Patterns of daily activity and time spent in bed of adult women and adolescent and preadolescent girls from a rural community in Senegal, West Africa

G. M. Ndiaye, Eric Bénéfice

Patterns of daily activity and time spent in bed of adult women and adolescent and preadolescent girls from a rural community in Senegal (West Africa)

Running title: Physical activity of female subjects in Senegal

Gnagna Mbaye Ndiaye [1] and Eric Benefice[2]

[1] Cheikh Anta Diop University (Dakar, Sénégal) and Institut de Recherche pour le Développement (IRD, UR024 Sénégal)
[2] Researcher, Institut de Recherche pour le Développement (IRD, UR024, Bolivia)

Authorship contributions: This study was part of the PhD dissertation of Gnagna Mbaye Ndiaye when she was a student at Dakar University in the R024 (Epidemiology and Prevention) Research Unit of the IRD. Eric Benefice (PhD, MD) was her supervisor. Both participated in the conception, supervision, data collection and analyses, and writing of the paper.

Corresponding author:

Dr Eric Benefice
IRD (Institut de Recherche pour le Développement)
Representación en Bolivia
Av Hernando Siles # 5290, Esq Calle 7 Obrajes
PBox: 9214
La Paz (Bolivia)
Tel: (591 2) 278 29 69
Fax: (591 2) 27829 44
Web: www.bo.ird.fr
Mail: benefice@ird.fr

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Abstract

Background: In rural Africa, women and adolescent girls sustain a high burden of domestic and agricultural tasks. This could result in energy imbalance and impair their nutritional status.

Objective: The aim of the study was to investigate activity during the day and time spent in bed during the night of adult women and adolescent and preadolescent girls living in the same household. Our hypothesis was that more prolonged physical inactivity and time spent in bed could be an efficient means for lowering energy expenditure and hence maintaining an adequate nutritional state.

Methods: Physical activity during the day was qualitatively recorded using "spot observation" (Super 1989), and quantitatively using accelerometers. A total of 110 females, 55 adult women, 45 adolescents and 10 preadolescents, were included in the study. Anthropometric measurements (weight, height and 4 subcutaneous skinfolds) served as indicators of nutritional status.

Results: Day-to-day reliability of accelerometry counts was acceptable (average intraclass correlation coefficient=0.73). Differences in daytime activity varied according to age group. Adolescent and preadolescent girls had higher overall activities than adults ($p<0.01$). Preadolescent girls went to bed earlier and for longer periods than adult women ($p<0.001$). There existed significant relationships between time spent in bed and activity during the day in adult women but not in adolescent or preadolescent girls. A significant relationship between nutritional status and physical activity indices was observed in preadolescent and adolescent girls, but not in women.

Conclusions Our findings partially support the hypothesis of some compensation of daytime activity by time spent in bed in adult women, but not in adolescent or preadolescent girls.

Key Words: Accelerometry, spot observations, time in bed, nutritional status.

Introduction

Rural societies in West Africa are characterized by poorly mechanized agriculture. Thus, in order to cope with subsistence needs, a high percentage of productive energy must lie in the form of human work efforts. This energy investment, together with a food insecurity status and chronic energy deprivation, may constitute key constraints for economic development. In adult farmers, an association was observed between low energy expenditure and low body mass index (Alemu and Lindtjorn 1995). Women and children are not spared the performing of productive tasks. In underdeveloped agricultural societies, work carried out by children appears to be compulsory in order to sustain the economy of the household (Kramer 2002). A vicious circle may exist between low agricultural productivity and nutritional deprivation (Branca *et al.* 1993,Pastore *et al.* 1993). In a context of poverty, women and preadolescent and adolescent girls are often called upon to work harder than other population groups (Fonchingong 1999,Yamanaka and Ashworth 2002). Indeed, it was previously demonstrated that an excessive workload during the rainy season created an energy deficit in Gambian women (Singh *et al.* 1989).

In order to cope with a high workload, traditional societies have developed a series of strategies based on sexual division of labor (Giampietro and Pimentel 1992), cooperation in sharing tasks and work pace (Panter-Brick 2003). In rural Senegal, men are generally responsible for activities requiring strong muscular power (hoeing, land clearing, animal caring), while women and children are employed in more moderate but time-consuming tasks such as domestic activities (Benefice *et al.* 2001). However, the cumulative cost of their habitual activities may result in a high level of energy expenditure for African women (Bleiberg *et al.* 1980), as well as for children and adolescent girls. Chronic energy deficiency (CED) is an acknowledged cause of stunting in children (Kurpad *et al.* 2005). Consequences of CED are not limited to linear growth retardation, but may also threaten physiological functions. CED may affect female reproductive status (Shaw 2003). Field studies indicate that it has a long-term impact on growth and pubertal maturation, postponing the occurrence of menstruation in West African adolescents and maintaining them in an immature state (Garnier *et al.* 2005,Pawloski 2002). Ultimately, this will delay the energy drain associated with pregnancy and lactation in malnourished adolescents. It is thus conceivable that these populations adapt to such situations in order to maintain an acceptable energy balance. Indeed, restful waking hours and sleep may constitute efficient mechanisms for sparing energy in active subjects.

