GROWTH-AND-OBESITY PROFILES OF CHILDREN OF KARACHI USING BOX-INTERPOLATION METHOD

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ABSTRACT

This paper introduces quantifiable growth-and-obesity profiles of children in family-centered care. This work presents a model based on the mathematical-statistical technique of 'box interpolation', which generates patient- and parent-friendly profiles based on one set of height and weight measurements of parents and children. Mid-parental (Target) heights and optimal weights were compared with measured heights and weights to determine if the children were obese (wasted) and tall (stunted), associating a numerical index with each condition, in the form of percentage. This model, also, estimated adult-heights and weights of children and indicated whether parents were obese (wasted). Data were collected by authors, following standard protocols developed by our team, as part of the NGDS (National Growth and Developmental Standards) Pilot Project. This project was approved by Institutional Review Board. Informed consents were obtained from parents of participating families. Each child was weighed and measured, in the presence of father and mother, barefoot, wearing short underpants, stripped to waist. Data from 70 participants of different localities of Karachi (17 families, consisting of 17 fathers, 17 mothers, 16 boys, 20 girls) were analyzed. Boys showed a greater risk of obesity (46.15%) as compared to girls (17.65%), when both parents were obese (15 families). Excessive obesity (wasting), failure-to-grow, short children developing normally, and failure-to-thrive, children neither growing nor developing normally, may be the cause of an underlying physical or psychological problem needing a head-to-toe evaluation. The method reported in this paper may be helpful in identifying such cases in children 3-10-year old, if regular height and weight screenings are conducted.

Keywords: Box interpolation, children, growth modeling, anthropometry, optimal weight, mid-parental height

INTRODUCTION

Children are assets of any nation. The future of a country depends on strong and healthy children (Shen *et al.*, 1996). Parents, teachers and counselors are interested in knowing growth profile of children to plan better their exercise and diet programs. In particular, parents are keen to find out how their children are doing in terms of height and weight. They are, also, eager to learn what is going to be final height and final weight of their sons or daughters (Karlberg, 1996; Joss *et al.*, 1983; Hintz *et al.*, 1999; Rosenfeld 2003).

Obesity is becoming a problem worldwide among children and adolescents (Whittaker *et al.*, 1997; Ebbeling *et al.*, 2002). The incidence of childhood obesity has increased by more than 50 percent in the last decade (Siedentop, 2003), mainly because of a lack of physical activity (Christodoulos, 2006). It is related to a number of complications in adulthood (Reilly *et al.*, 2003). There is a conscious that the earlier the problem is detected, the more efficient and effective are the intervention strategies (Ludwig, 2007). However, in the absence of an objective, quantifiable criterion to determine severity of obesity, it becomes difficult to identify at risk cases and, hence, control the situation. The problem is compounded by a lack of awareness among the communities, absence of standardized equipments and standard operating procedures, inadequate training of the anthropometrists (sometimes non-professionals collect the data) and improper handing of data (researchers not trained in the statistical techniques).

We have investigated the prevalence of obesity in children, when both parents are obese, based on a growth-and-obesity profile, after developing a mathematical model and standardized protocols.

MODELS OF GROWTH

Correlation Model

Argyle *et al.* (2007) modeled and fitted the serial correlation structure of growth measurements of children. By this process, they achieved the benefit that monitoring growth at specific ages did not remain crucial, statistically.

ICP Model

The ICP (infancy-childhood-puberty) model is a time series, representing height of child (on y axis) as a function of age (on x axis) (Karlberg, 1987; 1996). Zero time is the moment of birth and zero height corresponds to conception, x intercept representing term of baby and y intercept birth length. During the phase transitions, infancyto-childhood phase and childhood-to-puberty phase, the growth curve (height) is continuous, but not smooth. Therefore, height velocity is not defined during phase transitions.

