

# Growth Retardation among Children in Southern Iran: A 7-year Population Based Cohort Study

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## Research article

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# Abstract

**Background** Growth retardation is a common health problem, which requires early prevention and detection. This study was conducted to define the approximate age at which stunting starts among the Iranian boys and girls. **Method** The second phase of a population based cohort nested case-control study on 400 children who were followed from birth to 7 years of age. This study was performed to define the pattern of growth among stunted and normal children and to reveal the age at which stunting starts in each gender. **Results** For boys the height was relatively similar between the two groups until the age 6 months at which the difference in height between normal and stunted children starts to become significantly large (difference= 0.70 cm,  $P=0.04$ ). For girls, height in the two groups is relatively similar until the age of 9 months at which the difference starts to become significantly large (difference=0.97 cm,  $P=0.01$ ). No significant difference in the weight of the girls was observed between the normal and stunted groups during the study period (difference=283.21 gr,  $P>0.05$ ). However, boys from the stunted group were lighter since almost the same time that they started to become significantly shorter (difference= 1265.19 gr,  $P=0.001$ ). **Conclusions** Soon after birth (at about 6 months of age), the growth pattern of some (stunted) children starts to stumble and divert from normal. Six month is the age at which mothers start weaning with withdrawing breast milk and start supplementary foods and adult diet. A specially designed study is needed to understand the actual reason for observing such a phenomenon among Iranian children.

# Introduction

Anthropometric indexes during early life and childhood are among the most useful measures for assessing children's health [1]. Weight and height are widely used to assess children's health and nutritional status [2]. For example, growth indices are associated with the risk of morbidity and mortality and cognitive status of an individual [3-7]. In that regard, growth charts are provided as effective tools to determine and assess child's growth status [8]. Of the two major types of indices of physical growth, height is considered as the more stable indicator of health as it represents longer health conditions compared to weight, which is representing current or acute health issues. Although there is no universally accepted definition for growth retardation, in many cases, height shorter than 5<sup>th</sup> percentile or two standard deviations below the mean of the population's height is considered to be short stature or growth failure [1]. Although growth failure is a common health problem among children throughout the world, the condition is much more frequent in developing countries. It has been estimated that in several low-income countries, more than 50% of children under the age of 5 are suffering from stunting [2]. More generally, compared to developed countries, higher rates of growth retardation, including stunting and being underweight, are reported from developing countries. Short stature, if not attributed to any apparent pathologic condition is called idiopathic short stature (ISS) [6]. The condition often happens so slowly that cannot be noticed by parents or health providers in time. Therefore, the affected children cannot be appropriately and timely taken care of. Although, weight and height are used as the most important anthropometric measures representing the status of growth and health, other indexes are also used for

different proposes. For example, head circumference is an important measure, which may reflect individual's cognitive development [9, 10].

Although every person is born with a different growth potential, which is driven by his/her genetic background, other factors including health, socio-economic status and nutrition may also affect growth [6]. For example, the difference in linear growth between developed and developing countries is mostly attributed to socio-economics and nutritional factors rather than genetic diversity [11]. As a result, huge amount of efforts are still undergoing to understand growth-determining factors [1, 6, 11, 12]. Accordingly, WHO do not support the justification of the essential role of genetic diversity in the observed difference between developed and developing countries in children's growth. In fact, WHO is condemning the use of national growth standards in defining the growth status of a nation's young members. According to WHO, young children who were born and lived under appropriate conditions will catch up with their maximum growth potentials irrespective of their genetic background [8]. Based on epidemiological studies, although it seems that the causes of growth failure (including ISS) is unknown for a significant proportion of cases, dietary factors are believed to be important contributors in developing countries [13, 14]. The first phase of this study's report introduced several contributing factors, which were associated with stunting [14]. However, neither our previous report nor the existing literature, clearly stated the timing of the effect of the contributing factors (e.g. nutrition) on linear growth (i.e. at what age after birth the growth retardation starts) [15, 16]. By collecting extra information on anthropometric measures at different ages of the participants, we tried to study the timing of the start of stunting among boys and girls to see if there is any critical point for detection and prevention of growth retardation.

