Using Accelerometers
in Low- and Middle-Income Countries

A Field Manual for Practitioners

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SUGGESTED CITATION

Zanello, G., Srinivasan, C. S., Picchioni, F., Webb, P., Nkegbe, P., Cherukuri, R., Neupane, S., Ustarz, Y., Gowdru, N., Neupane, S., and Wyatt, A. J. (2018). *Using Accelerometers in Low- and Middle-Income Countries: A Field Manual for Practitioners*. University of Reading. Reading (UK).

Version 1.2 – March 2019

INTRODUCTION

The way in which a rural and agricultural intervention or technology increases or decreases energy expenditure or re-distribution of labour within a household can influence adoption. The effect of an intervention or technology on energy expenditure is particularly important when the intended population that will benefit is undernourished. For example, a low-cost micro irrigation pump introduced to a community of smallholder farmers can have complementary effects on energy. On the one hand, farmers can irrigate their crops year-round, instead of relying on rainfall, with a potential increase of yields and incomes. On the other hand, the same smallholder farmers might spend more time in physically demanding labour, carrying the pump and watering their plots. The pump could have a positive effect on their income, but a negative effect on their nutritional status if the gains in productivity are not reflected in better access to food. Similarly, some new crop varieties can increase yields but also agricultural labour. An important policy and programmatic question is: do the benefits outweigh the shortcomings?

The design, targeting, and evaluation of policy and programmatic interventions aimed at improving the welfare of rural and agricultural households in low- and middle-income countries (LMICs) tend to be limited by the challenge of accurately measuring several important dimensions of agriculture and rural livelihoods. Specifically, this is because three types of data are missing:

- The individual effort or energy household members spend on economic and non-economic activities, which is known as human energy expenditure;
- How individuals spend their time; and
- How labour and food consumption is allocated to different members of the household and across different agricultural seasons.

All three areas are notoriously expensive and time consuming to measure at a population level. However, recent technological progress has resulted in the development of a number of new measurement tools and analytical methods that now make it possible to collect and analyse data on human energy expenditure at a scale not feasible before. Importantly, these methodologies do not need expensive labs and can be used at scale to survey free-living populations. This opens up the potential for new avenues to accurately measure energy expenditure and complement an important part of human health and nutrition research in LMICs.

Accelerometers are wearable devices that have the potential to transform our understanding of the rural household economy capturing key dimensions that have been largely 'unobserved'. Accelerometers help to capture changes in patterns of human energy expenditure - an important but unmeasured (and therefore not very well understood) part of rural and agricultural life in LMICs. As a result, they provide a new evidence base for improved design of policy and programmatic interventions aimed at the rural household economy in LMICs.

WHAT THIS FIELD MANUAL IS ABOUT

A research team led by the University of Reading prepared this field manual to assist those who are interested in collecting and analysing human energy expenditure data using wearable devices called accelerometers. We introduce a methodological framework to demonstrate how energy expenditure data from accelerometers can be integrated with data on time use and food intake to generate energy expenditure profiles. These profiles can help answer questions like how energy expenditure and labour patterns differ across different parts of the agricultural season, within households, and between men and women.

Using Accelerometers in Low- And Middle-Income Countries: A Field Manual for Practitioners is intended to be a guidance document that points out the most critical issues for consideration and good practices in the design, collection, management, and analysis of aggregated accelerometry data. This manual can help policy makers and programme implementers see how accelerometry data, combined with other types of data, can improve the design, targeting, and evaluation of agricultural interventions to maximize health and nutrition outcomes (**Box 1**).

The field manual is organized into five parts. Part A covers different approaches for capturing human energy expenditure and introduces the ActiGraph device that we use in our studies. Part B explains how to use accelerometers in the field. Part C provides an adaptation of the methodology, in particular, how accelerometry data can complement time use and food intake data to enhance our understanding of the relationship between these three dimensions. Parts D provides three illustrative examples of how the methodology was applied in Ghana, Nepal, and India. References cited throughout the manual are included at the end.

Box 1. Relevance of energy expenditure data to research, programmes, and policies focused on improving the welfare of rural and agricultural households

Modelling energy expenditure data within an efficiency framework can contribute to the development of the notion of "energy use efficiency" in rural livelihoods and its determinants. The protocols and methods presented in this field manual can be used to understand the short-term and long-term effects of ill health and disease on agricultural productivity and wage earnings. More generally, we envisage several applications of the methods in labour economics where effort is usually not observed or is empirically not measurable.

Combining energy expenditure data with food intake and time use creates more accurate assessments of the incidence, depth and severity of undernutrition and poverty. The assessment of the incidence of undernutrition and poverty is still often based on expenditure/consumption/dietary surveys using normative energy requirement figures (which may vary by age group or gender). Energy expenditure profiles can provide a better understanding of the influence of livelihood strategies and activities, environmental factors (e.g., climate and temperature), and access to health and physical infrastructure on energy expenditure patterns and inform better targeting of nutrition interventions.

With intrahousehold data, gender or age-differentiated impacts associated with the adoption of productivity-enhancing agricultural innovations can be better understood. The methodology described in this field manual can be used to understand gender differentiation in labour allocation decisions of rural households or in particular, how women's labour could change with the adoption of an agricultural technology. Gender or age-differentiated household labour allocation decisions may influence the willingness of households to adopt new agricultural technologies or practices. Insights can also be gained into the trade-offs between different livelihood activities – for instance, the intensification of women's labour in agriculture may involve reduced maternal time for childcare.

Empirical measurement of energy expenditure profiles can help delineate the pathways of impact from agricultural growth to nutrition outcomes. The link between agricultural development and nutrition outcomes in LMICs is the focus of a number of research programmes. A better understanding of energy expenditure can shed light on the disconnect between gains in agricultural productivity and improvement in nutrition outcomes.

MEASURING ENERGY EXPENDITURE

I n Part A, we cover different approaches for capturing human energy expenditure and explain how accelerometry devices can be a practical tool for measuring energy expenditure in rural and agricultural settings in LMICs. We introduce the ActiGraph GT3X device, the accelerometry device which we use in our studies. At the end is a list of useful definitions (**Box 2**).

PART A

CAPTURING ENERGY EXPENDITURE

Various techniques have been developed to measure human energy expenditure (**Table 1**). Most studies capturing energy expenditure in rural households in low and middle-income countries (LMICs) have used the doubly-labelled water method (Singh et al., 1989; Speakman, 1998). Even though it is the gold standard, the doubly-labelled water method is difficult to implement outside of a controlled setting because it requires participants to drink a specific amount of doubly-labelled water - water in which both the hydrogen and oxygen have been partly or completely replaced with an uncommon isotope of these elements so that as the body eliminates it, it can be tracked - and provide several urine samples over 7-14 days. Since it requires a controlled setting and can be quite expensive, this method is not very practical for population-level studies.

ACCELEROMETRY DEVICES

Accelerometry devices, or motion sensor devices, are another tool for measuring energy expenditure. Accelerometry technology has advanced in recent years providing a new opportunity to collect more accurate population-level data on energy expenditure. Algorithms to extract activity-related information from the devices and associated software to manage the large volumes of data generated enhance the potential for empirically measuring energy expenditure profiles at a large scale. As the devices are both wearable and durable, they are an ideal tool for collecting data in rural and agricultural contexts.

How do accelerometers work?

Very simply, accelerometry devices have a sensor that continuously captures movements, recording both the direction and intensity. The device detects and records both speed and direction of movements at a very high frequency, up to 30 times every second.

