as spotting deterioration early, enabling remote care, supporting smart use of antimicrobial therapy, and enhancing monitoring in clinical trials of novel therapeutics.

4. RESEARCH QUESTION/AIM(S)

4.1. Objectives

Primary Objective: To evaluate the safety and tolerability of a biosensing device detecting lactate and glucose.

Secondary Objective: To evaluate the accuracy of the device compared to gold-standard measurements.

4.2. Outcomes

Objective 1: Safety and tolerability

- Visual assessment of insertion/removal sites
- Serial photography
- Recording of bleeding, erythema, swelling, bruising, infection, pain
- Follow-up until resolution

Objective 2: Device performance/accuracy

- Comparison of sensor reading vs venous reference measurements
- Assessment under both resting and physiologically dynamic conditions

5. STUDY DESIGN AND METHODS OF DATA COLLECTION

Study groups

The study consists of three groups that will be recruited consecutively:

1. Group 1 (n=5): The microneedles on the biosensor will be ‘blank’ and will not contain any sensing materials. The biosensor will be worn for 8 hours.
2. Group 2 (n=5): The microneedles will be functionalised to detect glucose and lactate. The biosensor will be worn for 8 hours.
3. Group 3 (n=5): The microneedles will be functionalised to detect glucose and lactate. The biosensor will be worn for 24 hours.

Any participants who drop out the study will be replaced.

Schedule of procedures

Timepoint and Location	Number of participants	Procedures	Description
Visit 1- **Clinical Research Facility**	All participants - 15	Eligibility Assessment	Final confirmation that healthy volunteers meet inclusion criteria and do not meet exclusion criteria.
	All participants - 15	Informed Consent	Informed consent taken, ensuring full understanding of study procedures.
	Female participants	Pregnancy test	Pregnant females excluded.
	All participants - 15	Case Report Form	Completed by study team with participant: Demographics: Date of birth, sex, ethnicity, smoking and alcohol consumption Medical history Concomitant medication including all over-the-counter or prescription medications, vitamins, and/or herbal supplements Study specific data: Hand dominance, Height and weight
	All participants - 15	Clinical observations	Heart rate, blood pressure, oxygen saturations, temperature, respiratory rate and pain score will be recorded
	Group 1 5 participants	Biosensor application for 8 hours	The upper limb (arm) used for biosensor application will be randomised using permuted blocked via an established online tool (sealed envelope). An appropriately sized cannula will be inserted in the hand or antecubital fossa and a blood sample will be collected into a blood gas syringe. After at least 15 minutes following cannula insertion, the biosensor will be applied on the same arm with a standardised

			applicator to the ventral aspect of the forearm and secured in place with a transparent dressing. A transparent dressing of the same design as that used to secure the biosensor will be applied to the opposite forearm as a control. Food and drink consumption will be recorded in the CRF but not restricted. A participant questionnaire will be completed including pain scores comparing the biosensor and cannula insertion and willingness to wear the biosensor in case of illness. Participants will be monitored for adverse events throughout biosensor application and for 1 hour afterwards. After 8 hours, the biosensor will be removed. Photographs will be taken of the forearm before biosensor application, immediately after removal of the biosensor and at 1 hour. The site of biosensor application will be assessed for visual inflammation and bleeding. The cannula will be removed before the participant leaves the Clinical Research Facility. Post-insertion, the biosensor will be examined under a scanning electron microscope.
	Group 2 5 participants	Biosensor application for 8 hours	As per Group 1, with the addition of: After application, the biosensor will be attached via a wire to the potentiostat device that records data. Blood samples: 2ml blood samples will be taken from the cannula every hour for 8 hours. The sample will be taken in a blood gas tube and transported by hand to the Siemens RAPIDPoint 500e Blood GasSystem with Integri-sense Technology. Glucose and lactate readings will be taken from the Siemens Analyser. This system includes automatic calibration, automatic quality control, system algorithm checks and other measures to improve accuracy such as temperature checks, clot and bubble detection. The system is maintained by the University Hospital of Liverpool Group. Exercise: After 2 hours of wearing the sensor, participants will have the 2-hour blood sample and then be asked to exercise on

