Physical activity and child growth in rural Timor-Leste

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Introduction

Child growth in Timor-Leste is well below international standards, across both urban and rural areas (National Statistics Directorate [Timor-Leste] 2010). Despite programs and interventions from various NGOs and the Timorese government (Democratic Republic of Timor-Leste), including vaccination programs, growth remains a significant problem. Improvement of child growth is of benefit to the current Timorese population and is an investment in the country's future. Poor growth is an immediate problem in that child health must be improved to reduce child mortality rates and improve child wellbeing. In addition, addressing poor growth now will ensure the current generation of children mature into healthy adults who reach their full work capacity, and are therefore better able to contribute to the country's development (Victora et al. 2008).

Poor child growth in developing countries, such as Timor-Leste, is commonly used as a diagnosis for malnutrition, meaning small children have received inadequate calories or nutrition (United Nations Children's Fund et al. 2013; Altieri 2004). While nutrition has a large effect on growth, multiple other factors are linked to poor child growth, including illness and poor sanitation (Guerrant et al. 2008). Parental occupation and household socioeconomic status also play a role in growth, indicating that the resources a child receives are important (Fetuga et al. 2013). To determine the strongest influences on growth in a specific context, and therefore better direct health policy and interventions, detailed contextual investigation is required. This is particularly important in the developing country context, where access to nutritious food and healthcare is often limited for the majority of the population. Early research in the Ossu sub-district of Viqueque district, Timor-Leste, located in the central east mountains, found that no crop or livestock indices based on dollar value (assumed to reflect household wealth), were related independently to variations in growth within the community (Reghupathy et al. 2012). In the context of rural Timor-Leste therefore, broader approaches to determining the causes of poor child growth are required.

One method of examining child growth is through a framework of energy allocation. Energy consumed by the child can be allocated to growth, to maintenance and repair (for example recovery from illness), or to physical activity. When food resources available to the child are low, there must be a trade-off in allocation between the three uses. For example, illnesses such as diarrhoea can redirect energy from growth to maintenance and repair, as well as reducing absorption of nutrients, leading to slowed growth (Guerrant et al. 2008). Physical activity is the most variable component of energy expenditure, both within and between individuals (Goran & Treuth 2001). As a result, this component would be most likely to show variation in response to low resource levels where trade-offs in energy expenditure are necessary.

Rural Timor-Leste is predominantly reliant on subsistence agriculture, which is characterised by seasonal periods of food scarcity (Seeds of Life 2009). The 'hungry' season is during the wet season (approximately Oct/Nov to March/April) when crops are growing for the next season, and food stores become depleted (Seeds of Life 2008). Families can be forced to eat seed reserved for the next season, or forage for wild foods in order to survive (Seeds of Life 2009). During the hungry season, when food is known to be scarce, we are more likely to see trade-offs in energy allocation in children. This study aimed to measure the relationship between children's activity levels and growth during the

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hungry season to determine if high activity levels under food restriction are a contributing factor to poor child growth.

Methods

As part of a larger longitudinal study of child growth, data were collected in April-June 2014 in the Natarbora sub-district (Manatuto district), an area in the flat coastal plains of Timor's south. The Ministry of Health, Timor-Leste, and the University of Western Australia Human Research Ethics committee approved this research. Fifty children in 18 households participated in this study, a sub-sample of 104 households participating in the larger study. Verbal permission was gained from household heads on the previous day, when the study was explained with the aid of a local research assistant. The 18 households were located in three distinct areas: Abatoan, Umaboku, and the Millennium Development Goal community (MDG)[2]. All children were measured for height and weight using standard anthropometric protocols (de Onis et al. 2004). Body mass index (BMI) was calculated from height and weight (kg/m^2). Growth measures were standardised according to the World Health Organization to produce z scores (standard deviations away from the international median), allowing for the comparison of children across ages and sexes. Standardised weight-for-age is available up to age ten, and height-for-age and BMI-for-age to age 19.

At the beginning of each school day (Monday to Saturday; approximately 6:45am across the sample), as many children as possible (up to five) in one household were fitted with Kenz Lifecorder e-STEP accelerometers set to standard settings (Freedson, Pober & Janz 2005). As this study included a recall interview, participating children were aged between six and 16, as younger children have lower cognitive functioning and therefore give less accurate recalls of their activities (Sirard & Pate 2001). Before attaching the accelerometers, we confirmed that children understood the purpose of the devices. Accelerometers were taped closed to deter children from tampering with the devices. The devices were removed at approximately 6:00pm across the sample, and number of steps and exact time spent wearing the accelerometer were recorded. The Kenz accelerometer measures activity level through an algorithmic calculation of vertical acceleration into nine continuous activity levels, with level four classified as moderate (Kumahara et al. 2004). Time spent in activity over moderate intensity (i.e. between levels four and nine) was also recorded.