Daily activity and sleep are associated with physiological and cultural characteristics, but also with development. Physical activity decreases in children prior to puberty, with a maximum at between 6 and 9 years of age (Goran *et al.* 1998). Similarly, total sleep length, but not sleep need, decreases steadily throughout childhood and puberty (Wolfson and Carskadon 1998). Sleep regulation clearly depends on social events: for example, the school schedule sometimes restrains its duration to the point of disturbing adolescent circadian rhythms (Dahl and Lewin 2002). In West Africa, sleep length is mainly dependent upon subsistence activities. The compulsory and repetitive nature of most domestic tasks dictates the daily timetable. This phenomenon is patent in rural communities as well as in the suburbs of cities. In Senegal, we recently reported that children and adult women differently used their physiological resources in order to cope with daily tasks (Benefice and Ndiaye 2005). Social and familial constraints were also shown to be important determinants of rest and physical activity of adolescents (Garnier and Benefice 2001). However, within fairly strict time limits, some adjustments in workload are likely to occur: in rural communities of Senegal, heavy duties are preferentially left to stronger, more mature adolescent girls (Garnier and Benefice 2001). Similarly, for a given age, thinner girls slept longer and more quietly than more robust girls (Benefice *et al.* 2004).

Hence, the main objective of this study was to document daily activity patterns and time spent in bed for girls and women living in the same household in rural Senegal. Within a context of heavy work load for female subjects, we hypothesized that activity during the day was counterbalanced by time spent in bed, thus enabling regulation of energy expenditure and finally, maintaining an adequate nutritional status. Alternatively, familial and social rules could efficiently control the distribution of tasks within the household and thus the workload of individuals.

Subjects and methods

Ecological setting

This study was performed in the Niakhar district located in the center of Senegal. About 30,000 people live here. It is characterized by a typical Sahelian climate, with a short rainy season (July to October) during which agricultural activities are performed, and a long dry season (November to June). Inhabitants practice a mixture of farming and herding. Seasonality is pronounced, leading to marked weight loss in women and wasting in children (Simondon *et al.* 1993). Inhabitants belong to the Sereer ethnic group. About two-thirds are Muslims, while a minority is Catholics or animists. Families are organized into compounds within villages or hamlets. One compound holds one or more households. Each household comprises family members eating the same meal prepared in the same kitchen. Hence, the "kitchen" constitutes the true basic domestic unit. The important point for our study is that the "kitchen" groups together one or more adult women and their daughters, all performing domestic duties (Ndiaye Mbaye 2004). Sharing of tasks, cooperation and assistance links are rooted in this elementary unit.

Study design

The original study design was that of a longitudinal survey performed at three different times of the year to take into account the seasonal effect: mid-rainy season (August), crop season (October-November) and end of dry season (June-July) (Ndiaye Mbaye 2004). Results presented here involve only those of the last visit (end of the dry season), at which time nutritional stress was at its maximum and a quantitative study of rest and sleep could be carried out using actigraphy (Ndiaye Mbaye 2004).

Subjects

Subjects were drawn from the "Agriculture et Elevage" database. Agriculture et Elevage is a survey that has been performed yearly in the Niakhar district since 2000. The studied population was randomly selected using a 3-stage procedure (drawing of village, compounds and kitchen): a total of 600 “kitchens” are being repeatedly investigated. From this database, we drew 28 “kitchens” covering the entire area and comprising 110 females: 55 adult women (>20 years of age; mean age = 36.4 ± 10.9 years); 45 adolescents (between 10 and 19.9 years of age; mean age 14.9 ± 2.9 years); and 10 preadolescents (<10 years of age; mean age 8.7 ±0.8 years)

Data collection and measurements

Physical activity measurements

Physical activity was evaluated qualitatively (nature and location of tasks) using the “spot observation method”, and quantitatively (intensity of activities) by means of accelerometers, for 2 consecutive days.

- Spot observation: This technique was first used by Super for nutritional purposes to observe malnourished children without interfering with their habitual behavior (Super 1989). It is derived from the works of Munroe (Munroe *et al.* 1984). A female investigator observed the behavior of the women during a one-minute period at 15 minute intervals. On an individual precodified form, she then noted their activities (expressed as main activity and secondary activity) and their location. The same surveyor observed one kitchen at a time. Subjects were followed up during the day over 2 time periods: from 7:00 am to 2:00 pm and from 2:00 pm to 8:00 pm, by two teams of trained surveyors.
- Actigraphy: Activity was quantitatively assessed for 48 h using a CSA accelerometer (model 7164, Computer Science and Applications, Inc., Shalimar, FL). This is a small electronic device that measures body accelerations on a vertical plane. The recording interval was set at 1 minute. Accelerometers were worn near the body center, fitted with a belt at the level of the left hip. Subjects were instructed on how to remove the apparatus for washing or bathing. Apart from these situations, they wore the accelerometers continuously night and day for 40 hours (from 7:00 am the first day to 23:00 to 24:00 pm the 2nd day). Proper functioning of the apparatus was checked early in the morning and in the evening by the supervisor. (Benefice *et al.* 2001). Activity intensity was

expressed as numbers of counts per minute (counts.minute^{-1} or cpm). The pattern of activity during the day was represented by the mean number of counts recorded every hour. Daytime activity was also categorized into 4 quarters (first quarter: from 7:00 am to 10:00 am; 2nd quarter: from 11:00 am to 14:00 pm; 3rd quarter: from 15:00 pm to 18:00 pm; and 4th quarter: from 19:00 pm to 22:00 pm). Levels of activity were determined using 3 thresholds: 0 to 25 cpm: rest; 26 to 890 cpm: light activity; 891 to 1890 cpm: moderate activity; >1891: vigorous activity. These thresholds had been established previously from a regression equation between minute by minute direct observation scores and accelerometry counts (Benefice *et al.* 2001). Activity intensity was then expressed as percent of time spent at rest and in performing light, moderate and vigorous activities.