The movement data on its own cannot tell us how much effort the person wearing the device put into the recorded movement. For example, if the person wearing the device was walking 4 kilometres/hour carrying a handbag (i.e., something requiring little effort) or walking 4 kilometres/hour carrying 20 litres of water (i.e., something requiring much greater effort), the difference could not be detected. Moreover, the movement data from an accelerometer does not reveal the specific activity the person wearing the device was doing. Additional information can be collected to help answer these questions.

Using a validated algorithm, the movement data is translated into aggregate measures of activity intensity (light activity, moderate activity, vigorous and very vigorous activity) or energy expenditure (kilocalories). Once the algorithm is applied, the

Table 1. Different methodologies for capturing energy expenditure

TECHNIQUE	FEATURES	LIMITATIONS
Doubly-labelled water	• Gold standard • Chemical method for measuring the amount of exhaled carbon dioxide (analysed in biological samples)	Does not quantify activity type, intensity or duration; not suitable for large-scale studies; expensive
Indirect calorimetry	• Precise. Calculates the consumption of oxygen, based on the production of energy that occurs during human energy metabolism	Difficult to use for large-scale studies since the experiments take place in laboratories
Heart rate monitoring	• Major physiological marker for physical activity	Influenced by a wide range of factors unrelated to activity; individuals differ significantly in movement efficiency (age and fitness)
Accelerometry	• Objective, practical, non-invasive • Detects acceleration of the body, i.e the intensity, frequency and duration of physical activity	Tends to underestimate energy expenditure compared to doubly-labelled water method; lower sensitivity to sedentary activities; unable to detect static exercises and additional load carried by user
Subjective methods	• Physical activity questionnaires (PAQs), activity diaries, direct observations, and interviews	Relies on one's recollection of and perception of physical activity; conversion of PAQs to energy expenditure using the compendium relies on many assumptions and can produce biased results (Ainsworth et al., 2011)

translated data provide information on minutes spent in different intensity categories and estimates of energy expenditure, pieces of information that get us closer to answering some of the questions we have about the health and nutritional status of people living in rural and agricultural settings.

The ActiGraph device

In our studies, we use the ActiGraph GT3X+ device, a research-graded accelerometer. The device is small, like a wristwatch, rugged and water resistant, and suitable for 24 hours of continuous use. It can be attached to an elastic belt and worn around the waist, under or over clothing. There is no screen, nor an on/off switch. These characteristics make it suitable for research in LMIC settings. Even though we do not list them here in this manual, there are many other accelerometry device options available for research.

Before use, the device is initialized using a desktop or laptop computer and basic characteristics about the participant are entered: unique identifier or number, plus the participant's sex, age, height, and weight. After initialization, the ActiGraph device continuously tracks and stores movement data

whether or not it is being worn until the battery runs out or the internal memory used to store the data is full. The device has a battery life of 15-30 days and can be recharged via a USB. ActiGraph has enough memory to store up to 30 days of data, depending on how frequently data are being collected (e.g., 100 hertz is the maximum frequency).

ActiGraph devices are validated and tailored for research application. Unlike most commercial devices, ActiGraph provides access to the raw accelerometry data, with proprietary software support for data management and analysis. The data is downloaded using the ActiLife software directly from the device via a USB to a desktop or laptop computer. The software can be used to manage the data (e.g., converting the movement data to calories and validating whether or not the device was worn). Data can then be exported for analysis or for storage in a compressed format.

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).

Box 2. Useful definitions

ACCELEROMETRY DEVICES refer to activity monitor devices that use motion sensors to continuously capture movements both in intensity and direction.

CALORIES are units of heat or work energy, commonly used as a measurement of the amount of energy that food provides. Energy is stored in the chemical structures of some of its molecules (mainly proteins, fats, and carbohydrates).

BASAL METABOLIC RATE (BMR) refers to the number of calories required to support basal physical functions each day. Basal functions represent the number of calories needed to fuel the brain, heart, lungs, kidneys, nervous system, and everything else that happens automatically to keep bodies alive without conscious muscle activity. The BMR is a function of age, sex, body size and body composition.

ACTIVITY ENERGY EXPENDITURE (AEE) represents the calories used to perform different forms of physical activities. AEE is a function of the intensity of activity and of body weight.

TOTAL ENERGY EXPENDITURE (TEE) is the sum of BMR, AEE and of the Thermic Effect of Food (TEF – or the energy needed to digest and metabolise food). Unless an individual engages in a great deal of physical activity, the BMR accounts for almost one-third of total caloric needs. On average, AEE represents 30% of TEE and TEF accounts for approximately 10%.

PHYSICAL ACTIVITY LEVEL (PAL) is the ratio of TEE to BMR and provides an index of the relative excess output related to physical activity. More simply, PAL is a measurement of the intensity of physical activity corrected for age, sex and body size. This feature makes PAL a suitable measure to compare the intensity of work across populations. Typical PAL values in free-living adults range from 1.40 to approximately 2.40.

TIME-USE SURVEYS refer to statistical methods aiming at measuring "the use of time by women and men, particularly in relation to paid and unpaid work, market and non-market activities, and leisure and personal time" (European Commission, 1998, p. 54). Time-use information can be gathered in different ways, such as time diaries or interviews.

USING ACCELEROMETRY DEVICES

PART B

This section describes how accelerometry devices can be used in research studies or evaluations to relate physical activities to energy expenditure. At the end, we list a few examples of recent applications in health research in LMICs (**Table 2**).

ETHICAL ISSUES

As in any research involving human subjects, ethical review is needed before data collection begins. The required ethical approvals for research can be obtained from the appropriate institutions and in-country agencies. As part of the review process, research plans and instruments may be submitted with the application, as well as copies of the informed consent forms provided to the participants. Accelerometry devices may be a technology that reviewers are not familiar with and therefore additional information about the nature of the technology and how it will be used may be needed. Likewise, the informed consent process should provide participants with all the information required about the study design and the technology.

ENUMERATOR TRAINING

Data quality depends a great deal on the skills and commitment of the enumerators, which is true in any household survey. We suggest a minimum of 3-4 days of training prior to beginning field work, so enumerators are confident and competent in deploying accelerometry devices and collecting anthropometric data. The training should include mock surveys, practice on initialising the devices and then downloading the data to a desktop or laptop computer. It can also be useful to provide hard or soft copies of the training materials to the enumerators, so they can refer to them throughout field work.

Antony N-yalkabong, an enumerator from the Ghana study team, demonstrates during a training session how partici-pants should wear the accelerometer.

Helpful Hints for Addressing Participants' Concerns about Wearing Accelerometers

- ✓ It is important to emphasize to participants that the devices record overall movement (much like a pedometer) but cannot detect what type of activity they are doing nor their location.
- ✓ We have found it is useful to explain that the technology runs on a battery, like a watch, and participants do not need to be an 'active' person for the device to work.
- ✓ As much as possible, the informed consent process should address concerns and questions about the technology so that when participants are wearing the accelerometry device, they do not deviate from their normal behaviour.

Helpful Hints for Selecting Enumerators

- ✓ Fluency in local dialects, which helps in building trust with participants and encouraging their compliance.
- ✓ Computer literacy, which is fundamental for electronic data management and if complementary data are being collected electronically through computer assisted personal interviewing (CAPI) technology.
- ✓ Commitment and dedication. Waking up very early in the morning to reach the communities and interview participants before they start their daily activities calls for total commitment .

