The influence of sex, age and season on child growth in Ossu sub-district, Timor Leste, 2009-2012

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Despite a recent decline in child mortality in Timor-Leste, the prevalence of child undernutrition remains high. Undernutrition negatively impacts children's growth, cognitive and social development and has long term consequences for adult disease risk and economic productivity (Victora 2008; Dewey and Begum 2011; Adair et al 2013). Child nutrition is a result of food availability and parental care practices and the broader social, economic and environmental conditions that influence these factors (United Nations Children's Fund (UNICEF) 2013). We study child growth as a function of family composition, resources and location within four local communities in the sub-district of Ossu, Viqueque district.

Anthropometric measures of height and weight provide useful information about a child's present and past nutritional status. Height for age indicates prior long-term nutrition with inadequate height for age (stunting) reflecting chronic undernutrition from an early age. In contrast weight for height, expressed as body mass index (BMI), reflects a child's current nutritional state (Waterlow et al 1977; de Onis 2001, p75). Inadequate weight for height (wasting) is a sign of acute undernutrition and is associated with a significantly elevated mortality risk (UNICEF 2013). Weight for age is a good indicator of general undernutrition and is useful for assessing young children in cross sectional studies (Waterlow et al 1977). The most recent Timor-Leste Demographic and Health Survey (National Statistics Directorate (NSD), Ministry of Finance and ICF Macro 2010) reports prevalence rates of 58% for stunting[6] and 19% for wasting[7] amongst children younger than 5 years.

On a global scale stunting is more common in rural than urban areas (UNICEF 2013) and this is also true in Timor-Leste (NSD, Ministry of Finance and ICF Macro 2010). Rural Timor-Leste families predominantly subsist on seasonal crops such as rice, maize, cassava and banana (Seeds of Life 2007). During the wet season, from November to April, families can experience food shortages (United Nations Food Programme 2005; Lopes and Nesbitt 2012; da Costa et al 2013). Children generally lose weight and body condition but family and individual factors can buffer or intensify the effect of this 'hungry season' on child growth (Judge et al 2012).

Resources and workload may be distributed differently according to age and sex of family members depending on societal and parental preferences. In societies with high infant mortality there may be preferential allocation of resources to older children with proven survival (Clutton-Brock 1991); alternatively older children may buffer younger children by providing child care or by contributing to family resources through work (Meehan 2009; Kramer 2011). In a cross sectional analysis of child growth parameters assessed during harvest in Ossu sub-district, we observed lower weight and BMI in older children relative to children aged 5 or less, but no sex differences were found (Reghupathy et al 2012). The

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[6] Stunting refers to the percentage of children aged 0 – 59 months whose height for age is more than 2 standard deviations below the median of the WHO Child Growth Standards
[7] Wasting refers to the percentage of children aged 0 – 59 months whose weight for height is more than 2 standard deviations below the median of the WHO Child Growth Standards

relative growth of children was related to household composition and community distance from the town centre but not to indices of family crops or livestock (Judge et al 2012).

In the present study we examine patterns of child growth in the four communities over a four year period. Children were measured in July-September (harvest) in 2009 and 2012, and March-May (post rainy season) in 2010 and 2011. In 2010 and 2011 the annual rainy season period of food scarcity was extended due to anomalous climatic patterns impacting planting and harvest (Lopes and Nesbitt 2012; da Costa et al 2013). We examine patterns of short and long term growth over this period according to children’s sex and age.

Methods

We initially sampled households with children in Ossu town (n = 48 households) and the rural *aldeias* of Liamida (3 km north of Ossu; n=19 households) and Kai-uai-hoo (7 km north of Ossu; n = 34 households). Sampling followed the nearest neighbour pattern as previously described (Reghupathy et al 2012; Judge et al 2012). In 2011 and 2012, at the request of the community, we expanded to include 12 households in Uaibua (1.5 km west of Ossu). In all cases, household heads were approached to participate in the study and were interviewed following provision of informed consent (see Reghupathy et al 2012 for details of interviews). With consent of the parents, children were then measured. At each time period, feedback was provided to parents on children’s growth since last measurement and included verbal information on sources of good nutrition, the importance of breastfeeding, child immunisation and visits to the health clinic.

