\*Title: **Indirect calorimetry**

\*Centre: IMPC

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{Sections:}

## \*1. Purpose:

Indirect calorimetry provides detailed information on the energy metabolism of mutant mice. Energy expenditure is evaluated through indirect calorimetry by measuring oxygen consumption with an open flow respirometric system. Very precise CO2 and O2 sensors measure the difference in CO2 and O2 concentrations in air volumes flowing through control or animal cages. The amount of oxygen consumed over a given period of time can thus be calculated, as far as the air flow through the cage is known. Data are expressed as ml O2 h-1animal-1. The system also monitors CO2 production, therefore, the respiratory exchange ratio (RER) and heat production can be calculated. An activity and food and water intake monitoring system are also integrated into the set up in order to investigate circadian pattern and behaviour.

Ontological description: MP:0005266 - abnormal metabolism.

## \*2. Experimental Design

Minimum number of mutant animals: 7 mice for each sex.

Age of animals at test: 12 weeks.

Sexual dimorphism: In general, female mice have higher metabolism compared to males therefore statement is not entirely correct. However, genotype x sex interaction are rare therefore testing only males is acceptable.

It is essential that all phenotyping experimentation is conducted at the same time of day because physiological and biochemical parameters e.g. metabolic rate, body temperature and activity are subject to temporal rhythms. In the indirect calorimetry module standard measurements begin five hours before lights-off (lights off = T0) and are finished at T16 i.e. four hours after lights-on the next morning. Optional: Mice can be given one day of acclimation before the trial, and the trial can be continued for more than 21 hours (up to 48 hours).

## \*3. Equipment

1. Calorimetric system equipped with respirometer, feeder and water bottles
2. Ambulatory activity monitor (dependent on system specifications)
3. Food and water intake monitor
4. Computer with apparatus software installed

## \*4. Procedure

1. Optionally mice are allowed to acclimatise to the phenotyping room, to the respirometry cage, food hoppers and drinking bottles 24 hours before testing.
2. Prepare and calibrate the calorimetric apparatus to confirm the accuracy of the gas sensors and flow meters. Specifically prior to each experiment:
3. Apply known volumes of CO2 and O2 to determine the sensitivity of the gas sensors and flow meters.
4. Run a complete calibration protocol according to the manufacturer’s recommendations.
5. Provide each respirometry cage with sufficient food and water for a period of ~24 (or 48) hours.
6. Remove a mouse from its home cage and place on the weighing balance. Record the weight of the mouse.
7. Place the mouse into a respirometry cage with food and water available *ad libitum*.
8. Label the chamber with the corresponding subject identification and close it ensuring there is adequate air flow.
9. Initiate the calorimetric system for measurement:
10. Set up a new experiment in accordance with the manual (or load a file from a previous experimental setting).
11. Start recording measurements five hours before lights off for a total duration of 21 hours at minimum.Optional: 24 hours acclimation can be applied and the recording may continue for 48 hours.
12. The latency of CO2 and O2 activity transmitted and recorded is dependent on the number of chambers in use but will be logged periodically.
13. Generating a data report:
14. Upload all data from the experimentation including:

* Gas analysis VO2 and VCO2 (ml/h/animal)
* Heat production (kJ/h/animal)
* Periodicity of measurements taken throughout experimentation (Figure 1)
* Animal and the corresponding chamber that was used
* The respiratory exchange ratio (RER) can be calculated using the VCO2/VO2 ratio.

1. Activity parameters recorded will depend on the specification of calorimetric system used:
2. Ambulatory activity can be derived from the number beam splits during the session
3. Total activity can be derived from the number of fine movement (e.g. grooming behaviours) as well as ambulatory activity
4. An average of each of these parameters of activity is calculated hourly across the measurement period (between T-5 and T16).
5. Water and food intake (cumulative, hourly or total food and water intake, between T-5 and T16, will be computable depending on the calorimetric system used).
6. Remove each mouse from its chamber in turn at the end of the experimental session and record its weight. Return to their home cage.
7. Monitor the animals carefully to observe any abnormal behaviour(s). Ensure that food and water are available *ad libitum.*
8. Wash and wipe clean the chambers with warm water and dilute alcohol or appropriate disinfectant respectively.

**Figure 1. Daily workflow of calorimetric experimentation (Note:T0 designates start of dark cycle).**

## \*5. Notes

The system requires periodic calibration of the gas sensors and flow meters to ensure precise measurements. The calibration procedure consists of the application of a gas of known composition and adjusting control knobs in the front of the oxygen and carbon dioxide sensors to obtain readings that reflect the contents of the calibration gas. It is recommended that the system be calibrated prior to the start of each experiment. The analyzers should not be shut down if not urgently required for maintenance. If this has to be done a warm up time of at least 90 minutes is required for the gas sensors for calibration (refer to manufacturer’s manual). Calibrations and shut downs should be recorded in the laboratory journal.

Calorimetry test is to be performed before the ECG/ECHO test to avoid effects of hair removal on the calorimetry results.

### Data QC

1. Respiratory Exchange Rate (RER) is between 0.7-1.00
2. Mice show normal feeding and drinking behaviour
3. Mice show stable weight before and after calorimetry
4. Correct calibration of gases according to manufacturer’s manual

## \*6 . Measured Parameters - list

{Placed in Parameters spreadsheet}

## \*7. MetaData Parameters - list

|  |  |  |  |
| --- | --- | --- | --- |
| **Metadata** | **Example** | **Required for data upload** | **Required for data analysis** |
| Light Cycle | 12 hour cycle | YES | NO |
| Room temperature |  | YES | NO |
| Acclimation to respirometry cages | Yes (for how long?) / NO | YES | NO |
| Duration of test | 21 hours / 48 hours | YES | NO |
| Equipment ID |  | YES | NO |
| Equipment manufacturer |  | YES | YES |