MEDICAL CRITERIA FOR INDUCTION INTO THE ARMED FORCES OF PAKISTAN: CUTOFF HEIGHTS FOR STILL-GROWING YOUTH

Syed Arif Kamal*, **Shakeel Ahmed Ansari**[$], **Maqsood Sarwar**[#] **and Ashfaq Ali Naz**[⊗]

SF-Growth-and-Imaging Laboratory, the NGDS Pilot Project, University of Karachi, Karachi 75270, *Pakistan*; **e-mail***:** sakamal@uok.edu.pk

ABSTRACT

*Objective***:** To propose objective criteria of cutoff heights for still-growing youth by examining current criteria and identifying their short comings

*Study Design***:** Observational study

*Place and Duration of Study***:** Initiated in 1998 in schools run by the Armed Forces of Pakistan; a civilian school added in 2011

*Subjects and Methods***:** Primary-school students' heights and masses were measured, to least counts of 0.1 *cm* (1998-2011); 0.01 *cm* (2012-2015); 0.005 *cm* (2016 to date) and 0.5 *kg* (1998-2011); 0.01 *kg* (2012-2015); 0.005 *kg* (2016 to date), respectively, during morning hours, implementing standardized protocols (ethical guidelines followed, students undressed to underpants, equipments calibrated daily, measurer reproducibility documented), and modeled to compute estimated-adult heights, estimated-adult masses, height and mass percentiles, optimal masses, estimated-adult *BMI*s (body-mass indices). In order to deal with extreme cases, CDC Growth Tables were extended using mathematical-statistical techniques to include 0.01^{th}, 0.1^{th}, 1^{st}, 99^{th}, 99.9^{th} and 99.99^{th} percentiles. Scaled percentiles of height and mass, suitable for the Pakistani population, were generated from CDC percentiles of height and mass by fitting parabolic curves with the condition that 40^{th} CDC percentile (of height/mass) corresponds to 50^{th} scaled percentile (of height/mass).

*Results***:** Data of 1185 students were analyzed. Mean age was (8.08 ± 2.23) years. Using Extended CDC Growth Tables, height percentiles corresponding to cutoff heights for induction into the Armed Forces of Pakistan were determined as 2.72 (for males) and 19.36 (for females).

*Conclusion***:** Induction criteria for still-growing youth (boys less than 21-*year* old and girls less than 19-*year* old) should be based on percentiles rather than measured heights.

Keywords: Estimated-adult height, height and mass management, optimal mass (weight)

INTRODUCTION

The computation of estimated-adult height of a boy or a girl is significant for career choices. For parents, knowing how tall their children will be as adults, becomes important if they want them to serve in the Armed Forces of Pakistan. These dreams are shattered, when youngsters do not reach full growth potentials due to genetic and environmental factors. It is easier to manage deficiencies if growth faltering is detected earlier (Maleta *et al.*, 2003). During recent years there has been considerable interest in spotting mother and child malnutrition (Black *et al.*, 2013; Tathiah et al., 2013).

This paper describes a Pakistani study, the NGDS (National Growth and Developmental Standards) Pilot Project, involving military and civilian families to deal with the issue of cutoff heights for still-growing youth. Under the directives of Governor Sindh/Chancellor, University of Karachi, a retired Lieutenant General of Pakistan Army, a team of University of Karachi, headed by the first author, undertook the task to establish such standards for the Pakistani children. In 1998, the NGDS Pilot Project was initiated in representative schools of Karachi, Army Public School, 'O' Levels, Fazaia Degree College, PAF Base 'Faisal', Bahria College, NORE-1 and Beacon Light Academy (civilian school added in 2011) after going through 'institutional review process'[®] (Kamal *et al.*, 2002).

PRELIMINARIES

Before describing the methodology, some preliminaries, stunting and tallness, wasting and obesity, 'Growth-and-Obesity Profiles', 'Growth-and-Obesity Roadmaps' as well as diet and exercise plans to manage height and mass (weight) are, briefly, described**:**

Correspondence*:** Prof. Dr. S. Arif Kamal **(**http://ngds-ku.org/kamal), PhD (Mathematical Neuroscience), MA, Johns Hopkins, Baltimore, MD, United States; Director, SF-Growth-and-Imaging Laboratory, Project Director, the NGDS Pilot Project (http://ngds-ku.org), Ex-Chairman, Department of Health, Physical Education and Sports Sciences, Ex-Dean, Faculty of Science, Ex-Acting Vice Chancellor, B-19, Staff Town, University of Karachi, Karachi 75270, Pakistan

[$]MPhil, Mathematics; PhD, Physics, University of Karachi

[#]PhD, Anthromathematics, University of Karachi

[⊗]MPhil, Physics, University of Punjab; PhD Candidate, Physics, University of Karachi

[®]Appendix A describes steps taken to ensure compliance with ethical standards.

Stunting and Tallness

The NGDS Team decided to classify children as stunted for heights below 40th percentile (CDC Growth Charts, American standards were used as reliable local charts were not available); severely stunted for heights below 3rd percentile (Kamal *et al.*, 2015*b*).

Target (Adult-Mid-Parental) Height

'Target Height' of a boy (girl) is computed by adding 6.5 *cm* to (subtracting 6.5 *cm* from) average of heights of father and mother — *cm* stands for *centimeter* (Tanner *et al.*, 1970). Algebraic status (pertaining-to-height) is expressed as percentage. Its numerical value is given by 100 times the ratio of measured-height and current-age-mid-parental height difference to current-age-mid-parental height; negative value indicates stunting; positive value tallness (Kamal *et al.*, 2015*b*).

Estimated-Adult (Final) Height

'Estimated-Adult (Final) Height' (Karlberg, 1996), computed from current-height percentile (height percentile obtained from CDC Growth Tables), may indicate whether the youngster is meeting targets for induction into the Armed Forces of Pakistan (Karpinos, 1961).

Wasting and Obesity

A child having lesser (more) mass-for-height is considered to have 'instantaneous wasting' ('instantaneous obesity'). 'True wasting' is defined as the condition in which a child is suggested, *not only*, to gain mass, *but also*, to climb on CDC-percentile-of-mass trajectory within the next half-a-*year* (Kamal *et al.*, 2017*a*). 'True obesity' was defined as the condition in which a youngster is recommended to lose mass at the end of 6-*month* period (Kamal, 2017). There are risks associated both with severe wasting and excessive obesity. A severely wasted child may not have enough energy to participate gainfully in physical education as well as suffer from loss of concentration in scholarly activities. Ludwig described a number of diseases related to childhood obesity (Ludwig, 2007). Former First Lady of the United States (Michelle Obama) declared childhood obesity as an epidemic for her country.

