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The Distribution of Effort

Physical Activity, Gender Roles, and Bargaining Power in an Agrarian Setting

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Abstract

The disutility of work, often summarily described as effort, is a primal component of economic models of worker and consumer behavior. However, empirical applications that measure effort, especially those that assess the distribution of effort across known populations, are historically scarce. This paper explores intra-household differences in physical activity in a rural agrarian setting. Physical activity is captured via wearable accelerometers that provide a proxy for physical effort expended per unit of time. In the study setting of agricultural households in Malawi, men devote significantly more time to sedentary activities than women (38 minutes per day), but also spend more time on moderate-to-vigorous activities (16 minutes). Using standardized energy expenditure as a summary measure for physical effort, women exert marginally higher levels of physical effort than men. However, gender differences in effort among married partners are strongly associated with intra-household differences in bargaining power, with significantly larger husband-wife effort gaps alongside larger differences in age and individual land ownership as well as whether the couple lives as part of a polygamous union. Physical activity—a proxy for physical effort, an understudied dimension of wellbeing—exhibits an unequal distribution across gender in this population.

This paper is a product of the Development Research Group, the Development Data Group, and the Gender Cross-Cutting Solution Area. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://www.worldbank.org/prwp. The authors may be contacted at jfriedman@worldank.org and igaddis@worldbank.org.

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1. Introduction

Human effort, both its determinants and consequences, has long been a subject of study in controlled settings in medicine and psychology. In economics, effort plays an integral role in theories of worker decision making (Chayanov 1966; Becker 1977; Becker 1985) and the marginal cost of human effort is a key factor in allocative decisions of limited resources such as time (e.g. Lazear 2000). However empirical studies are scarce as human effort has long been treated as a primal yet unobservable component of behavioral theory. Now, the recent development of wearable technologies makes available the standardized measurement of physical activity and expands the empiricist's ability to assess certain dimensions of human effort. We apply this technology to assess the distribution of physical activity across gender in a low-income rural setting.

Using a unique data set from Malawi, we measure physical activity of adult household members that wore, over a two-week period, research-grade accelerometers, whose time-stamped records can be matched to 24-hour recall time use diaries that were administered to the same subjects. The data on physical activity include physical activity counts that are used to classify each minute of accelerometer wear time to one of sedentary, light, and moderate-to-vigorous activity categories based on existing thresholds (Freedson, Melanson and Sirard 1998). These data provide us with an objective measure of the physical intensity of activity not observed in the more traditional time recall data. While effort takes various forms, including mental or attentional effort, physical exertion is a predominant form of occupational effort in low income agricultural settings, and therefore physical effort plays a key role in the productivity and wellbeing of the population studied here.

We explore the association between physical activity, our proxy for physical effort, and gender by documenting the distribution of physical effort across adult members of the same household. The results show that men accumulate significantly more sedentary time than women, with an average daily gender gap of 38 minutes in the full sample and of 51 minutes in the subsample of dyadic pairs, i.e. married partners. This is consistent with the often-observed stylized fact that women work more hours than men (when paid and unpaid activities are considered together) and spend less time on leisure. The physical activity data also reveal a pattern that is not observable from more traditional time use data. We find that men spend more time than women on moderate-to-vigorous activities, which comes at a greater energy cost and hence requires more physical effort than light activities that are disproportionately undertaken by women. Using standardized energy expenditure as a summary measure of physical effort (i.e. the measured total energy expenditure of an individual expressed as a multiple of the individual-specific basal metabolic rate) the results shows that, all told, women exert slightly higher levels of effort than men.

To analyze the proximate causes of this gender gap in effort we combine physical activity data with more traditional time use diaries. Gender differences in time use are among the most pertinent factors that distinguish the lives of men and women across the globe. Over a range of country contexts, men typically allocate more time to paid activities, while women spend a disproportionate amount of their time on care and other unpaid work (Ilahi 2000; Rubiano-Matulevich and Viollaz 2019). In addition, women typically work more hours than men when all work activities (paid and unpaid) are considered together and hence spend less time on leisure, particularly in lower income countries (Blackden and Wodon 2006; Burda, Hamermesh and Weil 2013). Gender differences in time use also vary over the life cycle, as parenthood may reinforce a traditional division of labor among couples (e.g. Anxo et al. 2011; Fengdan et al. 2016; Kongar and Memis 2017).

What explains such differences across gender in time use? One theory, formalized by Becker (1981), is that even if husband and wife have identical preferences (and their labor is perfectly substitutable), they gain from a specialization in either market work or household activities, as this specialization allows them to take advantage of economies of scale. In this setting, even small gender differences, for example related to market discrimination or women's biological advantage in child rearing during lactation, could cause large intra-household differences in time use. Theories of the distribution of effort expenditure within the household are less developed, but if effort costs are observable within husband-wife pairs then households may choose an equitable distribution of effort across spouses, despite each partner's specialization in either market or household work.

Becker's model assumes unitary household decision-making, either because of a single benevolent decision maker or consensus among members. This is an assumption that rarely finds empirical support (Alderman et al. 1995; Lundberg, Pollak and Wales 1997). Non-unitary models of household decision-making emphasize power and bargaining differentials between household members as a potential explanation for intra-household differences in effort and time use (Chiappori and Lewbel 2015). While no prior study has explored the relationship between intra-household bargaining and physical activity, a few have looked at time use and yielded mixed results. Friedberg and Webb (2005) show that an increase in wives' relative wages in dual-earner households in the United States is related to an increase in the amount of time they spend on leisure. Fengdan et al. (2016), based on time use data from China, demonstrate that husbands with higher bargaining power (proxied by the education gap between spouses) spend less time on unpaid work. Walther (2018) finds that men in patrilineal communities in Malawi, where men traditionally retain land ownership rights upon divorce, spend more time on agricultural labor and less time on wage labor compared to men in matrilineal communities, where women traditionally keep the land after divorce. Fafchamps, Kebede and Quisumbing (2009) find that while spouses who brought more land to the marriage devote more time to social activities, they do not necessarily spend more time on leisure activities (social and personal time combined) as a whole.