Two participants from our study site in India gave us permission to photograph them performing daily activities, such as preparing food and doing household chores, while wearing the ActiGraph device. In both photos, the women are wearing the device over their clothes, on an elastic belt around their waists.

SAMPLING

Sampling guidelines will depend on the overall objectives of the study. In several of our studies, we compare two agricultural systems - rainfed and irrigated agriculture. We stratify a random sample of households, based on the size of the land being cultivated, into three groups: smallholder, medium, and large-holder. In terms of participants, we select individuals who are able-bodied and available to complete the entire study. We also select two participants - one man and one woman - in each household so that comparisons on intra-household allocation of labour can be made.

DATA COLLECTION

Like sampling, data collection will depend on the overall objectives of the study. In our studies, we ask each participant to wear the accelerometry device for four non consecutive weeks across the agricultural season corresponding to (1) land preparation, (2) sowing, (3) maintaining (e.g., activities related to irrigation, weeding, fertilising), and (4) harvest. The accelerometry literature recommends 4-7 days of wear (Hart et al., 2011). In our studies, we ask participants to wear the devices for 7 days to account for periods of non-wear.

Helpful Hints for Collecting Accelerometry Data

✓ Before starting data collection, a series of community meetings can facilitate the acceptance of the field team and a communal demonstration on how the accelerometry devices work. In one of our studies, a participant from one of the pilots shared his experience with the community and answered their questions.

✓ Constant communication between enumerators, field coordinator, and research team provide a platform to mitigate any problems before they arise. During data collection, our research team provides help and guidance on a daily basis remotely through live messaging.

✓ The nature of the data collection, i.e., daily visits, allow the enumerators to build strong ties with the participants and a routine that facilitate data reporting.

Table 2. Recent examples of ways accelerometry devices have been used in health research in LMICs

COUNTRY	POPULATION	CITATION
Brazil	Three birth cohorts: adults (mean age 30.2 years); adolescents (mean age 18.4 years); and children (mean age 6.7 years)	da Silva et al. (2014)
Cameroon	Adults (25-50 years old)	Assah et al. (2009)
Ghana	Farmers (21-66 years old)	Zanello et al. (2017)
India	Adolescents (mean age 15.8 years)	Corder et al. (2007)
	School children (8-9 years old)	Krishnaveni et al. (2009)
Nigeria	Adults	Akogun et al. (2017)
South Africa	Adult women (mean age 32.6 years)	Cook, Alberts, & Lambert (2012)
	Infants and toddlers (3-24 months)	Prioreschi et al. (2017)

DATA MANAGEMENT

Accelerometry data are likely to be collected along with basic demographic information about the household and individual participants. As a result, there will be three streams of data that have to be managed separately before aggregating for analysis. Before the data collection begins, a protocol for data management should be developed with guidelines for (1) naming files and identifiers, (2) creating annotated Stata do-files, and (3) maintaining consistency across datasets.

   With ActiLife, the proprietary ActiGraph software, the accelerometry data are exported from the device to a desktop computer or laptop. In order to reduce computational time, experts suggest compressing the 30 hertz raw data to 3 second epochs, which will not result in significant loss of accuracy for the activities typical of the population in the sample (Chen and Basset, 2005). Next, each profile is processed in order to detect periods of 'non-wear' that will be excluded from the analysis (Choi et al., 2011). Raw data can then be exported to text files or aggregated to one-hour intervals that include the computation of the energy expenditure and cut points to classify

physical activity into light, moderate, vigorous, and very vigorous (based on Sasaki et al., 2011). Lastly, the Basal Metabolic Rate for each individual can be computed and embedded in the dataset (Harris and Benedict, 1918).

Helpful Hints to Reduce Potential Loss of Data

✓ Re-charge tablets and accelerometry devices at the end of each round of data collection.

✓ Upload completed questionnaires from the tablet to an encrypted server regularly.

✓ Update compressed data from the accelerometry devices to an encrypted server and create two backups of each raw data file.

✓ Regularly monitor the data that has been uploaded to check data integrity.

✓ Use checklists to enforce a strict work flow throughout the data collection.

✓ Back up, back up, and back up.

OUR METHODOLOGY

PART C

When combined with other kinds of data, accelerometry data have even more potential in research and programme monitoring and evaluation. In our studies, we triangulate accelerometry data with food intake and time-use data to improve our understanding of the links between undernutrition, labour patterns, and energy expenditure (**Figure 1**). In Part C, we describe how food intake and time use can be measured (**Table 3**) and explain the methodology we applied in our studies to triangulate these three sources of data.

DATA COLLECTION

Our data collection work flow is illustrated in **Figure 2**. On the first day, an enumerator visits the household and administers the household questionnaire. One man and one woman from the household are selected based on their willingness to wear the accelerometry devices for 7 full consecutive days. When possible, the head of the household and his or her spouse are invited to be part of the study. An individual questionnaire is administered to the man and the woman and anthropometric measures taken. Then, after initialising the devices, the enumerator gives one to each participant with instructions to wear it all the time - except when bathing or sleeping - for the next 7 days.

On each of the following 6 days, the enumerator returns to the household to administer the individual questionnaire to the man and the woman wearing the accelerometry devices. On the eighth day, the enumerator returns to the household and administers the last day individual questionnaire to the man and the woman and collects the devices from the
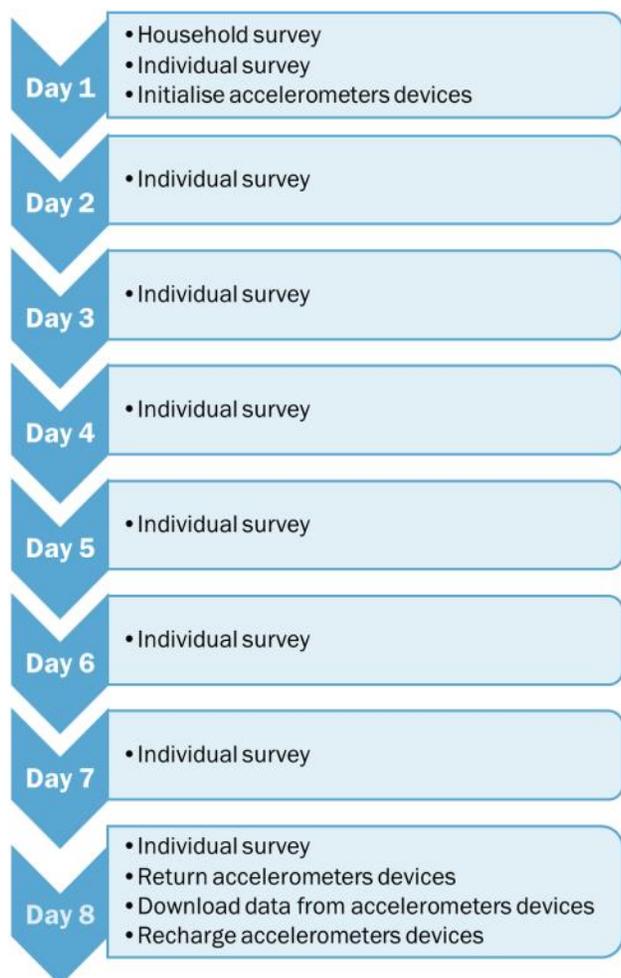

**Figure 2. Data collection work flow**
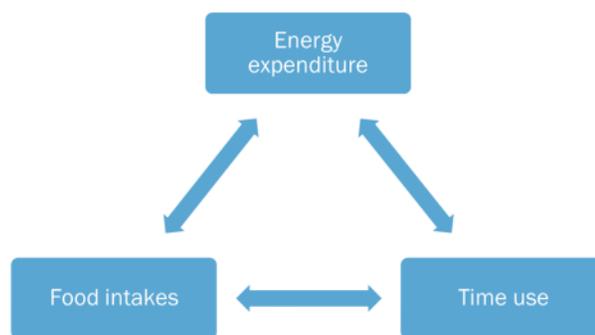
Figure 1. Triangulation of data

participants. On average, each individual interview takes around 30 minutes.

