PJSS
ISSN: 1309-0356
http://pjss.pau.edu.tr
http://psbd.pau.edu.tr
Pamukkale Journal of Sport Sciences
2017, Vol. 8, No. 2, 15-40
accepted: 27.02.2017

Psychological Testing, Physical Examination and Fitness Testing of Primary-School Students for Participation in Gymnastic Activities

Syed Arif Kamal[1 §], Humayun Imran Azeemi[2 $], Sadaf Rashid Khan[3 #]

[1]University of Karachi, SF-Growth-and-Imaging Laboratory, the NGDS Pilot Project, Karachi, Pakistan.
[2]University of Karachi, Department of Health, Physical Education and Sports Sciences, Karachi, Pakistan.
[3]University of Karachi, Department of Physiology, Karachi, Pakistan.

sakamal@uok.edu.pk

Abstract

The authors highlight significance of fitness testing, psychological and physical examinations for primary-school students, who wish to participate in gymnastic activities. The main purpose of pre-participation examination is safety of potential gymnasts, team members, coaches and staff. The prime function of end-of-term evaluation is performance assessment and possible improvement from the last term. Taking the example of a girl, who is participating in gymnastics, this work illustrates use of Growth-and-Obesity Roadmap in determining suitability for inclusion in gymnastic team, focusing on nutritional status, estimated-adult height and build of student. Build is computed using scaled percentiles adapted for the Pakistani children, which are generated from CDC (Centers for Disease Control and Prevention, Atlanta, United States) percentiles by fitting a parabolic curve. Mathematical-statistical definitions of normal, early, delayed, excessively delayed and precarious puberty are proposed. Approximate Tanner scores have been assigned to prepubertal, peripubertal, pubertal, adolescent and adult stages.

Keywords: Health-related fitness, skill-related fitness, stereophotogrammetry in scoliosis screening, height, mass (weight), month-wise recommendations, diet and exercise plans, lifestyle adjustment, definitions of puberty

Abbreviations: *cm*: centimeter(s) • *m*: meter(s) • *ft*: foot (feet) • *in*: inch(es) • *kg*: kilogram(s) • *lb*: pound(s) • *oz*: ounce(s) • MP: mid-parental • W/H: withheld to protect privacy

§ Professor Dr. Syed Arif Kamal, Project Director, the NGDS Pilot Project, Director, SF-Growth-and-Imaging Laboratory, Ex-Chairman, Department of Health, Physical Education and Sports Sciences, Ex-Dean, Faculty of Science, University of Karachi.
$ Humayun Imran Azeemi, Lecturer, Department of Health, Physical Education and Sports Sciences, is enrolled in MPhil leading to PhD Program of Department of Physiology, University of Karachi.
# Dr. Sadaf Rashid Khan, MBBS, is enrolled in MPhil leading to PhD Program of Department of Physiology, University of Karachi.

INTRODUCTION

Primary school coaching in gymnastics consists of aesthetic, cognitive, creative, physical, psychological and skill components, which could be using apparatus or without one (Caroll & Manners, 2003). Gymnastics deals with human-body-physiological functioning, for all-round harmonious development (Joseph, 1949). This sport is a show of strength, speed, coördination, balance and agility, requiring concentration, flexibility and devotion.

This paper discusses fitness testing, physical and psychological examinations of preteen students for participation in gymnastic activities. After deliberating on theoretical foundations of physical examination, pre-participation and end-of-the-term examinations are described, focusing on examination sequence, quality of examination, ethical and human-right protocols. The importance of puberty rating of peripubertal and pubertal gymnasts is elaborated. Growth-and-Obesity Vector-Roadmap of a young gymnast is included in the work to elaborate effect of gymnastic training on height and mass gains.

Physical examination

'Physical examination' is the examination, in which the physician uses physical senses (hearing, sight, smell, taste, touch) aided by instruments (ophthalmoscope, otoscope, stetho-scope, thermometer, *etc.*) to examine body organs (structure and function) in order to reach a diagnosis. The name makes it different from 'chemical examination' (laboratory testing involving chemical reactions) and 'radiological examination' (using ionizing radiations). The authors would like to include non-contact (clinical photography, moiré fringe topography, rasterstereo-graphy, dotted-rasterestereography) and non-invasive (pantograph for drawing spinal outline) procedures in physical examination. Good physicians do not just follow one line of thought but more than one hypothesis and use differential-diagnosis methods to eliminate all but one.

Concepts and Techniques

The mathematical concepts behind techniques used in the physical examination by a medical professional are summarized below (Kamal, 2011)**:**

a) *Symmetry* (left-right) in body shape, size, number of limbs (fingers, toes), anatomical land-marks — scapulae, body triangles, spinal dimples, shoulder/neck line, knee joints, in the context of scoliosis indicators (Kamal *et al.*, 2016*d*).

b) *Inverse Problem* — determining properties of source from the properties of field (*e. g.*, auscultation using stethoscope; the sound recorded from heart, lungs or stomach comes through the body tissue and the skin, which must be accounted for; it is obvious that auscultation over any thickness of clothing is unacceptable, scientifically), radiative-transfer equation may be used to compute intensity, if source function is known (proper interpretation of X-ray intensity in CT scan using radiative-transfer equation brought Nobel Prize in medicine; basis of clinical thermograms)

c) *Precedence Graph* — In the field of pediatrics, physical examination is the most important part of any intervention. Some checks must be performed 'before' the others. Otherwise, an undiscovered condition may affect adversely on a patient's health (Kamal *et al.*, 2002*a*). Everyone knows that an examination of the resting heart must be performed before treadmill

testing. Similarly, hernia check must 'precede' cardiac-function testing in the squatting position. 'Precedence Graphs' can show the procedures, which must precede the others. Some of the procedures can be performed 'concurrently'. For example, cardiac function in the standing position, and check for undescended testicles could be performed concurrently.

d) *Influence Graph* — In pediatrics, physical examination is the basis to start any intervention. However, some procedures 'influence' certain portions of the examination. For example, running can influence blood pressure and heart rate. 'Influence Graphs' can show various procedures influenced by others. Protocols of physical examination need to be designed in such a way that interacting procedures are performed in a laid-down sequence, or during separate sessions (Kamal *et al.*, 2002*b*).