Similar to these other contexts, men in our sample spend more time on market related activities (defined here to include all agricultural work) than women, while women spend more time on non-market related activities (e.g. care work, collection of water and firewood and other unpaid work). Since non-market activities in this setting are, on average, somewhat less strenuous than market activities, gender differences in time allocation across market and nonmarket activities tend to lower relative effort levels of women compared to men. However, men also spend more time than women on social activities, which are associated with even lower levels of effort than either market or nonmarket related activities. Further, with the ability to measure the intensity of time use we see that women exert more effort within each activity category – though these within-category gender differences are not always statistically significant. Together, these findings explain the slightly higher levels of effort for women than for men.

We then relate the observed inequalities in expended effort across men and women (among those co-residing in dyadic pairs) to more traditional measures of intra-household bargaining power. We find gender differences in physical effort within dyadic couples to be exacerbated by large intra-household differences in bargaining power, including husband-wife gaps in age, land ownership, and whether the couple lives in a polygamous union. This suggests greater gender differences in expended effort emerge in situations with an unequal intra-household distribution of power, and that disadvantage within the household extends to the dimension of physical exertion.

2. Activity measures and study setting

This work is part of a growing literature drawn from various academic disciplines – including metabolic physiology, behavioral medicine, anthropology, and economics – that use accelerometers to measure physical activity and, consequently, the expenditure of energy. Though the doubly labeled water (DLW) method remains the gold standard for measuring total energy expenditure in free living conditions in medical and nutrition studies, wearable technologies, such as accelerometers, have emerged as an attractive alternative for several reasons.[1] First, due to their greater cost-effectiveness and easier implementation, accelerometers allow gathering data on physical activity from larger samples of participants in comparisons to the DLW method. Second, accelerometers not only provide measures of total energy expenditure but also minute-by-minute profiles of physical activity, which allow for a more granular understanding of physical activity patterns and energy expenditure over the course of the day. Validation studies have shown that the Actigraph accelerometers, such as the ones used in this study, correlate acceptably with DLW-derived energy expenditure (Plasqui and Westerterp 2007; Plasqui, Bonomi and Westerterp 2013; Chomistek et al. 2017).[2]

The vast majority of previous accelerometry studies focus on the United States or other high-income countries, typically to document activity levels for specific population groups (Troiano et al. 2008; Colley et al. 2011) or to relate physical activity to environmental characteristics (van Dyck et al. 2010). However, some studies have measured physical activity levels of rural populations in developing countries and find that overall levels of physical activity are higher in low-income countries than in high-income countries (Benefice, Garnier and Ndiaye 2001; Assah et al. 2011; Christensen et al. 2012). Closely related to this study is the work by Zanello, Srinivasan and Nkegbe (2017), Picchioni et al. (2020) and Srinivasan et al. (2020), who pilot the use of accelerometers to capture energy expenditure in rural communities in Ghana, India and Nepal. These studies, however, relied on smaller sample sizes of approximately 40 individuals (i.e. around 20 households) in each of the three countries (compared with over 400 individuals in this study), which limits the type of performed analysis. Our paper is also related to the work by Akogun et al. (2020), who use accelerometer data to proxy for worker productivity in physical occupations and validate this approach in a piece-rate wage setting.

The data used in this paper were collected in the Ntcheu and Zomba districts of Malawi in 2017. A random subsample of 240 households, drawn from a larger representative household sample dedicated to an agricultural study, was interviewed weekly throughout the 2016/17 agricultural season to collect high frequency data on farm labor (i.e. the number of hours each household member spent working on each of the household's plots over the past seven days). In addition, the research team collected data on physical activity over a three-month period of March-May 2017, with each enumeration area (and all sampled households within) assigned in a random temporal order to a two-week physical activity data collection cycle. The target was to deploy Actigraph GT3X accelerometers to at least two working-age (15

[1] The DLW method administers study participants water containing marker isotopes, whose elimination from bodily fluids via metabolism can then be traced through urine samples. See Hills, Mokhtar and Byrne (2014) for a review of objective measures of physical activity and energy expenditure.

[2] Murakami et al. (2019) report lower levels of correlation between accelerometers and DLW estimates when accounting only for physical activity energy expenditure, i.e. the portion of energy expenditure linked only to physical activity, net of resting energy expenditure and the basal metabolic rate.

years and above) individuals in each household. The accelerometers were left with the individual household members for 17 days and study participants were instructed to always wear them during the day, except for sleep time and during washing/bathing. To ensure technical standards, the investigators partnered with the Active Living Research Team of the University of California at San Diego, who participated in the enumerator training and provided quality control (Pratt et al. 2020).

The enumerators visited the households three times during the 17 days when the accelerometers were with the participants, typically days 1 (deployment), 9 (check in) and 17 (pick up). On day 1, the enumerators explained the study objectives to the participants, obtained their consent and demonstrated how to wear the accelerometers (with a belt around their waist). Day 9 was a check-in visit, during which data were downloaded and enumerators checked on battery status and for any unusual patterns in the data (which could signal that the devices were not worn correctly). On day 17 the remaining data was downloaded, and the accelerometers returned for reassignment to subsequent participants. In addition, time use data were collected on days 9 and 17 using a 24-hour recall diary that was modeled after the time use module of the Women's Empowerment in Agriculture Index (WEIA) and that captured main and secondary activities in 15-minute intervals during the reference day, as self-reported.[3] During the visits on days 9 and 17 the team also measured the participants' bodyweight, while information on height was collected during the endline survey.

The time use module distinguished between 26 different types of activities. For analytic purposes and ease of exposition, these activities are grouped into six broad activity categories – market work, nonmarket work, personal activities, social activities, sleeping and resting, and other activities (see Appendix Table A2 for details; the analysis here is based on the main reported activity as only 8 percent of individuals reported any secondary activities). The subdivision of work into "market work" and "nonmarket work" is informed by the classification in Seymour, Malapit and Quisumbing (2020), who use a very similar WEIA-type time use module. However, this distinction should be regarded as a broad approximation since it is often difficult to determine with certainty whether an activity is destined for the market or for non-market (i.e. family consumption) purposes.[4] Due to these ambiguities – and the broader conceptual and empirical questions involved in separating market from non-market work – we also report on a combined category of "total work".[5]

The accelerometers provide time-stamped measures of an individual's physical activity per minute.[6] Starting from raw unit-record accelerometer files, all the data have been processed and validated according to accepted international standards and protocols (Kerr et al. 2013). Based on these minute-by-minute physical activity scores, each minute of the day (when the accelerometer was worn by the

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[3] See https://weai.ifpri.info/weai-resource-center/guides-and-instruments/ .

