School of Agriculture, Policy and Development

University of Reading

ENERGY COUNT(S)

Measuring energy expenditure in agricultural and rural livelihoods using accelerometer devices

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Innovative Methods and Metrics for Agriculture and Nutrition Actions

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ANH Academy 2018

OUTLINE

1. Setting the scene: Concepts and definitions
2. Using accelerometers in the field
   - Overview and Intuition
   - What accelerometers are and how they work
   - Practicalities (devices initialization, compliancy checks, survey designs of complementary questionnaires)
3. Data management
4. Presenting results
5. ‘I like to move it’
6. Group activity and discussion
7. Final reflections

WHY THE HUMAN ENERGY COMPONENT IS IMPORTANT IN NUTRITION RESEARCH (AND MORE GENERALLY IN AGRI-HEALTH ANALYSIS)?

SETTING THE SCENE: CONCEPTS AND DEFINITIONS

Fiorella Picchioni

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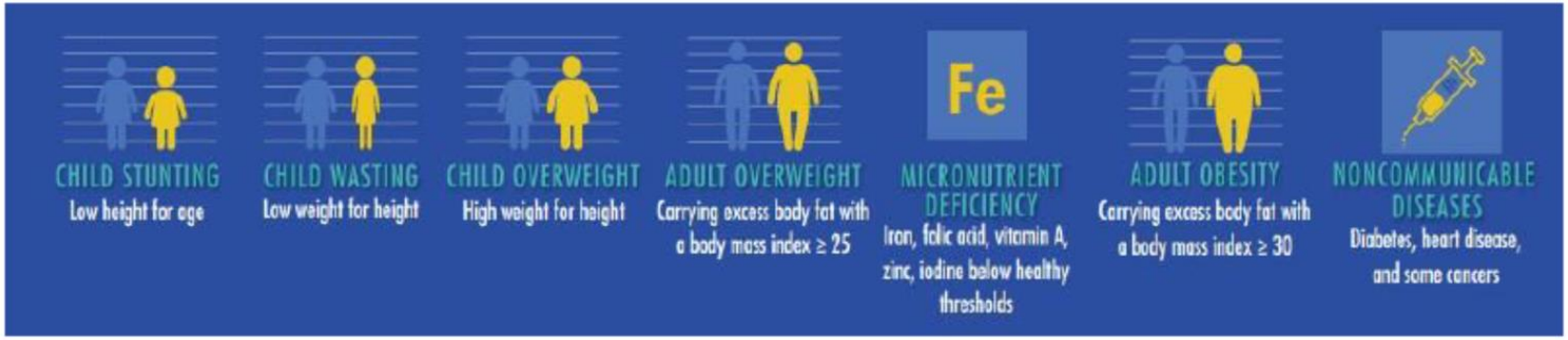
MULTIPLE BURDENS OF MALNUTRITION

- Undernutrition
- Hidden Hunger or Micronutrient deficiency
- Overnutrition and Obesity
- Non-communicable diseases (NCDs) – associated with unhealthy diets and lifestyles



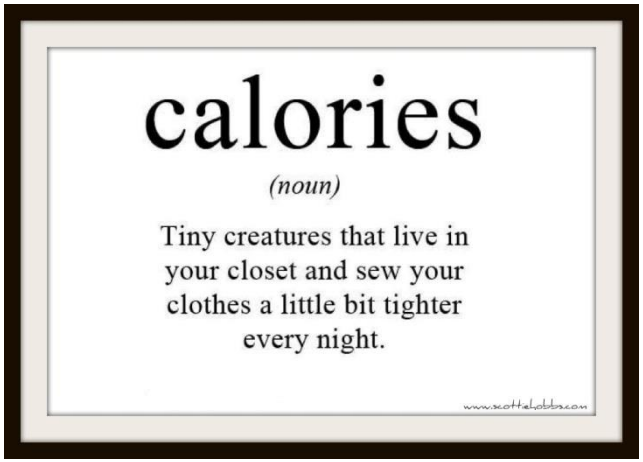
IFPRI
2016

BACK TO THE BASICS: WHAT IS A CALORIE?