			an exercise bike for 30 minutes at a level of exertion that is comfortable for them. During the time on the exercise bike and for 30 minutes afterwards (1 hour total), blood samples will be taken every 10 minutes. This enables assessment of dynamic lactate concentrations.
	Group 3 5 participants	Biosensor application for 24 hours	As per Group 2, however, the biosensor will not be removed at the end of the day and the participant will go home with the sensor in-situ and return the next day for removal at 24 hours.
Visit 2 – Clinical Research Facility	Group 3 only 5 participants	Biosensor removal	Participants will reattend the Clinical Research Facility 24 hours after biosensor application. The biosensor will be reconnected to the potentiostat to take a final reading of analyte concentrations. At the same time, a final venous blood sample will be taken by venepuncture and analysed on the blood gas machine for lactate and glucose.
Follow up visit – at 24 hours - Clinical Research Facility	All participants - 15	Follow-up	In groups 1 and 2, participants will return for follow-up 24 hours after Visit 1. In group 3, participants will return for follow-up 24 hours after Visit 2. Any adverse events will be recorded, and a photograph will be taken of the biosensor application site. Participants will receive remuneration of £100.
Remote follow up	All participants – 15	Follow-up 2	Participants will be asked to send a photograph of the biosensor application site 24 hours after the Follow-up Visit.

6. STUDY SETTING

The study will take place in the NIHR Liverpool Clinical Research Facility. Individuals in the Consent 4 Consent Database will be invited to participate. All study procedures will take place on-site.

7. SAMPLE AND RECRUITMENT PARTICIPANT ENTRY

8.1 Eligibility Criteria

Overall description of trial participants: Healthy volunteers

8.1.1 Inclusion Criteria

- Male or Female, 18-45 years of age
- Be in good health
- Able and willing to comply with all study requirements
- Negative pregnancy test (female participants)

8.1.2 Exclusion Criteria

The participant may not enter the study if ANY of the following apply:

- Previously diagnosed chronic medical condition
- Female participant who is pregnant, lactating or planning pregnancy during the course of the study
- Predisposition to bleeding
- Predisposition to skin infection or inflammation including a history of atopic dermatitis
- Participants who have participated in another research study involving an investigational product in the past 12 weeks or plan to participate during the course of the study
- Under investigation for malignancy
- Allergy to any component of sensor

No additional tests or procedures will be undertaken to confirm eligibility.

8.2 Recruitment

8.2.1 Sample identification

Individuals in the Liverpool Clinical Research Facility Consent 4 Consent Database will be invited to participate. Information about the study will also be shared on posters in paper and electronic form.

8.2.2 Informed Consent

Written and verbal versions of the participant information will be presented to the participants detailing: the exact nature and objectives of the study; the implications and constraints of the protocol and the risks involved in taking part. It will be clearly stated that the participant is free to withdraw from the study at any time for any reason without prejudice to future care, and with no obligation to give the reason for withdrawal. This process will be supported by the approved study Participant Information Sheet and Consent Form.

The participant will be allowed as much time as wished to consider the information, and the opportunity to question the Investigator or other independent parties to decide whether they will participate in the study. The study will be explained by the Clinical Research Fellow, who will assess capacity to consent.

8. ADVERSE EVENTS

9.1 Definitions

Adverse Event (AE): any untoward medical occurrence in a patient or clinical study subject, including unfavourable and unintended signs, including abnormal laboratory results, symptoms or a disease associated with treatment.

Serious Adverse Event (SAE): any untoward and unexpected medical occurrence or effect that:

- Results in death
- **Is life-threatening** – refers to an event in which the subject was at risk of death at the time of the event; it does not refer to an event which hypothetically might have caused death if it were more severe
- Requires hospitalisation, or prolongation of existing inpatients' hospitalisation
- Results in persistent or significant disability or incapacity
- Is a congenital anomaly or birth defect

Medical judgement should be exercised in deciding whether an AE is serious in other situations. Important AEs that are not immediately life-threatening or do not result in death or hospitalisation but may jeopardise the subject or may require intervention to prevent one of the other outcomes listed in the definition above, should also be considered serious.

Risk register

Mild transient erythema is expected following microneedle insertion/removal.