[4] For example, we classify "making goods (e.g. furniture, pottery, baskets, clothing)" as market work, whereas the same activity is classified as nonmarket work in Seymour, Malapit and Quisumbing (2020). Likewise, crop farming and animal husbandry – although classified as market work in this paper – is partially used for own consumption purposes (Gaddis et al 2020).

[5] Some studies refer to market work as "paid work"; non-market work is sometimes labeled "unpaid domestic work" (e.g. Rubiano-Matulevich and Viollaz 2019). However, market work is not always paid (e.g. helping in a non-farm enterprise). Moreover, non-market work includes productive activities that could be marketed (e.g. fetching water, collecting firewood).

[6] The accelerometers, which are waist-mounted, measure accelerations or movements in three orthogonal directions but cannot detect isolated upper body movements or the full physical effort related to lifting or carrying of loads.

participant) was classified according to the intensity of physical activity (i.e. sedentary, light, and moderate to vigorous activity (MVPA)) based on the cut-off points developed by Freedson, Melanson and Sirard (1998), which are the most widely used reference values for measuring physical activity in adults in the fields of public health and physical activity research. While we assume light activity levels during non-sleep non- wear time (i.e. times that the participants were likely awake but for some reasons not wearing the devices – mostly in the early mornings or evenings), we assume no physical activity during sleep time. Therefore, we disregard any activity that occurred between 10:00pm and 4:25am, as these cutoffs are the 95th and 5th percentiles, respectively, of self-reported sleep and wake times. Without this time censoring, accidental movements, such as when devices are unintentionally bumped while under a pillow, would be scored as activity (usually in the "sedentary time" category). Days are coded as valid if the total wear time on that day exceeds 10 hours, and as non-valid otherwise. The compliance with the physical activity tracking protocol was exceptionally high in our sample, thanks to intensive supervision and attention to data quality control during the fieldwork. The average number of valid days across the study participants was 13.3 (out of 14), and the average daily hours of wear time was 14.2. Akogun et al. (2020) review numerous accelerometry studies and find a typical compliance far lower than that achieved here.[7]

We use the minute-by-minute individual-level physical activity counts together with anthropometric data (weight, height) to estimate an individual's active energy expenditure, basal metabolic rate (BMR) and total energy expenditure. The latter is defined as the sum of the person's active energy expenditure and BMR. The daily BMR is computed using the Harris-Benedict equation (Harris and Benedict 1918; De Lorenzo et al. 2001; Wejis and Vansant 2010; Al-Domi and Al-Shorman 2018). Active energy expenditure for the time the participants were wearing the accelerometers is computed using the work-energy method (Actigraph Software Department 2012).[8] We translate different activity categories into the single metric of total energy expenditure, which combines both resting energy expenditure (i.e. the BMR) and the energy cost of activity. Since energy expenditure is partly a function of a person's weight and height, total energy expenditure is normed as a multiple of the BMR and expressed as normalized energy expenditure. This is our proposed proxy for effort (per hour or per day) – total energy expenditure relative to the individual's BMR, which is a commonly used index of physical activity, typically denoted as the physical activity level or PAL (e.g. Zanello, Srinivasan and Nkegbe 2017).

Appendix Table A1 depicts the characteristics of study individuals and their households, both for the full sample of all participants and the dyadic pairs. Here we briefly highlight gender differences in bargaining power. Of particular note, the average study participant is 35 years old, with no significant difference between men and women in the full sample. In the sub-sample of dyadic pairs, husbands are, on average, almost 5 years older than wives (39.3 versus 34.5 years). This age gap is statistically significant. Men also have significantly higher levels of education than women, with a difference of 1.3 years of schooling in the full sample, and of 1.7 years in the sample of dyadic pairs. Men in the full sample manage, on average, 2.7 plots, compared with 1.5 plots among women, and the difference is statistically significant. In the sample of dyadic pairs, this gender gap is even larger, with husbands managing 3.7 plots, compared with only 0.8

[7] For more information on the physical activity tracking data management, see Pratt et al. (2020).

[8] We also computed active calories using the method outlined in Freedson, Melanson and Sirard (1998). However, the Freedson-algorithm was calibrated for participants engaged in moderate to vigorous activities (i.e. walking or jogging on a treadmill) and assigns relatively high energy expenditure to light and sedentary activities. Since most of the activity in our sample is light, we prefer using the more conservative estimates of the work-energy method. The correlations reported in this paper are not affected by this choice (see section 4).

plots among wives. Similar gender gaps are present for the number of acres managed, the number of plots owned, and the number of acres owned. These differences are also statistically significant and to the disadvantage of women. The descriptive statistics suggest a possibility of differential bargaining power between men and women living in the same households, and especially between husband and wives. We relate these differences to observed physical activity patterns in the analysis below.

3. Gender differences in physical activity and effort

Table 1 summarizes the physical activity counts (upper panel) and estimated caloric expenditure (bottom panel) by sex – for the full sample (left) and the dyadic pairs (right). Physical activity is expressed in minutes per day and reported for three mutually exclusive categories of physical activity – sedentary, light and MVPA. Light activity is further subdivided into low light and high light, while MVPA consists of moderate and vigorous activity.[9]

In the full sample, men spend significantly more time sedentary (414 minutes, or 6 hours and 54 min) than women (377 minutes, or 6 hours and 17 minutes), amounting to a gender gap of 38 minutes. This gender gap is even larger within the dyadic pair (51 minutes). Conversely, women spend significantly more time doing light activities (mostly driven by the high light category) – with a gender gap of 50 minutes in the full sample and 59 minutes among the dyadic pairs. On the other end of the spectrum, men are more engaged in MVPA – with a gender gap of about 15 minutes. Gender differences in non-wear time (which, as mentioned in section 2, includes sleep time) are not statistically significant.

Overall, the data show that our sample of agricultural households in Malawi is a highly active population – with a total of 449 minutes (i.e. 7 hours and 29 minutes) of daily non-sedentary activity for males and 483 minutes (8 hours and 3 minutes) for females in the full sample. Although many of the participants are farmers and data were collected during the latter half of an agricultural season, it is not surprising that most of the activity is light or moderate. The defined vigorous physical activity category encompasses intense aerobic exercise of at least 6 metabolic equivalents (METs), or the equivalent of running at a minimum speed of 8 kilometers per hour.