Calories are units of work or heat

Popular definition:

100 calories is the amount of heat needed to bring 1 litre of water to the boiling point.



Source: Google Image

From food to calories:

- Calories are units of energy.
- Energy is the capacity to do work.
- Work can be chemical (biochemical, in this case) as well as physical (muscular).
- Biochemical reactions and muscle activity produce heat.

WHY DO WE NEED CALORIES?

Survival

- "Housekeeping" activity of our body
- Basal Metabolic Rate (BMR)
- BMR measurement and Resting Energy Expenditure (REE)

Warmth

- Thermic effect of food (TEF)
- When: Digesting and Metabolizing food
- Net Metabolizable Energy (or usable calories in foods)

Work

- Activity Energy Expenditure (AEE)
- Calories used in Physical Activity f(x) of intensity of the activity and body weight

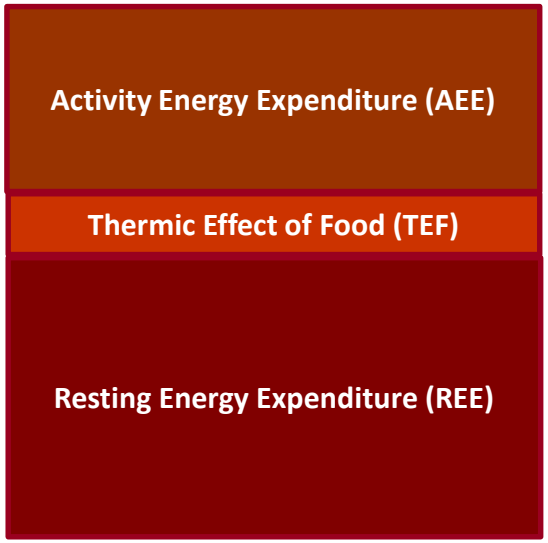
~ 60%

~ 10%

~ 30%

MEASURING ENERGY EXPENDITURE

Total Energy Expenditure (TEE)
TEE=AEE+TEF+REE



Heart Rate Monitoring
Accelerometery
Pedometry
Questionnaires
Diaries/Observations

Indirect Calorimetry

Doubly-Labelled-Water (DLW)

Physical Activity Level: ratio of
TEE (24h)/BMR or REE

Index of the intensity of physical activity (in 24h) relative to the BMR
(1.40 ~ 2.40)

MEASURING ENERGY EXPENDITURE

Measurement technique	Characteristics and Advantages	Limitations
Indirect Calorimetry	Precise, and calculate the consumption of oxygen. It is based on the relationship between consumption oxygen and production of energy that occurs during human energy metabolism	Difficult to use with free-living population since the experiments take place in laboratories and field settings
DLW	Considered the golden standard Chemical method for measuring the amount of exhaled carbon dioxide (analysed in biological samples - urine)	Does not quantify the activity type, intensity and duration It is expensive and therefore not suitable for large-scale studies
Heart Rate Monitoring	Major physiological marker for physical activity	HR is influenced by a wide range of factors unrelated to the activity Individuals differ significantly in movement efficiency (age and fitness). While there is a close relationship between HR and EE during exercise this is not the case during rest and light activity
Accelerometry	Motion sensor that detects acceleration of the body. Acceleration is defined as rate of change in velocity over time. So the intensity, frequency and duration of PA can be detected. Are objective practical and non-invasive, accurate and reliable and can be calibrated to each individual user.	Tend to underestimate EE compared to DLW Have lower sensitivity to sedentary activities Unable to register/detect static exercises and additional load carried by user.
Subjective Methods	They include: PAQ, activity diaries, direct observations and interviews	Rely on one's recollection and they state the perception of PA Tend to overestimate vigorous activity and underestimate time spent undertaking activities of daily living. Conversion of PAQs to EE using the Compendium relies on many assumption along the way and can produce biased results

QUIZ TIME

Discuss the following with your neighbour:

1. **What is the Basal Metabolic Rate (BMR)?**
2. **What is the Physical Activity Index and what are its advantages?**
3. **Discuss the pro and cons of Doubly-Labelled-Water (DLW), Accelerometry devices and Subjective methods**

USING ACCELEROMETERS IN THE FIELD

Paul Nkegbe, Yazidu Ustarz,
Fiorella Picchioni, Giacomo Zanello

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WHAT ACCELEROMETRY DATA CAN DO

- Data collected with accelerometers triangulated with other relevant data can be used to facilitate a better understanding of:
  i. The **prevalence, depth and severity of undernutrition** in rural areas in developing countries
  ii. The **intra-household, gender differentiated labour allocation and energy expenditure patterns**
  iii. The **link between agricultural development interventions and nutrition outcomes** for different members of rural households.

SCIENTIFIC JUSTIFICATION

1. The impact of **productivity-enhancing agricultural interventions** on nutrition and health outcomes in developing countries operates through **complex pathways**
2. Productivity-enhancing agricultural interventions impact the calorie deficits of the undernourished via their effects on **energy intakes** and **energy expenditure**
3. Energy expenditure dimensions have implications for **uptake of new agricultural technologies** (e.g. irrigation, new seeds varieties) and **intra-household allocation of labour**.

ENERGY EXPENDITURE IN LICS

- Traditionally energy expenditure has been captured with factorial method or Doubly-Labelled-Water (DLW) method
- Several studies from ‘60s and ‘70s involving small samples of rural households
- Only few studies in low-income countries have attempted to relate activities with energy expenditures, and none linking to time-use

ACCELEROMETERS DEVICES

- Accelerometers are devices that measure proper acceleration across the three axes (x, y, z).
- Acceleration can then be converted in movement and energy expenditure.
- It is based on physics: How much energy you need to move a body (you!) from A to B with the intensity of Q.

HOW THE ACCELEROMETERS CAPTURE PHYSICAL ACTIVITY (BIT TECHNICAL!)

- Tiny structures in the device produce electrical signals proportional to the acceleration it detects (data are sampled 30 times per second).
- Filtered to eliminate signals unlikely to be caused by human movement (vibration, temperature changes, electrical interference, car accidents, etc.).
- Further processing occurs to clean the signal and make it easier to interpret. Signals are summed across a user-defined period (the “epoch”- typically 1-3 mins) and an output read to the flash memory.

ACCELEROMETRY DEVICES

- Why ActiGraph GT3X+?
  - Non-intrusive and waterproof, and suitable for 24 hours continuous use in free living populations.
  - Rugged, no screen, no on/off switch. Little resale value
  - Adequate support and comprehensive software
  - Battery life of 30 days
- The reliability and validity of ActiGraph devices have been extensively assessed (Santos-Lozano et al., 2013; Sasaki et al., 2011) and these devices have been used in multiple studies involving free-living humans in various settings (Keino et al., 2014; Pawlowski et al., 2016)

WHICH DATA WE GET

- Minutes spent in different intensity categories
- Energy Expenditure
- Steps per day
- Inclinometer
- Light
- Pairing with hearth monitor

ACTIGRAPH: HOW TO WEAR IT

- Worn on waist, over right hip, snug fit.
- Over or under clothing.
- Please note the USB port must be placed at the top.

USING DEVICES ON THE FIELD: CHARGING AND INITIALIZATION

- The devices are always charged and initialized a day prior to the start of each round of data collection.
- The device is initialized using respondent's biodata (age, sex, height, weight).
- In the initialization process, there is a calendar (time and date) of start time and end time.
- Identification of devices by attaching pins to the belts.

COMPLIANCY

- Respondents understood clearly the nature and purpose of the survey.
- Choice of visiting hours.
- Choice of enumerators: understanding the local environment; ability to communicate in the local language; friendliness, commitment/dedication.
- A strict workflow, including checklists.
- Adequate training.
- Demonstration by wearing the device.
- Detection of idle moments.
- Incentives?

COMMUNITY ENGAGEMENT AND FEEDBACK FROM PARTICIPANTS

- **Community Engagement**
  - Community entry through the 'gatekeepers'.
  - Selection and sensitization of respondents: device records only energy output.
  - Cooking session to validate data on portion size.