Short, same-day activity recalls were recorded from each child. Recalls were constructed to account for problems in children's ability to accurately recall frequency, duration and intensity of activity (Welk, Corbin & Dale 2000). Interviews were constructed in tetum with aid from local assistants in order to create an interview format that would be comfortable for children, use language that would be understood, and include activities that children would likely be participating in given the cultural and social circumstances. Children were first asked to volunteer their activities in event delineated time periods, for example, "What activities did you do before school?" This protocol elicited activities as children freely recalled them. After free recall of the day's activities, the interviewer asked about participation in a specific list of activities in order to prompt recall, for example, "Did you fetch water today?" The latter responses were noted as recognition, as they were prompted as opposed to spontaneously recalled. The use of the two methods captures more fully the potential activities of children.

GPS waypoints of all households were taken using a Garmin 76SCx GPS. Distance travelled by each child to school was calculated using straight-line distances from the house to the child's school. For children in MDG, distances were calculated as two straight lines, one from the house to the marketplace, then from the market to the school. For children in Abatoan, one straight line from the house to the school was taken. For households in Umaboku, two straight-line distances were summed: from the house to either the church or the market, based on where the household fell on the midpoint of the main road, then to the school. These points were chosen based on roads and trails in the neighbourhoods.

[2] The MDG community is a group of prefabricated houses constructed in 2012-2013 by the Timorese government under the MDG Suco Program to partly address Timor's MDG targets.

Data treatment and analysis

Child activity was quantified by converting accelerometer readings into steps per hour (Sirard & Pate 2001). Activity from self-reports was aggregated to counts of distinct activities within 4 categorical variables ordered by activity intensity (Alemu & Lindtjørn 1995). For example, studying was classified as sedentary, light housework such as sweeping as light, and higher energy activities such as carrying water as heavy (Table 1). Activity counts are incidences of specific activities, not time spent in activity.

Table 1- Categorisation of children's activities by intensity.

Category	Activity
Sedentary	Study, after school courses
Play	Play
Light work	Washing dishes, cooking, sweeping, feeding pigs, cleaning house, care of siblings
Heavy work	Fetching water, collecting firewood, washing clothes, moving cows, weeding garden, harvesting vegetables

Preliminary analyses showed that total number of reported activities from the recall and recognition sections of the interview did not correlate, and that children underestimated the number of activities performed (paired samples $t = 10.64$; $p < 0.001$), so an overall count of activity was calculated from the complete interview response set. Activity counts from the recall section were added to the recognition section, with the exception of activities that were reported in both to prevent double counting. All statistical analyses were performed using IBM SPSS Statistics version 22.

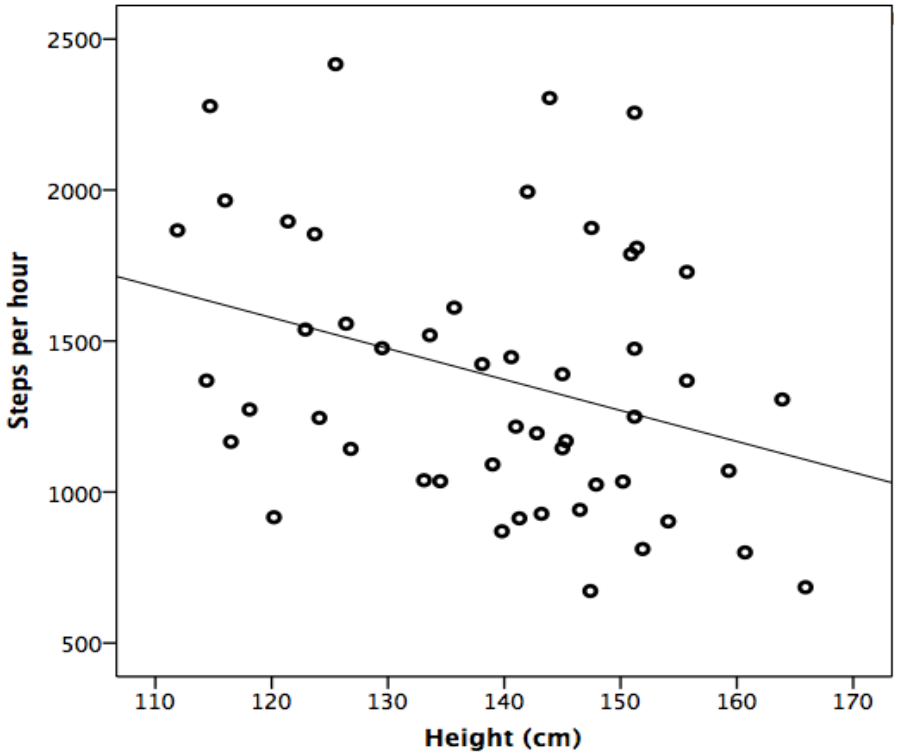
Results and discussion

Twenty-seven girls and 23 boys aged between six and 16 years (mean = 11.8; SD = 2.78) provided data. On average, children in Natarbora are below international standards for all growth measures. As children participating in this study were a subsample of a larger cohort, growth (measured as z BMI-for-age) of the sample was compared to the entire cohort of children and confirmed that this subsample was representative (independent $t = 0.890$, $p = 0.374$). Mean z weight-for-age for this subsample was -1.15 (SD = 0.95; n = 17), mean z height-for-age was -1.32 (SD = 1.00; n = 50), and mean z BMI-for-age was -1.11 (SD = 0.80; n = 50).