KFA Model

The growth model developed by our group (Kamal *et al.*, 2004), referred to as KFA (Kamal-Firdous-Alam) model, assumed that the growth curves (height and mass graphs) were linear if the measurements were performed 6-month apart — a good approximation for most of the regions, except where there was a rapid change (during phase transitions; height velocity undefined) of growth rate. Other than these transition regions, height at some age grid, say, 6.0 or 6.5 *years*, was computed using linear interpolation. Boys' (*B*) and girls' (*G*) target (mid-parental) heights (taken as reference), were computed using the biological father's (*F*) and the biological mother's (*M*) measured heights, respectively (Karllberg, 1996; Tanner *et al.*, 1970; Chianese, 2005).

$$B = \frac{F + M + 13}{2} \quad (1a)$$

$$G = \frac{F + M - 13}{2} \quad (1b)$$

All heights were in centimeters (*cm*) and masses in kilograms (*kg*). Multiplying mass by a factor of 2.205 would generate weight in pounds (*lb*). These computed heights were extrapolated backwards to compute desired height at the reference-age grid. This was compared with the interpolated-actual height at the same age to determine whether the child was stunted (short-for-age) or tall. Body-mass index was computed by taking the ratio of mass to square of height (in *meters*) and compared with the reference value to determine obesity profile. In addition, optimum mass for given height was determined and compared with the actual mass to find out whether the child was obese or wasted (lesser-mass-for-height). The model had provisions to compute height velocities and rates of gain/loss of weight, in order to predict height and weight during the next 6 months.

The KFA model required 2 sets of measurements separated by 6 months to generate a complete profile. While helpful for pediatricians, the time frame required in generating the first set of results (six and a half months after the original checkup) may put a severely wasted child at a great health risk.

METHODS

Project Protocols

The NGDS (National Growth and Developmental Standards for the Pakistani Children) Pilot Project Protocols were designed after taking into account of prevailing North American as well as European ethical and human-rights standards (Kamal *et al.*, 2002). The project was initiated after *Institutional Review Process* by University of Karachi authorities, which included committees of Chancellor (Governor Sindh) and Vice Chancellor. SGPP (Sibling Growth Pilot Project) is a subproject of the NGDS Pilot Project, in which preteen children, father and mother of a given family are weighed and measured at SF Growth and Imaging Laboratory. Informed consent was obtained by requiring both parents to sign the consent form, which included address of website (contains detailed information and photographs of procedures). The families were given detailed written and verbal instructions to prepare children for the checkups and maintain standardization of procedures. Upon arrival, the families were briefed on procedures and their questions answered. All measurements were carried out in the morning hours (children are, generally, taller in the morning as compared to bedtime), with the children completely undressed except for briefs or panties, in the presence of father and mother. Acoustic, visual and data privacy of the participants was maintained. Parents were given the opportunity to discuss growth-and-obesity profile with the Project Director.

Laboratory Techniques

Heights, *h*, and masses, *m*, were measured according to protocols developed by the NGDS Team (Kamal, 2006). These are, briefly, described here. For measurement of stature, the children were aligned to the mounted measuring tape and instructed to keep hands straight and open, palms touching thighs, holding breath. A pencil was held at eye level so that head is straight. Heights were recorded to nearest 0.1 *cm* by placing setsquares on the mounted engineering tape. Masses were recorded to nearest 0.1 *kg*, using a standard beam scale. Children were asked to step on the scale with empty hands, (anatomical position) holding breath, standing in the center and looking straight. At the start of each measurement session, a standard 100-*cm* ruler and a standard 2-*kg* mass were used to calibrate the height-measurement system and the beam scale, respectively (Kamal, 2009).

Table 1. Parents' Obesity Profiles

	Father	*Mother*
Date of Birth	1970-01-13	1973-11-04
Date of Checkup	2009-02-05	2009-02-05
Age (*years*)	39.08	35.25
Height, *h* (*cm*)	169.3	154.9
Height (*ft-in*) ®	5 *ft* 6.65 *in*	5 *ft* 0.98 *in*
Percentile for Height, *P*(*h*)	16.00	10.53
Gross Mass (*kg*)	71.4	50.7
Clothing Correction (*kg*)	0.4	0.5
Net Mass, *m* (*kg*)	71.0	50.2
Net Weight (*lb-oz*)	156 *lb* 8.88 *oz*	110 *lb* 11.06 *oz*
Percentile for Net Mass, *P*(*m*)	51.47	17.31
BMI, $10^4 m/h^2$ (kg/m^2)	24.77	20.92
Optimal Mass (*kg*)	60.25	48.39 *
Optimal Weight (*lb-oz*)	132 *lb* 13.62 *oz*	106 *lb* 11.24 *oz* *
Δ Mass-for-Height	+10.75	+1.81*
Δ Weight-for-Height (*lb-oz*)	+23 *lb* 11.26 *oz*	+3 *lb* 15.82 *oz* *
Status (pertaining to weight)	**17.84% OBESE**	**3.74% OBESE** *