- **Feedback (quotations from participants)**

"The project had not taken anything from us. We are rather at the receiving end. We went ahead with our normal daily activities while the project continues".

"Our friends teased us several times especially when any of the respondents fell sick or felt pains in any part of our body. People attributed such situations to the wearing of the devices".

"In the beginning I thought that, the devices were like some medical aid that could help us to do more work on the farm. The first day I wore it I worked so much on the farm so I thought it was due to the device but that was my perception anyway".

FEEDBACK

- Some respondents initially thought the devices could have some adverse effects on them.
- Some participants were concerned they were unable to see exactly what was recorded and only had to trust what they were told by the enumerators.
- Few participants thought the devices were like some medical aid that could help them to work more on the farm.
- Routine data collection also helped them take note of their daily activities and consumption.
- Participants held that information generated through the research would ultimately contribute to policy on energy consumption and thus improved welfare in northern Ghana.
- Even though intensive, they said the data collection process was flexible.

PHOTOS FROM THE FIELD

PHOTOS FROM THE FIELD

PHOTOS FROM THE FIELD

PHOTOS FROM THE FIELD

DATA MANAGEMENT

Giacomo Zanello

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ACCELEROMETRY DATA

- Accelerometery data alone is rather limited.
- Greater insights when data is triangulated.
- Importance of study design!

MULTIPLE SOURCES OF DATA - FILES

- Accelerometery data often is combined with other data, possibly collected with individual questionnaires.
- Benefit of collecting data electronically.
- Multiple dimensions of data: hourly data, daily, weekly, etc.
- Spend time developing a protocol for data management:
  - File names and identifier
  - Clear Stata do-files
  - Consistency across sources