On the day of data collection, children averaged 14 690.3 steps (SD = 4 733.2), at a rate of 1 381.0 steps per hour (SD = 446.3). On average, children spent close to an hour in "greater than moderate" activity (mean = 52.88 mins; SD = 28.11). Participating children live, on average, 1.22 km from school (SD = 0.67).

Neither pedometer readings nor activity recalls were significantly correlated on a bivariate level with any measures of standardised child growth. Steps per hour (Pearson's $r = -0.386$, $p = 0.006$) and total steps ($r = -0.323$, $p = 0.022$) were negatively associated with child age. Pedometers were set to standard settings and did not account for child height. Steps per hour and child height (unstandardised) were significantly negatively correlated (Pearson's $r = -0.327$, $p = 0.020$), which is to be expected, as taller children would take fewer, longer steps per unit distance (Figure 1).

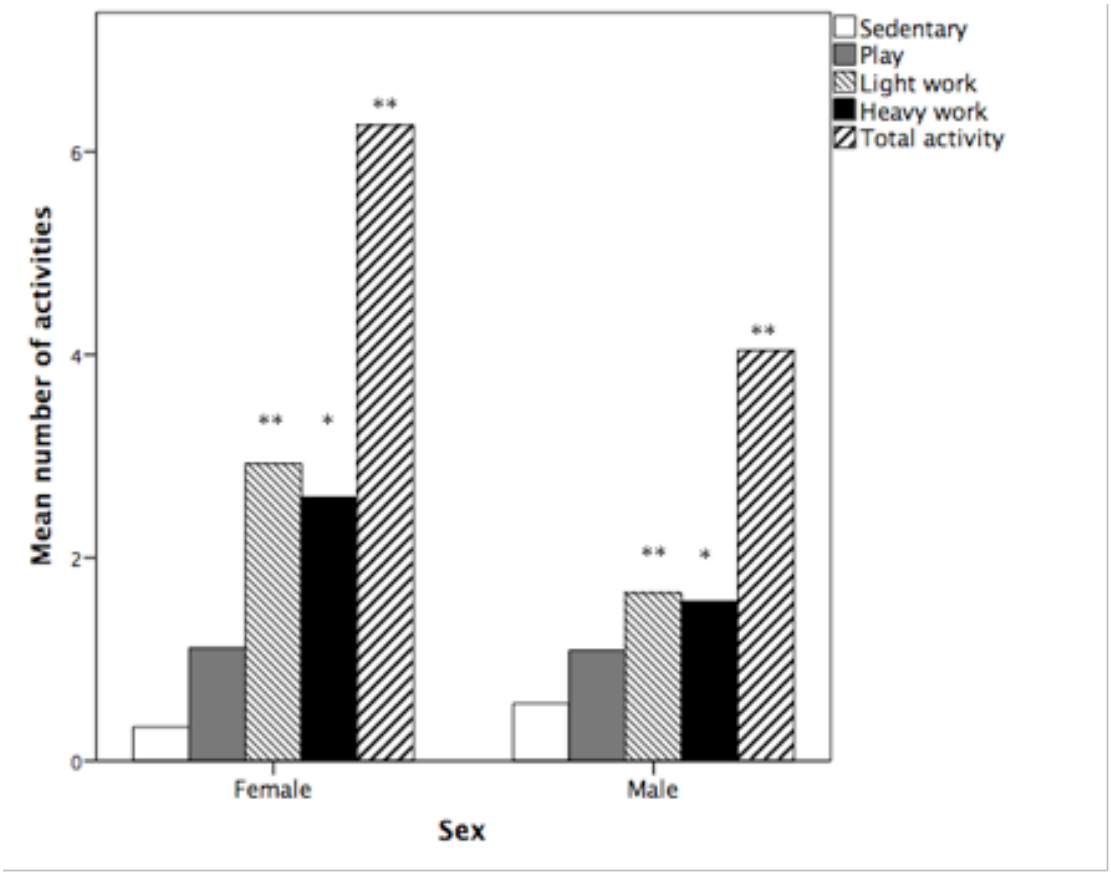
Figure 1 - Taller children take fewer steps per hour than shorter children.