Over the four year period 250 boys and 227 girls aged 0-18 years from 113 households were measured. At least one repeat measure was obtained on 332 (69.6%) of these children (180 boys and 152 girls) with 114 children (23.9%) having measures for all four years. Reasons for single measures include the addition of new babies and fostered children to households, movement of children to households outside of the study area, temporary absence of child or family at the time of interview due to school, work or holiday, child death and withdrawal of the family from the study. Child movement between households was common; for example between 2009 and 2010, 19% of children had moved residence (either in or out), and from 2011 to 2012 the figure was 14.7%.

Stature, weight, and mid-upper arm circumference (MUAC) were measured following standard procedures with participants lightly clothed and without shoes (de Onis et al 2004). Recumbent length was measured for infants unable to stand erect. BMI was calculated as weight in kilograms divided by height (or length) in metres squared. To adjust for the considerable biological influence of sex and age on child size, the anthropometric measures were converted to Z-scores using the WHO anthropometric references (World Health Organization 2007). These Z-scores were then used in all statistical analyses. Any observed age or sex differences in patterns of growth therefore should reflect variation inherent to the Ossu communities. Z-scores are available up to age 19 years for height and BMI and up to 10 years for weight. MUAC is not considered in this paper as Z-scores are only available to 5 years.

Linear mixed models were used to examine age and sex effects over the four sampling periods for each of the three growth measures. Child age was entered as a four category factor. Child identity number was entered as a random effect to allow for repeated measures within the same child over time. For each growth measure we started with a full model including all 2 way interactions between age, sex and sampling period and backward eliminated non-significant interaction terms and independent variables until only significant predictors remained. A probability value (p) less than 0.05 was deemed significant.

This research was approved the Human Research Ethics Committee of the University of Western Australia (RA/4/1/2401) and by the Ministry of Health, Timor-Leste (2009-2010) and the Ministry of Health, Timor-Leste Cabinet of Health Research and Development’s Technical and Ethical Review Committee (2011-2015). Research was funded by the School of Anatomy, Physiology and Human Biology at The University of Western Australia and by the Australian Research Council.

Results and discussion

Children's standardised weight and BMI were significantly lower during the 2010 and 2011 sampling periods than during 2009 and 2012 (Figures 1 and 2). This is not surprising given that body weight and BMI are sensitive to short term changes in nutritional status and measures in 2010 and 2011 were taken soon after the 'hungry season'. Children experienced further loss of body weight (p = 0.001) and BMI (p = 0.001) from 2010 to 2011. This is of concern given the low base from which they started, and is likely explained by a complexity of environmental and social factors in this primarily subsistence population. Due to extended rains in 2010 associated with *La Niña*, farmers could not burn their land in preparation for planting (Lopes and Nesbitt 2012); burning is the primary mode of maintaining soil fertility from year to year in hill and mountain regions of Timor-Leste (da Costa et al 2013). Farmers expressed uncertainty about the appropriate time to engage in field preparation and planting given the prolonged rains. Maize crops in particular were substantially lower (Lopes and Nesbitt 2012) exacerbating the effects of the 'hungry season' from 2010-2011.