## Materials And Methods

*Settings:* This is the second phase of a cohort nested case-control study on stunting and its related factors. The study was conducted on 400 children who were registered with Shiraz healthcare centers and were followed from birth to seven years of age. The methods of sampling and data collection are previously discussed in detail [14]. Briefly, in Iran, health centers provide primary health cares and general medical services to the residences who are living in their defined geographical areas. Mother and child's health cares are among the most important health services, which are provided by the health centers under the supervision of the Iranian ministry of health. The services include maternity and pregnancy cares, vaccination and monitoring child's growth and development. As childhood vaccination is mandatory for entering primary school in Iran, almost all children from birth to school age (7 years old) are registered to be monitored for growth and to receive immunization by the health centers in their residency areas.

*Sampling:* The total number of births registered with Shiraz health centers during 2009 to 2010 was 27000. A list of all health centers was obtained from Shiraz University of Medical Sciences (deputy of health), and 24 health centers were selected randomly. The selected health centers were visited by one of the research team members asking for a list of registered 6-7 years old children. At the next step, a trained health nurse reviewed the family's health files of the listed children and the required data on children's

health status, including weight and height was collected. The age range for inclusion of the study population was defined in order to exclude those who may have experienced puberty growth (puberty may occur before the age of nine in some girls). Moreover, children older than 7 years of age have no routine visits to health centers and anthropometric measures are not available for them.

*Data collection:* A data collection form was used to extract data from the family's health files. The information which was extracted from the families health files included child's gender and date of birth, measures of height (cm), weight (gr) and head circumference (cm) from birth to 7 years of age (i.e. at birth and months 2, 4, 6, 9, 12, 24, 36, 48, 60, 72 and 84), key nutritional information (i.e. starting and ending dates of breast feeding, starting date and types of complementary foods), parent's education and occupation, number of siblings, birth interval of the child, type of delivery and presence of any health problem. The experienced health nurses also used height at the age of 7 to define growth retardation among selected children and provided a list of children with ISS for each center. Mothers of selected children were later contacted by the female health nurse and via a phone interview the rest of required information was obtained. During the phone interview, the mothers first received a brief explanation about the research as a study on growth determinants and a verbal informed consent was obtained from them. To control recall and reporting biases, mothers were not told why they were selected (their child is a case or control). The information collected from the phone interview included, any medical condition the child had or had had suffered from and a few key questions with regard to the child's nutrition. The latest job and educational statuses of the parents were also reported by the mothers during the interview.

All children were between 6 and 7 years of age, were all born with height upper than 20<sup>th</sup> percentile of the NCHS growth chart and, based on the mother's report, were living with their both parents were included in the study. No or single parent children were not included due to the expected deep and complicated effects of missing parents on children's health. On the other hand, children were excluded if their mothers reported to have changed their address as it could have caused a significant alteration in the child's living and health conditions (e.g. moving from rural areas to the city during the participant's life). Children were also excluded if their mother reported, based on a physician's diagnosis, that their children were suffering from a condition that knowingly affects child's growth, e.g. growth hormone deficiency.

*Selection of cases:* While extracting data from the selected families' health files, the WHO's definition for stunting was used to define stunting among children. Accordingly, children with normal height at birth and height shorter than the 3<sup>rd</sup> percentile of NCHS/WHO growth reference of the same sex at the age 7 were selected as cases.

*Selection of controls:* controls were selected with the same sex ratio from 7 year old children with height taller than 20<sup>th</sup> percentile of corresponding sex-age NCHS/WHO growth reference who were registered with the same health center as were the selected stunted children (controls were frequency matched for sex).

*Statistical methods and sample size:* Post-hoc power analysis suggested that the sample size of the first phase of this study (200 stunted participants as cases and 200 controls with normal height at age 7) was adequate to obtain a significant difference in height between stunted and normal groups at different ages as small as 1 cm. In that regard, type one error and the power of the test were set to %5 and 80% respectively. The data was analyzed using SPSS statistical software, version 19. Independent sample t-test was used to define any significant difference in weight, height and head circumference between stunted and normal groups at different ages.

## Results

The demographic and anthropometric status of the stunted and normal groups are reported elsewhere [14] and not presented here to save the limited space. Briefly, 53.5% and 52.5% of the case and control groups were female ( $p=0.85$ ). In addition, 59% and 57% of the case and control groups parents were unemployed respectively ( $P=0.003$ ). Whereas, 83.5% and 88.5% of the mothers from case and control groups were homemaker respectively ( $P=0.15$ ). With regard to income, 17.0% and 36.5% of the participants' families of case and control groups had an income of more than 30 million Rials ( $P<0.001$ ). With regard to the parents education, both fathers and mothers of the participants in the control group were more educated ( $P<0.001$ ).