® *ft* stands for *feet* and *in* for *inch(es)*

* Valid if the mother is NOT PREGNANT. In case of pregnancy, add estimated weight of fetus and re-determine difference of mass (weight)-for-height and status.

Mathematical Model

Growth-and-obesity profile of the family was determined by first converting dates of birth and dates of measurement (all dates recorded as *YYYY-MM-DD*: year in four digits-month in two digits-day in two digits) in fractional form and computing age (both of them in *years*) as their difference (Appendix A gives the detailed procedure). For father (mother), height and mass percentiles of boy (girl) at the age 20 *years* were used to determine percentiles for measured height and mass, *P(h)* and *P(m)*, respectively, by linear interpolation. For this purpose, percentiles in the growth table corresponding to lower and higher values were used in the equation of straight line (2-point form). Once the height percentile, *P(h)*, was available, mass (weight) corresponding to this percentile was determined as optimal mass, m_{opt} (w_{opt}). The net mass (weight), *m* (*w*), was compared with the optimal mass (weight) and the person was classified as obese ($m > m_{\text{opt}}$) or wasted ($m < m_{\text{opt}}$). Percentage was computed as:

$$\text{(2)} \qquad \text{Percentage (pertaining to weight)} = 100\frac{|w - w_{\text{opt}}|}{w_{\text{opt}}} = 100\frac{|m - m_{\text{opt}}|}{m_{\text{opt}}}$$

1% variation from optimal mass (end points included) was considered normal. Equations (1) were used to compute mid-parental (target) heights for boy and girl. Percentiles, corresponding to target heights, were obtained using procedures similar to those for obtaining percentiles corresponding to heights of father and mother. Percentile corresponding to height (mass) of child was determined by first computing heights at the given age, which were lesser and greater than the measured height (mass) using linear interpolation (constant-percentile route; computations were done for 3 or 4 percentiles, to make sure that the required interval was not missed). Once the upper and the lower bounds were available at the given age, required percentile was determined by another linear interpolation (constant-age route). As soon as these percentiles were available, a qualitative judgment could be made. If the height percentile was lesser (greater) than the mass percentile, the child was considered as obese (wasted). Similarly, if the height percentile was greater (lesser) than the mid-parental-height percentile, the child was considered as tall (stunted). Optimal mass could be computed by 2 routes. First one was the constant-age route, which determined upper (lower) limit of optimal mass for later-(earlier-)age grid. From these limits, optimal mass was computed by linear interpolation (constant-percentile route). Second one was the constant-percentile route, which determined upper (lower) limit of optimal mass for higher (lower) percentile. From these limits, optimal mass was computed by linear interpolation (constant-age route). Both these procedures gave identical results. Obesity profile was, then,

Table 2. Adult-Mid-Parental (Target) Heights

BOY/GIRL=(FATHER+MOTHER ± 13)/2	*BOY*	*GIRL*
Adult-Mid-Parental (Target) Height (*cm*)	168.6	155.6
Adult-Mid-Parental (Target) Height (*ft-in*)	5 *ft* 6.38 *in*	5 *ft* 1.26 *in*
Percentile of Mid-Parental Height	13.67	13.00

determined using equation (2). A similar method was used to compute mid-parental height at current age, based on the percentile obtained earlier. A comparison of measured, h, and current-age-mid-parental, h_{MP}, heights indicated if the child was tall ($h > h_{\mathrm{MP}}$) or stunted ($h < h_{\mathrm{MP}}$). Percentage was determined using:

$$\text{(3)} \qquad \text{Percentage (pertaining to height)} = 100\ \frac{|h - h_{\mathrm{MP}}|}{h_{\mathrm{MP}}}$$

1% variation from current-age-mid-parental height (end points included) was considered normal. The above procedure was termed as *Box Interpolation*. This procedure worked well when the height and mass percentiles, both, lay between 3 and 97. Procedures for extreme cases are listed in Appendix B.