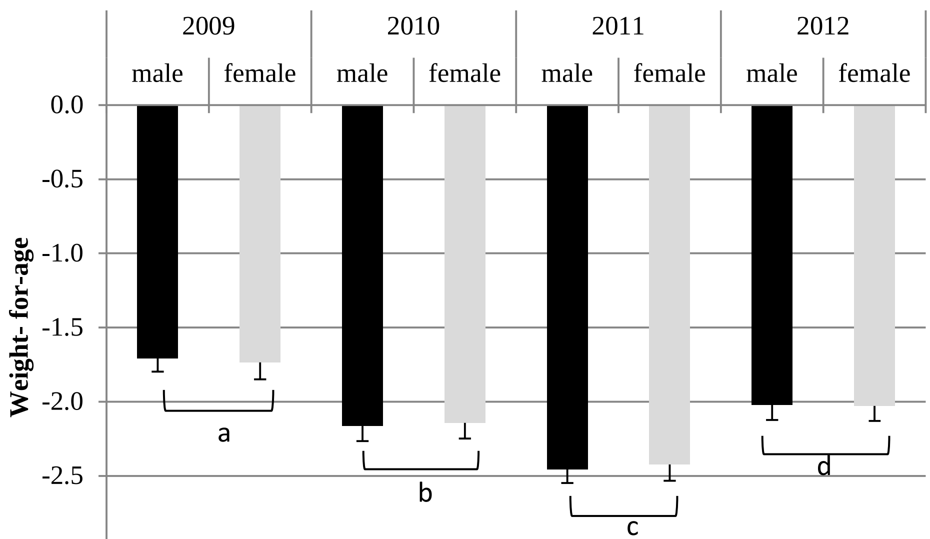

Figure 1. Mean standardised weight-for-age by sampling year and sex for children 0 – 10 years. Error bars represent 1 standard error. Weight during 2010 and 2011 differ from each other and all other years: ab, ac, bc, cd p = 0.001; bd p = 0.002, cd p = 0.038. Weight does not differ by sex of child.

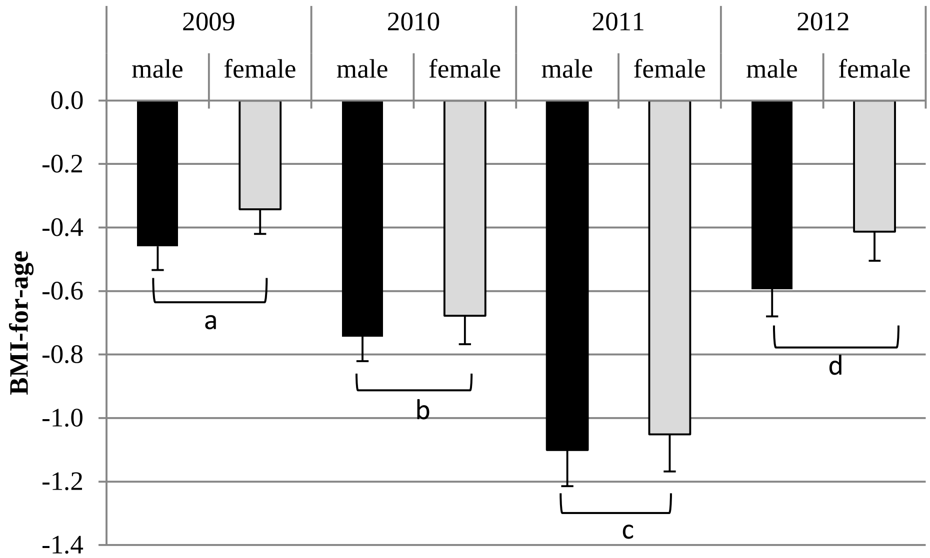

Figure 2. Standardised BMI-for-age by sampling year and sex for children 0-18 years. Error bars represent 1 standard error. BMI during 2010 and 2011 differ from each other and from all other years: ab, ac, bc, cd p = 0.001; bd = 0.01. BMI does not differ by sex of child.

For all years except 2011, children's weight declined with increasing age (Figure 3). Children aged 5+ - 10 years had significantly lower standardised weight than children 2+ -5 years (p = 0.001) and infants aged 2 years or less (p = 0.031). As 2011 was the second year of measurement after the food scarcity period and followed a year of poor agricultural production (Lopes and Nesbitt 2012; da Costa et al 2013), this suggests that while the youngest children experience 'buffering' from the growth impact of poor resources during normal years, years of poor production are not compensated by that buffering. There was no difference in male or female weight across the age groups or years. As is the case for weight, BMI also declined with age (p = 0.001), however, female children experienced less of an age-related BMI decline than males (age x sex interaction p = 0.013; Figure 4).