As presented in table1, the comparison of height, weight and head circumference at birth reached no significant difference between the stunted and normal groups. The observed similarity of birth height between the stunted and normal groups remains relatively unchanged until 6 months of age (difference=0.70 cm, CI95%= 0.006 to 1.41) and older, during which the observed differences (in height) remains statistically significant ( $P<0.05$ ). With regard to weight, no significant difference was observed until the age of 9 months (difference=379.62 gr, CI95%= 58.21 to 701.03) and older ages, during which the observed differences in weight are statistically significant. The pattern of growth in head circumference is also presented in table1. Accordingly, no significant difference was observed between the two groups in head circumference during the study period.

The comparisons of height, weight and head circumference between the two groups among girls are presented in table2. With regard to height, the observed difference in height remains relatively constant until 9 months (difference=0.97 cm, CI95%= 0.20 to 1.73) and older ages, during which the differences are significant ( $P<0.05$ ). According to the results, height and head circumference of girls at birth is similar between the stunted and normal groups. However, significant differences in weight were observed from birth to 6 months of age in the benefit of stunted group ( $P<0.05$ ). The benefit turns to non-significant at age 9 months and onward ( $P>0.05$ ). In addition, in favor of the stunted group a constant and marginally significant difference was observed between the two groups in head circumference during the whole study period.

The graphical patterns of the growth of the study groups for each gender are separately presented by figures 1 to 4. According to the figures1 and 2, for male participants for weight, growth retardation started

at about the age of 6 months with a relatively constant rate of deterioration till the end of the follow up period. However, when looking at height, a higher rate of diversion has been started since 48 months (4 years) of age. As presented in figures 3-4, growth retardation for girls is to some degree different from boys. First, it doesn't seem that weight gaining is affected by stunting among girls. Also, retardation in linear growth seems to start later (9 months) among girls than boys with no apparent change in its rate then after. The figures reveal that growth retardation starts a couple of months later among girls compared to boys. For better illustration, the standard growth patterns for weight and height are also presented in the figures to make the conclusion easier.

## Discussion

Results of pooled data have demonstrated significant benefits of exclusive breastfeeding on morbidity and mortality among children, [17, 18]. During infancy, several issues cause major concern regarding growth of the child. These include, genetic deformities, environment hazards and nutritional factors [19]. At birth, the recruited infants in the current population based cohort study were all apparently healthy with normal growth indexed at birth. This was done to minimize the effects of genetic factors and factors related to antenatal period. The report from the first phase of our study revealed a number of factors altering the chance of stunting among the study population. Accordingly, diet (i.e. animal protein and dairy products, duration of breast-feeding) and socio-economic factors (family's income and mother's being a housewife) were reported to be effective in growth failure [14]. The aim of the current study was to define the age of the participants at which the condition (stunting) starts. Also, to make a contrast between the pattern of growth among stunted and normal children and to reveal the age at which stunting starts in either genders, three important anthropometric measures from birth to the age of 7 (12 measures for height and weight and 6 measures for head circumference) were included in the analysis. The results revealed a very important phenomenon in the linear growth of the children, which is in fact the milestone of linear growth. According to the results, stunted boys and girls, experienced a significant diversion from the linear growth of the normal children (and the corresponding standard growth chart) at about 6 months and 9 months of age respectively. However, as presented in the results section, the timing of stunting seems actually similar in boys and girls, as on average, the stunted girls were taller than the normal children from birth to 6<sup>th</sup> month of age, at which the stunted children became shorter than the normal children. At about this age, children start experiencing important changes, most importantly, weaning from breast milk and start eating supplementary and more solid foods.

A study in rural Guatemalan children shows that growth faltering starts soon after birth. Authors suggested that at 3 year of age, growth-retarded children were on average 3.6 kg lighter than the WHO/CDC growth chart. Also, between 19% and 34% of the deficit at 3 year of age was due to failure to thrive during the first 3 months of life, 12% to 19% between 3 and 6 months and 12% to 25% between 6 and 9 months of age [20]. However, the authors did not report the status of linear growth of the study population.