Data collection occurs throughout the agricultural season, so the enumerator returns during another 8-day period in a different agricultural season to repeat this protocol with the same individual household members. If feasible, we recommend that all survey data be collected electronically using CAPI.

DATA MANAGEMENT

The three datasets should be managed and cleaned separately before aggregating for analysis.

1. The **accelerometry** data records the participant's movements and can be converted into energy expenditure (kilocalories) and compressed in hour intervals, which was described in Part B.

2. Data from the **household questionnaire** captures a wide range of household level information, including household composition, dwelling characteristics (as part of a wealth index), employment and labour force activities, land and agriculture, livestock, assets ownership, decision-making in the household, and access to infrastructure.

3. The **individual questionnaire** administered on Day 1 collects anthropometric data (height and weight) and information on general health.

As part of the individual questionnaire, the **24-hour dietary recall module** collects information from the individual participants about the type and amount of food and beverages they consumed at each meal (breakfast, mid-morning, noon, mid-afternoon, evening, before going to bed) in the prior 24-hour period. When culturally appropriate, the enumerators provide participants a set of dishes and cutlery to use during the study period so that consistent portion

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In one of the cooking sessions held in the study site in Ghana, participants were invited to attend and prepare dishes that are regularly consumed in their households. The ingredients, amounts, and preparation methods were recorded and later combined into a recipe book, which is used by our study team as part of analysis of the 24-hour dietary recall data.

sizes can be recorded across households. Then, the weight of the cooked dish consumed is converted into energy (calories) and main nutrients using conversion tables. The description of different food items and dishes consumed can be standardised based on the knowledge of local enumerators.

In our studies, we organize cooking sessions in which participants cook common dishes. We compile the details into a recipe book, which we use to validate or integrate with freely available country-specific food composition tables. For Ghana, we refer to the National Nutrient Database for Standard Reference (USDA, 2017); for Nepal, we refer to Harris-Fry et al. (2018); and for India, we refer to Bowen et al. (2011).

The **individual activity module** collects information to match the hour-intervals of the accelerometry data. Time-use data is recorded in 1-hour time slots and lists primary, secondary and tertiary activities (if any). A pre-compiled list of activities can be provided, or each participant can freely report his/her activities. The latter approach increases the overall time for administering the questionnaire, yet it provides more granular details of the activities. If this approach is followed, at this stage, the activities are coded in previously defined categories of 'macro activities' and 'micro activities' that fit within the local context (Antonopoulos and Hirway, 2009). For example, our study has produced more than 2,000 activities that we have categorized into groups of 5 macro activities and 21 micro activities (**Box 3**).

Match and aggregate all three datasets using a unique identifier, or ID, that captures the field site ID,

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Box 3. Categories of micro- and macro-level activities identified from the time-use data

✓ **Domestic activities**: Child/adult care; getting services; household chores (e.g., cooking, cleaning, fetching water or firewood); and travelling

✓ **Economic activities**: Crop production (activities in the field, e.g., seeding, ploughing, harvesting); livestock (looking after animals); marketing (e.g., selling products); off-farm processing (e.g., cracking groundnuts, boiling shea nuts); and travelling

✓ **Individual activities**: Eating; leisure (e.g., playing musical instruments, watching TV, reading); medical care; personal care (e.g., bathing, hair care); and travelling

✓ **Sleeping and resting**: Resting; sleeping

✓ **Social activities**: Eating; religious activities (e.g., funeral, naming ceremony, praying, church service); social-community; and travelling

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household ID, individual ID, week ID, day ID, and hour ID. For each participant, the daily accelerometry data is merged with the individual time-use data, both recorded in 1-hour intervals. Additional information to contextualize each observation is added from the individual-level questionnaire (e.g. sex, age, education) and household questionnaire (e.g. household composition, wealth, land size). Based on the level of the analysis, the hourly-based dataset can be compressed at the level of day, week, or individual.

Table 3. Characteristics of methods for measuring food intake and time use

	FOOD INTAKE	TIME USE
Recommended method	24-hour dietary recall (Gibson and Ferguson, 2008)	Time-use questionnaire adapted from the time-use module in the Women's Empowerment in Agriculture Index (WEAI), (Alkire et al., 2013)
Characteristics	• An enumerator uses a structured interview to ask the participant to recall the type and amount of all food and beverages consumed in the previous 24-hour period • Data can be used to assess dietary patterns, food groups, or nutrient intake • Food data must be matched with nutrient information from food composition tables or database in order to analyze the nutrient content	• Through a structured face-to-face interview administered by an enumerator, a participant recalls how s/he spent the previous 24-hour time period in one-hour increments (Antonopoulos and Hirway, 2009) • The narrative nature of the interview prompts participants to recall activities around the common parts of a day (sunrise, meals, sunset) in longer periods of time (1 hour) versus shorter ones (15 minutes), both which help mitigate recall errors
Other methods	Food frequency questionnaire Weighed food record	Direct observation

The energy expenditure data recorded by the ActiGraph devices can be exported into MS Excel using the ActiLife software. Using CAPI technology, the data from the household and individual questionnaires can be imported directly into STATA and merged with the accelerometry data. The unique identifier, or ID, assigned to each participant is the key to merge the various streams of data.

All the datasets – from the accelerometer, the household survey, and the individual survey – can be cleaned and consolidated using STATA. Aspects of data cleaning include translating and classifying activities and addressing compliancy issues with accelerometry devices. For example, we exclude days in which the participants have not worn the devices for more than 3 hours in a day.

Once data collection is complete, ActiGraph devices are returned and our study team puts them in a small bag, labelled with the household ID and the individual participant's names and IDs. Once the data is downloaded, the bags are destroyed and the ActiGraph can be re-initialized for a new participant.

DATA ANALYSIS

We used Stata 15 for both data management and analysis (StataCorp, 2017). **Figure 3** illustrates how the different datasets are managed and analysed and more details on the analysis can be found in the case studies (Part D).