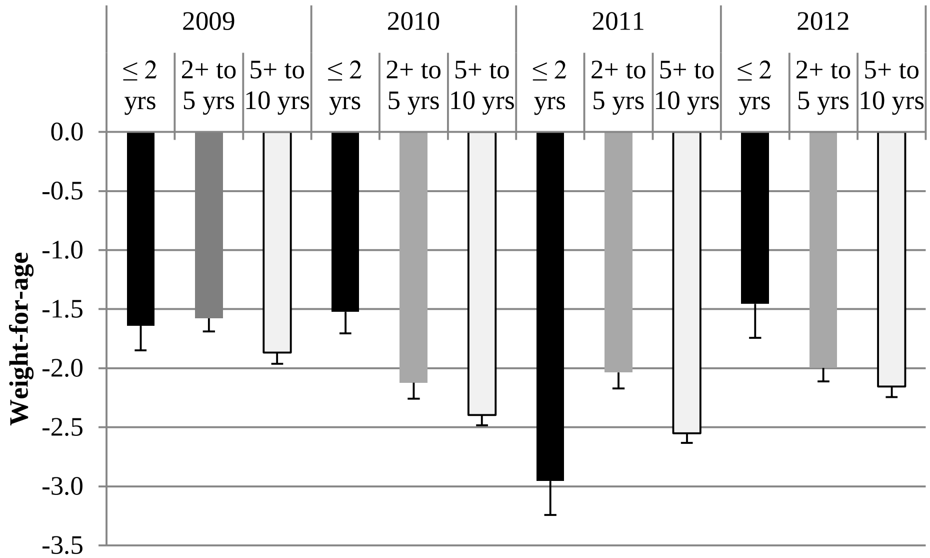

Figure 3. Mean standardised weight-for-age by sampling year and age group for children 0 – 10 years. Error bars represent 1 standard error. Children aged 5+ - 10 years show significantly lower weight than children 2+ -5 years ($p = 0.001$) and infants aged 2 years or less ($p = 0.031$).

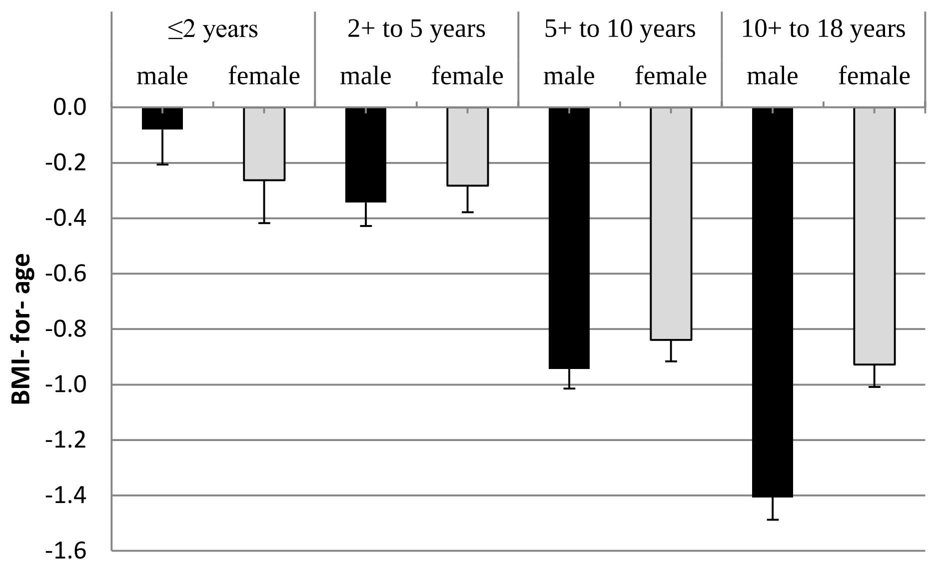

Figure 4. Mean standardised BMI-for-age by age group and sex for children 0 – 18 years. Error bars represent one standard error. Males older than 10 years show significantly poorer BMI for age and sex than do females in the same age group and males in younger age groups.