Results of a community-based cohort study provided evidence that faltering of linear growth among children under 5 years of age in sub-Saharan Africa started soon after birth and continued throughout infancy [21]. Authors suggested that among a wide range of factors in the study (including; complementary feeding, morbidity, maternal short stature, gender) the strongest predictor of severe stunting at 12 month of age was small birth size [21].

Another cohort study has recently suggested that faltering in linear growth among Zambian infants is more severe at about 13 months of age. According to the authors, the suggested age is about the time which nearly all the infants have completely been weaned off breast milk. This may have severe effects on children's growth [19].

The results of current study also suggested that apparently, another important timing of even more diversion from normal growth is about 24 months of age at which growth rate becomes smaller among stunted children. At this age, children start walking, touching objects outside home and more importantly fully feed by family foods. Interestingly, the reduced rate continues for girls to the end of the follow-up period but another major reduction occurs for boys at fourth year of age. At this age, boys start more active playing with friends or other siblings, whereas girls do sedentary plays [22]. That is why, as presented in the figures, weight for age among girls of both stunted and normal groups is higher than the standard corresponding weight for age of the corresponding gender.

Strength and limitations: The participants in the present study were selected randomly among all children in the defined population. Participant's growth indexes were followed from birth until 7 years of age. All children had normal height and weight at birth helping us to control for genetic and antenatal related factors affecting growth. All information regarding growth and diet of the participants were collected from the participant's health file. Therefore, major sources of recall or reporting bias is not expected to exist. No detailed information was available for the supplementary foods and timing of weaning and adequacy of breast milk.

## Conclusions

Iranian children are mainly born with a normal weight and height, which suggest a normal growth during the antenatal period (or pregnancy of mother). However, after birth (at about 6 months of age for boys and girls) the growth pattern of some children starts to stumble and divert from the normal pattern. The similarity in timing of stunting in girls and boys suggests similarity in affecting factors, which according to the results of the previous study are mainly modifiable (e.g. mother's involvement in child's daily care, timing of weaning breast milk and types of diet including supplementary foods). In addition, the higher weight for age among the normal and stunted children compared to the standard figures at age 7 suggests that high energy-low protein diet may play important roles in the growth of the study population. With regard to the results of the previous and current studies, the approaches of Iranian mothers for breast feeding and weaning should be observed closely to understand how diet during infancy affect growth. We raised the importance of providing families with proper and cost-effective strategies and

recommendations for timing and methods of weaning and supplementary diet. We could not conclude whether the growth-retarded children are able to catchup if the contributing factors are corrected. The results highlight the necessity of effective and timely preventive interventions for growth retardation among Iranian population. A specially designed study is needed to understand the actual reason for observing such a phenomenon among Iranian children.

## **Abbreviations**

WHO= World Health Organization; NCHS= National Center for Health Statistics; OR= Odds Ratio; 95% CI= 95% Confidence Interval

## **Declarations**

### **Ethics approval and consent to participate**

The research proposal was approved by the Ethics Committee of Shiraz University of Medical Sciences (decree code: 7294).

### **Consent for publication**

All authors provided critical revisions, read and approved the final manuscript to be published.

### **Availability of data and materials**

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

### **Competing interests**

The authors stated no conflict of interest.

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### **Authors' contributions**

MD, MJF, and MF co-designed the study and survey materials. MJF and HM were involved in data collection. MF and MJF were responsible for conducting the statistical analyses, interpretation and drafting the manuscript. MD and MF revised the manuscript critically for important content. All authors provided critical revisions, read and approved the final manuscript.