Step 1: Hourly Level Data

Hourly Individual time-use data

ID

Hourly Accelerometry data

Merge
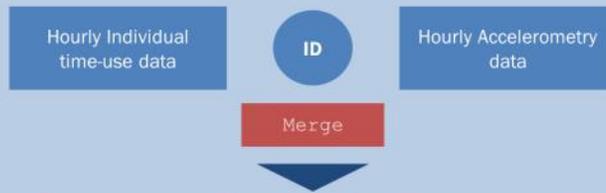
ID	Day	Hour	Activity	AEE/hr (kcals)
ID 1	Day 1	07.00		
ID 1	Day 1	08.00		

Step 2: Daily Level Data

Collapse

Daily data on energy expenditure

ID

Individual Information

Merge
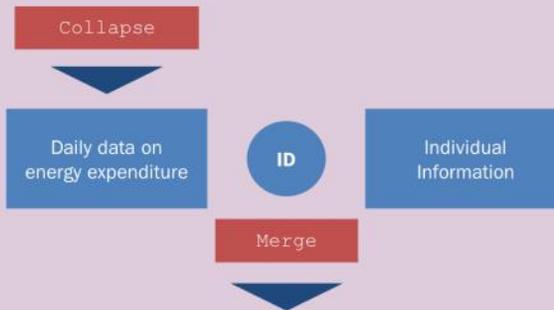
ID	Day	Age	Kcal Intake	AEE/hr (kcals)
ID 1	Day 1			
ID 1	Day 2			

Step 3: Individual Level Data and Household Information

Collapse

Individual data on energy expenditure

ID

HH Survey

Merge
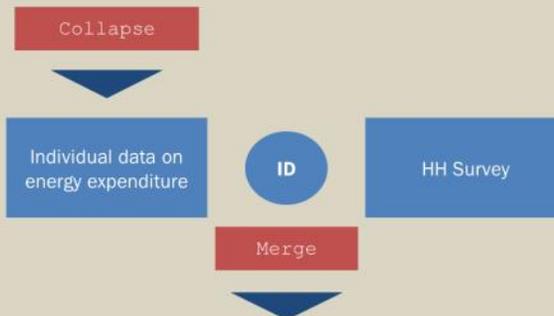
ID	Individual Info	HH Info
ID 1		
ID 2		

Legend

STATA command

ID: Unique identifier at the appropriate data level

Figure 3. Flow chart describing different levels and steps for merging the triangulated data

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CASE STUDIES

P art D concludes the manual by offering an overview of our case studies in Ghana, Nepal and India. Each section provides a concise description of the study context and information on the sample population. This is followed by descriptive statistics on information derived from accelerometer devices and activity data. Finally, we expose readers to three different applications of the technology (one for each case study) by providing different examples of how accelerometry data can be interpreted and integrated with other sources of information.

PART D

GHANA

CONTEXT

Data on energy expenditure and time use were collected from 20 households from two villages (one irrigated and one rain-fed) in Wa municipality in the Upper West region in northern Ghana. The Upper West region in Northern Ghana is part of the guinea savannah vegetation belt dominated by grassland with scattered drought resistant trees. The area's economy is agrarian with about 80% of the population engaged in agriculture. The major crops grown in the area are maize, sorghum, millet, groundnut and cowpea. Goat, sheep, pigs and poultry are the main livestock in the area. The area is characterised by one rainy season, from May to September. Conditional to regular rainfalls, land preparation tends to start in mid-May, immediately followed by sowing and planting. The harvest occurs in September. According to the Ghana Statistical Service (2017), the incidence of poverty in the Upper West region of Ghana where the selected communities in our study are located, is the highest in the country – 70.9%.

In each household, the head and the spouse were interviewed, and both were asked to wear the accelerometry devices for four non-consecutive weeks across the agricultural season. The survey covered four main agricultural stages: land preparation, sowing/seeding (e.g., ploughing and transplanting), land maintenance (e.g., weeding) and harvesting. The survey was implemented between May and October in the rain-fed village and again between January and May in the irrigated village.

SAMPLE

The households selected for the survey were rural with agriculture as their principal source of livelihood and income (**Table 4**). All households surveyed were headed by men and nearly one-fifth reported being literate. The average household size was 7.59 members. A household was defined as all individuals living together and eating from the 'same pot'. This is slightly higher than the average household size recorded for rural Wa municipality in the most recent census, which was 6.4 persons (GSS, 2014).

All households reported having access to agricultural land with an average holding of 4.52 acres. In terms of access to infrastructure, all-weather roads were an average of 3 kilometres (km) from the participants'

Table 4. Descriptive characteristics of households in Ghana

CHARACTERISTICS	MEAN	SD
Age of the household head (years)	39.09	(9.56)
Literacy of the head (%)	0.18	(0.39)
Household size	7.59	(3.69)
Number of adult males in the household	2.18	(1.47)
Number of adult females in the household	2.41	(1.47)
Number of children in the household	4.32	(2.59)
Total land holding (acres)	4.52	(3.85)
Distance from the nearest all-weather/tarmac road (km)	2.50	(2.25)
Distance from the nearest local trading centre (km)	5.93	(2.40)
Distance from the nearest major products market (km)	3.68	(2.79)
Number of households	20	

homes and the nearest major products market was almost 4 km. However, the nearest local trading centres were even farther, almost 6 km.

RESULTS ON ENERGY EXPENDITURE AND OTHER MEASURES OF PHYSICAL ACTIVITY

Table 5 reports some of the information derived from the accelerometry devices and summarises the descriptive statistics, anthropometric and activity data. Information is presented for men and women who wore the accelerometry devices and answered the time-use questionnaires for a period of four non-consecutive weeks. (Technical terms are defined in **Box 1** of this manual on page 2).

In this sample, men were significantly taller and weighed more than women, while the average body mass index (BMI) among women was significantly higher than among men. The average total energy expenditure (TEE) and activity energy expenditure (AEE) of men were significantly higher than that of women. The basal metabolic rate (BMR), namely the energy needed for the survival of the body, is expected to be generally lower for women compared to men. However, when the physical activity level (PAL) was calculated across the sample (TEE/BMR), the average PAL among women was significantly higher than the

average among men. This means that given their BMR, women in this sample were more active than men even though the average TEE among men was higher.

In addition to energy expenditure levels and indicators of physical activity, the accelerometry devices indicate the percentage of the movements that fall under the definition of light, moderate, and vigorous activities. In this sample, 85% of the activities undertaken were categorized as light, 13% were categorized as moderately active, and 2% of the recorded movements were categorized as vigorous. On average, women in the sample were engaged in a significantly higher percentage of moderate activities than were men.

On average, very few days of data had to be omitted as a result of individuals not wearing the devices for more than three hours on a given day. We analysed 26.82 days of data from men and 25.89 days of data from women.

ENERGY AND TIME

The proportion of energy expenditure and time use related to different activities for men and women is presented in **Table 6**. For the classification of

Table 5. Anthropometric and activity data of participants in Ghana, by gender

	MEN (n = 20; days=556)		WOMEN (n = 20; days=531)			FULL SAMPLE (n = 40; days=1,087)	
	MEAN	SD	MEAN	SD	DIFFERENCE	MEAN	SD
Age (years)	39.64	(9.15)	33.06	(7.77)	6.57***	36.43	(9.11)
Height (cm)	172.62	(5.91)	162.77	(7.55)	9.84***	167.81	(8.36)
Weight (kg)	61.86	(5.05)	56.86	(4.78)	5.00***	59.41	(5.52)
Kcal intakes (kcals/d)	2,107.56	(762.50)	1,902.84	(733.79)	204.7***	2,007.56	(755.24)
BMI (kg/m^2)	20.76	(1.30)	21.52	(2.08)	-0.76***	21.13	(1.77)
AEE (kcal/d)	1,164.13	(474.43)	1,100.13	(333.81)	64.00*	1,132.86	(412.84)
TEE (kcal/d)	2,668.36	(509.54)	2,359.69	(358.95)	308.7***	2,517.57	(468.39)
BMR	1,504.23	(100.76)	1,259.56	(93.15)	244.7***	1,384.71	(156.19)
PAL	1.77	(0.30)	1.88	(0.27)	-0.10***	1.82	(0.29)
Light activity (%)	0.85	(0.05)	0.84	(0.05)	0.01***	0.85	(0.05)
Moderate activity (%)	0.13	(0.05)	0.14	(0.04)	-0.01***	0.13	(0.05)
Vigorous activity (%)	0.02	(0.02)	0.02	(0.01)	0.00**	0.02	(0.02)
Steps/day	14,676.27	(5,250.29)	16,797.64	(5,702.04)	-2,121.4***	15,712.56	(5,574.97)
Number of days	26.82	(3.64)	25.89	(4.38)	0.94***	26.37	(4.05)

Statistics based on day-level data in which non-wearing time is less than four hours between 7am and 9pm. Asterisks show level of significance: ***= significant at 0.1%, **=significant at 1%, and *=significant at 5%.