Body-Mass Index (BMI)

'Body-Mass Index (*BMI*)' is considered an indicator to determine obesity or wasting. It was introduced in 1832 as 'Quetelet Index' by Adolphe Quetelet and renamed as 'Body-Mass Index' in 1972 by Ancel Keys (Keys *et al.*, 1972; Kamal and Jamil, 2014). *BMI*, reported in kg/m^2, is computed by dividing mass (in *kg*) by square of height (in *m*) — *kg* stands for *kilogram* and *m* for *meter*. A *BMI* of 24 kg/m^2 is taken as reference (Kamal *et al.*, 2015*b*). However, *BMI* fails to consider factors like body frame size and muscularity. *BMI*, also, is not able to create a universal threshold for overweight and underweight conditions. *BMI* range, used for estimating statuses for adults, cannot be employed for children. One needs *BMI* tables to determine *BMI* percentiles used to classify children as obese (wasted). Ramzan *et al.* (2008) studied *BMI* of Dera Ismail Khan (KP, Pakistan) children.

Estimated-Adult BMI

Defined in 2012, 'Estimated-Adult *BMI*' provides a snapshot of obesity status of children, when they would be fully grown (Kamal and Jamil, 2012). This index may be computed by substituting estimated-adult mass and estimated-adult height in place of mass and height of a child, respectively. The strong point of this formulation is that prevailing adult scales (instead of *BMI* tables) could be used to classify children.

Optimal Mass

'Height-Percentile-based-Optimal Mass' was introduced in 2004, with a rigorous definition provided in 2011 — mass corresponding to height percentile (Kamal *et al.*, 2004; 2011). A child is considered to have instantaneous wasting (instantaneous obesity), if measured mass is lesser than (exceeds) optimal mass. Algebraic status (pertaining-to-mass) is expressed as percentage, numerical value given by 100 times the ratio of measured mass and height-percentile-based-optimal mass difference to height-percentile-based-optimal mass; negative value indicates instantaneous wasting; positive value indicates instantaneous obesity (Kamal *et al.*, 2015*b*).

'*BMI*-based-Optimal Mass', introduced on the first day of this year, is computed in three steps (Kamal, 2017). In the first step, 'Estimated-Adult-*BMI*-based-Optimal Mass' is evaluated by multiplying square of estimated-adult height (expressed in *m*) with 24 (numerical value of reference *BMI*). In the second step, 'Percentile for *BMI*-based-Optimal Mass' is estimated using linear interpolation applied to estimated-adult-*BMI*-based-optimal mass. In the third and the final step, box interpolation (Kamal *et al.*, 2011) is used to compute *BMI*-based-optimal mass at the given age.

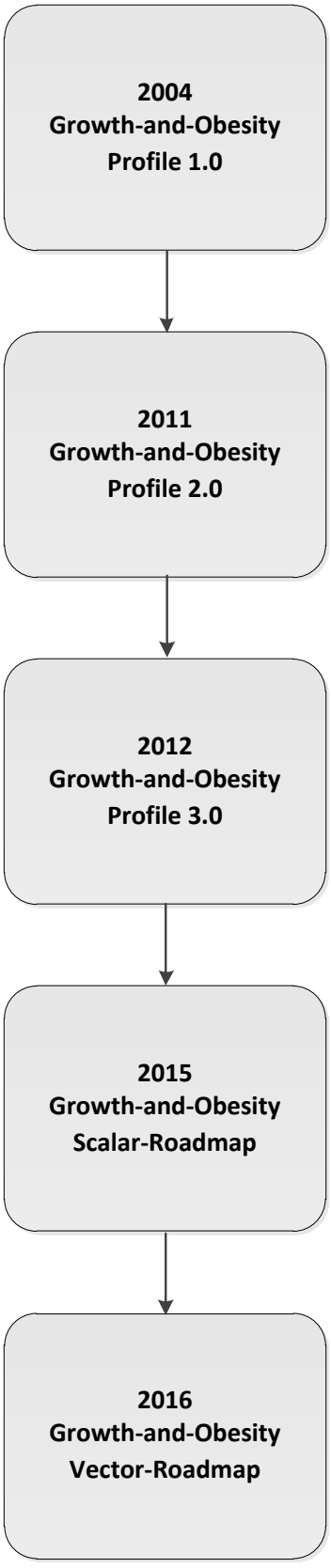


Fig. 1. Timeline of modeling of child growth and obesity

Growth-and-Obesity Profiles

'Growth-and-Obesity Profiles 1.0' generate growth and obesity status of child after at least 2 checkups and include height (growth) velocity as well as rate of mass gain/loss over this period (Kamal *et al.*, 2004).

'Growth-and-Obesity Profiles 2.0' consist of 'Obesity Profiles' of parents in terms of algebraic status (pertaining-to-mass) as well as 'Growth-and- Obesity Profile' of each sibling based on a single check up (Kamal *et al.*, 2011). They give a snapshot in terms of height and mass management through algebraic statuses (pertaining-to-height) and (pertaining-to-mass).

'Growth-and-Obesity Profiles 3.0' extend the above model to still growing-parents (Kamal and Jamil, 2012). In this model, target height of a child is computed by replacing heights of biological father and mother with their respective estimated-adult heights in the formulae.

Growth-and-Obesity Roadmaps

'Growth-and-Obesity Scalar-Roadmaps' (Kamal *et al.*, 2015*b*) are generalizations of 'Growth-and-Obesity Moving-Profiles' (Kamal *et al.*, 2014), which have month-wise recommendations to gain/lose mass for parents as well as manage both height and mass for each sibling (Kamal, 2015*b*). These roadmaps, also, include build (Kamal and Khan, 2015; Kamal *et al.*, 2017*b*) and nutritional-status classification**:** energy-channelization I-III, over-nutrition, under-nutrition and acute malnutrition (Kamal, 2014; 2015; Kamal *et al.*, 2017*a*; *b*). Pseudo gain of height (mass) may be spotted by examining these roadmaps (Kamal *et al.*, 2014). Over a period of 2 to 3 consecutive checkups, the student shows slight gain in height (mass) but drops on CDC-percentile trajectory.