There was no consistent difference in mean standardised height across sampling years (Figure 5) or age groups (Figure 6). Both male and female children were short by international standards, but as a group female children were significantly taller for their age (mean z = -2.36 ± 0.08) than their male counterparts (mean z = -2.58 ± 0.08, p = 0.021). National statistics show a higher incidence of stunting amongst boys aged less than five years (60%) than girls (56%; NSD, Ministry of Finance and ICF Macro, 2010). Our data indicate that differences in standardized height increased in the teenage years (Figure 6).

Sex differences in the prevalence of stunting have been observed in other populations. Wamani et al (2007) found a higher prevalence of stunting in male children than female children in a meta-analysis of demographic health surveys from sub-Saharan Africa. Similarly, Simondon et al (1998) found a greater teenage height deficit amongst boys (stunted as pre-schoolers) than similarly stunted girls in a longitudinal study of rural Senegalese children. Some studies have posed behavioural explanations for these differences with suggestions of preferential treatment of girls due to women's value in agricultural labour (Svedberg 1990). Adaptive explanations have also been proposed. In resource poor environments natural selection will favour parents who favour females because of their better reproductive prospects (Cronk 1989; Cronk 2007). Rates of child agricultural labour are similar for boys and girls in Timor-Leste; however girls spend more time than boys doing housework and child care related activities (Government of the Democratic Republic of Timor Leste et al 2003). While sex differentials in breastfeeding or immunisation might result in sex differences in growth, there does not appear to be preferential treatment of female children over male children in these behaviours in Timor-Leste (NSD, Ministry of Finance and ICF Macro, 2010). There may be a physiological explanation; while we are measuring growth relative to international standards, those standards are sex specific. In absolute terms male children tend to be bigger than female children and therefore have a higher daily energy requirement (Butte et al 2000). Hence even if the activity levels of male and female children are similar, male children by virtue of their greater body mass may be more adversely affected by limited food availability and thus show greater deviations from expected growth. Future research should examine food distribution among family members and quantify children's energy expenditure, although this is particularly difficult information to acquire.

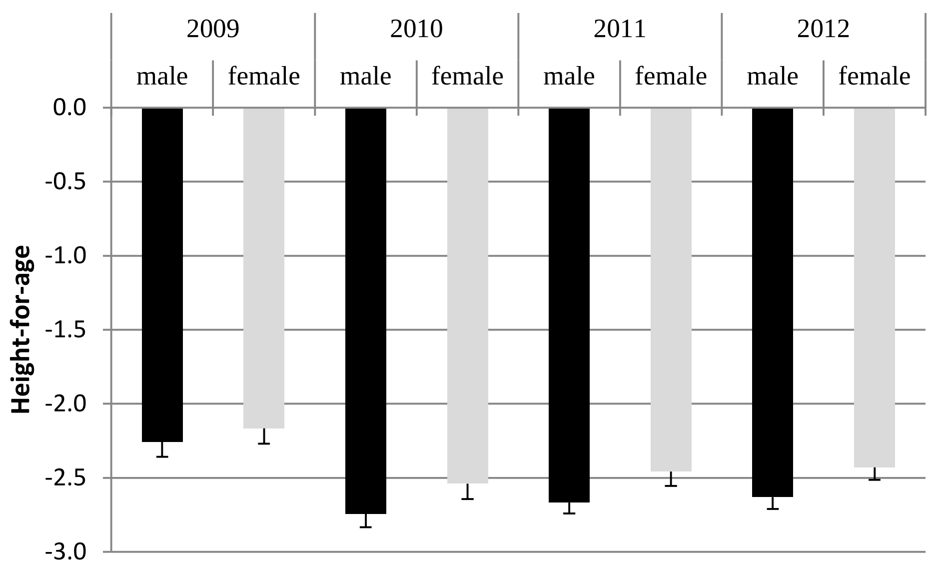

Figure 5. Mean standardised height-for-age by sampling year and sex for children 0 - 18 years. Error bars represent 1 standard error. On average, Ossu children of all ages are short by international standards; girls are less short for age than are boys.