Senses Enhanced by Instruments

The instruments used in the physical examination enhance the natural senses of physician (Table 1), sharpened and channelized by concentration and practice. Each one carries its own

Table 1. Techniques used in physical examination by a medical professional

Physical-Exam Technique	*Underlying Concept*	*Physical Sense*
Inspection	Symmetry	Sight
Auscultation	Inverse problem	Hearing
Percussion	Inverse problem	Hearing, touch
Palpation	Properties of material, body temperature	Touch
Olfaction	Inverse problem	Smell

Table 2. Instruments/Procedures used in physical examination by a medical professional

Instrument	*Purpose*	*Associated Risks*[⊆]
Stethoscope	Auscultation (heart, lungs, abdomen), blood pressure	*A*
Otoscope	Ear examination	*A, B*
Ophthalmoscope	Eye examination	
Thermometer	Recording of temperature	*A, C*
Electrocardiograph (ECG or EKG)	Recording of electrical activity of heart	*A, D*
Electroencephalograph (EEG)	Recording of electrical activity of brain	*A, D*
Electromyograph (EMG)	Recording of electrical activity of muscles	*A, D*
Magnetocardiograph (MCG or MKG)	Recording of magnetic activity of heart	
Mangnetoencphalograph (MEG)	Recording of magnetic activity of brain	
Mangnetomyograph (MMG)	Recording of magnetic activity of muscles	

[⊆]***A*:** Infection transmission through contact

***B*:** Injuring organ because of spontaneous movement

***C*:** In case of breakage, swallowing of glass pieces and mercury (toxic substance) — this is one of the reasons for abandoning the practice of taking oral temperature

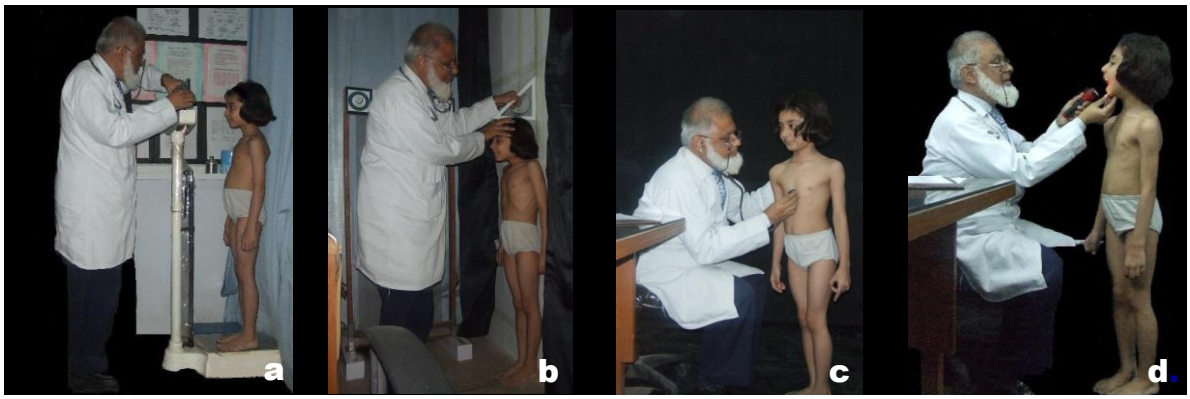
***D*:** Death from electrical shock in the absence of body-isolation mechanism

risk, which must be spelled out so that necessary precautions could be taken (Table 2).

Fitness testing, physical and psychological examinations of young gymnasts

Psychological and physical examinations as well as fitness testing are done in gender-segregated groups, whereas private-part examinations are to be conducted individually.

*Pre-Participation Examinations***:** The main objective of pre-participation psychological as well as physical examination and (health- + skill-) related fitness testing is safety of the pros-pective gymnasts, their teammates, their coaches and the gymnastic-club/the gymnastic-school staff. Besides routine anthropometry (Figures 1*a*, *b*), it is supposed to find out conditions, which

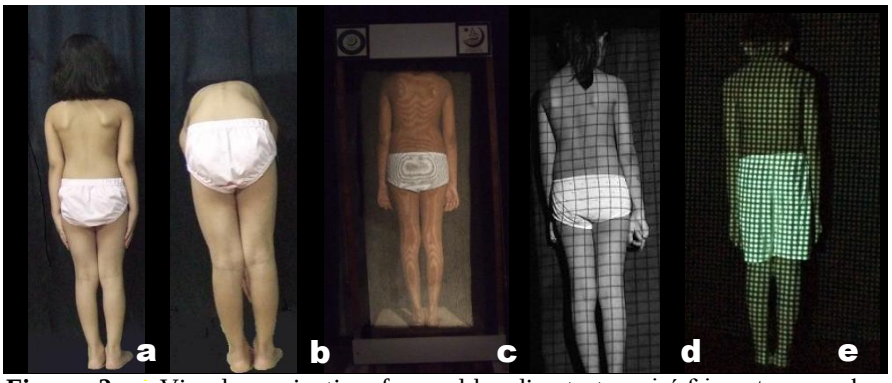


Figures 1*a-d*. Anthropometry (mass and height recording), heart-sound auscultation and mouth inspection for signs of anemia in SF-Growth-and-Imaging Laboratory — pictures of anthropometry first appeared in Kamal & Jamil (2014)