PRESENTING RESULTS

Fiorella Picchioni

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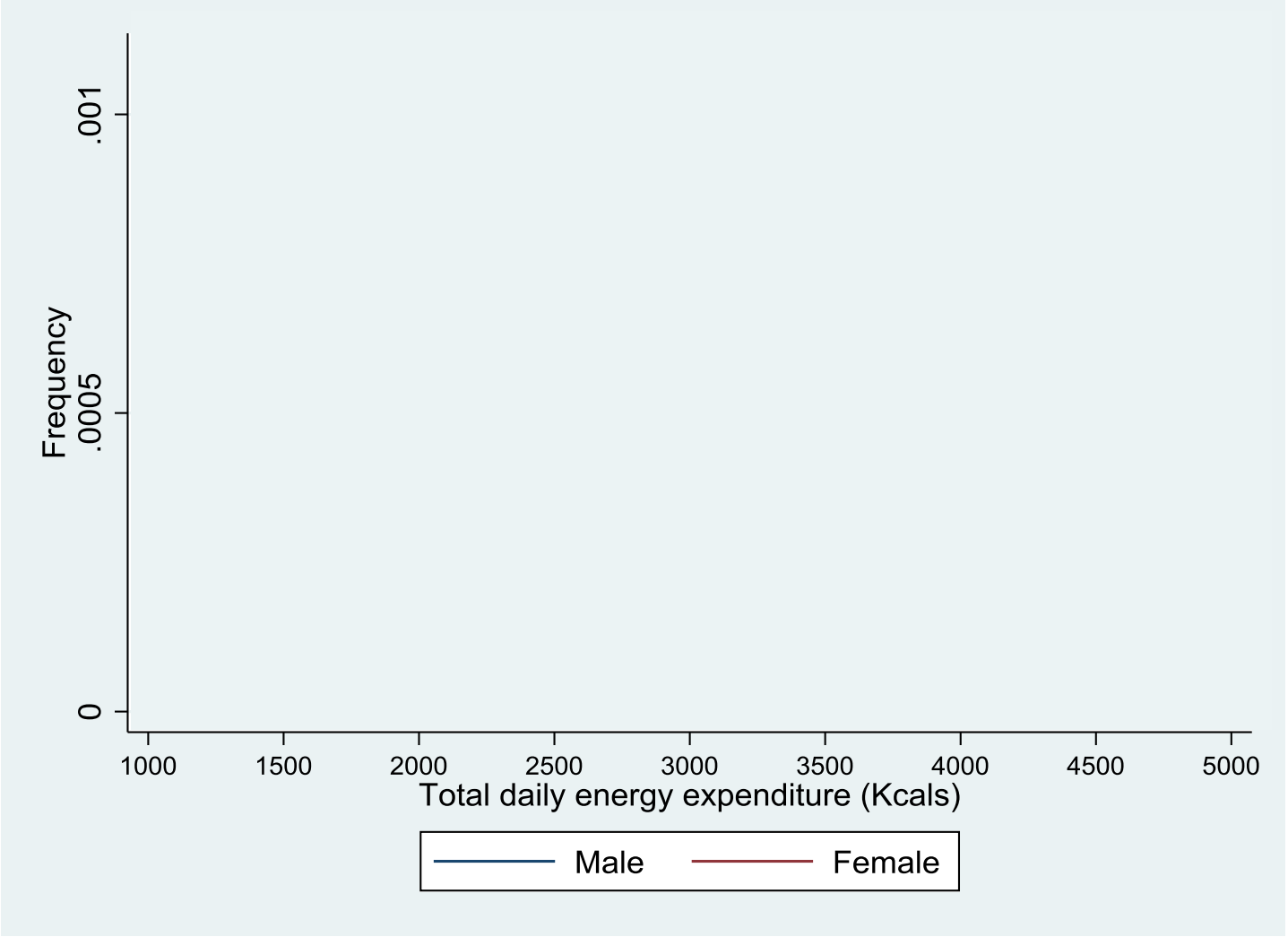