The gender differences in physical activity do not tell us immediately whether women or men, on average, exert more physical effort. While women spend less time sedentary, they also spend less time engaging in MVPA. The bottom panel of Table 1 shows that men in the full sample expend on average 2,120 calories per day, compared with 1,955 calories for women (with similar numbers for the dyadic pairs). This gender gap, however, reflects partly that the average man is taller and heavier than the average woman (and thus exhibits a higher BMR). If we normalize for differences in basal metabolism, by expressing total energy expenditure as multiples of the BMR, we see that women exert, on average, slightly higher levels of effort than men (1.52 vs. 1.50). However, this gender gap is only marginally statistically significant in the full sample and insignificant in the smaller sample of dyadic pairs.

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[9] This uses the Freedson adult cut points for moderate and vigorous PA (1,952 counts/minute for moderate and 5,725 counts /minute for vigorous or “hard”; Freedson, Melanson and Sirard 1998). Light activity was categorized as low- light (101-929 counts/minute) or high-light (930-1951 counts/minute), and sedentary time was scored with the commonly used cut-off point of ≤100 counts per minute.

While the physical activity data provide us with measures of effort at high temporal resolution, they do not inform the exact types of activities men and women engage in. To explore this, we aggregate each participant's time-stamped physical activity tracking data into 15-minute intervals and match the activity data to the recall-based time use information that was elicited from the study participants. In doing so, we gain contextual understanding of physical activity patterns and can link the intensive margin of physical activity with the reports of time use on the extensive margin.

Table 2 shows the average number of hours women and men spend per day by self-reported time use category, grouped into six broad activity categories as described in section 2. The data show clearly the traditional intra-household division of labor, with women in the full sample spending significantly more time than men on nonmarket activities (3.3 hours versus 1.0 hour) and significantly less time on market activities (2.8 hours versus 4.4 hours). In addition, women spend significantly less time than men on social activities (2.1 hours versus 3.0 hours). There are no significant gender differences in the number of hours spent on personal activities or resting/sleeping. These broad patterns of time use carry over to the sample of dyadic pairs, where the gender differences in time spent on nonmarket vs. market activities are even larger.

To relate differences in men's and women's allocation of time to gender differences in effort, Panel B of Table 2 reports total energy expenditure relative to BMR by sex and self-reported activity. Market activities are associated with a somewhat higher level of effort than nonmarket activities (1.85 vs. 1.73 PALs). In other words, gender differences in the allocation of time across market and non-market activities (as highlighted in Table 2) should lower women's total effort compared to that of men. On the other hand, women exert greater levels of effort within each activity category. These within-activity gender gaps, though typically not statistically significant, tend to increase women's effort levels. The self-reported categories with significantly higher effort expenditure for women are, interestingly "resting and sleeping" and the residual "other" category. Among married pairs, women also exert more effort in the reported "personal" category. The higher mean effort expended by women during "market" and "nonmarket" time is not a statistically significant difference. Moreover, as reported in Table 2, men spend more time than women on social activities, which are associated with lower levels of effort than either market or nonmarket activities. All told, the combination of extensive and intensive margin differences in activity explains the marginally greater average levels of effort among women than men.

4. Sociodemographic predictors of effort, including bargaining power

We next turn to the question of whether physical effort is related, differentially by male and female respondents, to individual- or household-level characteristics. Appendix Table A3 summarizes descriptive regressions where the dependent variable is the effort measure and the independent variables are (i) a dichotomous variable that is equal to 1 if the participant is female, (ii) an individual or household-level characteristic, i.e. age, and (iii) the interaction between these two variables. With respect to characteristics such as education, household size, marital status, or household dependency ratio we do not observe differential associations by gender, as indicated by insignificant interaction terms under columns (2) through (5). However, we see that effort declines with age among men, as indicated by the positive and significant interaction effect, while effort expended by women is relatively constant over the age-range. The gender differentiated age-effort profiles are also summarized in Figure 1, which shows declining activity levels for men but not women.

While women exert higher levels of effort than men, especially at older ages, the gender gap in effort is relatively modest. However, it is possible that substantial gender differences in effort still emerge in situations with unequal distributions of bargaining power within the household. To explore this hypothesis, we focus on the sub-sample of individuals living in dyadic pairs and construct seven different proxy measures of intra-household differences in bargaining power. Six measures are centered on the differences between the husband and wife in (1) age, (2) years of schooling, (3) the number of plots managed, (4) the number of acres (of agricultural land) managed, (5) the number of plots owned, and (6) the number of agricultural acres managed; in each case, a positive gap indicates a higher value for the husband. These are all commonly used proxy indicators for intrahousehold differences in bargaining power - based on the notion that demographic and economic characteristics that improve an individual's outside options (i.e. the utility level attained if they were to leave the marriage) translate into greater intra-household bargaining power.[10]

The seventh measure of bargaining power is a dichotomous variable that is equal to 1 if the couple is in a polygamous marriage. Being in a polygamous marriage has been linked to reduced bargaining power for wives, especially lower-ranking co-wives (Agadjanian and Ezeh 2000; Nanama and Frongillo 2012; Anderson et al. 2016).

We estimate a series of regressions where the dependent variable is physical effort and the independent variables are (i) a dichotomous variable that is equal to 1 if the participant is female, (ii) a specific measure of intra-household differences in bargaining power, and (iii) the interaction between these two variables. The last term helps us understand whether the difference in bargaining power between husbands and wives is associated with a more unequal distribution of effort among spouses. As age may have an independent effect on any gender differences in activity, the analysis also controls for the age of the husband and the age differential between the pair. Results presented in Table 3 support the supposition that imbalances within the households, at least by certain measures, are associated with differential levels of effort.