Table 6. Average Energy Expenditure and time use by activity and by gender (ratios)

	MEN		WOMEN		FULL SAMPLE	
	AEE	TIME	AEE	TIME	AEE	TIME
Domestic activities	*0.03*	*0.02*	*0.28*	*0.18*	*0.15*	*0.10*
Child/adult care	0.00	0.00	0.02	0.02	0.01	0.01
Getting services	0.00	0.00	0.00	0.00	0.00	0.00
Household chores	0.03	0.02	0.26	0.17	0.14	0.09
Travelling	0.00	0.00	0.00	0.00	0.00	0.00
Economic activities	*0.66*	*0.37*	*0.45*	*0.26*	*0.56*	*0.31*
Crop production	0.40	0.20	0.22	0.13	0.32	0.16
Livestock	0.01	0.01	0.00	0.00	0.01	0.00
Marketing	0.03	0.02	0.03	0.02	0.03	0.02
Off-farm	0.03	0.02	0.01	0.00	0.02	0.01
Processing	0.04	0.03	0.07	0.04	0.05	0.04
Travelling	0.14	0.09	0.13	0.07	0.13	0.08
Individual activities	*0.07*	*0.06*	*0.09*	*0.07*	*0.08*	*0.07*
Eating	0.02	0.02	0.03	0.02	0.03	0.02
Leisure	0.01	0.01	0.01	0.01	0.01	0.01
Medical care	0.00	0.00	0.00	0.00	0.00	0.00
Personal care	0.04	0.03	0.06	0.04	0.05	0.04
Travelling	0.00	0.00	0.00	0.00	0.00	0.00
Sleeping and resting	*0.11*	*0.44*	*0.08*	*0.41*	*0.09*	*0.43*
Resting	0.10	0.14	0.07	0.12	0.09	0.13
Sleeping	0.01	0.30	0.00	0.30	0.01	0.30
Social activities	*0.14*	*0.12*	*0.09*	*0.07*	*0.11*	*0.10*
Eating	0.01	0.02	0.02	0.02	0.02	0.02
Religious activities	0.03	0.02	0.02	0.01	0.03	0.02
Social-Community	0.05	0.05	0.02	0.01	0.04	0.03
Official (survey)	0.01	0.02	0.02	0.02	0.01	0.02
Travelling	0.03	0.02	0.02	0.01	0.02	0.01

activities, please refer to **Box 3** in Part C. We report this table as an example of the nature of the data and analysis that can be produced by triangulating accelerometer data with time-use information.

The entire sample devoted most of their time and energy to economic activities and this was true for men and for women. The average AEE for men was 66% and they reported spending an average of 37% of their time in economic activities. For women, the average AEE was 45% and they reported spending 26% of their time in economic activities. For both sexes, tasks related to agriculture represented the largest proportion of their AEE and time, followed by travelling for economic reasons. These results suggest that men in this sample are spending more of their time and energy in the physically demanding (energy intensive) crop production activities.

Women in this sample shouldered most of the household activities and child care. Women spent a greater proportion of their energy and time on domestic activities (28% of AEE and 18% of time) compared to their husbands (3% of AEE and 2% of time). Based on the analysis we conducted on household chores, men's participation in domestic activities was mainly represented by reparations and maintenance work of the household premises, both classified as household chores. The proportion of time spent by women in domestic activities appears to leave them less time for social activities and interactions. The time spent on sleeping-resting and for individual activities is broadly similar for men and women.

NEPAL

CONTEXT

Data on energy expenditure and movement were collected from 23 agricultural households from Shaktikhor Village Development Committee (VDC) of Chitwan and Devbhumi Baluwa VDC of Kavrepalanchowk district in Nepal. Shaktikhor is located in the Terai, a lowland region in southern Nepal, and Devbhumi Baluwa is located in the hills. The economy of both VDCs is largely agrarian with a majority of the population engaged in agriculture. The main agricultural products produced in Shaktikhor include rice, maize and mustard. Although Kavre district lies in the hilly region, Devbhumi has flat land suitable for various crops. The major crops grown in Devbhumi are rice, maize and potato. Cow, buffalo, goat and poultry are the main livestock in both study areas. About one fourth of the population (25.16%) lives below poverty (CBS, 2011). The Gini coefficient, which indicates inequality in consumption and expenditure, stands at 0.328. The urban and rural difference of poverty incidence is wide. The poverty head count rate in urban areas is 15.5% compared with 27.4% in rural areas (CBS, 2011).

In each household, the head and the spouse were interviewed and both were asked to wear the accelerometry devices for four non-consecutive weeks across the agricultural season. In Nepal, the seasons are categorized into six seasons, each lasting two months: (1) spring, (2) early summer, (3) summer monsoon season, (4) early autumn, (5) late autumn and (6) winter. Land preparation takes place between May and June and harvesting follows between September and October in both the irrigated and rain-fed areas. Shaktikhor, represented the irrigated farming system and Devbhumi Baluwa, the rain-fed one. The survey was conducted between June and October in the irrigated village and again between March and September in the rain-fed village.

SAMPLE

The 23 households participating in the survey were living in rural areas with agriculture representing their primary economic activity and main source of livelihood and income (**Table 7**). All households were headed by men and more than half of them were literate, a figure in line with a recent nationally representative survey of rural areas (59.7%), (GON,

Table 7. Descriptive characteristics of households in Nepal

CHARACTERISTICS	MEAN	SD
Age of the head of the household (years)	46.35	(8.65)
Literacy of the head (whether literate), (%)	0.65	(0.49)
Household size	4.65	(1.97)
Number of adult males in the household	1.96	(0.93)
Number of adult females in the household	2.04	(1.11)
Number of children in the household	1.30	(1.06)
Total land holding (acres)	1.10	(6.13)
Distance from the nearest all weather/tarmac road (km)	0.49	(1.25)
Distance from the nearest local trading centre (km)	5.85	(5.83)
Km from the nearest major products market (km)	2.90	(3.69)
Number of households	23	