'Growth-and-Obesity Vector-Roadmaps' (Kamal *et al.*, 2016*a*) have same entries as in 'Growth-and-Obesity Scalar-Roadmaps' in the age range of actual checkups. The principal difference is in goals of height and mass management. These goals are determined by fitting a parabolic curve to desired trajectories of height and mass, starting at the age of most-recent checkup and ending at the reference age, taken as 10 *years*, in such a way that slope of desired trajectory matches with the reference trajectory (both slopes vanish, reference trajectory becomes tangent). Such a mechanism generates softer targets, which are easier to achieve. The end result is that correction is achieved by the end-of-childhood phase.

Lifestyle Adjustment, Diet and Exercise Plans

A proper combination of lifestyle adjustment, diet and exercise plans is needed to meet month-wise targets. For increasing height, the student's diet should be rich in calcium, protein and fiber. To gain weight, student's diet should include potato items as well as high-protein-content food but avoiding fiber-rich food. To shed off weight, student should consume salad and yogurt (Moza-

ffarain *et al.*, 2011). Table 1 lists recommendations for lifestyle adjustment, diet and exercise plans given to parents.

Table 1. Lifestyle adjustment, diet and exercise plans for children to achieve month-wise targets[¶]

	Height Management	*Mass (Weight) Management*
[∈]**Lifestyle Adjustment**	Recommended daily dose of vitamin D (600 IU) through 10-15-*minute* guarded-graduated[∈] sun-exposure (early morning or late afternoon) with the child minimally dressed (leaving head, arms, legs and spinal column exposed, last one from external auditory meatus to hip joint; eyes protected through UV-cutoff glasses, hair spread out and opened up); 1-2-*hour* fresh air exposure to spread-out hair and uncovered skin; hair and body massage with olive oil before bathing; 8-hour, night-time, sound sleep dressed in fire-resistant pajama-shorts only, stripped-to-waist[@] (3-minute, slow-stoke back massage to improve quality and quantity of sleep) — before putting to bed (girls') hair unbraided and opened up[⊕], all hair accessories, jewelry, watch, belt removed (for safety reasons), glass of milk consumed before bedtime; teeth brushed 5 times (upon rising, after breakfast, lunch and dinner each and before going to bed), additional brushing after consuming candies/chocolates/cookies/juices/milk; maximum 2-*hour* screen time (one hour computer/video games — computer monitor at eye level, neck and back straight and normal to thighs; one hour TV/DVD); pure cotton undergarments and socks (disinfectant powder to be applied to dry body parts and wiped feet before putting on underwear/socks), pure leather mocation shoes with foot support — tight undergarments, clothes and shoes should not be worn; absolutely NO high heels for girls	
Diet Plans	3 relaxed and balanced meals; 10-12 glasses of water daily; absolutely NO carbonated drinks[&]	
	To gain height, diet plan should include calcium-, protein- and fiber-rich diet (chicken, fish, fresh fruit and milk)	To put on mass (weight), diet plan should include milk, potato items (baked or boiled, but not fried) and protein-rich diet; to shed off mass (weight), diet plan should include salad, yogurt and skimmed milk
Exercise Plans	Exercises for 5 *minutes* each after waking up, at the end of every hour and before going to bed — bending on sides, focusing eyes far away and moving eyeballs, moving fingers and wrists after computer work and writing, stretching, touching toes without flexing knees, exercising neck muscles (left, right, up, down), light exercises during TV/DVD watching; guarded-graduated[©] structured exercises, preceded by warm-up and followed by cool-down routines, preferably outdoors (weather permitting) in exercise-friendly clothing[ɔ]	
	To pick up height, child should perform light-stretching exercises (bar hanging, mild-stretching, summersault, cartwheel)	To increase mass (weight), heavy exercises performed for shorter duration, consistently; to lose mass (weight), child should perform light exercises for longer duration, consistently

[¶]Lifestyle-adjustment guidelines are taken from Kamal *et al.* (2013*a*), height-management guidelines from Kamal *et al.* (2013*b*) and mass-management guidelines from Kamal *et al.* (2013*c*).

[∈]'Guarded' implies surveillance of overexposure, which may cause skin burn (short term) and skin cancer (long term); 'graduated' means systematic increase in exposure for body conditioning (Kamal and Khan, 2015).

[@]Sleeping in day clothes or underwear should be discouraged. In gender-segregated sleeping quarters, boys of all ages and younger girls should be encouraged to sleep unclothed from the waist up, allowing the body to breathe and increasing tactile stimulation — pajama-shorts are loose-fitting, pure-cotton garments in briefs/panties (knickers) style with elastic bands around the waist and the thighs offering proper protection (Kamal and Khan, 2014).

[⊕]Allowing hair to breathe during night

[&]Carbonated drinks take away body's capacity to absorb calcium and iron and hence should be avoided, *not only*, by children, *but also*, by persons of all ages, in particular, older individuals.

[©]Guarded-graduated exercises should contribute towards health- as well as skill-related .fitness (performance considerations). Such practices, also, avoid exercise-related injuries (safety considerations). 'Guarded' is related to the concept that different body ligaments are in stable equilibrium, locally, during different exercise phases and 'graduated' implies that sequential exercise phases are related by infinitesimal transformations (Kamal and Khan, (2013). *Height Management*

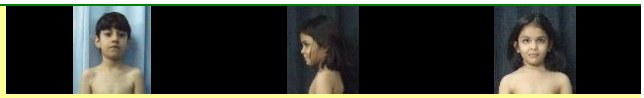
[ɔ]Details of exercise-friendly clothing are given in Kamal and Khan (2015).