- Night measurements: Bedtime was visually determined by examining accelerometer recordings between 8:00 pm and 9:00 am. The onset of sleep was straightforward and appeared to be a consecutive sequence of zeros. Conversely, the time of awakening was evident in the form of a steep onset of counts over 100 cpm. After determining in this way, bedtime and waking-up hours (which were not equivalent to falling asleep and awakening) and then, the time spent in bed corresponding to the difference between the 2 hours (Garnier and Benefice 2005). Due to errors in the handling of the apparatus we had to exclude data for one adult and one adolescent girl. Total recordings refer to 108 subjects out of 110.

Anthropometric measurements

All subjects were weighed (kg) lightly clothed and barefoot, with an electronic scale accurate to 100 g. Their stature (cm) was measured with a portable Harpenden ® anthropometer. In adolescents and preadolescent girls, we measured 4 skinfolds at the triceps, biceps, subscapular and supra-iliac sites employing a Holtain ® caliper. Sites were marked beforehand and measurements were taken in duplicate by the same observer (GN). The sum of the 4 skinfolds (Sum 4 skf, mm) was used as an index of total fat mass.

The body mass index (BMI = weight/stature^2, kg/m^2) was calculated. In girls and younger adolescents, calculation of the height-for-age (H-age) index, expressed in z-scores, was made using Anthro software (Centers for Diseases Control: http://www.cdc.gov). In young children, it is considered to be an indicator of chronic malnutrition.

Sexual maturity was determined on the basis of breast development (Tanner 1962). Adolescent girls were also questioned about the occurrence of menstruation.

Ethical considerations

The study protocol was approved by the review board of the IRD (French Institute of Research for Development) and the Cheikh Anta Diop University of Dakar (Senegal). It was submitted to and approved by the Comité National d'Ethique du Sénégal under the supervision of the Direction des Etudes, de la Recherche et de la Formation (DERF), of the Senegalese Ministry of Health. All subjects and their parents were informed of the nature and purpose of the study and gave oral consent, since most were illiterate.

Statistical analysis

Spot observations were entered in duplicate and quality control was performed with Epi Info software. Accelerometry counts were transferred to an Excel ® file. Statistical analyses were done using NCSS ® software (NCSS 2000 statistical version for Windows, Kaysville, UT) (http://www.ncss.com/). Variables were checked and normality of distribution verified. For comparison purposes between age groups, a simple Student t test or one-way analysis of variance was used. Scheffe's post hoc multiple comparison tests were also used. In case of not-normally-distributed variables, a log transformation was applied. If variable distribution continued to be abnormal, the Kruskall-Wallis one-way ANOVA non-parametric test was employed. Associations between variables were studied using the multiple regression analysis procedure. All specified independent variables were used in the regression without attempt of subset selection. A full saturated model was generated. Existence of multicollinearity between dependent variables was checked and was not a problem. Residuals of regressions were all normally distributed.

In adolescent and preadolescent girls, anthropometric indices of nutrition such as BMI and skinfold thickness varied significantly with age and maturation status. As activity indices also varied according to the age group, there was a risk of biasing results by erroneously attributing variability in activity to nutritional indices, when in fact it could be linked to age or maturity. To avoid this problem, in preadolescent and adolescent girls, linear regression analyses between age, BMI and Sum 4 skf were performed. BMI and Sum 4 skf were strongly correlated with age, and resulted in elevated coefficients of determination (R^2). Hence, we used residuals of BMI and Sum 4 skf on age instead of the crude value.

Day to day reliability of accelerometry counts was estimated on the basis of intraclass correlations (ICC) calculated from a two-way mixed effect model with measures of consistency (subjects were considered to be chosen at random without interaction with the instrument error). SPSS-11.0 reliability procedures were used (http://www.spss.com/). These measures are different from the internal reliability of accelerometers, which is determined, under laboratory conditions, by the manufacturer.

Results

General characteristics

Based on breast development (Tanner 1962), 15 adolescent girls out of 45 (33%) were at the beginning of puberty; 5 (11%) were in mid-puberty; and 25 (55.5%) were nearing the end of puberty. Nevertheless, at the time of the study, only 20 (44.5%) had experienced menstruation. All girls aged eight to 10-years-old were sexually immature. Anthropometric characteristics of subjects are indicated in Table 1. Preadolescent and adolescent girls were slightly stunted (H-age: -1.06 ± 0.85 and -0.98 ± 1.0 z-scores respectively). Adolescents had a mean BMI equal to18.4 ± 3.7 kg/m^2, corresponding to the 25^{th} percentile of the CDC reference (Kuczmarski *et al.* 2002). School-age girls had a BMI of 14.9 ± 0.8 kg/m^2 corresponding to the 10^{th} percentile of their age reference. These values denoted the existence of mild malnutrition and pubertal retardation. Mothers were generally slim, with mean BMI of 22.4 ± 2.6 kg/m^2. Six women (11%) had values under 17 kg/m^2, considered to be the limit of chronic energy deficiency; unexpectedly, 9 (16.5%) had a BMI>25 kg/m^2 which suggested overweight.