In column (1), the interaction between the husband-wife gap in age and the female indicator variable is positive and marginally significant, which indicates that the gender gap in effort is exacerbated among couples where the husband is significantly older than his wife, as suggested by Figure 1. Differences in effort tied to intra-household differences in bargaining power are even more pronounced under columns (5) through (7). In column (5), the interaction between the intra-household gender gap in the number of plots owned and the female indicator variable is positive, statistically significant and large in magnitude. Specifically, a one standard deviation increase in the intra-household gender gap in plot ownership (by 3.7 plots) is associated with an increase in the effort gender gap by 0.033. In other words, in a couple in which the husband owns 3.7 more plots than his wife, the wife expends approximately 42 calories per day more than in a couple without any gender gap in plot ownership. While this increase in energy expenditure

[10] Many other studies use a similar approach. For gaps in age and education see Oduro, Deere and Catanzarite 2015; Doepke and Tertilt 2018; and Afoakwah, Deng and Onur 2020. For gaps in the ownership of land and other assets see Doss 2005; Doss 2013; Behrman 2017; and Schaner 2017. We include intra-household differences in land management as a proxy of de-facto use rights, though it is arguably a weaker measure of bargaining power than intra-household differences in land ownership.

may not appear significant if viewed within a narrow time frame, it grows salient over longer time horizons. All else equal, expending 42 additional daily calories daily translates into a loss of 4.3 pounds of body weight over a period of 12 months.[11] Given the prevailing rate of undernourishment among the Malawian population – estimated at 17.5 percent (FAO 2019) – an effort differential of this magnitude can translate into longer-run health consequences.

Under column (6) of Table 3, the interaction between the intra-household gender gap in the area of land owned and the female indicator variable is also positive, albeit marginally significant. Conversely, the interaction terms under columns (3) and (4) are not statistically significant, indicating that spousal differences in land ownership, as opposed to land management, are more meaningful proxies for intra-household differences in bargaining power.

Finally, under column (7), we document that the gender gap in effort is exacerbated among spouses in polygamous unions – the interaction term is positive and statistically significant. The point estimate of effort differential corresponds to 7 percent of the average effort exerted by females in dyadic pairs, as reported in Table 1. This result is driven, primarily, by significantly lower levels of effort among men in polygamous unions, compared with men in monogamous unions. Women in polygamous unions also exert lower levels of effort than women in monogamous unions, but the difference is much smaller and not statistically significant.[12]

Given that we observe effort differentials for certain household types, it is natural to ask whether these effort differences are expressed in differential time use and, if so, which activity categories are affected. Table 4 explores this question by adopting similar specifications as in Table 3, but now with time devoted to various activity categories as the dependent variable. We report results with the four most common activity categories: nonmarket work, market work, rest and sleep, and social activity.

Interestingly, the results show that any relation between household inequality and effort does not translate into greater levels of nonmarket work. Reported nonmarket work times stay constant across all inequality measures (with women spending 2.5 hours more per day on these activities). For households where there is more inequality in plots owned or managed, women spend significantly more time working (about 20 minutes more per plot of difference) and less time in social activities. It is noteworthy that these forms of inequality (differential plot ownership/management) result specifically in more female work. Even though greater differential plot ownership/management are related to greater total land holdings, men in these households do not report working more than other men – only women.

For the households that are polygamous, the increased activity for women translates into significantly less rest and sleep than their male counterparts (almost 2.5 hours/day), and this time difference appears

[11] This is based on the widely used rule of thumb that a cumulative energy deficit of 3,500 kcal is associated with a one-pound decline in body weight (e.g. Hall 2008). It should be noted that this rule does not account for metabolic adaptations, which may dampen the long-term effects of reduced calorie consumption (Thomas et al. 2013; Hall 2018).

[12] To assess the robustness of these correlations to alternative approaches of computed active calories, Appendix Table A4 repeats the estimations using the algorithm described in Freedson, Melanson and Sirard (1998). As a result, the interaction between the husband-wife gap in age and the female indicator variable (in column (1)) loses significance. However, gender gaps in effort are larger among couples with more unequal landownership (columns (5) and (6)) or in polygamous union (column (7)) and the effects are quantitatively similar to those in Table 3.

distributed across all categories, especially market, social, and personal time, rather than concentrated in one particular activity. Finally, even though Table 3 did not find an effort difference related to spousal education differentials, where there is an education difference between spouses, men engage in market work a bit more (13 minutes per year of difference) and women less (17 minutes per year of difference). Most likely this difference reflects an income or specialization effect of the education difference. These women then reallocate time to nonmarket and social activities, but the effects are not precisely estimated.

5. Conclusion

We apply emergent wearable technologies to measure the distribution of physical effort across gender in a low-income agricultural setting. Compared to other regions of Sub-Saharan Africa, Malawi has relatively small gender gaps in property ownership (Gaddis, Lahoti, and Li 2018) and son-preferred fertility stopping behavior (Filmer, Friedman, and Schady 2009), suggesting that the communities we study reside in a relatively gender equitable region. Perhaps reflecting this, women in our study experience only marginally higher rates of physical activity than men experience. While women spend significantly less time sedentary than men, they also spend somewhat less time in moderate and physical activity. On balance, the normalized energy expenditure for women is almost 2 percent greater than for men, a slight difference that is still precisely estimated in our full study sample.

Women in the most gender disadvantaged households, however, also exert the highest levels of differential physical effort. Conditioning on differences in traditional measures of household bargaining power, we observe clear differentials in physical activity for husband-wife pairs in marriages with a large age difference, with a difference in the number of plots owned, or whether the pair lives as part of a polygamous union. This suggests that disadvantage in the household can extend to expended effort – an often unobserved primal of behavioral theory that plays a key role in conceptions of wellbeing.

Various questions emerge with our economic treatment of effort that need to be addressed in future work. Our analysis assumes a mapping between measures of physical activity and experienced physical effort, however economic and psychological theory ultimately posit effort as a subjective phenomenon. For example, a recent paper defines effort as “the subjective intensification of mental and/or physical activity in the service of meeting some goal” (Inzlicht, Shenhav, and Olivola 2018). Field-based researchers currently do not observe the process by which physical activity is experienced as effort and, further, how effort is translated into disutility – a process that presumably involves a subjective assessment of intensity and the degree of pleasantness or unpleasantness of the activity. Combining accelerometry with psychological approaches to appraise quality of time could be an interesting avenue for further study. This subjective component of effort can also play a role in decision making. For example, Dillon, Friedman and Serneels (2021) find evidence that information regarding a worker’s health status may increase intensive margin productivity when the news of a good health diagnosis is unexpected. The authors posit that the surprise good health news may shift the perceived cost of effort, at least in the short run. Future extensions of the methods used here can perhaps match time-stamped physical activity measures with subjective assessments of activity intensity or with complementary biometric measurement. For now, our approach simply posits a direct correspondence between physical activity and physical effort.