may be responsible for serious injury and harm during gymnastic activities, *e. g.*, heart problems (Figure 1*c*), epilepsy, hernia or hydro seal and correctable conditions (if detected early), *e. g.*, knees knocking. Primary focus should be on discovering communicable diseases, in particular, skin infections (so that other teammates do not get the condition), evaluation of hearing and sight (so that the prospective gymnast could follow instructions and copy routines; severe impairment may be cause of accidents in gymnasts) as well as presence of fatigue, emotional disorders and malnutrition. Acutely malnourished (Kamal, 2015*a*) and severely anemic candidates (Figure 1*d*) are not allowed to participate in gymnastic activities. In addition, psychological disorders, *e. g.*, trends of destructive behavior, anorexia nervosa and bulimia nervosa (in particular, among female gymnasts), should be looked into (Rumball & Leburn, 2004).

*End-of-the-Term Evaluation***:** This should combine psychological and physical examination with fitness testing (Kamal and Khan, 2013; 2014). It should concentrate on performance considerations and improvements achieved from the previous term. The psychological segment may contain free speech/writing as well as drawing analysis.

In both of the above health appraisals, height and mass of each gymnast should be recorded by reproducible measurers according to laid-down protocols (Kamal, 2006). Measured heights and masses should be used to generate Growth-and-Obesity Profiles (Kamal *et al.*, 2011) as well as Growth-and-Obesity Roadmaps (Kamal *et al.*, 2015*a*; 2016*a*; *b*) of gymnasts. Maintaining optimal-weight-for-height (Kamal, 2015*c*) is of prime importance for efficient and effective participation in gymnastics. End-of-the-Term Evaluation should, also, include a detailed exami-nation of posture and gait, both walking and running (Kamal *et al.*, 2016*c*). Scoliosis screening (Kamal *et al.*, 2015*b*) using visual examination (Figure 2*a*), forward-bending test (Figure 2*b*) and



Figures 2*a*-*e*. Visual examination, forward-bending test, moiré fringe topography, rasterstereography and dotted-rasterstereography for detection of scoliosis — pictures of visual examination, forward-bending test, rastersterography and dotted-rasterstereography first appeared in Kamal *et al.* (2016*d*)

moiré fringe topography (Figure 2*c*) should be a part of every evaluation (Akram and Kamal, 1991; Kamal *et al.*, 2013*f*). In addition, rasterstereography (Kamal *et al.*, 2013*b*) and dotted-rasterstereography (Wasim *et al.*, 2013) may be employed, where relevant software is available (Figures 2*d*, *e*).

Health Surveillance of Gymnasts

The gymnasts, who show slightest deviation from normal health status, during daily inspection upon arrival, should receive head-to-toe unclothed checkup by doctor-on-duty before being allowed to mix with other teammates. A complete, stripped examination of any gymnast, reporting for even a minor cut or a bruise, is mandatory to rule out internal injuries, abrasions and damages to other body parts. Self-diagnosis and self-treatment, beyond essential first aid, should be avoided; as such practices are uncoördinated with history and etiology of the disease. Self-medication runs the risk of adverse drug interaction.

Preparation for Pediatrician's Office Visit

The following timeline is proposed to get maximum value from such visit.

*One week before the proposed visit***:** Parents should start brainstorming the points (*i. e.*, jot them down without consideration of logical sequence), which should be included in note to pediatrician — progress/problems since last check up, medicines/treatments taken, areas the parents wish the pediatrician to look for, get advice from pediatrician.

*Four days before the proposed visit***:** Parents should organize, in a sequence, the points collected — date-wise progress, problems, from most important to least important for areas the parents wish the physician to concentrate on and provide recommendations.

*Two days before the proposed visit***:** Parents should collect medical records, brief children about the upcoming examination, making it crystal clear that they have to undress during the examination, show them a video/a drawing or conduct an activity related to well-child visit.

*One day before the proposed visit***:** Parents should conduct mock check up (children stripped to waist, wearing only briefs/panties), call pediatrician' office to confirm appointment, write down or type out (preferred) note for doctor containing points organized three days ago.

*Day of proposed visit***:** Hair of girls should be left open with only hair band used to restrain hair. Parents should bring ponies for each of their daughters to be used during fitness-testing segment, dress children in appropriate footwear and clothing, which can be easily removed by children themselves (Table 3). Avoid garments that open in the back, belts for boys and shoes

Table 3. Hairstyle, clothing and footwear for free play and observation, psychological testing, physical examination and fitness testing of primary- school children for participation in gymnastic activities

Session	*Boys*	*Girls*
HAIRSTYLE		
Free Play and Observation[∀]	Very short hair	Hair completely unbraided and opened up — only hair-band allowed to hold hair from front
Psychological Testing	Very short hair	Hair completely unbraided and opened up — only hair-band allowed to hold hair from front
Physical Examination	Very short hair	Hair completely unbraided and opened up — all accessories stored in numbered boxes
Fitness Testing[∃]	Very short hair	Long hair should be tied in the form of (hair) bun using pony, exposing the upper-neck area
CLOTHING		
Free Play and Observation[Σ]	*Younger*: Vest and shorts (with briefs) *Older*: T-shirt and trousers (with briefs)	*Younger*: Vest and miniskirt (with panties) *Older*: T-shirt and skirt (with panties)
Psychological Testing	Shorts or trousers (with briefs), stripped-to-waist*	Miniskirt or skirt (with panties), stripped-to-waist*
Physical Examination	White[⊇] briefs only, legs exposed from upper thighs to feet, stripped-to-waist	White[⊇] panties (knickers) only, legs exposed from upper thighs to feet, stripped-to-waist
Fitness Testing[∃]	White[⊇] briefs only, legs exposed from upper thighs to feet, stripped-to-waist	White[⊇] panties (knickers) only, legs exposed from upper thighs to feet, stripped-to-waist
FOOTWEAR		
Free Play and Observation[Ξ]	White pure-cotton socks + black pure-leather (mocation) shoes with foot support	White pure-cotton socks + black pure-leather (mocation) shoes with foot support
Psychological Testing	White pure-cotton socks + black pure-leather (mocation) shoes with foot support	White pure-cotton socks + black pure-leather (mocation) shoes with foot support
Physical Examination	Barefoot	Barefoot
Fitness Testing[∃]	Barefoot	Barefoot