Nature of daily activities

Differences in the patterns of activities performed by adult women, preadolescent and adolescent girls appear in Figure 1. It could be observed that preadolescent girls had more leisure or personal time than adult women, and spent less time at light domestic tasks. Detailed analysis of the most frequently performed tasks in the three age groups is given in Table 2. Interestingly, adolescent girls spent more time than women performing strenuous duties: pounding millet, gathering wood and fetching water. Adult women spent longer time cooking.

Reliability of accelerometry counts

The average measurement of intraclass correlation (ICC) of movement counts during the 2 days was equal to 0.73 (95% confidence interval: 0.61 ~ 0.82). Extrapolating these results for k measurements indicated that 3 days of observation would be necessary to achieve an ICC greater than 0.80. The ICC value was greater during the 3rd quarter (15:00-18:00 h pm): ICC_3=0.75 and lower during the 4th quarter (ICC_4=0.50). Finally, preadolescent girls displayed the greatest reliability (ICC_{pa}=0.86) in comparison with adult women (ICC_w=0.60) and adolescent girls (ICC_a=0.76).

Intensity of daily activities

In figure 2, mean accelerometry counts were plotted every hour between 7:00 am and 10:00 pm. Activity intensity differed according to the period of the day. Two peaks were discernible: the first occurred at about 8:00 am, and the second at 18:00 pm. Activity was lowest between 12:00 am and 13:00 pm. These differences were statistically significant ($F = 31.1$, $p<0.000$). There also existed significant differences in activity intensity between subjects: Preadolescent girls were more active than adolescents and women both during the 2nd quarter ($F = 4.88$, $p<0.009$) and the 3rd quarter of the day ($F = 8.02$, $p<0.0005$). Physical activity provided by accelerometry counts, after categorization into 4 intensity levels, is represented in Table 3. Percent of time spent at rest or at vigorous activities was skewed to the right. After log transformation, normality of distributions could be assumed. Preadolescent girls were significantly more active than the other two groups. They spent less time resting and more time performing moderate levels of activity. Adult women tended to spend less time doing vigorous activity than their daughters ($p=0.07$). When adolescent and preadolescent girls were combined into a single group, the difference became significant ($t=2.29$, $p<0.02$). These results suggest that adult women were less intensively active than their daughters. They spent more time at rest and less time performing vigorous activities.

Time spent in bed during the night

As complete data existed for only one night, we had to exclude from the analysis a group of 11 subjects (6 adults and 5 adolescents) whose sleep behavior differed markedly from that of the others: they had attended a social event and went to bed after midnight. Results for time spent in bed appear in table 4. Adult women went to bed significantly later and woke up earlier than adolescent and preadolescent girls. Logically, the time spent in bed was longer for adolescent and preadolescent girls than for adult women. When separately considering the group of eleven "night owls", we noted that they went to bed very late (2:08 ±0.52 am), but woke up only slightly later than the other women (7:02 ± 0.58 am versus 6:12 ± 0:37 am, $p<0.0002$).

Influence of daytime activity on time spent in bed

To study the relationship between the activity pattern during the day and time in bed, a multiple regression analysis was carried out separately in adult women and preadolescent and adolescent girls (pooled into a single group), after exclusion of 11 subjects who had gone to bed after midnight (Table 5). In adult women, there existed significant relationships between activity during the 2nd and 3rd quarter of the day and time spent in bed. The relationship was negative during the 2nd quarter and positive during the 3rd quarter. In adolescent and preadolescent girls, time in bed was independent of activities during the day.

We also examined the influence of family composition in terms of number of active women, adolescents or girls, on the physical activity pattern during the day and time in bed at night. There were no significant relationships.

Activity during the day, time spent in bed and anthropometric indices of nutrition

Among preadolescent and adolescent girls, the distribution of residuals of the BMI and Sum of 4 skf with age tended to be platykurtic (kurtosis =3.7 and 3.4), but the hypothesis of normality was accepted. In women, absolute values of BMI served as a global nutritional indicator. Relationships between activity indices and nutritional status were studied with multiple regression analysis. Results are presented in table 6. In adult women, no relationships were brought to light between BMI, average daily activity and time spent in bed. In preadolescent and adolescent girls, subcutaneous fat mass was significantly and negatively associated with time spent in bed and mean daily activity, but positively with rest during the day. BMI was positively associated with mean daily activity, and tentatively, with longer time in bed. It was negatively associated with the rest. H-age (linear growth retardation) was unrelated to any of the activity indices.

When separately analyzing the association between BMI, average daily activity and rest in the eleven women and adolescents who had gone to bed late, no significant relationship was demonstrated. Finally, we were unable to demonstrate the existence of a relationship between the composition of the household and the nutritional status of the subjects.

Discussion

This study analyzes the physical activity pattern and time in bed of a sample of mothers and daughters living in the same household and thus sharing most of their domestic duties. Results confirm the high level of activity of these subjects, as well as the compulsory and repetitive nature of most of their duties. In this sense, these findings do not differ markedly from those of other studies carried out in West Africa (Bleiberg *et al.* 1980,Heini *et al.* 1991). Interestingly, our study points to the existence of a link between physical activity and inactivity indices in women, and between activity indices and nutritional status in preadolescent and adolescent girls.