This will be documented and monitored until resolution.

Risk	Consequence	Severity	Mitigating action
Sterility inadequate	Possible infection	Moderate	Bioburden and sterility studies completed before study
Bleeding	Very low volume blood loss, distress	Mild	Exclude potential participants at higher risk of bleeding Short (1mm) needle
Inflammation	Discomfort	Mild	Exclude potential participants at higher risk of skin inflammation
Needle breakage	Local irritation, probable spontaneous expulsion of needle	Moderate	Previous pre-clinical and clinical testing and has not resulted in needle breakage Device applied and removed with minimal force

Vasovagal syncope	Temporarily and reversibly feeling faint or unwell	Mild	Vasovagal syncope is occasionally observed in reaction to needle insertion including cannulation and venepuncture. In case of suspected vasovagal syncope, blood glucose will be checked to exclude hypoglycaemia. Suspected vasovagal syncope will be managed with supportive measures.

This is a healthy volunteer study without anticipated benefit to volunteers.

9.2 REPORTING PROCEDURES

All adverse events should be reported. Depending on the nature of the event the reporting procedures below should be followed. Any questions concerning adverse event reporting should be directed to the Chief Investigator in the first instance.

9.2.1 Non-serious Adverse Events (AEs)

Adverse Events (AEs) are any instances of needle breakage, significant bleeding or skin inflammation or evidence of skin infection.

All such events, whether expected or not, should be recorded. These will be recorded on a Case Report Form (CRF) and in the patient's medical notes.

9.2.2 Serious Adverse Events (SAEs)

Upon identification of an SAE the Principle Investigator should complete a study specific SAE form and sent to the Chief Investigator within 24 hours. Hospitalisations for elective treatment of a pre-existing condition do not need reporting as SAEs.

Contact details for reporting SAEs – Prof Benedict Michael

All SAEs should be reported to the NHS REC where in the opinion of the Chief Investigator, the event was:

- **'related'**, i.e. resulted from the administration of any of the research procedures; and
- **'unexpected'**, i.e. an event that is not listed in the protocol as an expected occurrence

Reports of related and unexpected SAEs should be submitted within 15 days of the Chief Investigator becoming aware of the event, using the HRA Non-CTIMP safety report to REC form. The Chief Investigator must also notify the Sponsor of all SAEs.

9. STATISTICS AND DATA ANALYSIS

10.1 Sampling

10.1.1 Sample Size

A sample size of 15 individuals enables identification of common adverse events. No formal statistical analysis will be undertaken and no formal sample size calculation has been undertaken. This study is for prototype development and optimisation. The sample size of n=15 is conventional in such development work.

10.1.2 Sampling Technique

Volunteers will be invited to participate from the Consent 4 Consent Database. This enables recruitment of healthy volunteers who are contactable.

10.2 Data Analysis

Data will be recorded on REDCAP using a unique study identifier allowing pseudo-anonymised recording. Pseudo-anonymised data will be stored in the NIHR Liverpool Clinical Research Facility Data Management system. The data will be accessed by the study team for the purposes of completing the study and analysing the data.

Data will be visualised in R software. The data will be described including the frequency of adverse events and summarised participant surveys.

Primary Objective: Safety

Safety will be considered the absence of serious adverse events and absence of needle breakage. The rate of other adverse events, specifically bleeding, skin inflammation, and skin infection will be recorded.

Primary Objective: Tolerability

Tolerability will be assessed by:

A) Subjective assessment of photography after device removal

B) Pain scores on participant survey. Good tolerability will be defined as median pain score $\leq$3/10.

Secondary Objective: Accuracy

Device performance will be evaluated by comparison of sensor-derived glucose and lactate measurements with time-matched venous reference measurements obtained using the Siemens RAPIDPoint 500e Blood Gas System. The potentiostat measures data from the device which is processed using software associated with the potentiostat.

Glucose Performance

The glucose sensor will be evaluated during physiological variation, including postprandial excursions. Timing of food intake will be recorded relative to sensor and blood measurements. Data will be summarised using Mean Absolute Relative Difference and Clarke Error Grid analysis.