[∀] Gymnast is observed unaware for 10 minutes for social interaction with parent(s) and other children as well as passive observation of hair.

[∃] Fitness testing includes routines of gymnastic activities — hairstyle, clothing and footwear must take care of this aspect. Untied hair of girls pose risk of obstructing vision by coming in front of eyes in addition to tangling in the apparatus (Kamal & Khan, 2015).

[Σ] Absolutely nothing is to be worn under vest or T-shirt, which must be put on only dry skin. Disinfectant powder is to be applied on dry skin before wearing underpants.

* Passive observation of posture and gait (with shoes on), concentrating on upper torso, is conducted during walking, standing (free speech), sitting (on chair/free writing), sitting (on floor/working on jigsaw puzzle) and drawing various figures (self, family) on whiteboard in this segment of examination.

[⊇] White color is needed to conduct moiré and raster examinations (Kamal & Khan, 2015).

[Ξ] Disinfectant powder is to be applied between toe and thumb as well as between toes before wearing clean socks on dry feet.

having shoelaces. When weather is pleasant, boys may be dressed in shorts/trousers with white briefs; girls in miniskirt/skirt with white panties, adding T-shirt/vest, if desired (nothing under T-shirt/vest).

*Upon arrival in the pediatrician's office***:** Parents should inform the receptionist and, when called for psychological examination, ask the children to remove T-shirt or vest. The children keep on miniskirts/shorts/skirts/trousers, shoes and socks during psychological examination and passive observation of posture (conducted in groups of same gender). Afterwards, they are instructed to remove garments below waist and footwear retaining only underwear to be sent to gender-segregated play area. The pediatrician gets useful orthopedic and neurological information from observation and video recording of free play of partially dressed youngsters. Parents should refuse gowns for their children (if offered by pediatrician's office),

*After the examination is completed***:** Parents should instruct the children to get dressed, ask the pediatrician to brief them about the examination findings and give specific recommendations. Also, inquire the caregiver, when to bring their offsprings, again, for a follow-up visit.

The Examination Sequence

Instead of head-to-toe sequence the examinations are performed according to precedence and influence graphs established for each routine (Kamal *et al.*, 2002*a*, *b*). The depth and the breadth of examination should be guided by history (physical, psychological, social and economic, including history of one day). The contents of examination should be defined in writing. All findings should be documented. Both overt (gymnast knows that examination is being conducted) and covert (gymnast is unaware of assessment being performed) examinations have diagnostic values. Posture and gait may be better observed in a covert examination. A clinical summary should be prepared, which would become part of gymnast's medical record.

Mode of Undressing

For children, there are three modes of undressing in practice among the clinical community worldwide**:**

a) Undress the children to skin (everything removed) in the beginning. The children remain unclad till the end of examination.

b) Strip the youngster to briefs or panties (all clothing above the waist taken off) in the beginning. The underpants are, later, removed for genital (puberty rating for relevant ages), orthopedic (fine observation of posture and gait) and skin (to rule out communicable diseases) examinations.

c) Unclothe boys and girls as the examination progresses — allows pediatrician to observe examinees' fine motor skills involved in undressing.

For school checkups, *b*) is recommended, whereas for a more detailed checkup, like the one proposed in this work, *c*) is preferred.

At the ages in question (5-10 *years*), gowns should not be used during the examinations — extra cost, wastage of time in putting on and removing during various parts of examination, difficult to change into and keep on the body by youngster, child becomes more conscious of undressing, obstruct proper examination of posture, gait and skin conditions, cloth-gown strings become sources of infection transmission as they can not be washed properly. Its strings could get tied into the necks of younger ones and strangulate them. In one school, when the first author measured 5-*year*-old students, teachers removed their clothes for anthropometry, but they had to put clothes back on themselves. No help

provided! Took one hour, but they learnt to wear their uniforms, otherwise they had to return to class in a state of undress. This exercise was, therefore, transformed into an activity to practice self-dressing.

For psychological testing as well as passive observation of posture and gait (to detect gross abnormalities) the potential gymnasts are asked to strip-to-waist. Girls should have their hair open, only held by a hair band. For physical examination and fitness testing, gross observation of posture and gait as well as 3-D-surface and -motion analyses, anthropometry and partial skin examination, the incumbent must remove everything (including shirt/T-shirt/vest/blouse/dress, miniskirt/shorts/skirt/trousers, shoes, socks/stockings/leggings, accessories — belt, bow, cap, hair band, hair clips, hair pins, jewelry, scarf, tie, watch) except short underpants. During physical examination, hair must be unbraided and opened up for a detailed checkup. For fitness testing, hair should be tied up in the form of (hair) bun using pony to leave neck-area exposed (Table 3).

Briefs or panties should be taken off for genital (signs of sexual abuse, venereal diseases), fine motor (gait), orthopedic (cerebral palsy, posture, rickets, trunk deformities), nutritional-status (signs of neglect) and skin (signs of physical abuse, skin cancers) examinations. Net mass (mass with nothing on) may, also, be noted during this segment. These exams should be grouped together to minimize time for the examinee to remain totally stripped and must be conducted individually.