Sample Growth-and-Obesity Profiles

Estimated-adult heights and estimated-adult masses (weights) are based on percentiles of current heights and current masses, respectively. Parents' obesity profiles and adult-mid-parental (target) heights are listed in Tables 1 and 2, respectively:

Obesity Profiles of Parents: FATHER has 10.75 *kg* EXCESS mass (OVERWEIGHT by 23 *lb* 11.26 *oz*) for height [17.64% OBESE]. MOTHER has 1.81 *kg* EXCESS mass (OVERWEIGHT by 3 *lb* 15.82 *oz*) for height [3.74% OBESE], provided she is not pregnant (see note below Table 1). Since both children are girls, mid-parental percentile, 13^{th}, is taken as reference. Table 3 lists growth-and-obesity profiles of children. Figures 1 and 2 consist of bar-chart representations of heights and masses. Percentiles of height and mass are shown in Figure 3.

Height Profile of F. N. (mid-parental percentile = 13.00, taken as reference)**:** At the age of 9.17 *years*, (average) height of F. N. comes out to 128.15 *cm* (4 *ft* 2.45 *in*), which lies at 18^{th} (18.45 to be exact) percentile [1.00% (+)]. F. N. has 1.27 *cm* (0.50 *in*) EXCESS height with respect to current-age-mid-parental (reference) height (126.88 *cm*), but is not considered tall. Based on this percentile, her estimated-adult height comes out to be 157.14 *cm* (5 *ft* 1.87 *in*).

*Mass Profile of F. N.***:** At the age of 9.17 *years*, (average) net mass (weight) of F. N. comes out to 18.9 *kg* (41 *lb* 10.79 *oz*), which lies below 3^{rd} percentile [24.73% WASTED]. F. N. has 6.21 *kg* LESSER mass (UNDERWEIGHT by 13 *lb* 11.06 *oz*) for her height. Based on this percentile, her estimated-adult mass (weight) comes out to be less than 45.25 *kg* (less than 99 *lb* 12.42 *oz*). Her body-mass index (BMI) is computed as 11.51 kg/m^2.

Height Profile of M. N. (mid-parental percentile = 13.00, taken as reference)**:** At the age of 6.27 *years*, (average) height of M. N. comes out to 117.15 *cm* (3 *ft* 10.12 *in*), which lies at 57^{th} (56.67 to be exact) percentile [6.04% TALL]. M. N. has 6.68 *cm* (2.63 *in*) EXCESS height with respect to current-age-mid-parental (reference) height (110.47 *cm*). Based on this percentile, her estimated-adult height comes out to be 164.57 *cm* (5 *ft* 4.79 *in*).

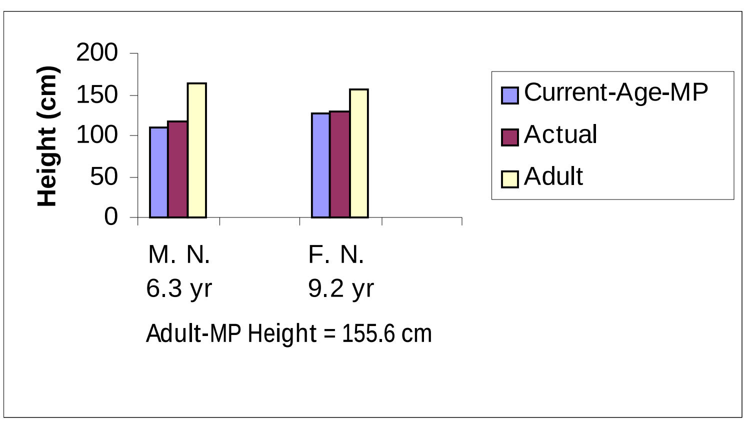
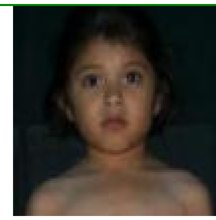