SAMPLE GROWTH-AND-OBESITY VECTOR-ROADMAP

Table 2*a* shows Growth-and-Obesity Vector-Roadmap of Hr. S., female, oldest of 3 siblings, parents holding

Table 2*a*. Growth-and-Obesity Vector-Roadmap of Hr. S. (SGPP-KHI-20110614-01/01)

Gender: Female ♀ • *Date of Birth* (*year-month-day*): 2005-04-10 • *Army-Cutoff Height*: 157.48 *cm* (19.36^{P})§
Father's Height: ♂ 172.01 *cm* • *Mother's Height*: ♀ 162.94 *cm* • *Target Height*: 162.975 *cm* (36.49^{P})

Checkup	*1st*	*2nd*	*3rd*
Photograph			
Scanned Signatures	*HrS*	*HrS*	*HrS*
Class	I	II	III
Date of Checkup (*year-month-day*)	2012-07-15	2013-05-15	2013-11-21
Age (*year-month-day*)	07-03-05	08-01-05	08-07-11
Age (*decimal year*)	7.26	8.10	8.62
Dress Code[£]	0/0.5[£]	0/0.5[£]	0/0.5[£]
Behavior Code[¥]	1[¥]	0[¥]	0
Height (*cm*)	119.36	124.53	126.45
Height (*ft-in*)	3 *ft* 10.99 *in*	4 *ft* 1.03 *in*	4 *ft* 1.78 *in*
CDC Percentile-of-Height	24.63	27.08	23.09
Scaled Percentile-of-Height	32.37	35.30	30.49
Estimated-Adult Height (*cm*)	158.87	159.33	158.46
Estimated-Adult Height (*ft–in*)	**5 *ft* 2.55 *in***	**5 *ft* 2.73 *in***	**5 *ft* 2.39 *in***
CA-MP (Current-Age-Mid-Parental) Height (*cm*)	121.15	126.00	128.76
Δ Height *w. r. t.* CA-MP Height (*cm*)	–1.79	–1.47	–2.29
Algebraic Status (pertaining-to-height)	–1.48%	–1.17%	–1.78%
Qualitative Status (pertaining-to-height)	**1st-Deg Stunted**	**1st-Deg Stunted**	**1st-Deg Stunted**
CA-AC (Current-Age-Army-Cutoff) Height (*cm*)	118.28	122.99	125.64
Δ Height *w. r. t.* CA-AC Height (*cm*)	+1.08	+1.54	+0.81
Reference Height (*cm*)	121.15	126.00	128.76
Percentile-of-Reference-Height	36.49	36.49	36.49
Gross Mass (*kg*)	19.19	21.90	22.53
Clothing Correction (*kg*)	0	0	0
Net Mass (*kg*)	19.19	21.90	22.53
Net Weight (*lb-oz*)	42 *lb* 5.02 *oz*	48 *lb* 4.63 *oz*	49 *lb* 10.86 *oz*
CDC Percentile-of-Net-Mass	8.13	14.74	10.30
Scaled Percentile-of-Net-Mass	11.49	19.98	14.14
Estimated-Adult Mass (*kg*)	47.60	49.68	48.46
Estimated-Adult Weight (*lb–oz*)	104 *lb* 15.37 *oz*	109 *lb* 8.67 *oz*	106 *lb* 13.82 *oz*
Height-Percentile-based-Optimal Mass (*kg*)	21.15	23.47	24.39
Δ Mass-for-Height (*kg*)	–1.96	–1.57	–1.86
Algebraic Status (pertaining-to-mass)	–9.28%	–6.68%	–7.61%
Qualitative Status (pertaining-to-mass)	**1st-Deg Wasted**	**1st-Deg Wasted**	**1st-Deg Wasted**
CDC Percentile-of-*BMI*-based-Optimal-Mass	57.71	58.86	56.70
BMI-based-Optimal-Mass (*kg*)	24.39	27.16	28.67
Estimated-Adult *BMI* (*kg*/*m*^{2})	18.86	19.57	19.30
Nutritional Status	**Under-Nutrition**	**Under-Nutrition**	**Under-Nutrition**
Sum of Scaled Percentiles	43.85	55.29	44.63
Build	**Small**	**Medium**	**Small**

§The superscript P stands for percentile.

$^{£}$'Dress Code' 0/0.5 implies that the child was measured wearing panties only, barefoot, all clothing above the waist removed (Kamal, 2006; Kamal *et al.*, 2002).

$^{¥}$'Behavior Code' 0 means that the child was relaxed and coöpertative; 1 means the child was timid and shy, but coöperative, during the examination (Kamal, 2006; Kamal *et al.*, 2002).

Table 2*b*. Month-wise targets determined using Growth-and-Obesity Vector-Roadmap for Hr. S. based on her last checkup

Target Date	*Height Target*		*Mass Target*	
	cm	*ft-in*	*kg*	*lb-oz*
December 21, 2013	127.22	4 *ft* 2.09 *in*	23.18	51 *lb* 1.74 *oz*
January 21, 2014	127.90	4 *ft* 2.36 *in*	23.83	52 *lb* 8.89 *oz*
February 21, 2014	128.55	4 *ft* 2.61 *in*	24.48	53 *lb* 15.49 *oz*
March 21, 2014	129.12	4 *ft* 2.84 *in*	25.04	55 *lb* 3.39 *oz*
April 21, 2014	129.74	4 *ft* 3.08 *in*	25.65	56 *lb* 9.05 *oz*
May 21, 2014	130.31	4 *ft* 3.30 *in*	26.22	57 *lb* 13.08 *oz*

professional degrees at masters level. Brief history and physical examination findings are presented below**:**

History (first visit)**:** *a*) Paternal grandfather cardiac patient, paternal cousin having severe scoliosis, father, grand parents have diabetes, biological child, blood group B+, 37-week baby delivered using forceps, jaundice at birth, breast-fed for one *month*, reported shin pain; *b*) academics**:** excellent; co-curricular**:** good; *c*) social (interaction with teachers, peers, family)**:** better, dependent, shy; *d*) lifestyle**:** 9-hour sleep; *e*) meals**:** 2 meals (relaxed), 1 or none snacks; *f*) name of pediatrician**:** withheld, last check up**:** 6 *month* ago

Physical Examination (first visit)**:** *a*) School bag not brought, smartly dressed, quiet, sober, right handed; *b*) umbilical cord not properly cut, hair dry, white spots on nails, teeth yellow; *c*) normal heart sounds (standing and squatting), *d*) gait with toes inward; *e*) positive Trendelenburg sign (right); *f*) positive forward bending — opposite sides from front and back, *g*) posture (from back) left shoulder drooping, left scapula down, and body triangles unequal, spinal dimples level, midline of back showing S curve — not corrected upon mild stretching, (from front) right shoulder drooping, right nipple down

Examining the table entries, one notes pseudo gain (Kamal *et al*., 2014) of both height and mass between 2nd and 3rd checkups — height pick up from 124.53 *cm* to 126.45 *cm*, CDC height percentile dropping from 27.08 to 23.09; mass put on from 21.90 *kg* to 22.53 *kg*, CDC mass percentile dropping from 14.74 to 10.30. Table 2*b* lists month-wise targets generated from software (named as SOFTGROWTH).