Quality of Examinations

The most important factors, taken to consideration by the parents, while selecting a pediatrician for their children, may be summarized as**:**

a) The pediatrician examines the child gymnasts most thoroughly. Child gymnasts are appropriately undressed for each part of examination.
b) The pediatrician explains every step to the child gymnast (whenever possible) and discusses thoroughly the findings with the parents in the end.
c) The pediatrician has an unhurried approach to the examination.
d) The pediatrician is friendly to the child gymnast and courteous to the parents.

In fact, the key to an effective examination is establishing initial rapport with the examinee, which should be retained throughout the checkup by conversation with the parents as well as the child. The examiner should start the examination by moving not too fast and refraining from sudden, jerky movements. The health-care provider should be gentle but firm in dealing with the youngster (Alexander & Brown, 1979).

A good pediatrician has, *not only*, learnt the science of examination — mastered techniques, knows normal range of tests for the specific age group, *but also*, the art of examination — efficient conduct of examination in optimal time, effective communication (communicate *with* the parents; not communicate *to* the parents) and persuasion skills to inculcate good health habits in family (Ferholt, 1980).

The parents were displeased, if any of the following happened during the examination of their children**:**

a) A part of the examination was omitted (mainly, genitals, scoliosis check, puberty rating).
b) The pediatrician did not inform the child gymnast before conducting a certain portion of the

examination.

c) The caregiver did not explain the results to parents after the conduct of examination — when results were explained, medical jargon was used, which could not be understood by parents (asking for education and occupation of each parent in the history form should give the doctor clues to the depth and the breadth of medical knowledge of each parent —Additional File 1**:** http://www.ngds-ku.org/Papers/J48/Additional_File_1.pdf; pages 5, 11). At times, physician used a foreign language (*e. g.*, English) to communicate with the parents, forgetting that English was not the common language of masses in that part of the world.

d) Examination was not performed thoroughly (mainly, auscultation of heart over shirt/gown or reaching under shirt/gown; taking of blood pressure over shirt sleeve).

The pediatricians should have evaluation forms in easy-to-understand language, to assess quality of care offered by their offices, which should be filled out by parents and, also, older child gymnasts.

Ethical and Human-Right Protocols

Each office should comply with the ethical and the human-right protocols applicable in the respective region. The pediatrician should seek parental permission before starting the examina-tion. Consent should be taken, again, from the parent before conducting examination of private parts.

All clinical studies should be approved by the appropriate bodies, in case of examination of children enrolled in a gymnastic school or a gymnastic club; the relevant body is 'Institutional Review Board', formed by the respective Board of Governors (Karlberg *et al.*, 1998).

The NGDS Pilot Project (http://ngds-ku.org) passed through 'Institutional Review Process' by authorities of University of Karachi, which included committees of Chancellor (Governor, Province of Sindh, Pakistan), Vice Chancellor and Dean, Faculty of Science. Subsequently, the project was scrutinized by Commanders of the Armed-Forces of Pakistan as well as Principals of the participating institutions (Kamal *et al.*, 2002*c*). Interactive sessions were conducted for students, teachers and school-health teams. Detailed written and verbal instructions were provided to students. Measuring equipment was shown to them a day in advance. Older students were invited to participate in height-scale mounting and handling of equipment to generate interest. Verbal consent was taken prior to checkup. Section at the end of this paper discusses confidentiality issues and informed consent. Additional File 1 gives details of project protocols.

Right to the Second as well as the Third Opinion

The parents have a right to know the exact nature of disease their child is suffering from, in language, which they are able to understand, with different options of treatment available. Benefits and risks of each one should be explained to them by their caregiver. For surgeries, amputations and other such invasive procedures, the second and even the third opinion should be sought before making the final decision.

In 2015, Faculty of Pharmacy, University of Karachi established Drug Information Center in University Clinic to educate their students as well as employees and their families about the side effects of medicines prescribed to them.

Hygiene, Patient Comfort and Privacy

Attempt should be made to comply with JCI (Joint Commission International) infection-control protocols. Physicians and anthropometrists should wash and sanitize hands, remove hand-worn chains, rings and wristwatches (for safety reasons) before starting examination. This exercise should be repeated after the conduct of examination of genitalia. Thermometers should be placed in the armpit instead of mouth. The thermometer bulb should be placed in dettol-mixed water, when not in use to record temperatures (generic name of dettol is chloroxylenol).

A year ago, the entire floor of SF-Growth-and-Imaging Laboratory was reconstructed using black tiles. Outside shoes cannot be worn in lab area by children, parents or even staff. Floor is mopped at the start of each session with dettol-mixed water.

Comfort of children is of prime concern. Even in mild weather, fans are not turned on, as children are unclothed for examination. In colder weather, physicians should warm hands before palpation and percussion. Similarly, diaphragm and bell of stethoscope should be warmed before auscultation.

Both acoustic as well as visual privacy is offered in SF-Growth-and-Imaging Laboratory. Doors are closed and locked and second level of privacy is offered through a curtained-off area. Although, both parents are encouraged to come to the examination session and share history and progress (during the very first session, heights of biological father and biological mother are measured to compute target height), same-gender parent is preferred to accompany actual physical examination in the curtained-off area.

Puberty rating of Gymnasts

It is, strongly, recommended that puberty rating based on Tanner scales must be conducted at every checkup for peripubertal and pubertal gymnasts (Tanner, 1962). Because of energy channelization due to vigorous routines of gymnastics, these students often experience 'delayed puberty', which may result in not achieving their full potential in terms of height gain (Kamal & Jamil, 2012). A very well known case is of Romanian gymnast Nadia Elena Comăneci.