Fig. 1. Bar chart representing heights of girls

Table 3. Growth-and-Obesity Profiles of Children [@]

Child's Initials	*F. N.*	*M. N.*
Photograph [©]		
Scanned Signatures [©]	*FN*	*MN*
Gender	Female	Female
Date of Birth	1999-12-05	2002-10-28
Birth Weight (*lb*)	6	7
Date of Checkup	2009-02-05	2009-02-05
Age (*years*)	9.17	6.27
Height, *h* (*cm*)	128.15	117.15
Height (*ft-in*)	4 *ft* 2.45 *in*	3 *ft* 10.12 *in*
Percentile for Height, *P*(*h*)	18.45	56.67
Estimated-Adult Height (*cm*) [§]	157.14	164.57
Estimated-Adult Height (*ft-in*) [§]	5 *ft* 1.87 *in*	5 *ft* 4.79 *in*
Mid-Parental-Height Percentile	13.00	13.00
Current-Age-MP Height (*cm*)	126.88	110.47
Δ Height-for-Age (*cm*)	+1.27	+6.68
Δ Height-for-Age (*in*)	+0.50	+2.63
Status (pertaining to height)	**1.00% (+)** [#]	**6.04% TALL**
Gross Mass (*kg*)	18.9	17.2
Clothing Correction (*kg*) [¶]	0	0
Net Mass, *m* (*kg*)	18.9	17.2
Net Weight (*lb-oz*)	41 *lb* 10.79 *oz*	37 *lb* 14.82 *oz*
Percentile for Net Mass, *P*(*m*)	< 3	6.87
Estimated-Adult Mass (*kg*)	< 45.25	47.15
Estimated-Adult Weight (*lb-oz*)	< 99 *lb* 12.42 *oz*	103 *lb* 15.58 *oz*
BMI, $10^4 m/h^2$ (kg/m^2)	11.51	12.53
Optimal Mass (*kg*)	25.11	21.49
Optimal Weight (*lb-oz*)	55 *lb* 5.85 *oz*	47 *lb* 6.17 *oz*
Δ Mass-for-Height (*kg*)	–6.21	–4.29
Δ Weight-for-Height (*lb-oz*)	–3 lb 11.06 oz	–9 lb 7.30 oz
Status (pertaining to weight)	**24.73% WASTED**	**19.80% WASTED**

@ Detailed Growth-and-Obesity Profile (which is mailed to parents) along with recommendations is available at: http://www.ngds-ku.org/ngds_folder/Protocols/Growth_Profile.pdf
Detailed Growth-and-Obesity Calculations (for the benefit of graduate students and researchers) available at: http://www.ngds-ku.org/ngds_folder/Protocols/Growth_Calculations.pdf

© Photograph and scanned signatures on the day, check up was conducted. In order to protect the privacy of N. Family, the photograph, inserted in this Growth-and-Obesity Profile, does not show the actual child.

§ Cutoff heights for induction in Armed Forces of Pakistan**:** Boys 5 *ft* 4 *in* (162.56 *cm*); Girls 5 *ft* 2 *in* (157.48 *cm*)

¶ For children, clothing correction is taken as zero because both girls were weighed and measured wearing panties only, barefoot, stripped to waist

(+) means the child has excess height as compared to mid-parental (reference) height, but is not considered tall.