Controlling for child height resulted in no significant correlation between steps per hour and child age ($r = -0.216$, $p = 0.136$). Distance travelled by children to school also was not significantly related to growth measures. This may be because the energy expended by children walking to school is only a small part of overall daily activity, thus has little independent influence on growth. No children reported illness on the day of data collection, so the relationship between illness and activity, that is, if children reduce activity in response to illness, could not be determined.

The number of activities reported was significantly associated with sex (Figure 2). Girls performed a greater number of total activities than did boys (independent $t = 3.148$, $p = 0.003$). This relationship was consistent for both light work ($t = 4.246$, $p < 0.001$) and heavy work ($t = 2.327$, $p = 0.025$) categories. Girls and boys did not differ in play ($t = -1.431$, $p = 0.813$) or sedentary categories ($t = 0.231$, $p = 0.161$). Girls and boys did not differ in the number of steps per hour ($t = -1.033$, $p = 0.307$).

Figure 2 - Mean number of activities in each category for boys and girls. Asterisks show significant differences between sexes within categories of activity (* $p < 0.05$; ** $p < 0.01$).



While this does not provide direct insight into the relationship between activity and growth, it appears as though there is a gender difference in how work-related activities are allocated to children by heads of households. Males tend to be more sensitive to environmental stress than females, which can be shown as increased mortality and slower growth (Stinson 1985). Other research by this group shows poorer growth in Timorese boys than in girls, particularly in the teen years (Sanders et al. 2014). There may be an unconscious buffering of boys by household heads against this environmental sensitivity through reducing the number of work-related activities.

When prompted by a list of activities, children remembered engaging in more activities than they recalled without prompts. Interviews were created in consultation with local Timorese in order to tailor the recall protocol to the local setting with an understanding of cultural and age-related perspectives; however, it appears further work is required to construct a more accurate free recall interview technique. The problem may lie in Timorese children not recognising the concept of 'activity' in the sense of 'what activities did you do today?' and this in turn may mean some activities performed by children were not revealed, even though the word 'activity' (*actividade* in tetum) was understood by all children. It also may be that some activities are so common they are not cognitively recalled, such as helping with household tasks.

Boys and girls differed in their accuracy of free recall of activities, with females more likely to underestimate the number of activities they performed than were boys (independent $t = -2.326$, $p = 0.028$). As girls and boys differ in the number of work-related activities they performed, but not in other activity categories, it may be that girls are not cognitively recalling work activities. Controlling for this sex difference in recall, the number of activities reported in the free recall section of the interview were predictive of the number reported under prompt ($r = 0.338$, $p = 0.018$).

These preliminary results did not show a relationship between an "end of the rainy season" measure of child activity and achieved growth. This may be due to the fact that measurements were taken during a period of food restriction, and that most or all children had decreased activity levels in response to food restriction. This means that instead of allocating energy to activity at the expense of growth, children were preserving energy for growth by reducing activity. Parents may have also been moderating child activity by reducing their work-related tasks, thereby partially buffering children from the effect of food scarcity. Judge et al. (2012) indicate that children with poorer harvest season scores from the previous year exhibit less negative change over the rainy season than children with higher previous year measures, and propose that a buffering effect occurs within families.

A potential problem in this methodology is the lack of data collected on child food intake. When modelling energy allocations, quantification of energy taken in is needed to calculate overall energy balance, that is, what energy children have available to allocate. Without knowing intake, we cannot calculate if children are in energy deficit during this period of data collection. However, children's growth worsens between harvest season (food plenty time) and the hungry season in the Ossu region of Timor-Leste, indicating that the decline in food resources is sufficient to be reflected in growth (Sanders et al. 2014; Judge et al. 2012). It is therefore likely that children in Natarbora during the time of data collection were in energy deficit.

While BMI-for-age and weight-for-age are measures of short-term growth, there is likely to be a lag effect between growth and activity, that is, short-term growth is not immediately reflective of current physical activity. Energy imbalance, for example from excess physical activity, needs to continue over to time to be reflected in growth (Goran & Treuth 2001). This study will therefore be developed by continuation of activity measurements with growth measurements over time.

Conclusions

Child growth in Natarbora is below World Health Organization standards for height, weight and BMI. Activity measures did not correlate with growth at one point in time; however, this does not mean there is a lack of relationship between the two. Further investigation of children's activity and overall energy balance is required to determine if children are moderating activity levels under food restriction. We plan on continuing investigation into children's activity and improving the methodology by data collection over several days in order to check internal reliability of results and to determine within-child variation. Data on child nutritional intake, through recall interviews or observations, will allow calculation of overall energy balance. Collection of similar activity data for the same children during the harvest season will provide more variation in activity amongst children, as higher food levels would mean it is less likely activity is restricted.

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