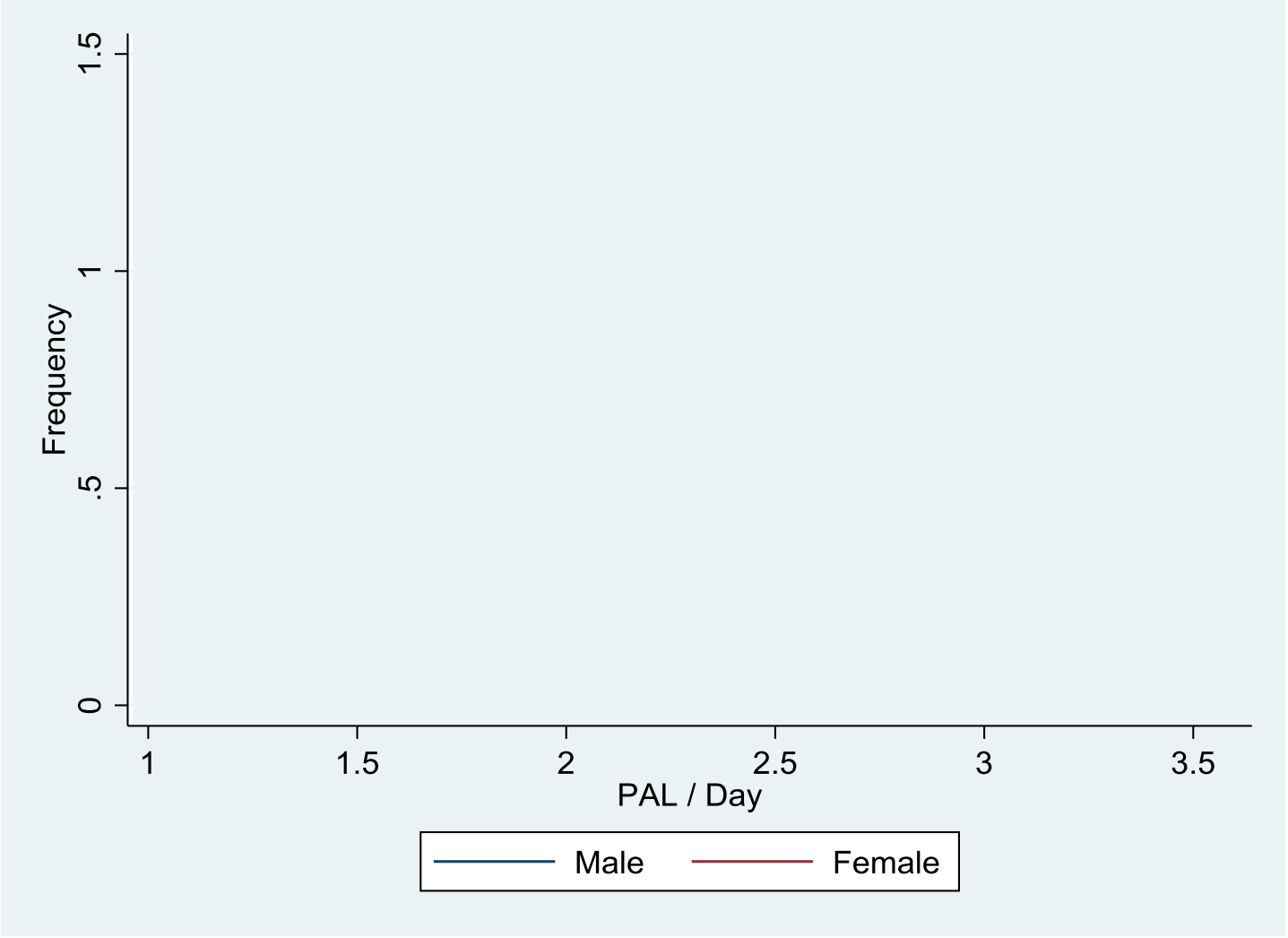
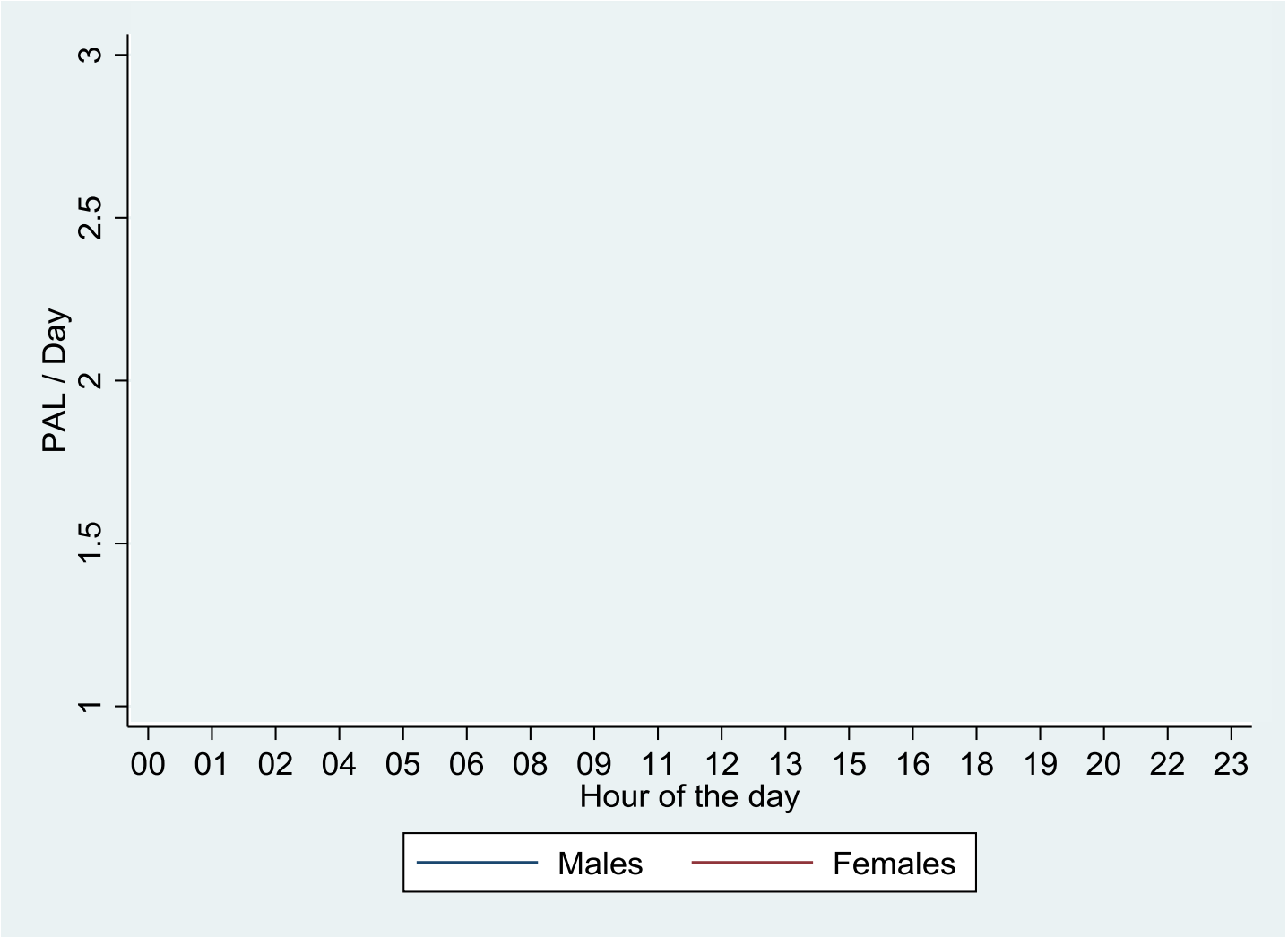
DISTRIBUTION OF TOTAL DAILY ENERGY EXPENDITURE (KCALS) BY GENDER