*Mass Profile of M. N.***:** At the age of 6.27 *years*, (average) net mass (weight) of M. N. comes out to 17.2 *kg* (37 *lb* 14.82 *oz*), which lies at 7th (6.87 to be exact) percentile [19.80% WASTED]. M. N. has 4.29 *kg* LESSER mass

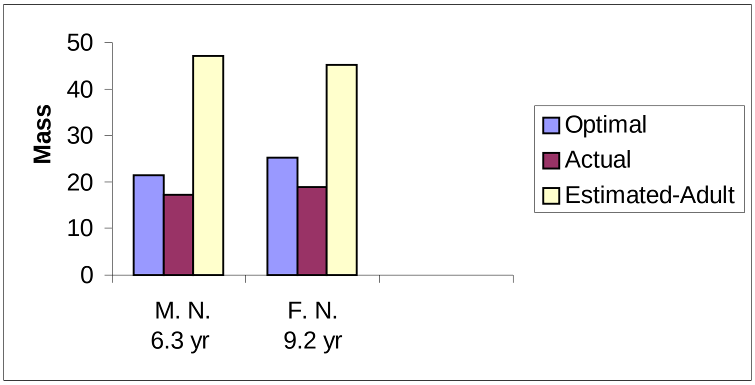


Fig. 2. Bar chart representing masses of girls; yellow bar for FN gives upper limit (her mass lies at less than 3 percentile)

(UNDERWEIGHT by 9 *lb* 7.30 *oz*) for her height. Based on this percentile, her estimated-adult mass (weight) comes out to be 47.15 *kg* (103 *lb* 15.58 *oz*). Her body-mass index (BMI) is computed as 12.53 kg/m^2.

Study Population and Parameters

Families from different localities of Karachi were invited to participate in the study. We studied those families in which children 3-10-year old were not suffering from any disease and both parents were willing to come to SF Growth Laboratory for measurements. Results from 70 participants (17 fathers + 17 mothers + 16 boys + 20 girls) are presented. Based on the above mathematical model a detailed growth profile of each family was generated and prevalence of obesity among children was studied keeping in view whether one or both parents are obese.

RESULTS

Out of 16 boys, 6 were found to be obese (both parents obese), 4 in the normal range (both parents obese) and 5 wasted (3 had both parents obese, 2 had wasted fathers and obese mothers). Obesity status for one boy could not be determined because his height and weight both fell below 3rd percentile. Out of 20 girls, 3 were found to be obese (both parents obese), 4 in the normal range (both parents obese) and 12 wasted (11 had both parents obese, 1 had normal father and wasted mother). Obesity status for one girl could not be determined because her height and weight both fell below 3rd percentile. Next, we considered prevalence of obesity in children of families, where both parents were obese. There were 15 such families. Out of a total of 13 such boys, 6 were obese (46.15%), 4 normal (30.77%) and 3 wasted (23.08%), whereas among 17 such girls, 3 were obese (17.65%), 4 normal (23.53%) and 10 wasted (58.82%). Hence, it appears that boys have a greater risk of obesity as compared to girls, when both parents were obese. Girls, in these families, on the other hand, are showing a tendency of being underweight — a common phenomenon in developing countries undergoing the nutrition transition (Armstrong *et al.*, 2003; Caballero, 2005; Jinabhai *et al.*, 2003).

DISCUSSION

Childhood obesity is associated with a number of adverse consequences (Dietz, 2005). Even a very small amount of increase in weight is going to elevate the risk factor of coronary heart disease in adulthood (Baker *et al.*, 2007; Bibbins-Domingo *et al.*, 2007). Obesity, combined with inactivity, has been linked to diabetes (Rocchini, 2002; Sinha *et al.*, 2002) and cancer (Roizen *et al.*, 2005). Many obese children have low levels of spontaneous activity (Brukner *et al.*, 2002). Degree of obesity, expressed as percentage in our method, has many clinical implications in children and adolescents (Weiss *et al.*, 2004; Jolliffe, 2004). An obese child with Blount's disease faces significant morbidity (Campbell *et al.*, 2006). Similarly, obesity is a common problem occurring in children with myelomeningocele that can affect independence and proficiency with transfers, mobility and self-care activities (Campbell *et al.*, 2006).