Appendix B contains flow chart of SOFTGROWTH 1.1, modified from SOFTGROWTH 1.0 described in Kamal *et al.* (2017*a*). SOFTGROWTH 1.1 is different from SOFTGROWTH 1.0 in the aspect that it computes scaled percentiles of height and mass from the corresponding CDC percentiles to evaluate build and severity of acute malnutrition (when present). Mathematical model, including transformation equations, was proposed in Kamal *et al.* (2017*b*). Appendix C displays screen shots of front end and results panel for the third checkup of Hr. S.

Figure 2 displays time evolution of CDC height and mass percentiles for three checkups of Hr. S. in the age range 7.26-8.62 *years*. Note that Hr. S., *not only*, presented 'instantaneous wasting' at her 3rd checkup, status

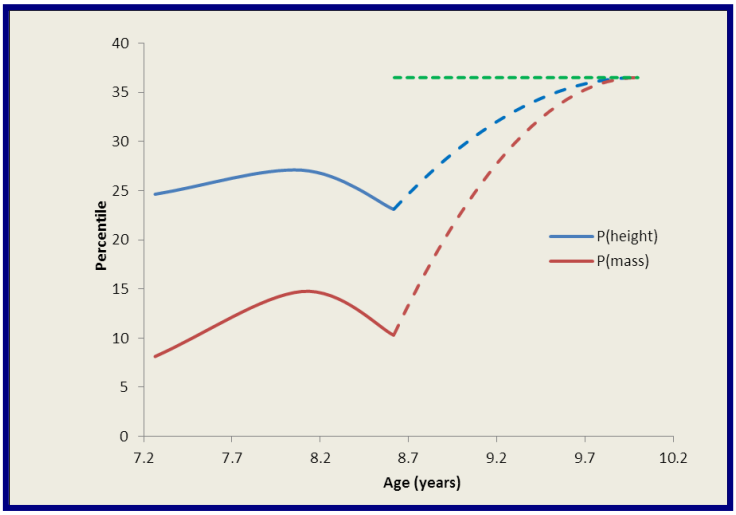


Fig. 2. Time evolution of CDC height and mass percentiles of Hr. S. for her three checkups in the age range 7.26-8.62 *years* (navigational trajectories**:** solid curves), including the desired course-of-action (guidance trajectory**:** green-dashed line) and recommended intervention (control action**:** blue-dashed for height-percentile curve and maroon-dashed for mass-percentile curve)

(pertaining-to-mass) negative (3rd-checkup entry in Table 2*a*), *but also*, 'true wasting' (Kamal *et al.*, 2017*a*), as she was recommended to gain 3.06 *kg* within the next 6 *months* (Table 2*b*) at the same time climbing on CDC-mass-percentile trajectory from 13.32 to 25.71, as shown in screen shot of results panel given in appendix C.

SUBJECTS AND METHODS

The study was designed in consultation with pediatricians taking care of the applicable ethical protocols (Kamal *et al.*, 2002). This was an observational study with main emphasis on anthropometric-data collection, based on convenience sampling. The participants comprised of boys and girls from all provinces of Pakistan in three schools run by the Armed Forces of Pakistan and a civilian school during 1998-2013. Parents were sent 'Informed Consent Forms'. Only those students were measured, whose parents sent back the signed consent slip. Data were collected on school premises during weekdays (Monday-Friday) between 0900h and 1200h. First author was present during all the measurement sessions. Heights of 1185 students are reported in this work and analyzed. These were the students, who could stand straight and provide their heights and weights. Anthropometric measurements of one male student, who had severe musculoskeletal deformities and could not stand upright, were omitted at the data-processing stage.

Students were screened for factors, which might contribute to growth retardation, *i. e.*, anemia, cardiac disease (Kamal, 2015) and scoliosis (Kamal *et al.*, 2015*a*; 2016*d*). Knees joining (static examination) and knees knocking (dynamic examination) were given particular attention. Gaits were observed to look for toes inward/outward, spastic gait and limp (Kamal *et al.*, 1996; 2016*c*).

Heights and masses of students were measured by reproducible anthropometrists to least counts of 0.1 *cm* (1998-2011, setsquare); 0.01 *cm* (2012-2015, Vernier scale); 0.005 *cm* (2016 till date, enhanced Vernier scale) and 0.5 *kg* (1998-2011, bathroom scale); 0.01 *kg* (2012-2015, modified beam scale); 0.005 *kg* (2016 till date, enhanced beam scale), respectively, before noon (pupils are taller in the morning), students fully undressed except under shorts as per protocols given elsewhere (Kamal, 2006). 7-*year* ago, least count of height- and mass-measurement systems were enhanced to 0.01 *cm* and 0.01 *kg*, respectively, from existing global standards of 0.1 *cm* and 0.1 *kg* (Kamal, 2010) and were upgraded last year to 0.005 *cm* and 0.005 *kg*, respectively (Kamal *et al.*, 2016*b*). Height was measured with the student instructed to inhale fully and stand touching the mounted (engineering) tape, keeping hands straight, palms touching thighs, feet together — attention position (Figure 2*a*). Mass was recorded, when the student breathed in and stood in beam-scale center, hands by thighs, feet separated — stand-at-ease position (Figure 3*b*). Instruments were calibrated (using a 100 *cm* ruler and a 2 *kg* mass) and zero errors determined at the start of each daily session. Disrobing helped measurers ascertain standard posture; knees not flexed, toes not lifted and proper inhaling. Measurements were carried out giving due regard to dignity, privacy, confidentiality, comfort and safety of students. The demographic and the clinical data were entered in a structured proforma. Demographic data included date of birth, gender, parents' education and occupation as well as details of siblings. Data analysis was performed using software, named SOFTGROWTH, developed in SF-Growth-and-Imaging Laboratory to generate 'Growth-and-Obesity Vector-Roadmaps'. Measured heights of students were fed into SOFTGROWTH to determine CDC percentiles for cutoff heights using linear interpolation from age-20 values read from 'Gender Specific Extended CDC Growth Tables' (Kamal and Jamil, 2014), which include 0.01th, 0.1th, 1st, 99th, 99.9th and 99.99th percentiles in addition to the regular entries in the range 3rd-97th percentile. Descriptive statistics were used to describe the collected data. Mean and standard deviation were calculated for age (quantitative variable); frequencies and percentages reported for gender (qualitative variable).