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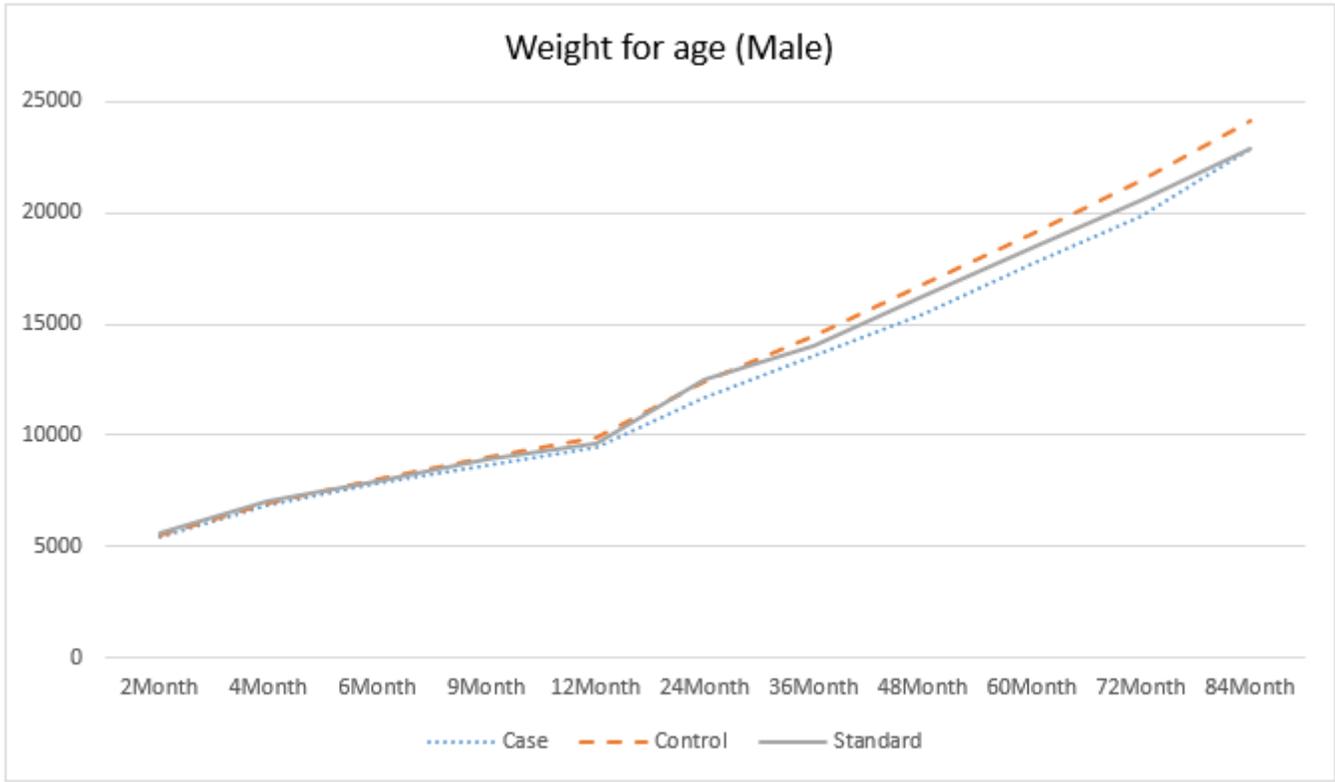
## Tables

<b>Table1: Height, weight and head circumference differences between normal and stunted male children from birth to age 7</b>									
Age (month)	Height (cm)			Weight (gr)			Head circumference (cm)		
	Difference between groups*	CI95%	P. value	Difference between groups	CI95%	P. value	Difference between groups	CI95%	P. value
Birth	0.37	(-0.25 to 0.99)	0.24	56.61	(-60.38 to 173.62)	0.34	-0.23	(-1.02 to 0.55)	0.55
2	0.47	(-0.26 to 1.22)	0.20	118.19	(-95.41 to 331.81)	0.27	0.06	(-0.38 to 0.50)	0.79
4	0.22	(-0.47 to 0.91)	0.52	45.79	(-212.09 to 303.68)	0.72	-0.07	(-0.52 to 0.36)	0.72
6	0.70	(0.006 to 1.41)	0.04	105.54	(-139.16 to 350.26)	0.39	-0.11	(-0.52 to 0.28)	0.56
9	1.22	(0.45 to 1.99)	0.002	379.62	(58.21 to 701.03)	0.02	0.06	(-0.35 to 0.48)	0.75
12	1.87	(1.09 to 2.64)	<0.001	438.50	(135.82 to 741.17)	0.005	-0.002	(-0.40 to 0.39)	0.98
24	3.91	(2.79 to 5.03)	<0.001	726.65	(265.57 to 1187.74)	0.002			
36	4.83	(3.51 to 6.14)	<0.001	854.88	(395.02 to 1314.75)	<0.001			
48	5.89	(3.39 to 8.40)	<0.001	1384.50	(824.00 to 1945.01)	<0.001			
60	7.95	(6.58 to 9.32)	<0.001	1384.98	(672.85 to 2097.10)	<0.001			
72	8.77	(7.60 to 9.94)	<0.001	1606.14	(836.09 to 2376.19)	<0.001			
84	9.38	(8.45 to 10.32)	<0.001	1265.19	(502.56 to 2027.82)	0.001			