Table 4. Tanner scoring and stages of puberty[£]

Stage of Puberty	*Tanner Scor*
Prepubertal	1
Peripubertal	2
Pubertal	3
Adolescent	4
Adult	5

[£]Approximate Tanner scores assigned to stages of puberty by the authors; in case there were different scores in various segments, an average (arithmetic mean) was taken to assign score

According to the Wroclow Growth Study (WGS) and the Wroclow Longitudinal Twin Study (WLTS), the growth and the maturity characteristics of gymnasts are different from other sports (Malina & Bielicki, 1996)**:** gymnastics is the only sport that presents a profile of short stature in both sexes; …., though data are not extensive and female participants in gymnastics, ballet, and figure skating present later sexual and skeletal maturation.

Prepubertal, Peripubertal and Pubertal Children

Peripubertal children are those, who are about to enter puberty. The height function levels off (height velocity approaches zero) according to ICP model of Karlberg (1987). Pubertal children are those, who

have started to enter puberty. Adolescents are classified as individuals, who have achieved puberty. Table 4 gives the approximate Tanner classification (Goldbloom, 1992) proposed by the authors.

Age of Onset of Puberty and Classification of Puberty

Age of onset of puberty is of utmost importance for a gymnast. We define this as the age when Tanner stage of 3 (arithmetic mean of 'thelarche' and 'adrenarche' in girls; equivalent average in boys) is achieved (Behrman & Vaughan III, 1983). If $A_{\text{Onset}-\text{Puberty}}$ represents age of onset of puberty for a gymnast, $\mu_{\text{Onset}-\text{Puberty}}$ gender-specific mean age of onset of puberty for a certain country and $\sigma_{\text{Onset}-\text{Puberty}}$ gender-specific standard deviation for age of onset of puberty for that country, we define 'normal puberty' if the age of onset of puberty lies within one standard deviation of the mean age — Equation cum Inequality (1)

(1) $$\mu_{\text{Onset}-\text{Puberty}} - \sigma_{\text{Onset}-\text{Puberty}} \leq A_{\text{Onset}-\text{Puberty}} \leq \mu_{\text{Onset}-\text{Puberty}} + \sigma_{\text{Onset}-\text{Puberty}}$$

The gymnast is considered to experience 'early puberty' ('early bloomer' in layman language) if the age of onset lies between two and one standard deviation each subtracted from the mean age — Equation cum Inequality (2)

Table 5. Nutritional-status classification for career of a child gymnast

Classification	*Description*	$P_{\text{Scaled}}(h),\ STATUS_{\pm}(h)^{\Leftrightarrow}$	$P_{\text{Scaled}}(\mu),\ STATUS_{\pm}(\mu)^{\Leftrightarrow}$
Acute Malnutrition	Severe Stunting + Severe Wasting	$P_{\text{Scaled}}(h) + P_{\text{Scaled}}(\mu) < 6^{\P}$	
Under-Nutrition	Stunting + Wasting	$STATUS_{\pm}(h) < 0$	$STATUS_{\pm}(\mu) < 0$
Energy-Channelization I	**Tallness + Wasting**	$\boldsymbol{STATUS_{\pm}(h) > 0}$	$\boldsymbol{STATUS_{\pm}(\mu) < 0}$
Energy-Channelization II	Stunting + Obesity	$STATUS_{\pm}(h) < 0$	$STATUS_{\pm}(\mu) > 0$
Over-Nutrition	Tallness + Obesity	$STATUS_{\pm}(h) > 0$	$STATUS_{\pm}(\mu) > 0$
Energy-Channelization III	Puberty-Induced Energy-Channel.	Height gain levels off	Below waist fat & mass gain

$^{\Leftrightarrow}P_{\text{Scaled}}(h)$: Scaled Percentile-of-Height • $P_{\text{Scaled}}(\mu)$: Scaled Percentile-of-Mass • $STATUS_{\pm}(h)$: Algebraic Status (pertaining-to-height) • $STATUS_{\pm}(\mu)$: Algebraic Status (pertaining-to-mass)

¶Modified definition proposed in Kamal *et al.* (2017*b*) adapted for scaled percentiles — section on 'Growth-and-Obesity Roadmaps of a Gymnast' explains scaled percentiles obtained by fitting a parabolic curve to CDC percentiles

(2) $$\mu_{\text{Onset}-\text{Puberty}} - 2\sigma_{\text{Onset}-\text{Puberty}} \leq A_{\text{Onset}-\text{Puberty}} < \mu_{\text{Onset}-\text{Puberty}} - \sigma_{\text{Onset}-\text{Puberty}}$$

The gymnast is supposed to exhibit the phenomenon of 'delayed puberty' ('late bloomer' in layman language) if the age of onset lies between one and two standard deviations each added to the mean age — Equation cum Inequality (3)

(3) $$\mu_{\text{Onset}-\text{Puberty}} + \sigma_{\text{Onset}-\text{Puberty}} < A_{\text{Onset}-\text{Puberty}} \leq \mu_{\text{Onset}-\text{Puberty}} + 2\sigma_{\text{Onset}-\text{Puberty}}$$

The gymnast may be having 'excessively-delayed puberty' if the age of onset is more than two standard deviations added to the mean age — Inequality (4)

(4) $$A_{\text{Onset}-\text{Puberty}} > \mu_{\text{Onset}-\text{Puberty}} + 2\sigma_{\text{Onset}-\text{Puberty}}$$

'Precarious puberty' is defined by our group as the condition in which the age of onset is less than two standard deviations subtracted from the mean age and sum of scaled percentiles of height and mass (see next section) falls below 100, Inequalities (5*a*, *b*), which means that the child enters puberty without experiencing associated puberty-induced energy-channelization, also termed as energy-channelization III (Table 5).