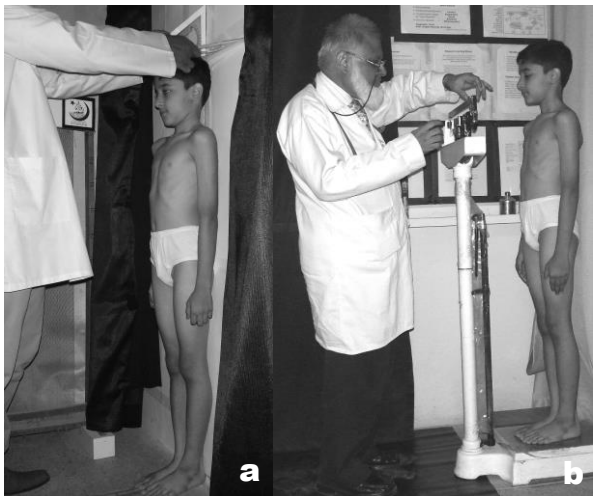


Fig. 3*a*, *b*. Measuring height (*a*) and mass (*b*) of a boy in SF-Growth-and-Imaging Laboratory — pictures first appeared in Kamal and Jamil (2012), published in the same journal

Army Cutoff Heights: *Scientific Criteria*

Cutoff height for career in the Armed Forces of Pakistan could become a turning point in a boy's/girl's life aspiring to serve one's country, in particular, for fourteen- and fifteen-*year* olds reporting to induction centers. Boys (Girls) continue to gain height till the age of 21 (19) *years*. At times, because of limited information of growth trajectories of such youngsters, genuine candidates may be rejected on medical grounds.

Table 3. Cutoff heights for military and paramilitary occupations in Pakistan

Cutoff Height (for induction into the Armed Forces of Pakistan)	*Boys*	*Girls*
Height (*ft-in*)	5 *ft* 4.00 *in*	5 *ft* 2.00 *in*
Height (*cm*)	162.56	157.48
CDC Percentile-of-Height	2.72	19.36

RESULTS

In this paper, the authors report data of 304 male (25.65%) and 881 female (74.35%) students (mean age 8.08 years; standard deviation 2.23 years) belonging to different parts of Pakistan. Table 3 lists cutoff heights and corresponding percentiles for males and females.

DISCUSSION

The present induction criteria set higher cutoff values for girls (19^{th} CDC percentile-of-height — 19.36 to be exact) as compared to boys (3^{rd} CDC percentile-of-height — 2.72 to be exact). The cutoff CDC percentiles-of-height should be uniform for boys and girls, based on height and mass (weight) data of the Pakistani youth. Once the indigenous data are available through systematic nation-wide data collection with proper statistical analysis, boys and girls above median (50^{th} percentile of the indigenous data) should be inducted in the forces and the paramilitary occupations.

RECOMMENDATIONS

The percentiles corresponding to cutoff heights should be the prime selection criteria for still growing youth (ages below 21 *years* for boys and below 19 *years* for girls) instead of the numerical values of their measured heights, as they would not have achieved their full growth potentials at the time of their induction examinations. Hence, the measured heights may be below the threshold, *i. e.*, 5 *ft* 4 *in* and 5 *ft* 2 *in*, for males and females, respectively.

This paper reported work of the NGDS Pilot Project, which is in the nineteenth year of operation. Figure 4 lists some accomplishments of the NGDS Team. The team measured students as young as 2.76-*year* old, studying in Montessori/ ECE-I (Early Childhood Education). Students are given month-wise recommendations and guidelines for height and mass (weight) management (Table 2*b*) through combination of lifestyle adjustment, diet and exercise plans (Table 1). To develop strong muscles and bones as well as shed off excess weight, it is suggested that gymnastics

Model of Child Growth and Obesity **GROWTH-AND-OBESITY VECTOR-ROADMAP 1.1**	*Software* **SOFTGROWTH 1.1**
Instrumentation **HEIGHT-MEASUREMENT SYSTEM (least count 0.005 *cm*)** **MASS-MEASUREMENT SYSTEM (least count 0.005 *kg*)**	*Growth Charts and Tables* **EXTENDED CDC GROWTH CHARTS AND TABLES (contain entries for 0.01^{th}, 0.1^{th}, 1^{st}, 99^{th}, 99.9^{th} and 99.99^{th} percentiles of height and mass, in addition to regular entries 3^{rd}-97^{th} percentile)**
Training Resource **MANUAL FOR OBTAINING ANTHROPOMETRIC MEASUREMENTS (version 9.11)**	*Laboratory Facilities* **DEDICATED LABORATORY (black-tiled floor, dust- and germ-free environment; acoustic and visual privacy)**

Fig. 4. Accomplishments of the NGDS Pilot Project (1998 to date)

be made compulsory from pre-primary to higher secondary levels (Kamal and Khan, 2014; 2015), but only after a mandatory pre-participation psychological testing, physical examination and fitness testing (Kamal *et al.*, 2017*b*).

To establish a national height- and weight-monitoring program (the NGDS Health Initiative), local scientists should prepare training manuals and establish training programs in all provincial capitals. Reproducible measurers, with documented accuracy and precision, should take measurements according to laid-down procedures (WHO, 2006). Height- and mass-measurement systems (calibrated daily) should be upgraded to least counts of 0.005 *cm* and 0.005 *kg*, respectively.

All the students enrolled in schools, run by the Armed Forces of Pakistan (and later, all civilian schools), should be measured yearly following standard protocols. Those meeting month-wise height and mass (weight) targets, should be honored by awarding certificates and scholarships. Their names and photographs should be put on special notice boards constructed in each class to motivate other students to follow their path.

Since height and weight charts of the Pakistani children are not available except for some preliminary work (Aziz *et al.*, 2012; Mushtaq *et al.*, 2012), patchwork is needed by applying mathematical (Kamal *et al.*, 2004; 2017*b*) and statistical (Al Frayh and Bamgboye, 1993) techniques. 'The NGDS Health Initiative' should be able to generate growth charts of the Pakistani children. Such a task should be taken up by the Armed Forces of Pakistan and not left to NGOs, as foreign nationals would not be able to go to all parts of country and collect unbiased samples.