Table 8. Anthropometric and activity data of participants in Nepal, by gender

	MEN (n = 20; days=526)		WOMEN (n = 20; days=520)			FULL SAMPLE (n = 40; days=1,046)	
	MEAN	SD	MEAN	SD	DIFFERENCE	MEAN	SD
Age (years)	47.33	(7.90)	44.17	(6.95)	3.15***	45.76	(7.60)
Height (cm)	164.98	(5.60)	151.57	(5.59)	13.41***	158.31	(8.73)
Weight (kg)	63.40	(11.09)	54.09	(10.36)	9.31***	58.77	(11.70)
Kcal intake (kcals/d)	2,340.16	(705.97)	1,999.62	(659.19)	340.5***	2,170.87	(703.72)
BMI (kg/m^2)	23.21	(3.24)	23.46	(3.80)	-0.25	23.33	(3.53)
AEE (kcal/d)	1,074.85	(407.94)	898.39	(373.08)	176.5***	987.13	(400.66)
TEE (kcal/d)	2,508.32	(471.39)	2,004.70	(490.83)	503.6***	2,257.96	(542.91)
BMR	1,433.47	(153.37)	1,106.32	(146.40)	327.1***	1,270.83	(221.91)
PAL	1.75	(0.28)	1.80	(0.25)	-0.05**	1.77	(0.27)
Light activity (%)	0.86	(0.05)	0.86	(0.04)	-0.00	0.86	(0.05)
Moderate activity (%)	0.12	(0.05)	0.12	(0.03)	0.00*	0.12	(0.04)
Vigorous activity (%)	0.02	(0.01)	0.02	(0.01)	-0.00	0.02	(0.01)
Steps/day	13,507.38	(5,217.73)	12,269.20	(3,898.38)	1,238.2***	12,891.84	(4,648.53)
Number of days	25.39	(4.50)	24.39	(5.16)	1.003***	24.89	(4.86)

Statistics based on day-level data in which non-wearing time is less than four hours between 7am and 9pm. Asterisks show level of significance: ***= significant at 0.1%, **=significant at 1%, and *=significant at 5%.

UNDP, 2017). The average household size was 4.65 members, and included all individuals living within a household compound. This is similar to the average household size recorded for rural areas in Nepal, which is 4.8 persons (GON, UNDP, 2017).

All households reported having access to agricultural land with an average holding of 1.10 acres. In terms of access to infrastructure, households reported living a relatively close distance to all-weather roads (average of 0.49 km). The major products market was an average of 2.90 km and the local trading centre was an average of 5.85 km from their homes, both considered a walkable distance.

ENERGY EXPENDITURE AND OTHER MEASURES OF PHYSICAL ACTIVITIES

Table 8 presents some of the information derived from the accelerometry devices and summarises the descriptive statistics, anthropometric and activity data. The table includes average caloric intakes for men and women. In this study, alongside wearing accelerometry devices, the enumerators visited the households on 7 consecutive days to collect 24-hour dietary recalls from both participants. Data on food intake were subsequently used to estimate caloric

intake. As in the previous case study from Ghana, the results are presented for wife-husband dyads in each household who wore the accelerometry devices and answered the time-use questionnaires for a period of four non-consecutive weeks.

The mean height and weight of men in this sample were greater than for women, by an average of 9 cm and 13 kg respectively, and these differences were statistically significant. The mean BMI for women was higher than for men, but the difference was not statistically significant. Men's average daily caloric intake was significantly higher than that of women. The same pattern across sexes was observed for Total Energy Expenditure (TEE) and Activity Energy Expenditure (AEE). The Basal Metabolic Rate (BMR), namely the energy needed for the survival of the body, is expected to be generally lower for women compared to men. However, when the Physical Activity Level (PAL) was calculated across the sample (TEE/BMR), the mean PAL among women was higher than the mean among men, although this was only found to be statistically significant at the 5% level. This means that given their BMR, women in the sample were more active than men even if the TEE of men was higher.

In addition to energy expenditure levels and indicators of physical activity, the accelerometry data

indicate the percentage of movement that falls under the definition of light, moderate and vigorous activities. In this sample, 86% of the activities undertaken were categorized as light, 12% were categorized as moderately active, and 2% of the recorded movements were categorized as vigorous.

Finally, very few days of data had to be omitted as a result of individuals not wearing the devices for more than three hours on a given day. We analysed an average of 25.39 days of data from men and 24.39 days for women.

ENERGY AND CALORIC INTAKE

Figure 4 shows the distribution of the Caloric Adequacy Ratio (CAR) among women and men. CAR refers to the ratio of caloric intake to energy expenditure (namely calories in over calories out). We collected 7 days of food intake and energy expenditure data from all participants, which enabled us to calculate the CAR. Ideally, daily caloric intake should match energy expenditure in order to maintain a healthy weight and BMI (corresponding to the red line in **Figure 4**). Low caloric intake compared to energy expenditure (CAR<1) could result in weight loss and reduced BMI while caloric intake that exceeds energy expenditure (CAR>1) may result in weight gain and higher BMI. It is however important to stress that the problem of malnutrition goes beyond caloric intake. In order to ensure optimal nutritional status and health, meeting caloric needs should go hand in hand with balanced intake of nutritious foods (both in terms of micronutrient and macronutrients) and physical activity.
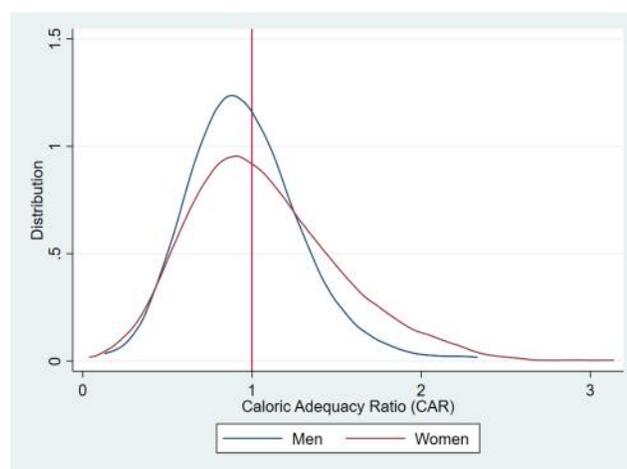

Figure 4. Caloric Adequacy Ratio (Calorie Intake/Energy Expenditure)

Our results indicated that individuals in the sample suffered from caloric deficiency (CAR<1) during 55% of the days when data collection took place. Caloric deficiency was more severe for men than for women (61% and 49% of days respectively). It is important to note that we might have observed caloric deficiency because data collection coincided with agricultural seasons and so there was likely higher levels of physical activity related to crop production during these times than during other parts of the year. On the other hand, BMI is a longer-term indicator influenced by multiple factors, including caloric intake and energy expenditure.

INDIA

CONTEXT

Data was collected from 20 households in two villages of Jogulamba Gadwal district (State of Telangana): Gonpad village represented the rain-fed farming system and Bijjawaram the irrigated. The selected district is located in southern Telangana agro-climatic zone and is well-known for its handloom and quality fabrics. The area's economy is agrarian with about 82% of the population engaged in agriculture of which 81% belong to the small and marginal category of farmers that rely on rain-fed farming system. The average annual rainfall of the district ranges between 600mm and 780mm.

This areas is predominantly a red soil track having red with loamy sub-soil. The cropping season is classified into two main seasons namely Kharif (July to October) and Rabi (October to March) and crops grown between March and June are considered summer crops. Depending on rainfall patterns, land preparation starts in June, immediately followed by sowing, planting and transplanting. The harvesting of crops, including those selected in the study (chili and castor), occurs between October and November.

The survey was implemented between June and November in both the rain-fed and irrigated villages. In each household, the head and the spouse were interviewed and asked to wear the accelerometry devices for four non-consecutive weeks across the agricultural season, covering land preparation (e.g. ploughing), sowing/seeding, transplanting, land maintenance (e.g. weeding) and harvesting.