Additionally, effort is widely seen to encompass at least two dimensions, mental and physical. This study measures physical activity as a proxy for physical effort, in the same vein as Akogun et al. (2020). We only observe the one, physical, dimension through the use of accelerometers. With total disutility from work modeled as a function of effort expended in both mental and physical dimensions, it is possible that the intra-household distribution of total effort is yet more unequal if the sedentary and light-activity tasks commonly conducted by women in this study setting, such as child-care or cooking, also require greater mental effort than those conducted by men (such as attending social and religious events, eating, and drinking). Gender gaps in physical effort could also be underestimated given that the accelerometers cannot detect the effort related to carrying loads, only physical movement. If women are more likely than men to carry children or heavy objects, as may well be the case considering women's disproportionate engagement in childcare and the collection of water and firewood, their physical effort and energy expenditure would be underestimated relative to those of men.

Finally, experienced disutility from physical activity can vary quite widely by setting. In advanced economies, populations exhibit generally low levels of physical activity and indeed a moderate level of physical activity is an important contributor to good health, with a reduced risk of cardiovascular disease, cancer, diabetes, and other non-communicable diseases (Vogel et al. 2009). In the setting studied here, like many rural low-income settings, physical occupations predominate, and few individuals have the ability to select a less physical lifestyle.

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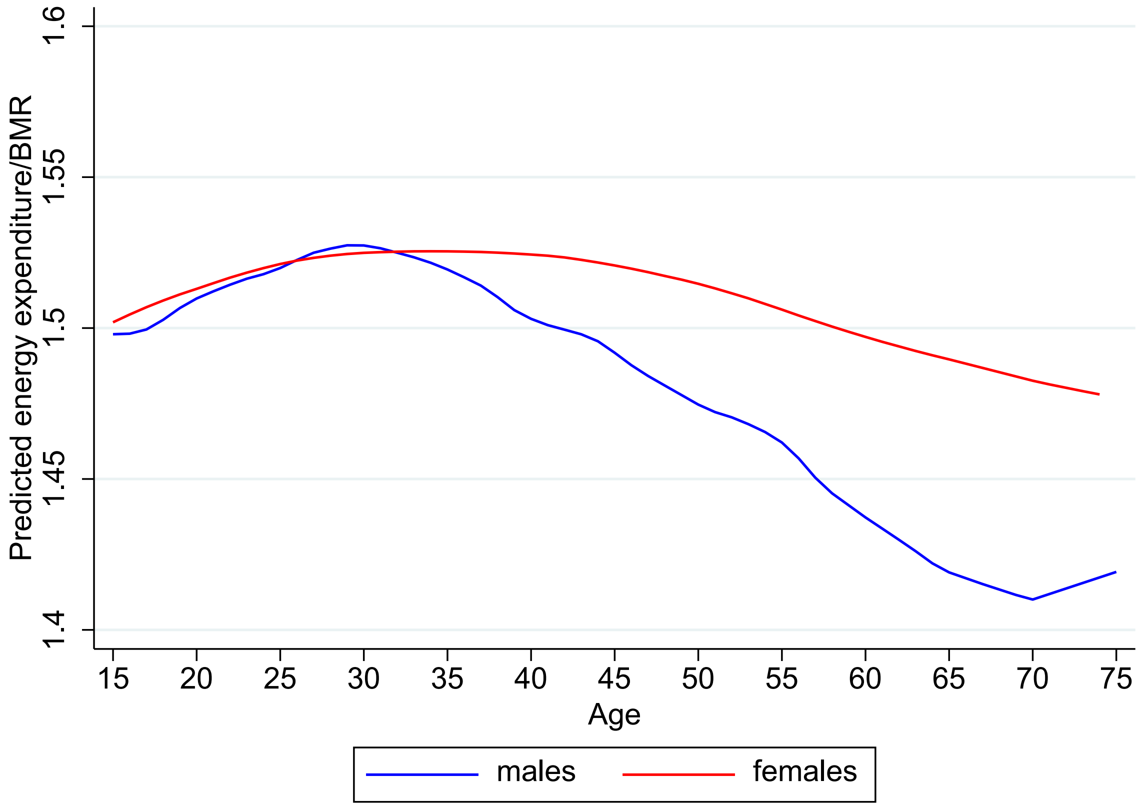
Figure 1: Physical activity level (PAL) by sex and age



Note: The non-parametric relationship between energy expenditure and age, separate by gender, is estimated by non-parametric kernel regression.

Table 1: Physical activity and energy expenditure by sex, full sample and dyadic pairs

	Full sample					Dyadic pairs			
	Total	**Male**	**Female**	**Δ (M-F)**	**p-value**	**Male**	**Female**	**Δ (M-F)**	**p-value**
Activity (min/day)									
A. Sedentary	393.1	414.4	376.6	37.9	0.00	417.1	365.8	51.3	0.00
B. Light	383.8	355.6	405.6	-50.0	0.00	358.4	416.9	-58.5	0.00
Low light	232.7	234.9	231.0	4.0	0.42	237.7	235.3	2.4	0.72
High light	151.1	120.7	174.7	-54.0	0.00	120.7	181.6	-60.9	0.00
C. MVPA	84.4	93.2	77.6	15.6	0.00	89.5	75.3	14.2	0.02
Moderate	82.9	90.2	77.2	13.0	0.00	87.1	75.1	12.0	0.05
Vigorous	1.5	3.0	0.4	2.6	0.00	2.4	0.2	2.2	0.00
Total non-sedentary (=B+C)	468.2	448.8	483.3	-34.5	0.00	447.9	492.2	-44.3	0.00
Non-wear time	578.7	576.8	580.2	-3.4	0.61	575.1	582.0	-7.0	0.44
Caloric exp.	2,027	2,120	1,955	166	0.00	2,112	1,973	139	0.00
BMR	1,340	1,412	1,284	129	0.00	1,406	1,293	113	0.00
Caloric exp./BMR	1.51	1.50	1.52	-0.02	0.09	1.50	1.52	-0.02	0.22
N (individuals)	410	179	231			108	108		
N (individual-days)	5,639	2,452	3,187			1,479	1,485		

Note: Active energy expenditure calculated using the work-energy method. T-tests on differences between males and females.