CONCLUSION

This paper described an anthropometric study conducted in schools run by the Armed Forces of Pakistan and a civilian school. Data were collected and analyzed using software developed indigenously. Growth charts were extended to include extreme percentiles. Using these charts percentiles were computed corresponding to cutoff heights of male and female applicants for induction into the Armed Forces of Pakistan. Induction criteria for still growing youth (under-21 boys and under-19 girls) have been suggested, which should focus on percentiles rather than measured heights.

Induction into the Armed Forces of Pakistan should not be based on a single measurement of height and mass (weight) at the induction center, but on height and mass percentile trajectories maintained from school admission till the youngster reports in the recruitment center.

APPENDIX A: COMPLIANCE WITH ETHICAL STANDARDS

*Conflict of Interest***:** The authors state that there are no financial/non-financial competing interests in the research presented in this paper.

*Institutional Review***:** The project protocols were prepared after taking into consideration North American and European, ethical and human-right standards.

*Informed Consent***:** For school studies, 'The Informed Consent Form' was employed, which was based on opt-in policy. This form may be downloaded from**:** http://www.ngds-ku.org/ngds_folder/Protocols/NGDS_form.pdf. For detailed checkups in SF-Growth-and-Imaging Laboratory, 'The SGPP Participation Form' was used. This form is placed at the address**:** http://www.ngds-ku.org/SGPP/SGPP_form.pdf. Both forms required signatures of each parent as well as participating children. At the beginning of examination, verbal permission was obtained from the examinees and the attending parent(s).

*Privacy, Confidentiality, Comfort and Safety***:** Both acoustic as well as visual privacy was ascertained in SF-Growth-and-Imaging Laboratory. Initials of child included in this work do not correspond to first letters in her real name (as per confidentiality standards established by the NGDS Team). Same is true about case number as well as pictures of child appearing in this work. Comfort of patients was given due consideration. Although, both father and mother were encouraged to attend checkups to give history and share progress, same-gender parent was preferred to be present at the unclothed physical examination in the curtained-off area for utmost comfort of the youngster. Before checkups, school-checkup-room floor was mopped and sharp objects removed from floor. Chairs/benches were checked for sharp edges of wood/metal as well as both boundaries of the mounted engineering tape to safeguard abrasions and cuts of skin. In SF-Growth-and-Imaging Laboratory, the entire floor is black-tiled, street shoes are not allowed for anyone, floor mopped with dettol (chloroxylenol)-mixed water. Thermometer bulbs, when not in use, remain dipped in dettol-mixed water. Hand washing/sanitization is compulsory at the start of each checkup. Health professionals and anthropometrists are required to remove hand-worn chains, rings and wristwatches to prevent injury to examinees.

*Disclosure and Regret Model***:** Adapted from University of Michigan Health System's Disclosure, Apology and Offer Model (Simmons, 2016), 'Disclosure and Regret Model' is formulated on the principle that any wrong entry in report is communicated immediately to the parents with regrets and corrected printout of report is provided.

*Report Discussion and Guidance***:** After the report is prepared and delivered to parents, mother, along with father, is invited to come and discuss the report with the principal investigator (the first author).

APPENDIX B: FLOW CHART OF 'SOFTGROWTH 1.1'

Flow chart of SOFTGROWTH 1.1 is given in Figure 5 — compare with flow chart of SOFT-GROWTH 1.0 shown in Figure 7*b* (Kamal *et al.*, 2017*a*).

