# Estimation of Energy Expenditure and Physical Activity Classification with Wearables

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Primary Objective: The primary objective of this study is to develop and validate an energy expenditure estimation and physical activity classification algorithm based on wearable sensors. To do so the relevant signals contributing to the...

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| **Ethical review** | Approved WMO |
| **Status** | Recruitment stopped |
| **Health condition type** | Other condition |
| **Study type** | Observational non invasive |

## Summary

### ID

NL-OMON53398

**Source**
ToetsingOnline

**Brief title**
EEPAC

### Condition

- Other condition

**Synonym**
energy expenditure, general fitness

**Health condition**

algemen fysieke gezonheid

**Research involving**
Human

## Sponsors and support

**Primary sponsor:** Universiteit Maastricht
**Source(s) of monetary or material Support:** Ministerie van Economische Zaken

## Intervention

**Keyword:** Energy Expenditure, Physical Activity, Validation, Wearables

## Outcome measures

### Primary outcome

The main study parameter is energy expenditure and physical activity. The main endpoint of this study is an energy expenditure estimation and physical activity classification algorithm based on wearable sensors. Energy expenditure will be measured in units of kcal per time. Physical activity will be classified as time spent in sedentary, standing, low physical activity (LPA), moderate physical activity (MPA), vigorous physical activity (VPA).

### Secondary outcome

Secondary study parameters are:

- Heart rate (variability)

- Breathing rate

- Average skin temperature

- PA intensity

- Body composition

The secondary endpoints are:

- a heart rate (variability) algorithm based on raw ECG signals

- explained contribution of different bio-signals to the estimation of EE

- an algorithm for the estimation of instantaneous EE

# Study description

### Background summary

Physical activity (PA) is defined as any bodily movement produced by skeletal muscle that requires energy expenditure. The scientific evidence for the beneficial effects are irrefutable. Regular PA is proven to help prevent and treat several non-communicable diseases such as heart disease, stroke, diabetes and different forms of cancer.
PA is a complex behaviour that is characterized by frequency, intensity, time and type (FITT). In order to understand the effect of PA on health and our general well-being, it is essential to monitor all four characteristics of PA.
A PA classification algorithm can assess the amount of time spent in different body postures and activity. Making it possible to assess frequency, time and type. In order to completely characterize PA, intensity needs to be estimated. This can be done by the estimation of energy expenditure (EE).
Wearables play a crucial role in the monitoring of PA. They are practical way to collect objective PA data in daily life, in an unobtrusive way, at a relatively low cost. Furthermore they can be applied as a motivational tool to increase PA. Accelerometry has been routinely used to quantify PA and to predict EE using linear and non-linear models. However, the relationship between EE and acceleration differs from one activity to another. For example, cycling can generate the same acceleration amplitude as running, but the EE may differ greatly. It is clear that acceleration alone has a limited accuracy to estimate EE from different activities.
Improving the estimation of EE could be achieved by first classifying the activity type. For each type of activity, different estimations can be used. There are numerous methods to classify PA and estimate EE. Literature describes the use of regression based equations combined with cut-points, linear models, non-linear models, decision trees, artificial neural networks, etc. It is still unclear what would be the best method to estimate EE, not to mention which features would contribute to the model.
Another possibility is to add a relevant bio-signal to the estimation model. Heart rate, breathing rate, temperature are all signals that have a response related to an increase in PA. Heart rate has been used previously to improve the EE estimation in combination with accelerometry. The breathing rate and temperature could contribute to the estimation of EE is still unclear.
Therefore, the goal of the current study is twofold. Firstly, to explore the contribution of different variables (physiological signals) to the estimation of EE and the classification of PA. Secondly, develop and validate a model to estimate EE and classify PA in simulated free-living conditions based on the relevant variables.

### Study objective

Primary Objective:
The primary objective of this study is to develop and validate an energy expenditure estimation and physical activity classification algorithm based on wearable sensors. To do so the relevant signals contributing to the classification of physical activity and the estimation of energy expenditure will be identified.

Secondary Objectives:
Based on the collected data secondary objectives are:
- Design and validate a heart rate (variability) algorithm
- Assess the contribution of different bio signals to the estimation of energy expenditure
- Investigate the feasibility of modelling the instantaneous energy expenditure

### Study design

Study Design:
Cross-sectional exploratory and validation study. Using stratified, repeated k-fold cross validation the models for the classification of PA and the estimation of EE will be developed.

Setting:
Data will be collected at the facilities of the Metabolic Research Unit Maastricht (MRUM).

Duration:
12 months from the start of inclusion, planned March 2022, after approval of the METC.

### Study burden and risks

The possible harms, burden and risks for the subject are minimal. The wearables and electrodes are attached with medical grade patches. However, subjects might experience some burden form the patch. The activities included in the simulated free-living protocol do not induce additional risks, since they are all activities of daily living. Subjects will need to walk and run at a moderate speed on a treadmill. Therefore, we will use the physical activity readiness questionnaire (PAR-Q+) as an inclusion criterium.
No major risks are involved and the burden for the subject is low to moderate.

## Contacts

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# Trial sites

## Listed location countries

Netherlands

# Eligibility criteria

**Age**
Adults (18-64 years)

## Inclusion criteria

- Aged between 18 and 64 years
- Provided written informed consent
- Able to be physically active assed with PAR-Q+

## Exclusion criteria

- A contraindication to physical activity
- A contraindication to wearing wearables, fixed by a hypoallergenic plaster
- Chronic disease
- A pace maker or any chest-implanted device

# Study design

## Design

**Study type:** Observational non invasive

| | |
|---|---|
| Masking: | Open (masking not used) |
| Control: | Uncontrolled |
| Primary purpose: | Other |

## Recruitment

NL

| | |
|---|---|
| Recruitment status: | Recruitment stopped |
| Start date (anticipated): | 18-05-2022 |
| Enrollment: | 56 |
| Type: | Actual |

# Ethics review

Approved WMO

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| Date: | 19-04-2022 |
| Application type: | First submission |
| Review commission: | METC academisch ziekenhuis Maastricht/Universiteit Maastricht, METC azM/UM (Maastricht) |

# Study registrations

## Followed up by the following (possibly more current) registration

No registrations found.

## Other (possibly less up-to-date) registrations in this register

No registrations found.

## In other registers

| Register | ID |
| --- | --- |
| CCMO | NL80580.068.22 |