The limitations of the present work should be mentioned. The first is that only one night of observation was recorded and did not permit confident assessment of sleep. The advantage of actigraphy in assessing sleep in epidemiological studies has recently been emphasized (Tryon 2004). Sleep specialists use this technique in children and adolescents (Sadeh *et al.* 2000) as well as in adults (Tworoger *et al.* 2005). However, authors generally agree that several nights of recording are necessary to improve reliability. For these reasons we used only one variable, "time spent in bed", to represent physical inactivity during the night, without assuming that it consists of sleep or not. Thus, this variable is not equivalent to sleep duration. However, when comparing findings concerning the present adolescent girls with those from another longitudinal study (Benefice *et al.* 2004), we obtained extremely close results for bedtime (9:43 ± 0:40 pm in this study versus 9:57 ± 0:41 pm), time of awakening (6:31 ± 0:44 am in this study versus 6:38 ± 0:31 am) and time spent in bed (8:36 ± 1:00 h in this study versus 8:33 ± 0:54 h). For accelerometry counts during the day, reliability was acceptable (ICC=0.73) according to criteria found in the literature (Janz *et al.* 1995). A 3-day investigation would have enabled us to obtain better reliability, but it was not possible in practice. Taking into account the practical limitations of such field studies, we feel that our present results provide an accurate view of habitual daily activity in this population.

Another limitation stems from the "spot observation" method. It is clearly a qualitative technique that gives a global idea of the activity pattern, but does not permit calculation of an accurate energy equivalent for activities. Its main interest lies in its simplicity and accurate concordance between 2 observers: a correlation agreement of between 0.80 and 0.85 was found by Munroe and colleagues (Munroe *et al.* 1984). Most importantly, in situations in which several persons perform complementary tasks at the same time (i.e. cooking in the same kitchen), this method captures all activities performed by the different actors without interfering with their habitual behavior.

Activities during the day appeared to be quite repetitive, with two discernible peaks, the first occurring around 8:00 am, and the second around 18:00 pm. These peaks corresponded to periods of intense domestic tasks: cleaning and washing in the morning, gathering wood, carrying water, pounding and preparing the main meals in the evening. Interestingly, the highest reliability coefficient was observed during the 3rd quarter ($ICC_3 = 0.75$) when the work load was intense, while the lowest ($ICC_4 = 0.5$) was observed in the evening before going to bed, when a marked decline in activity was observed. The last quarter was a period of personal activities which varied greatly from day to day and also between subjects.

As a whole, the youngest girls were the most active. Their activities were not limited to domestic tasks. Spot observations reported that they spent significantly more time in personal activities, including play, than the other subjects. Adolescents and preadolescent activity was in conformity with studies reporting a decline in activity with age (Armstrong *et al.* 2000). From their higher day-to-day ICC, it could also be inferred that these girls were more repetitive in their daily activities than their mothers. Conversely, this suggests that adult women had a richer and more varyied repertoire of activities, perhaps in connection with their role and responsibilities in taking care of the household. This does not imply that adult women were more quantitatively active. On the contrary, their activity level was the lowest. They rested for a longer period during the day and tended to be less frequently engaged in moderate or strenuous activity than adolescents and girls. One plausible explanation is that their training and experience in performing tasks enabled them to move at a slower pace while maintaining high labor productivity. This kind of adjustment may be very effective in practice, as recently suggested by Panter-Brick (Panter-Brick 2003).

One important point raised by the present study is that, in adult women, there existed a relationship between daytime activity and time spent in bed: women who were more active during the 3rd quarter of the day (a period of substantial domestic duties) spent more time in bed. This could be viewed as a direct physiological compensation for their previous efforts. Alternatively, it could also be linked to the intrahousehold turnover of domestic chores. Women active during the 3rd quarter may be allowed to rest or to go bed earlier in the evening. The inverse relationship between activity during the 2nd quarter of the day and time spent in bed is more difficult to explain. It could nevertheless be observed that this was a period of relaxation and, at times, of napping after lunch. This fits with the hypothesis of a balance between rest and activity during the day and sleep duration at night. As in the previous situation, this could also be due to the organization of chores within the household. In preadolescent or adolescent girls, such a relationship was not observed: their activity during the day was completely independent of that at night. It should be pointed out that in any case, they were allowed a longer time to sleep than their mothers. This could be one explanation for the discrepancy between adults and girls.

Significant relationships were observed between the sum of 4 skinfolds (indicator of adiposity) and activity indices in preadolescent and adolescent girls. The relationship was negative for overall activity and positive for rest during the day. This seems reasonable: more active subjects tend to accumulate less subcutaneous fat. In children, this association is generally weak but genuine (Rowlands *et al.* 1999). Interestingly, there was a negative association between time in bed and subcutaneous fat. We reported a similar finding previously in data on another group of girls (Benefice *et al.* 2004). A first plausible explanation is that, in these marginally nourished girls, longer time in bed would improve recovery from a hard day's work and restore the energy balance. An alternative explanation is that the frail appearance of these probably malnourished girls elicits a protective and compassionate attitude on the part of their mothers. Such solicitude was already described in the same area for mothers who breastfed malnourished babies (Simondon *et al.* 2001). In the case of the BMI, it was positively associated with overall activity, but negatively with rest during the day. It should be stressed that, in this group, no girls were truly overweight. The BMI should be viewed as an index of muscularity and heaviness rather than of adiposity (Campbell *et al.* 2001). Hence, the BMI has a different meaning here than subcutaneous fatness: the stronger and undoubtedly fitter girls were more active than the thinner girls. There was a non-significant trend (p=0.06) toward a positive association between BMI and time spent in bed. Interestingly, a negative relationship between BMI and sleep duration has been reported, especially in male adolescents (Knutson 2005b). Such a relationship may exist during childhood, and some authors postulate that it could be a risk factor for overweight (Sugimori *et al.* 2004). The relationship observed here in preadolescents and adolescents does not fit with this assumption.