Table 2: Average hours per day and normalized energy expenditure by self-reported activity, full sample and dyadic pairs

Panel A. Average hours per day by self-reported activity

	Full sample					Dyadic pairs			
Activity category	**Total**	**Male**	**Female**	**Δ (M-F)**	**p-value**	**Male**	**Female**	**Δ (M-F)**	**p-value**
Work (total)	5.8	5.4	6.0	-0.6	0.03	6.0	6.4	-0.4	0.25
Market	3.5	4.4	2.8	1.6	0.00	4.9	2.7	2.2	0.00
Nonmarket	2.3	1.0	3.3	-2.2	0.00	1.1	3.7	-2.6	0.00
Personal	1.5	1.4	1.5	-0.1	0.24	1.3	1.5	-0.1	0.26
Resting & sleeping	9.6	9.5	9.6	-0.2	0.32	9.5	9.6	-0.1	0.62
Social	2.5	3.0	2.1	0.9	0.00	2.7	1.8	0.9	0.00
Other	1.3	1.6	1.2	0.4	0.01	1.4	0.9	0.6	0.00
N/A	3.4	3.1	3.6	-0.5	0.00	3.0	3.8	-0.8	0.00

Panel B. Normalized energy expenditure by self-reported activity

	Full sample					Dyadic pairs			
Activity category	**Total**	**Male**	**Female**	**Δ (M-F)**	**p-value**	**Male**	**Female**	**Δ (M-F)**	**p-value**
Work (total)	1.78	1.79	1.78	0.01	0.82	1.80	1.77	0.03	0.50
Market	1.85	1.83	1.87	-0.04	0.31	1.85	1.88	-0.03	0.65
Nonmarket	1.73	1.69	1.75	-0.06	0.19	1.70	1.74	-0.05	0.48
Personal	1.64	1.60	1.67	-0.07	0.12	1.56	1.68	-0.12	0.05
Resting & sleeping	1.31	1.30	1.32	-0.03	0.00	1.29	1.33	-0.03	0.00
Social	1.62	1.63	1.60	0.03	0.47	1.60	1.59	0.01	0.87
Other	1.91	1.81	2.00	-0.19	0.01	1.87	2.09	-0.22	0.04

Note: Normalized energy expenditure is measured as individual total energy expenditure/BMR. Active energy expenditure calculated using the work-energy method. T-tests on differences between males and females.

Table 3: Individual effort (exp/BMR) and within-household power differentials, dyadic pairs

	(1) Age Δ	(2) Education Δ	(3) Managed plots Δ	(4) Managed area Δ	(5) Plots owned Δ	(6) Area owned Δ	(7) Polygamy
Female	-0.00880	0.0173	0.0142	0.0192	0.00163	0.00664	0.0184
	(-0.41)	(1.12)	(0.77)	(1.03)	(0.09)	(0.37)	(1.23)
[Category]	-0.00652**	0.000262	0.00524	0.0105*	-0.00393	-0.00366	-0.143***
	(-2.21)	(0.07)	(1.31)	(1.89)	(-0.97)	(-0.66)	(-4.56)
Interaction	0.00640*	0.00290	0.00285	0.00134	0.00881**	0.00851*	0.103**
	(1.92)	(0.73)	(0.74)	(0.28)	(2.52)	(1.78)	(2.07)
Constant	1.532***	1.575***	1.561***	1.556***	1.585***	1.583***	1.569***
	(71.88)	(52.13)	(52.60)	(53.52)	(53.95)	(54.82)	(51.95)
Observations	216	216	216	216	216	216	216
R-squared	0.027	0.059	0.085	0.104	0.070	0.063	0.074

Notes: t statistics are in parentheses. * p<0.10; ** p<0.05; *** p<0.01. Dependent variable is individual total energy expenditure/BMR. Active energy expenditure calculated using the work-energy method. Except for column (1), regressions also control for husband's age and husband-wife age differential. Standard errors are clustered at the household-level.

Table 4: Self-reported activity (hours/day) and within-household power differentials, dyadic pairs

	(1) Age Δ	(2) Education Δ	(3) Managed plots Δ	(4) Managed area Δ	(5) Plots owned Δ	(6) Area owned Δ	(7) Polygamy
Market work							
Female	-1.941***	-1.710***	-2.530***	-2.305***	-2.412***	-2.222***	-2.026***
	(-3.78)	(-4.71)	(-5.94)	(-5.34)	(-5.78)	(-5.41)	(-6.14)
[Category]	0.0178	0.125*	-0.189**	-0.0889	-0.130*	-0.0456	-1.738
	(0.27)	(1.95)	(-2.32)	(-0.79)	(-1.81)	(-0.48)	(-1.06)
Interaction	-0.0155	-0.173**	0.183**	0.130	0.171**	0.114	0.276
	(-0.19)	(-2.35)	(2.40)	(1.19)	(2.36)	(1.16)	(0.14)
Nonmarket work							
Female	2.207***	2.335***	2.405***	2.409***	2.460***	2.436***	2.470***
	(5.74)	(8.18)	(6.73)	(7.16)	(7.95)	(8.02)	(9.97)
[Category]	-0.0547	-0.0843*	-0.0479	-0.0384	-0.0508	-0.0569	0.0686
	(-1.40)	(-1.96)	(-0.88)	(-0.60)	(-0.90)	(-0.75)	(0.08)
Interaction	0.0495	0.0638	0.0150	0.0173	-0.00543	0.00620	-0.595
	(1.01)	(1.11)	(0.20)	(0.21)	(-0.09)	(0.09)	(-0.72)
Resting and sleeping							
Female	-0.00448	0.147	0.190	0.282	0.216	0.192	0.178
	(-0.02)	(0.68)	(0.71)	(1.06)	(0.90)	(0.83)	(0.91)
[Category]	0.00263	-0.0672	0.0834	0.0489	0.0787	0.0503	2.129*
	(0.08)	(-1.52)	(1.35)	(0.86)	(1.38)	(0.93)	(1.89)
Interaction	0.0196	-0.0322	-0.0353	-0.0859	-0.0542	-0.0563	-2.303***
	(0.45)	(-0.67)	(-0.47)	(-1.17)	(-0.77)	(-0.86)	(-2.64)
Social activity							
Female	-0.815**	-0.908***	-0.418	-0.585*	-0.479*	-0.628**	-0.799***
	(-2.32)	(-3.56)	(-1.38)	(-1.94)	(-1.73)	(-2.41)	(-3.36)
[Category]	0.00934	0.0330	0.0472	0.00880	0.0839	0.0627	0.926
	(0.20)	(0.65)	(0.84)	(0.13)	(1.59)	(1.01)	(1.01)
Interaction	0.00663	0.0713	-0.130**	-0.0886	-0.131**	-0.0854	0.424
	(0.13)	(1.32)	(-2.25)	(-1.17)	(-2.37)	(-1.24)	(0.33)
Observations	216	216	216	216	216	216	216

Notes: t statistics are in parentheses. * p<0.10; ** p<0.05; *** p<0.01. Dependent variable is number of hours reported for each activity type. Except for column (1), regressions also control for husband's age and husband-wife age differential. Standard errors are clustered at the household-level.