DISTRIBUTION OF PHYSICAL ACTIVITY LEVEL (PAL) BY GENDER



MEAN PAL FOR MEN AND WOMEN THROUGH THE DAY



ACTIVITY ENERGY EXPENDITURE AND PHYSICAL ACTIVITY LEVELS FOR DIFFERENT ACTIVITIES

	Males	Females		Full sample
	Mean	Mean	Difference	Mean
PAL	1.79	1.96	-0.171	1.88
Observations	1029	1151		2180

‘I LIKE TO MOVE IT’

I like to move it move it
I like to move it move it
I like to move it move it
Ya like to (move it!)

5

‘I LIKE TO MOVE IT’

- 6 volunteers will wear an accelerometer over lunch.
- We will download the data and look at the results afterward
- Do not change your own behaviour! No marathon, etc.

GROUP ACTIVITY

6

GUIDELINES

- Design research protocol for using accelerometry technology in nutrition and health analysis. Participants will select the target group, topic and nutrition challenge.
- Five sections:
  1. Problem Identification
  2. Target Group
  3. Location
  4. Study Design
  5. Expected Outcome

GUIDELINES

- Think of double burden of malnutrition.
- Think of different age-groups and life stages.
- Think of rural – urban.
- Think of animal – human exchange of labour.
- Which data can be triangulated with? Many dimensions: intra-household, labour, ill-health, adoption of technology… Think outside the box.

WRAP UP DISCUSSIONS AND ETHICAL ISSUES

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HOW THE ACCELEROMETER WORKS: WHAT YOU TELL PARTICIPANTS

- It records overall movement, much like a pedometer
- It is harmless – it runs on a battery, like your watch
- There is not an ‘on’ and ‘off’ switch
- It cannot tell what type of activity you are doing
- It cannot tell where you are, it is not a tracking device
- You do not need to be an ‘active’ person for the device to work
- “Movement meter” – it is just recording, not monitoring or measuring
- There is no screen to look at
- It is expensive for researchers, but has no street value

HOW THE ACCELEROMETER WORKS: DO NOT TELL PARTICIPANTS

- “The accelerometer will tell us how much you exercise, walk, etc.” (we do not want to influence activities)
- “Make sure to move a lot while you are wearing the device!”
- “You have a large farm so we expect the accelerometer to show you will be walking a lot”
- “It is OK to remove the accelerometer when you are not doing much since we are mostly interested in physical activity”
- “The accelerometer can tell if you are sitting around cooking, working on the field, etc.”