\*Normal - stunt children

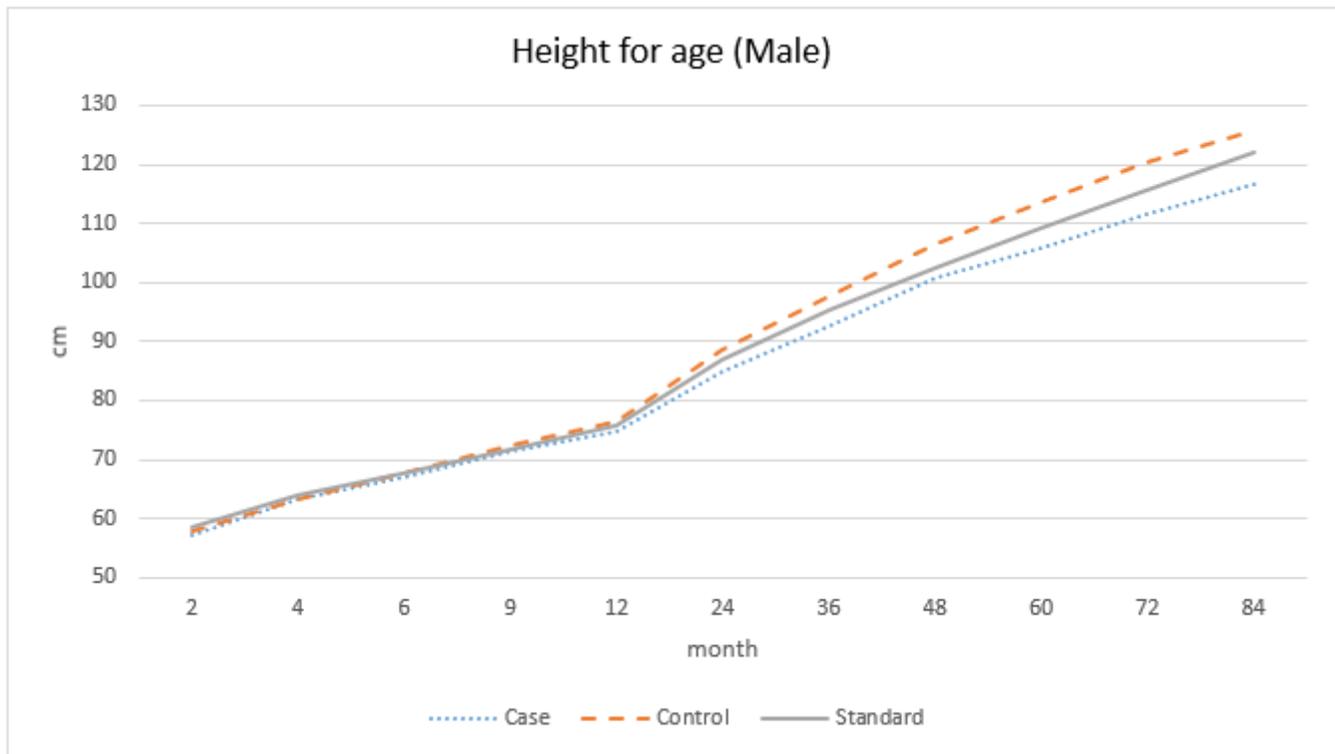
Table2: height, weight and head circumference differences between normal and stunted female children from birth to age 7									
Age (month)	Height (cm)			Weight (gr)			Head circumference (cm)		
	Difference between groups	CI95%	P. v	Difference between groups	CI95%	P. v	Difference between groups	CI95%	P. v
BIRTH	-0.53	(-1.68 to 0.62)	0.36	-142.96	(-271.83 to -14.08)	0.03	-0.79	(-1.56 to -0.01)	0.04
2	-0.72	(-2.01 to 0.56)	0.26	-234.37	(-416.93 to -51.81)	0.01	-0.59	(-1.42 to 0.22)	0.15
4	-0.68	(-2.06 to 0.70)	0.33	-311.09	(-569.99 to -52.19)	0.01	-0.79	(-1.62 to 0.03)	0.06
6	0.09	(-1.34 to 1.54)	0.89	-289.40	(-556.27 to -22.52)	0.03	-0.81	(-1.66 to 0.036)	0.06
9	0.97	(0.20 to 1.73)	0.01	-247.71	(-561.41 to 65.98)	0.12	-0.31	(-0.67 to 0.05)	0.09
12	0.61	(-0.18 to 1.41)	0.13	-137.19	(-450.52 to 176.13)	0.38	-0.17	(-0.51 to 0.17)	0.32
24	0.93	(-0.11 to 1.98)	0.08	-181.43	(-586.30 to 223.43)	0.37			
36	1.90	(0.71 to 3.09)	0.002	-18.57	(-544.46 to 507.31)	0.94			
48	3.10	(1.85 to 4.35)	<0.001	87.11	(-465.52 to 639.74)	0.75			
60	5.64	(4.46 to 6.82)	<0.001	-14.06	(-670.00 to 641.88)	0.96			
72	7.01	(5.97 to 8.05)	<0.001	119.27	(-631.02 to 869.56)	0.75			
84	8.11	(7.24 to 8.97)	<0.001	283.21	(-457.54 to 1023.97)	0.45			