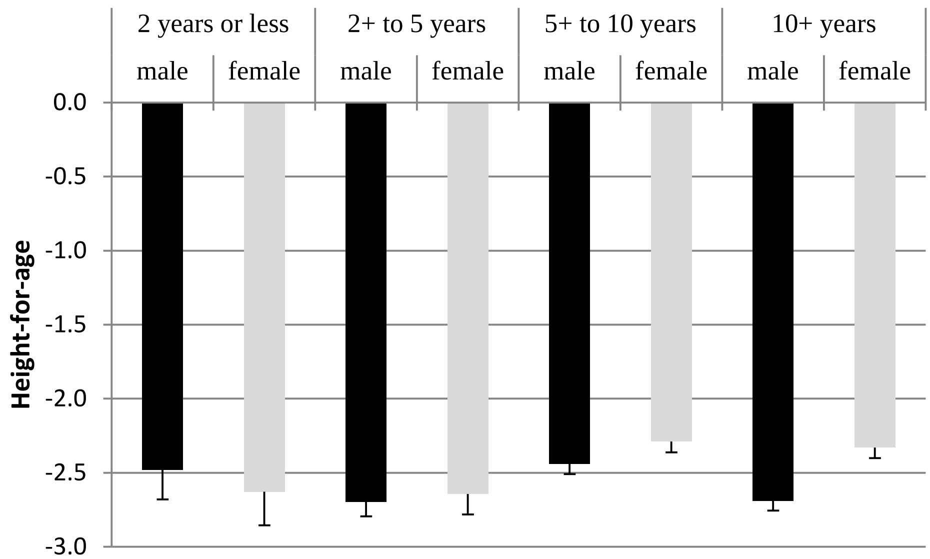

Figure 6. Mean standardised height-for-age by age category and sex for children 0 – 18 years. Error bars represent 1 standard error. Ossu children of all ages are short relative to international standards and this does not differ by age; males are shorter for age than females.

Short height for age in infancy followed by rapid weight gain later in childhood increases the risk of obesity and adult onset conditions such as heart disease and Type II diabetes (Bateson et al 2004; Gluckman et al 2007). That weight and BMI declines with age in our sample indicates that there is no evidence of 'catch-up' growth in this community to-date. However, with shifts in diet and lifestyle as a consequence of modernisation and a move to a cash economy (e.g. availability of snack foods and television with the introduction of reticulated electricity in 2012) there may be a risk of these conditions in the adult population of the future (UNICEF 2013). Thus addressing the factors that lead to both inadequate linear growth during infancy and early childhood (undernutrition) and later catch up growth (inappropriate nutrition; sedentary lifestyle) will be an important challenge. As the electricity grid allows storage and availability of a wider array of foodstuffs in more distant areas of Timor-Leste, educational campaigns focused on good nutrition in addition to programs to increase availability of foods may become increasingly important.

Conclusion

To our knowledge, this is the first longitudinal anthropometric data set for a community sample in Timor-Leste. Children in these rural communities exhibit reduced growth in the both the short term and the long term. Short term growth limitation related to the growing season becomes long term when environmental perturbations and extreme events disturb the recuperative effects of the harvest season. Male children appear more adversely affected than female children but whether this is due to sex differences in childcare practices, physiological sex differences or a combination of both is not yet clear. While shorter stature and associated lower metabolic requirements may be an adaptive response to nutritionally stressed environments, low BMI and weight for age is indicative of current nutritional stress and this is particularly evident amongst older children. Understanding the reasons for sex and age differences in growth will be important for targeted programs to improve child nutritional status.

The predictions of more extreme weather events associated with climate change, together with a rapidly changing way of life, present important challenges to improving the nutritional and growth outcomes of rural Timorese children. The longitudinal data presented in this study provide a basis to assess the outcomes of future interventions to improve community food security, child health and nutritional status.

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