The interest of studying sleep in industrialized countries lies in the high prevalence of sleep disturbance during childhood and adolescence, and its association with psychosocial and medical conditions (Dahl and Lewin 2002,Iglowstein *et al.* 2003,Vignau *et al.* 1997). Such associations are difficult to assess in field studies; moreover, this was not the purpose of our study. However, it was observed that time spent in bed as recorded here were apparently slightly shorter than that described in recently published references from Switzerland. We found a duration of 9:21 h in preadolescents compared to 10:30 h in Swiss subjects, and 8:36 h in adolescents compared to 9:00 h in their Swiss counterparts (Iglowstein *et al.* 2003).. Some of these divergences can be explained by the methods used: an interview method with discrete hourly intervals in Switzerland and an objective record here. Senegalese girls went to bed later and woke up earlier than their Swiss peers.

Finally, we were unable to demonstrate an influence of household composition on either the pattern of activity of women and girls or on their nutritional state. The role of child labor in familial economy has been addressed within the framework of the “helpers-at-the-nest” theory by biological anthropologists, especially as concerns maternal fertility (Hames and Draper 2004). However, in the present study, the hypothesis of a positive effect of sharing of tasks upon the nutritional status of mothers and their daughters cannot be completely dismissed. Participation in domestic or extradomestic duties by children or adolescents was a general practice in these communities, and it was thus not possible to compare mothers who had help with mothers who had no help. Moreover, a recent paper analyzing data from a subsistence agricultural society in Guatemala demonstrated that in economic terms, mid-teen children produced more than they consumed, and their parents required their labor force to support the family (Kramer 2002). This situation might also be present here. It is interesting to note that these girls matured very late, at a median age of 15.9 years (95% CI ¼ 15.7–15.9) (Garnier *et al.* 2005); their first pregnancy was late, at about 20 years of age. Thus, they stayed in their mothers’ homes until the end of puberty, providing considerable help with daily tasks.

This study underlines the differences in physical activity within the same household between mothers and their daughters. Discrepancies between groups suggest that beyond physiological characteristics, the social and cultural dimensions of physical activity must be taken into account. It is very likely that adult women work for a longer period of time, but at a much slower rhythm than younger adolescents. Combined with better techniques and training in performing difficult tasks (carrying, pounding) and with better physical fitness, this may result in higher work efficiency and productivity. Such socially and culturally acquired behavior is in contrast with that of younger people, whose conduct seems to be driven by their physical and developmental characteristics.

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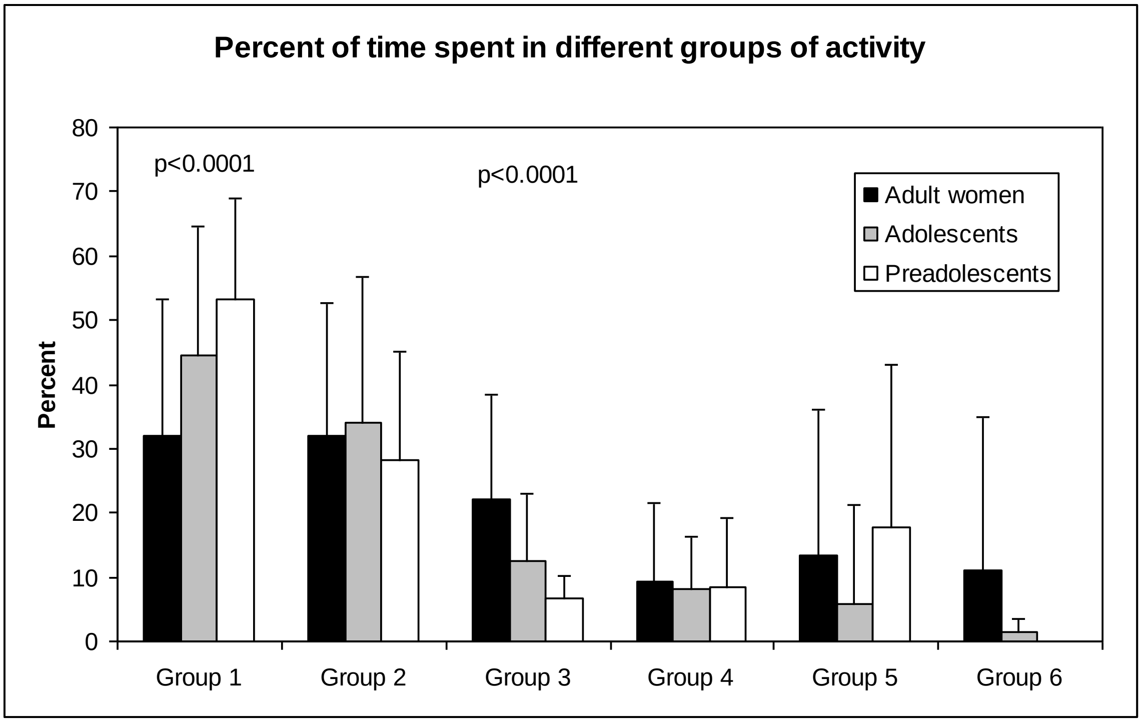
List of Figures