## Figures



**Figure 1**

Weight (gr) for age among stunted and normal male participants from birth to age 84 months (7 years)



**Figure 2**

Height (cm) for age among stunted and normal male participants from birth to age 84 months (7 years)

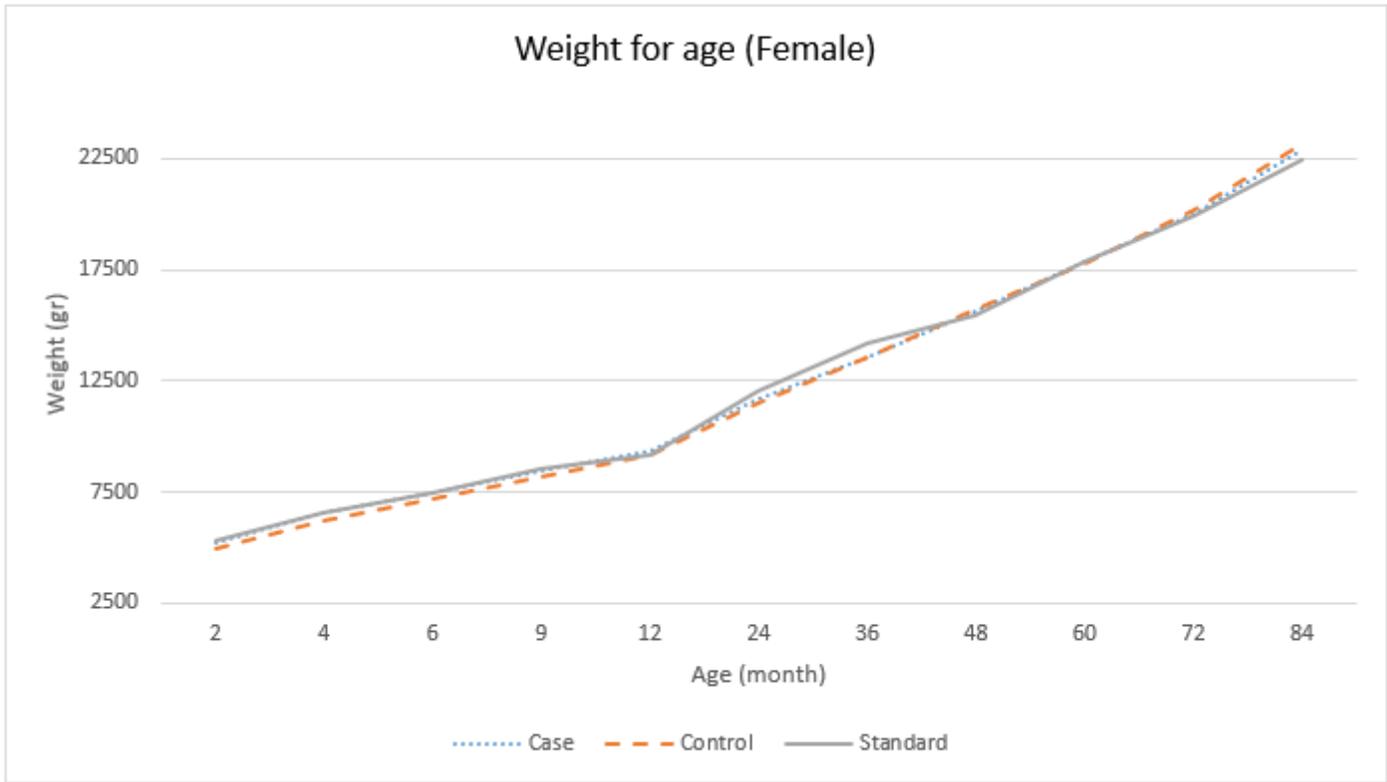


Figure 3

Weight (gr) for age among stunted and normal female participants from birth to age 84 months (7 years)