The methods, presented in this paper, generate results in a format easily understandable by parents and older children, avoiding technical jargon. In addition to the descriptive format, the information is presented in bar chart form (for giving a general perspective to families) and tabular form (for quick review by the attending pediatrician). This growth-and-obesity profile may prove valuable for pediatricians, nutritionists (Nestle, 2006) and physical

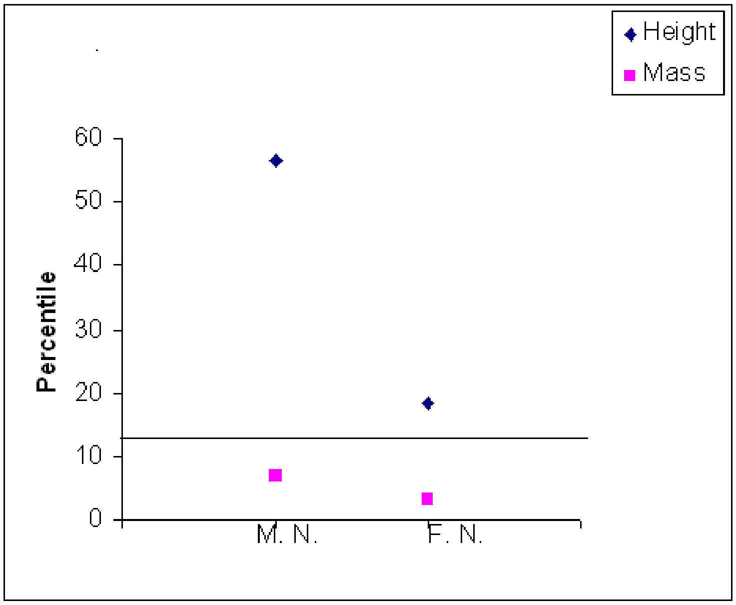


Fig. 3. Percentiles of heights and masses of girls; pink square for F. N. gives upper limit (her mass lies at less than 3 percentile) — solid line gives mid-parental (reference) percentile

education teachers (Siedentop, 2003), who may, together, plan diet-cum-exercise programs (Sheth *et al.*, 2006), supplemented by medicines, if required. In addition, parental obesity profile may be taken as a guideline to initiate family-centered-optimum-weight-for-height programs. There is a dire need to accurately monitor growth and development of a child (Freedman *et al.*, 2004; Barker *et al.*, 2005; Lawlor *et al.*, 2006). Failure-to-Grow (Harris *et al.*, 2001) is the first indictor of an underlying physical problem, requiring a complete examination by a pediatrician. Failure-to-Thrive may signal a much deeper problem, psychosomatic in origin, which must be taken seriously requiring a head-to-toe (stripped totally) examination as well as a psychiatric evaluation of the child to rule out neglect, emotional, physical or sexual abuse. According to Adam, "growth hormone is necessary, but not sufficient for a successful childhood" (Chianese, 2005). The authors recommend nationwide programs (Sultz *et al.*, 2004) to monitor height and weight of 3-10-year-old children, with improved techniques for measurement of height and weight (height and weight can now be measured to accuracies of 0.01 *cm* and 0.01 *kg*, respectively — Kamal, 2010), combined with a comprehensive approach to manage pediatric obesity (Miller *et al.*, 2007), to ensure a happy, a healthy and an emotionally balanced adulthood, resulting in increase in life expectancy (Olshansky *et al.*, 2005).

Table 4. Cumulative Days in a Year

S. No.	***Months***	**Non-leap Year**		**Leap Year**	
		Days	*Cumulative Days*	*Days*	*Cumulative Days*
01	January	31	31	31	31
02	February	28	59	29	60
03	March	31	90	31	91
04	April	30	120	30	121
05	May	31	151	31	152
06	June	30	181	30	182
07	July	31	212	31	213
08	August	31	243	31	244
09	September	30	273	30	274
10	October	31	304	31	305
11	November	30	334	30	335
12	December	31	365	31	366

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APPENDIX A: DATES IN FRACTIONAL FORM

Dates in the format *YYYY–MM–DD* may be converted to fractional form using the formulae

$$YYYY + \frac{Days(MM-1)+Days(DD)}{365} \text{ (non-leap year)}$$

$$YYYY + \frac{Days(MM-1)+Days(DD)}{366} \text{ (leap year)}$$

and data in Table 4, *e. g.*, 1973-11-04 becomes

$$1973 + \frac{Days(11-1)+04}{365} = 1973 + \frac{304+04}{365} = 1973.84383561643\,years$$