Codes:
Group1: Personal or social activities; leisure; play
Group 2: Moving, traveling
Group 3: Light domestic tasks
Group4: Heavy domestic tasks
Group 5: Agriculture
Group 6: Handicraft, small trading

Figure 1

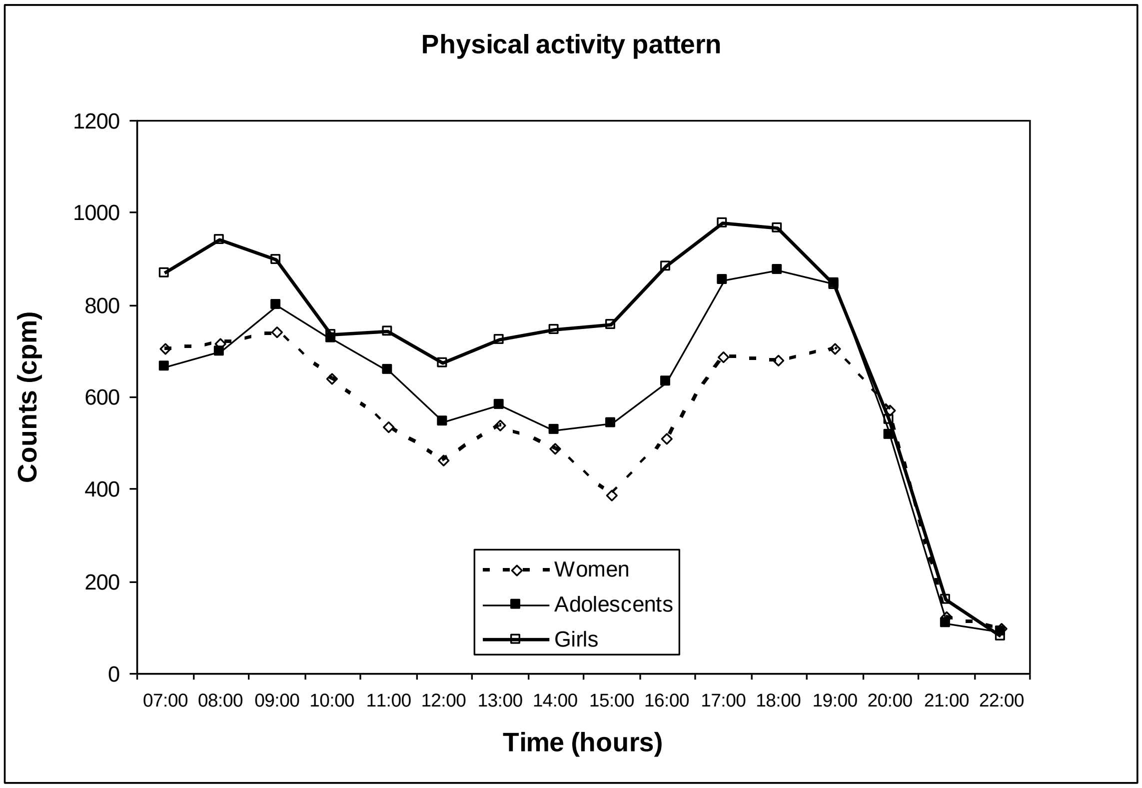


Figure 2: Variation in accelerometry counts during the day

Table1 Characteristics of the sample

	Adult women (n=51)	Adolescent girls (n=45)	Preadolescents (n=10)
Age (years)	35.9 [1]	15.1	8.8
	11.1 [2]	3.1	0.8
Weight (kg)	57.8	43.1	23.2
	7.3	11.6	3.0
Height (cm)	160.5	151.8	124.6
	4.9	10.5	6.2
BMI (kg/m2)	22.4	18.3	14.9
	2.6	3.1	0.8
Sum 4 skinfolds (mm)		28.2	18.2
		11.3	1.9

[1] mean
[2] Standard deviation

Table 2: Time spent (%) at different activities across 3 age groups

Activity group	Nature of tasks	Preadolescent girls n=10	Adolescent girls n=45	Adult women n=55	p
Light domestic tasks	Cooking	6.8[1]±1.1	12.9±1.1	22.6±0.2	0.002
	Cleaning. washing	3.7±0.8	5.3±0.6	6.9±0.1	0.02
Tedious domestic tasks	Gathering wood, fetching water	2.8 ±0.3	4.7 ±0.2	3.9 ±0.1	0.001
	Pounding millet	2.5 ±1.0	6.6 ±0.2	4.8 ±0.3	0.001
	Sweeping out the courtyard	0.7 ±0.4	2.5 ±0.5	3.8 ±0.1	0.05
	Carrying loads	0.1 ±0.1	2.0 ±0.1	1.9 ±0.3	ns

[1] Mean ± 1 standard error
[2] Probability (One-way ANOVA)