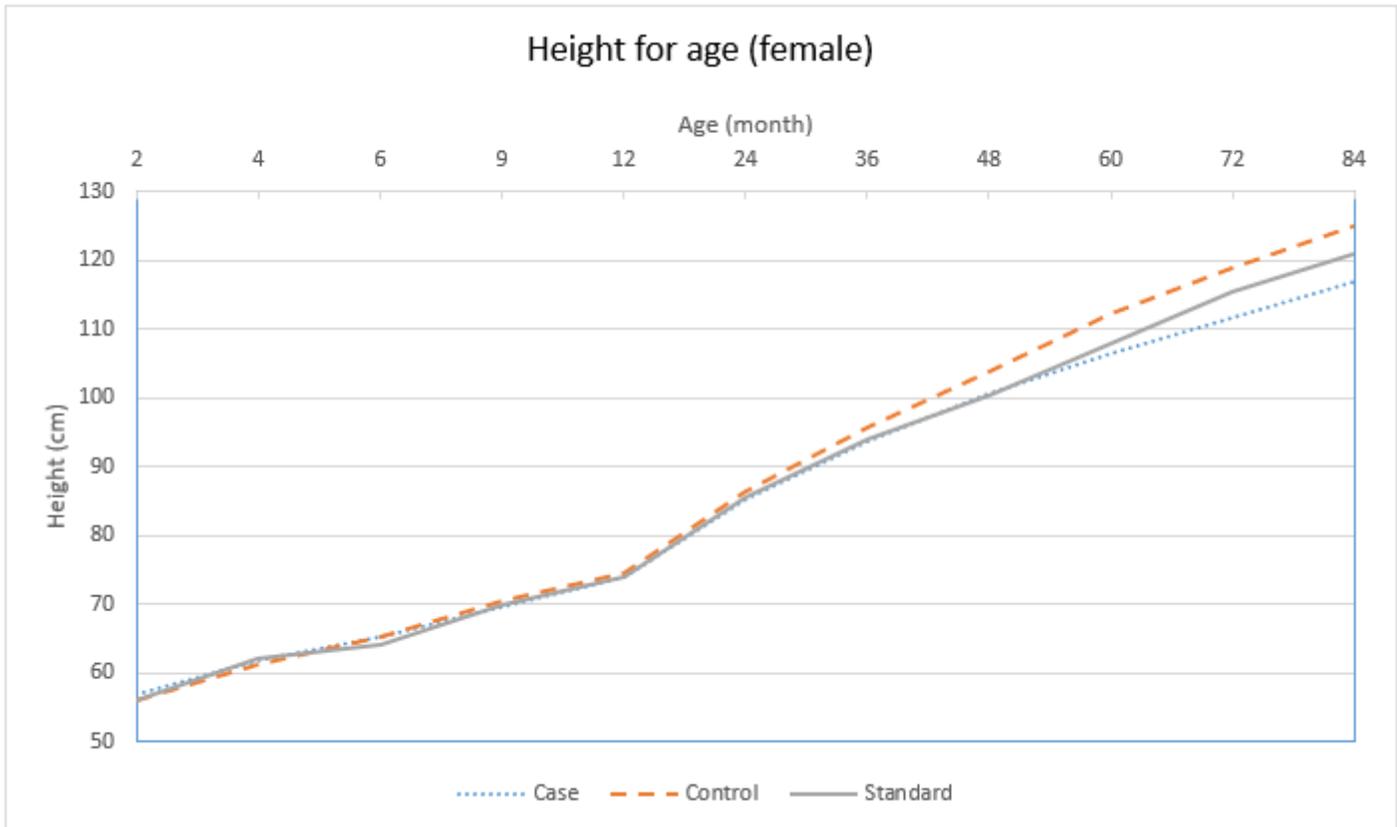


Figure 4

Height (cm) for age among stunted and normal female participants from birth to age 84 months (7 years)