SAMPLE

The descriptive statistics of the selected households in India are summarised in **Table 9**. The households selected for the survey were rural households with agriculture as their principal economic activity. All households surveyed were headed by men, 30% of them able to read and write. Household average size was 4.30 members, including all individuals living together in the same dwelling and eating from the 'same pot'.

All households reported having access to agricultural land with an average holding of 4.05 acres. In terms of access to infrastructure, all weather roads were on average of less than 1 kilometre (km) from the partici-

Table 9. Descriptive characteristics of households in India

CHARACTERISTICS	MEAN	SD
Age of the head of the household (years)	39.60	(10.38)
Literacy of the head (whether literate), (%)	0.30	(0.47)
Household size	4.30	(1.59)
Number of adult males in the household	1.80	(0.95)
Number of adult females in the household	1.45	(0.69)
Number of children in the household	1.50	(0.95)
Total land holding (acres)	4.05	(3.16)
Distance from the nearest all weather/tarmac road (km)	0.77	(2.24)
Distance from the nearest local trading centre (km)	8.10	(4.01)
Km from the nearest major products market (km)	7.90	(4.31)
Number of households	20	

Table 10. Anthropometric and activity data of participants in India, by gender

	MEN (n = 20; days=545)		WOMEN (n = 20; days=540)			FULL SAMPLE (n = 40; days=1,085)	
	MEAN	SD	MEAN	SD	DIFFERENCE	MEAN	SD
Age (years)	40.81	(15.70)	34.07	(9.51)	6.719***	37.58	(13.37)
Height (cm)	162.86	(7.28)	150.36	(4.57)	12.53***	156.67	(8.75)
Weight (kg)	58.49	(8.86)	46.47	(5.94)	12.05***	52.52	(9.68)
Kcal intake (kcals/d)	1,781.17	(561.73)	1,610.07	(530.22)	171.1***	1,696.02	(552.69)
BMI (kg/m^2)	22.05	(3.20)	20.56	(2.48)	1.493***	21.30	(2.96)
AEE (kcal/d)	771.97	(447.88)	620.26	(290.79)	151.7***	694.83	(383.57)
TEE (kcal/d)	2,175.68	(497.62)	1,693.34	(331.05)	482.9***	1,933.72	(485.32)
BMR	1,403.72	(123.36)	1,073.08	(86.16)	331.2***	1,238.89	(197.03)
PAL	1.55	(0.31)	1.57	(0.25)	-0.03	1.56	(0.28)
Light activity (%)	0.90	(0.06)	0.89	(0.05)	0.01*	0.89	(0.06)
Moderate activity (%)	0.09	(0.05)	0.10	(0.04)	-0.01	0.09	(0.05)
Vigorous activity (%)	0.01	(0.01)	0.01	(0.01)	-0.00**	0.01	(0.01)
Steps/day	12,131.45	(6,185.19)	9,706.59	(4,056.39)	2,414.1***	10,891.87	(5,349.20)
Number of days	27.30	(1.06)	27.06	(1.23)	0.24***	27.18	(1.16)

Statistics based on day-level data in which non-wearing time is less than four hours between 7am and 9pm. Asterisks show level of significance: ***= significant at 0.1%, **=significant at 1%, and *=significant at 5%.

pants' homes. The nearest major inputs market were placed almost 8 km away and the most accessible local trading centre at about 6.5 km.

ENERGY EXPENDITURE AND OTHER MEASURES OF PHYSICAL ACTIVITIES

Table 10 summarises descriptive statistics on anthropometric measures, information retrieved by the accelerometry devices and average caloric intake for husbands and wives in surveyed households. Food consumption and time-use surveys were administered on the same days individuals wore accelerometry devices.

In this sample, men were significantly taller and weight more than women, by about 12.5cm and 12kg on average respectively and men's BMI was significantly higher than women. Average daily calories intake of men is significantly higher than that of women. As it is normally expected, a similar pattern across sexes was appreciated for Total Energy Expenditure (TEE), Activity Energy Expenditure (AEE), and Basal Metabolic Rate (BMR). However, Physical Activity Level (PAL) (Total Energy Expenditure/BMR) of women was slightly higher than for men (although not significantly). This means that given their BMR, women in this

sample were more active than men even if TEE of men was higher.

In addition to energy expenditure levels and indicators of physical activity, the accelerometry devices indicate the percentage of the movements that fall under the definition of light, moderate and vigorous activities. For example, 89% of the activities undertaken by the sample was considered light, 9% considered moderate and only 1% were vigorous.

ENERGY INTENSITY OF ACTIVITIES: COMPARING ACTIVITY ENERGY EXPENDITURE AND PHYSICAL ACTIVITY LEVELS

Figures 5 and **6** illustrate the distribution of AEE and PAL of men and women, respectively. AEE expresses the calorie exertion needed to undertake daily activities without considering BMR, which is the energy required for the survival of the body. AEE was higher for men than women, suggesting that men were physically more active than women in this sample.

However, AEE does not correct for sex, age, height and weight differences between individuals and can overshadow some important information. Indeed, PAL, calculated as a ratio between TEE and BMR, which corrects energy expenditure for the above mentioned
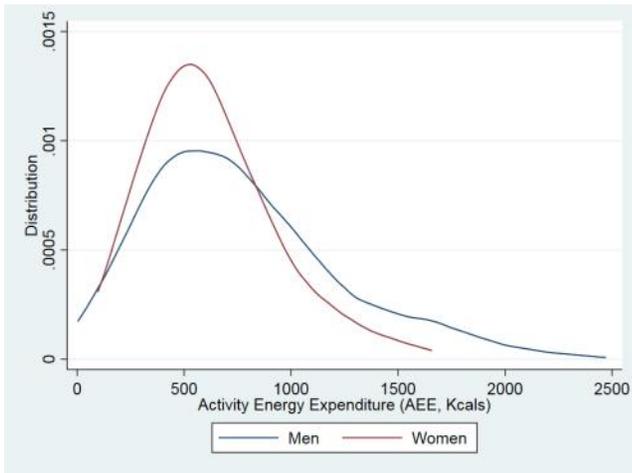
Figure 5. Daily activity energy expenditure (AEE), by sex
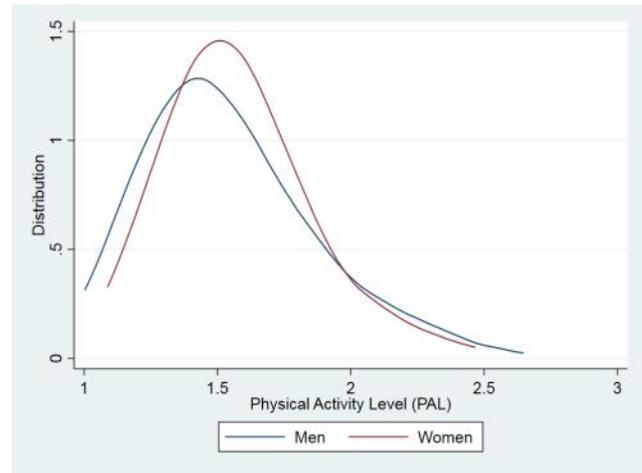
Figure 6. Daily physical activity level (PAL), by sex

parameters, was greater for women than for men. **Figure 6** shows the distribution of PAL for both sexes, with the distribution for women lying slightly to the right of the distribution for men.

In conclusion, the activities undertaken by men in this sample were more energy intensive, but women were physically more active in the performance of these activities as they require greater "effort" in relation to their BMR. This contributed to the overall higher levels of PAL for women in our sample.

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