Table 3: Percent of time spent at 4 activity levels among the 3 age groups

	Mean	SD	F (2, 105)	p	Contrasts[1]
Total activity during the day (cpm)					
Adult women (1) n=54	593.8	159.9	7.21	0.01	
Adolescents (2) n=44	679.1	179.6			1>2,3
Preadolescent girls (3) n=10	786.8	115.6			
Log percent time spent at rest					
Adult women (1)	2.9	0.5	12.50	0.0001	1<2,3
Adolescents (2)	2.6	0.6			
Preadolescent girls (3)	1.9	0.5			
Percent time spent in light activities					
Adult women (1)	53.2	7.1	0.25	NS[2]	
Adolescents (2)	52.4	8.5			
Preadolescent girls (3)	54.1	5.3			
Percent time spent in moderate activities					
Adult women (1)	22.0	6.3	10.60	0.0001	3>1,2
Adolescents (2)	24.5	7.0			
Preadolescent girls (3)	32.4	6.8			
Log percent time spent in vigorous activities					
Adult women (1)	1.4	0.9	2.65	0.07	
Adolescents (2)	1.7	0.7			
Preadolescent girls (3)	1.6	0.4			

[1] Scheffe's multiple comparison test
[2] NS: not significant

Table 4: Comparison of time spent in bed among 3 age groups (after exclusion of 11 women and adolescents who had gone to bed late)

	Mean	SD	F	p	Contrasts[1]
Bedtime (h:min, pm)					
Women (1) (n=49)	10:09	1:03	4.46	0.01	1>2,3
Adolescents (2) (n=38)	9:43	0:40			
Pre-adolescents (3) (n=10)	9:21	0:44			
Time awake (h:min, am)					
Women (1)	6:06	0:38	4.74	0.01	1<2,3
Adolescents (2)	6:19	0:35			
Pre-adolescents (3)	6:43	0:15			
Time in bed (h:min)					
Women (1)	7:57	1:10	9.13	0.001	1<2,3
Adolescents (2)	8:36	0:56			
Pre-adolescents (3)	9:21	0:43			

[1] Scheffe's multiple comparison test
[2] Kruskall Wallis one-way ANOVA on ranks

Table 5: Influence of activity during four periods of the day upon time spent in bed

1) Adult women (after exclusion of 6 women who had gone to bed late)

$R^2=0.25$
Error: 11.9% (average percent)
F= 3.75 ($p<0.01$)

Period of the day	Regression coefficient	Standard error	Probability [1]	Partial R^2 [2]
1st quarter [3]	-0.050	0.0622	ns	0.017
2nd quarter	-0.163	0.0599	0.009	0.144
3rd quarter	0.150	0.0574	0.012	0.134
4th quarter	-0.122	0.0862	ns	0.043

[1] p-Value for significance test of regression coefficient
[2] R^2 adjusted for all other independent variables
[3]: Period of time during the day: 1st quarter: 7.00-10:00 am; 2nd quarter: 10:00 am-14:00 pm; 3rd quarter: 15:00-18:00 pm; 19:00-22:00 pm.

2) Adolescent and preadolescent girls (after exclusion of 5 girls who had gone to bed late)

$R^2=0.03$
Error: 9.3% (average percent error)
F= 0.4 (Model not significant)

Period of the day	Regression coefficient	Standard error	Probability [1]	Partial R^2 [2]
1st quarter [3]	0.006	0.06	n.s	0.00
2nd quarter	0.07	0.08	ns	0.02
3rd quarter	-0.007	0.04	ns	0.00
4th quarter	-0.006	0.04	ns	0.001

[1] p-Value for significance test of regression coefficient
[2] R^2 adjusted for all other independent variables
[3]: Period of time during the day: 1st quarter: 7.00-10:00 am; 2nd quarter: 10:00 am-14:00 pm; 3rd quarter: 15:00-18:00 pm; 19:00-22:00 pm.

Table 6: Influence of activity during the day and time spent in bed on indices of nutritional status (*after exclusion of subjects who had gone to bed late*)

3) Adult women: Activity indices versus BMI

Activity indices	R^2	Regression coefficient	Standard error	Probability [3]
Time spent in bed (minutes)	0.03 [1] (12.9 [2])	-5.3	4.4	ns
Mean daily activity (cpm)	0.005 (25.8)	4.5	9.6	ns
Percent of rest during day	0.04 (13.8)	-0.03	0.02	ns

[1] Coefficient of determination
[2] Average percent of error
[3] p value for the significance test of the regression coefficient

4) Adolescent and preadolescent girls: Activity indices versus BMI and Sum 4 skinfolds[1]

Activity indices	Total R^2	Nutritional indices	Regression coefficient	Standard error	Probability [3]
Time spent in bed (minutes)	0.22 [1] (8.0) [2]	Res BMI [4]	3.2	1.7	0.06
		Res Sum 4 SKF [4]	-9.8	2.9	0.001
Mean daily activity (cpm)	0.11 (18.0)	Res BMI	11.0	5.2	0.03
		Res Sum 4 SKF	-13.7	9.0	ns
Percent of rest during day	0.29 (20.6)	Res BMI	-0.05	0.01	0.04
		Res Sum 4 SKF	0.10	0.03	0.001

[1] Coefficient of determination
[2] Average percent of error
[3] p value for the significance test of the regression coefficient
[4] Residuals of BMI and sum of 4 skinfolds on age

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