(5*a*, *b*) $A_{\text{Onset}-\text{Puberty}} < \mu_{\text{Onset}-\text{Puberty}} - 2\sigma_{\text{Onset}-\text{Puberty}}$, $P_{\text{Scaled}}(h) + P_{\text{Scaled}}(\mu) < 100$

If the sum of percentiles is equal to or above 100, the child is considered to experience 'excessively-early puberty', which needs to be differentiated from 'precarious puberty' to prevent over-treatment (Kamal *et al.*, 2013*g*).

Let us illustrate the above concepts with numbers given by Ayatollahi *et al.* (2002) regarding age of onset of puberty, $\mu_{\text{Onset}-\text{Puberty}} \pm \sigma_{\text{Onset}-\text{Puberty}} = (12.91 \pm 1.23)$ *years*, in Iranian girls. According to Equation cum Inequality (1), 'normal puberty' corresponds to the age range (11.68-14.14) *years*, end-points included. According to Equation cum Inequality (2), 'early puberty' is associated with the age range (9.45-11.68) *years*, left-end-point included. According to Equation cum Inequality (3), 'delayed puberty' is experienced, when the age of onset lies in the age range (14.14-15.37) *years*, right-end-point included. According to Inequality (4), a girl is having 'excessively-delayed puberty' if the age of onset exceeds 15.37 *years*. According to Inequalities (5*a*, *b*), 'precarious puberty' is classified, when the age of onset is less than 9.45 *years* and the child is not experiencing energy-channelization III (puberty-induced energy-channelization), *i. e.*, $P_{\text{Scaled}}(h) + P_{\text{Scaled}}(\mu) < 100.$ If the child is experiencing energy-channelization III, *i. e.*, $P_{\text{Scaled}}(h) + P_{\text{Scaled}}(\mu) \geq 100,$ combined with age of onset of puberty earlier than 9.45 *years*, youngster is classified as having 'excessively-early puberty'.

Ayatollahi *et al.* (2002) concluded that body-mass index as well as socio-economic status (SES) had the most dominant effects on menarcheal-age variation in the context of a unified statistical model — for wasted girls menarcheal age was delayed, whereas it decreased as SES improved. Bone-growth study in peripubertal and pubertal gymnasts becomes most important to prevent sport-related injuries (Magarey *et al.*, 1999).

Growth-and-obesity roadmaps of a gymnast

'Growth-and-Obesity Profile' is a snapshot of health status of growing gymnast, which includes status (pertaining-to-height) and status (pertaining-to-mass). Such a profile can be generated after the first checkup, allowing the pediatrician to intervene in cases, where waiting for the second checkup (to determine growth velocity and rate of weight or loss) may not be recommended, *e. g.*, the case of acute malnutrition (Kamal, 2015*a*). It is prepared based on methods given in Kamal *et al.* (2011). 'Growth-and-Obesity Scalar-Roadmap' is a collection of

Growth-and-Obesity Profiles, which gives build (Figure 3), nutritional-status classification

Classification	*Scaled-Percentile Range*	*Dominating Function*	*Suitable for*
Small	$0 \leq P_{\text{Scaled}}(h) + P_{\text{Scaled}}(\mu) < 50$	**Brain**	**Intellectual work, planning and development**
Medium	$50 \leq P_{\text{Scaled}}(h) + P_{\text{Scaled}}(\mu) < 150$	**Body and brain functions equally contributing**	**May adapt to body- or brain-dominating tasks**
Big	$150 \leq P_{\text{Scaled}}(h) + P_{\text{Scaled}}(\mu) < 200$	**Body**	**Tasks involving strength and speed**

Figure 3. Classification of build of a child gymnast

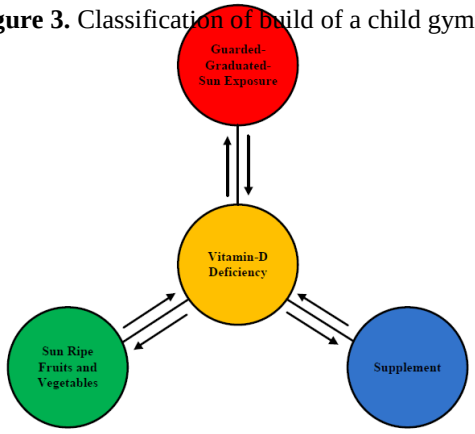


Figure 4. Measures to overcome vitamin-D deficiency — first appeared in Kamal (2017)

(Table 4) and month-wise recommendations (on the checkup date of each successive month for the next 6 *months*) to gain height and shed off/put on mass (weight), along with lifestyle adjustment, diet and exercise plans to achieve each of these targets (Kamal *et al.*, 2013*a*; *d*), with an emphasis on overcoming vitamin-D deficiency (Figure 4), as all diet-based interventions become ineffective if this condition exists (Kamal *et al.*, 2013*c*). The method was presented, originally, in Kamal *et al.* (2015*a*) and explained in detail in Kamal (2015*a*). Recently, month-wise recommendations have been fine-tuned in the light of height- and mass-gain trends suggested by ICP model (Karlberg, 1987). The modified model is given the name 'Growth-and-Obesity Vector-Roadmap' (Kamal *et al.*, 2016*a*; *b*).