Appendix Tables

Appendix Table A1: Summary sample characteristics

	Full sample					Dyadic pairs			
	Total	**Male**	**Female**	**Δ (M-F)**	**p-value**	**Male**	**Female**	**Δ (M-F)**	**p-value**
Individual characteristics									
Height (m.)	1.59	1.64	1.56	0.08	0.00	1.65	1.56	0.09	0.00
Weight (kg.)	53.83	55.24	52.74	2.50	0.00	56.77	53.33	3.44	0.00
Age (years)	35.00	34.31	35.54	-1.23	0.44	39.31	34.45	4.85	0.01
Education (years)	5.37	6.09	4.80	1.29	0.00	6.12	4.40	1.72	0.00
Marital status									
Married	0.64	0.69	0.59	0.10	0.04	1.00	0.99	0.01	
Married (polyg. Union)	0.04	0.03	0.04	0.00	0.77	0.04	0.04	0.00	1.00
Widowed	0.06	0.01	0.11	-0.10	0.00	0.00	0.00	0.00	.
Separated	0.09	0.03	0.14	-0.11	0.00	0.00	0.00	0.00	.
Unmarried	0.21	0.27	0.16	0.11	0.01	0.00	0.01	-0.01	
Area managed (acres)	1.50	2.08	1.05	1.02	0.00	2.79	0.52	2.27	0.00
Plots managed (number)	2.03	2.72	1.50	1.22	0.00	3.69	0.84	2.84	0.00
Area owned (acres)	1.45	1.87	1.13	0.74	0.00	2.52	0.68	1.84	0.00
Plots owned (number)	1.93	2.44	1.53	0.90	0.00	3.35	1.01	2.34	0.00
Household characteristics									
Dependency ratio	0.63	0.57	0.67	-0.09	0.05	0.71	0.71	.	.
Household size	5.35	5.35	5.34	0.01	0.96	5.22	5.22	.	.
N (individuals)	410	179	231			108	108		

Note: The dependency ratio is defined as children aged 0-10 years divided by members aged over 10. T-tests on differences between males and females.

Appendix Table A2: Activity groups

Activity groups	Disaggregated activity (as self-reported)
Market work	Working for a wage, salary, commission or in-kind payment
	Working for other households free of charge as exchange laborer
	Managing, working, or helping in a non-agricultural or non-fishing household business
	Farming
	Livestock tending
	Fishing
	Hunting or gathering foodstuffs
	Making goods (furniture, pottery, baskets, clothing)
Nonmarket work	Buying food or other items or obtain services
	Cooking or preparing food or drinks to preserve them
	Collecting firewood or other natural products
	Fetching water from natural or public sources
	Cleaning the house, washing or ironing
	Household maintenance or own construction work
	Providing care or assistance to adults (18+ years)
	Looking after children (17 years or younger)
	Planning the household's finances or bills
Social activities	Social or religious activities and hobbies
Personal activities	Eating and drinking
	Personal care
	Watching TV/listening to radio/reading
	Exercising
Sleeping and resting	Sleeping and resting
Other activities	School (incl. homework)
	Travelling and commuting
	Other

Appendix Table A3: Sociodemographic correlates of effort – age, education, household size, marital status and dependency ratio

	(1) Age	(2) Education	(3) Household Size	(4) Currently Married	(5) Dependency Ratio
Female	-0.021	0.045*	0.006	0.014	0.010
	(0.028)	(0.025)	(0.036)	(0.021)	(0.020)
[Category]	-0.002***	0.002	-0.000	0.004	-0.007
	(0.001)	(0.003)	(0.005)	(0.022)	(0.024)
interaction	0.001*	-0.005	0.003	0.013	0.018
	(0.001)	(0.004)	(0.006)	(0.024)	(0.025)
Constant	1.552***	1.489***	1.501***	1.496***	1.503***
	(0.022)	(0.022)	(0.031)	(0.018)	(0.018)
Observations	406	406	406	406	406
R-squared	0.025	0.011	0.008	0.009	0.008

Notes: t statistics are in parentheses. * p<0.10; ** p<0.05; *** p<0.01. Dependent variable is individual total energy expenditure/BMR. Active energy expenditure calculated using the work-energy method. Standard errors are clustered at the household-level. Except for column (1), regressions also control for husband's age and husband-wife age differential. Age and education are measured for the individual, while household size and dependency ratio are measured for the household level.

Appendix Table A4: Individual Effort (exp/BMR) and within-household power differentials using Freedson-algorithm, dyadic pairs

	(1) Age Δ	(2) Education Δ	(3) Managed plots Δ	(4) Managed area Δ	(5) Plots owned Δ	(6) Area owned Δ	(7) Polygamy
Female	0.019	0.0291**	0.0288	0.0335*	0.0171	0.0211	0.0333**
	(0.96)	(2.02)	(1.58)	(1.86)	(0.99)	(1.23)	(2.36)
[Category]	-0.00517*	-0.00137	0.00504	0.00893*	-0.00348	-0.00372	-0.147***
	(-1.96)	(-0.37)	(1.27)	(1.74)	(-0.89)	(-0.75)	(-4.33)
Interaction	0.00384	0.00498	0.00310	0.00185	0.00879**	0.00901*	0.117**
	(1.30)	(1.36)	(0.74)	(0.38)	(2.38)	(1.91)	(2.33)
Constant	1.478***	1.510***	1.492***	1.491***	1.516***	1.514***	1.499***
	(75.87)	(52.55)	(53.95)	(54.23)	(54.65)	(54.40)	(51.87)
Observations	216	216	216	216	216	216	216
R-squared	0.04	0.059	0.087	0.097	0.069	0.062	0.075

Notes: t statistics are in parentheses. * p<0.10; ** p<0.05; *** p<0.01. Dependent variable is individual total energy expenditure/BMR. Active energy expenditure calculated using the method outlined in Freedson, Melanson and Sirard (1998). Except for column (1), regressions also control for husband's age and husband-wife age differential. Standard errors are clustered at the household-level.