Lactate Performance

Lactate performance will be assessed under resting and exercise-induced conditions, with agreement evaluated using Bland-Altman analysis. Correlation and time-series analyses will be presented as supportive measures.

Data Visualisation

The data from the device, reported in Current (µA), will be plotted against the venous glucose and lactate measurements over time. This will allow interpretation of the lag time between venous blood and measurements by the device, as well as a visual representation of the agreement between measurements.

10.REGULATORY ISSUES

11.1 Ethics Approval

Before the start of the study, a favourable opinion will be sought from the UK Health Departments Research Ethics Service NHS REC for the study protocol, informed consent forms and other relevant documents e.g. advertisements.

The study will be conducted in accordance with the recommendations for physicians involved in research on human subjects adopted by the 18th World Medical Assembly, Helsinki 1964 and later revisions.

11.2 Confidentiality

The Chief Investigator will preserve the confidentiality of participants taking part in the study and will abide by the Data Protection Act 2018 and the UK GDPR as amended from time to time and any successor legislation in the UK and any other directly applicable regulation relating to data protection and privacy.

All personally identifiable data recorded on consent forms and source data will be kept in a locked cupboard within the CRF, itself a secure area accessible only by authorised personnel. All study data necessary to capture endpoint/clinical outcomes will be pseudo anonymised and uploaded onto REDCAP, the data stored on an internal sever within the ULHG trust. No personally identifiable data will be input into REDCAP.

All eCRF and source data will be stored in the Investigator Site File at the end of the study for archiving, which will mirror all Trial Master File data kept by Sponsor.

There will be physical documentation linking personally identifiable information to the unique study identifier, kept secure with the consent forms and source data.

Sponsor will take custody of the final dataset at end of study and store on a secure platform. During the study, the REDCAP database is secure and access is only granted for authorised users. Access to REDCAP will be limited to users delegated to work on the study and approved by the CI.

Data will be transferred using a secure system as described in the Data Management Plan.

11.3 Indemnity

The University of Liverpool holds Indemnity and insurance cover with Newline Insurance Company, which apply to this study.

11.4 Audits

The study may be subject to inspection and audit by the University of Liverpool under their remit as sponsor and other regulatory bodies to ensure adherence to GCP and the UK Policy Framework for Health and Social Care Research (v3.2 10th October 2017).

11.5 Medical Device Regulations

The study is part of pre-clinical device development, specifically early stage in-vivo optimisation for prototype development. Notification to the MHRA is therefore not required.

11. END OF STUDY

Last participant, last visit.

12. DISSEMINIATION POLICY

13.1 Dissemination policy

Data arising from the study is owned by the Investigators and the University of Liverpool. On completion of the study, data will be analysed and a Final Study Report prepared. The participating investigators will have the right to publish the study data. The funder will be recognised in any resulting publications which will be shared open access. Participants will be informed of the outcome of the study via a written update in lay language. The study protocol will be made publicly available. No participant level data will be made routinely publicly available, however, adverse events occurring to a single individual only may be anonymously reported.

13.2 Authorship eligibility guidelines

Authorship will be guided by The International Committee of Medical Journal Editors authorship criteria.

13. ARCHIVING

Data and all appropriate documentation should be stored for a minimum of 5 years after the completion of the study, including the follow-up period. Data will be stored in the University of Liverpool, the custodian of the data.

14. REFERENCES

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15. APPENDICES

15.1 Appendix 1- Required documentation

- Participant Information Sheet
- Participant Consent Form
- Chief Investigator CV
- Evidence of CI Training – GCP/ HTA

15.2 Appendix 2 – Schedule of Research Procedures

Procedures	Visits (insert visit numbers as appropriate)		
	Visit 1	Visit 2 (Group 3 only)	Follow-up
Eligibility confirmation	x		
Informed consent	x		
Pregnancy test	x		
Case Report Form	x		
Biosensor application	x		
Biosensor removal	x (Group 1 and 2)	x	
Photography	x	x	x

15.3 Appendix 3 – Amendment History

Amendment No.	Protocol version no.	Date issued	Author(s) of changes	Details of changes made

List details of all protocol amendments here whenever a new version of the protocol is produced.

Protocol amendments must be submitted to the Sponsor for approval prior to submission to the REC.