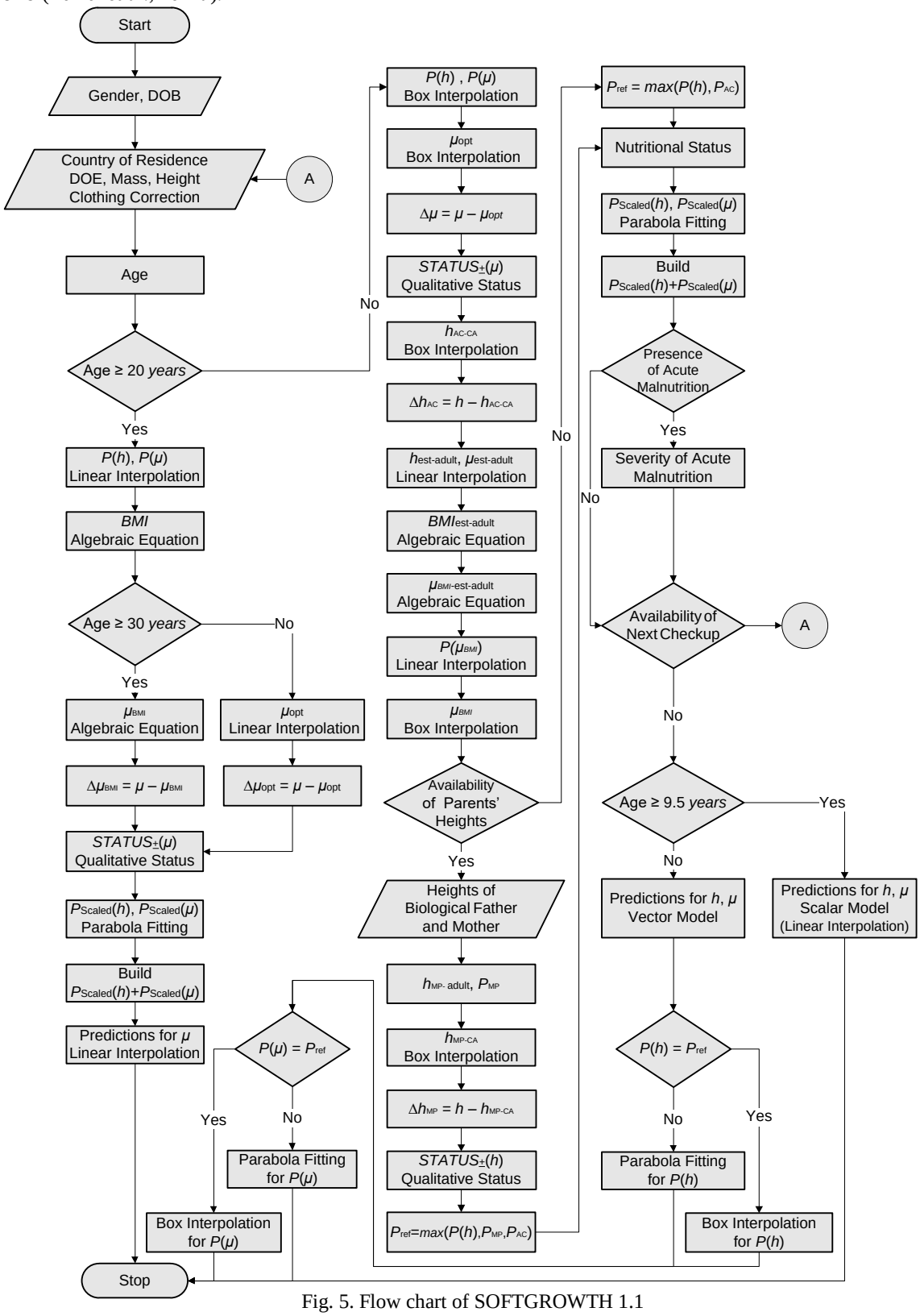


Fig. 5. Flow chart of SOFTGROWTH 1.1

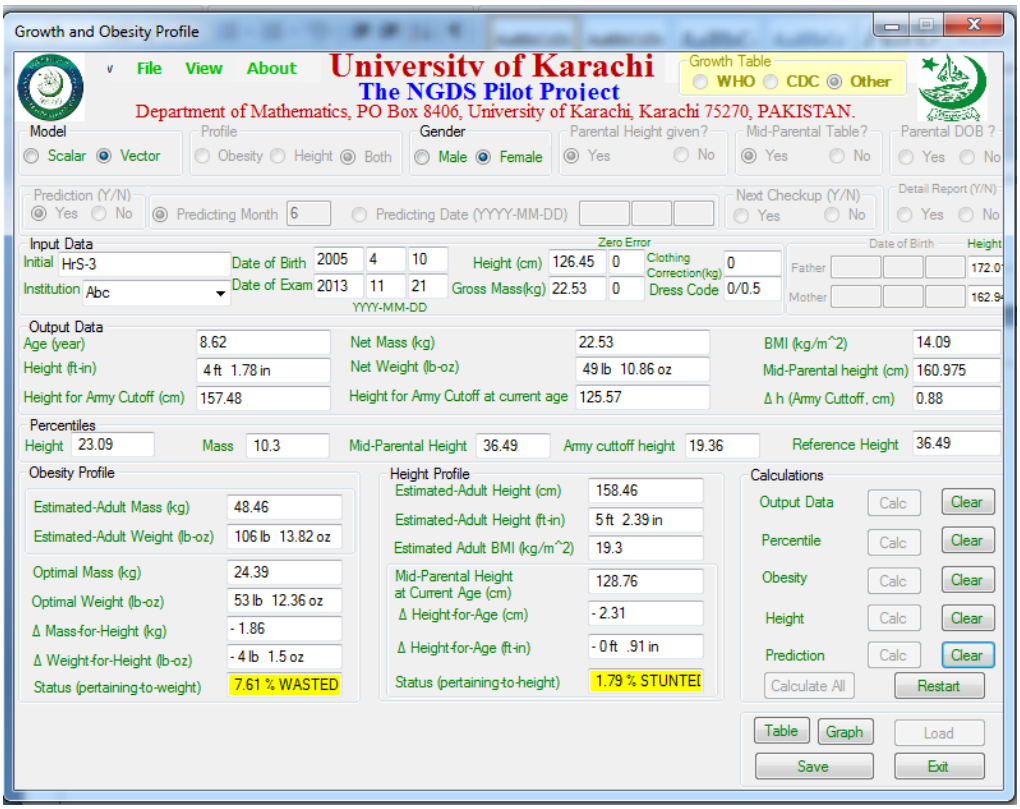


Fig. 6*a*. Screen shot of front end for generating Growth-and-Obesity Vector-Roadmap

APPENDIX C: FRONT END AND RESULTS PANEL GENERATED BY 'SOFTGROWTH 1.1'

Screen shots of font end (Figure 6*a*) and results (Figure 6*b*) for Growth-and-Obesity Vector-Roadmap of Hr. S. are given in this appendix.

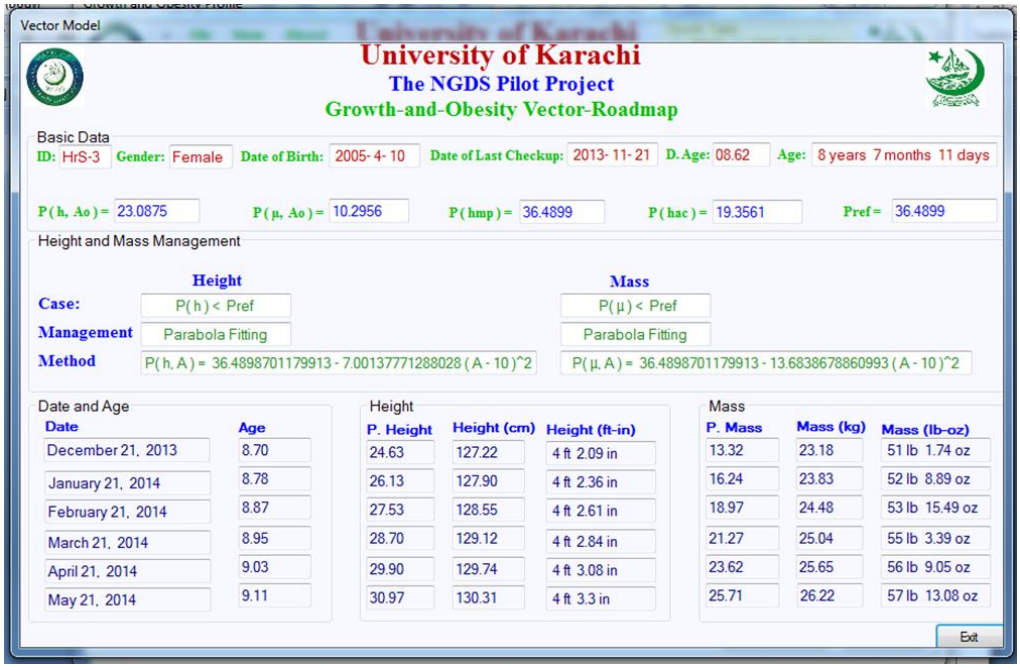


Fig. 6*b*. Screen shot of results generated (month-wise height and mass recommendations) from SOFTGROWTH 1.1

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