APPENDIX B: EXTREME CASES (PERTANING TO OPTIMAL WEIGHT-FOR-HEIGHT)

If any one or both percentiles of height and mass, $P(h)$ and $P(m)$, lie outside the range [3, 97], the procedure for status computation is different from the one reported (cf. Table 5).

a) $P(h) < 3,\ P(m) \geq 3,\ \text{STATUS} > \frac{100(m - m_{3-p})}{m_{3-p}}\%$ OBESE, m_{3-p} = 54.5 *kg* (for males), 45.25 *kg* (for females) and gender-specific-age-based mass corresponding to 3rd percentile computed from growth charts (for children), examples are worked out after discussion of case *d)* [valid even if $P(m) > 97$].

b) $P(m) > 97,\ 3 \leq P(h) \leq 97,\ \text{STATUS} = \frac{100(m - m_{opt})}{m_{opt}}\%$ OBESE. If $P(h) < 3$, use the formula given in (*a*).

c) $P(m) < 3,\ 3 \leq P(h) \leq 97,\ \text{STATUS} = \frac{100(m_{opt} - m)}{m_{opt}}\%$ WASTED.

d) $P(m) \leq 97,\ P(h) > 97$, $\text{STATUS} > \frac{100(m_{97-p} - m)}{m_{97-p}}\%$ WASTED, m_{97-p} = 101.0 *kg* (for males), 88.75 *kg* (for females) and gender-specific-age-based mass corresponding to 97th percentile computed from growth charts (for children), examples are worked out below [valid even if $P(m) < 3$]. This result can be easily proved by writing the status formula as $100(1 - \frac{m}{m_{opt}})$ and using $>$ 101.0 *kg* ($>$ 88.75 *kg*), in place of m_{opt}

Gender-Specific-Age-Based Masses

a) Corresponding to 3rd Percentile

Let us compute this parameter for the girl F. N., whose growth-and-obesity profile is given in Table 3. Her age is 9.17 *years*. From the table of masses for girls, read off the masses corresponding to 3rd percentile at ages 9.0 *years* and 9.5 *years*, as 21.5 *kg* and 22.5 *kg*, respectively. Using the equation of straight line (2-point form), with age, as independent variable, and mass, as dependent variable, $m_{3-p}(9.17\ years)$ comes out to 21.84 *kg.* Similar calculations for a boy, U. K., age 5.82 *years*, require that one reads of the masses corresponding to 3rd percentile at

Table 5. Extreme Cases

$P(h)$	$P(m)$	*Case (as referred below)*
< 3	< 3	Status non-determinable
< 3	$3 \le P(m) \le 97$	(a)
< 3	> 97	(a)
$3 \le P(h) \le 97$	< 3	(c)
$3 \le P(h) \le 97$	$3 \le P(m) \le 97$	Regular calculations
$3 \le P(h) \le 97$	> 97	(b), Regular calculations
> 97	< 3	(d)
> 97	$3 \le P(m) \le 97$	(d)
> 97	> 97	Status non-determinable

ages 5.5 *years* and 6.0 *years*, as 16.0 *kg* and 16.5 *kg* and applies linear interpolation to obtain m_{3-p} (5.82 *years*) as 16.32 *kg*.

b) Corresponding to 97th Percentile

Let us compute this parameter for the girl R. K. Her age is 9.53 *years*. From the table of masses for girls, read off the masses corresponding to 97th percentile at ages 9.5 *years* and 10.0 *years*, as 47.25 *kg* and 51.0 *kg*, respectively. Using the equation of straight line (2-point form), with age, as independent variable, and mass, as dependent variable, m_{97-p} (9.53 *years*) comes out to 47.475 *kg*. Similar calculations for a boy, M. U. Z. T., age 7.91 *years*, require that one reads of the masses corresponding to 97th percentile at ages 7.5 *years* and 8.0 *years*, as 34.5 *kg* and 37.0 *kg* and applies linear interpolation to obtain m_{97-p} (7.91 *years*) as 36.55 *kg*.

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