Anthropometry

For measuring height (stature), the undressed student gymnast was required to stand touching the engineering tape (mounted on wall, vertical alignment checked through plumb line) and instructed to align hands with body, palms touching thighs and heels together (Figure 1*b*). Height was measured, when the youngster fully inhaled so that the incumbent's chest was expanded and tummy was in (attention position). The anthropometrist held a pencil at eye level to make sure that chin of the incumbent was parallel to floor. For measuring mass (weight), the stripped student gymnast stood in beam-scale center (Figure 1*a*), palms on thighs and feet separated, looking straight and breathed in to trap maximum air (stand-at-ease position). A standard 100-*cm* ruler and a standard 2-*kg* mass were used to calibrate height- and mass-measurement instruments at the beginning of each daily session along with noting down of zero errors. Disrobing helped ascertain proper posture, non-flexing of elbows and knees

as well as complete inhaling (Figures 1*a*-*d*). Step-by-step procedures are given in Kamal (2006). The anthropometric measurements were taken by anthropometrists with documented accuracy and precision (Kamal *et al.*, 2013*e*) — mathematical definitions of accuracy and precision are given in Kamal (2009). During 2012-2015, heights and masses were measured to least counts of 0.01 *cm* and 0.01 *kg*, respectively, in SF-Growth-and-Imaging Laboratory (Kamal, 2010). Since 2016, the least counts have been upgraded to 0.005 *cm* and 0.005 *kg*, respectively (Kamal *et al.*, 2016*b*).

Heights Important for a Gymnast

Student gymnast's estimated-adult height (Table 6) is obtained by mathematical extrapolation of the student's measured height trajectory to 20 years — may be termed as 'the navigational curve' (pertaining to actual values). This height is, mainly, the prime selection criterion in gym-nastic teams. However, the incumbent's height could be 'controlled' by suitable interventions — lifestyle adjustment, diet and exercise plans (Kamal *et al.*, 2013*d*). These plans should be integrated in such a way that the net effect is reduction in sedentary behavior (Straker *et al.*, 2016).

Target (Adult-mid-parental) height of boy (girl) is computed by adding (subtracting) 6.5 *cm* to (from) average (arithmetic mean) of heights of biological father and biological mother (Tanner *et al.*, 1970). Target height may be extrapolated backwards to current age; the resulting curve generated may be visualized as 'the guidance curve' (pertaining to reference values), provided target height exceeds army-cutoff height or estimated-adult height (Kamal *et al.*, 2016*a*). Otherwise, army-cutoff height or estimated-adult height (whichever is greater) is taken as reference. Army-cutoff height is the least height required for induction into the Armed Forces of a certain country. In Pakistan, this height is 5 *ft* 4 *in* (162.56 *cm*), corresponding to 3rd (2.72 to be exact) percentile for males and 5 *ft* 2 *in* (157.48 *cm*), corresponding to 19th (19.36 to be exact) percentile for females (Kamal *et al.*, 2017*a*).

Scaling of Percentiles for the Pakistani Gymnasts

A parabolic curve, Equations (6*a*, *b*), was fitted to transform percentiles obtained from

Table 6. Heights important for career of a child gymnast

Nomenclature	*Depends on*	*Corresponding Percentile*
Estimated-adult height, $h_{\text{est-adult}}$	**Student's height**	**$P(h)$**
Target (Adult-mid-parental) height, h_{MP}	Parents' heights	P_{MP}
Army-cutoff height, h_{AC}	Country-wide standards	P_{AC}

Table 7. Scaling of percentiles to be used for the Pakistani gymnasts

$P_{\text{CDC}}(h), P_{\text{CDC}}(\mu)$	→	$P_{\text{Scaled}}(h), P_{\text{Scaled}}(\mu)$
0	→	0
40	→	50
100	→	100

Extended CDC Growth Charts (Kamal & Jamil, 2014), $P_{\text{CDC}}(h)$ and $P_{\text{CDC}}(\mu)$, to scaled percentiles, $P_{\text{Scaled}}(h)$ and $P_{\text{Scaled}}(\mu)$, applicable for the Pakistani population, satisfying the conditions given in Table 7 (Kamal *et al.*, 2015*a*).

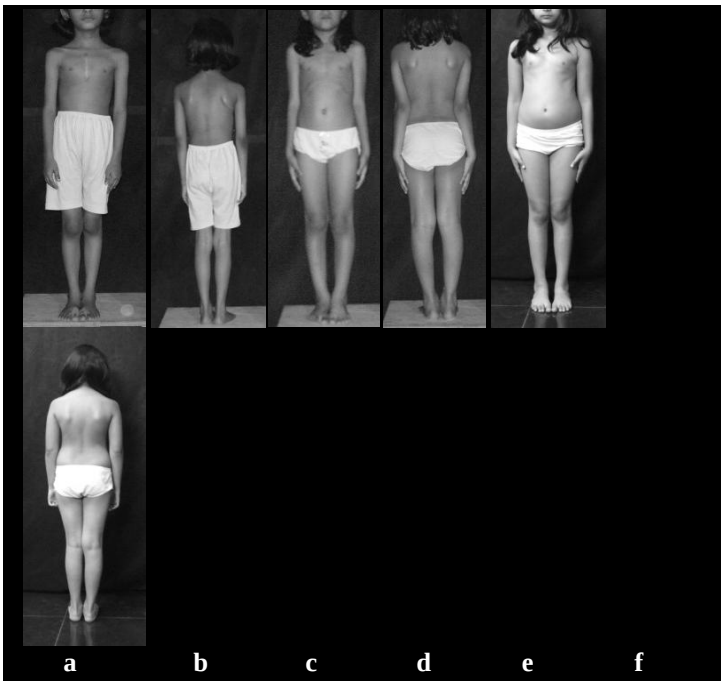
(6*a*, *b*) $$P_{\text{Scaled}}(h)=\frac{17P_{\text{CDC}}(h)}{12}-\frac{P^2_{\text{CDC}}(h)}{240};\ P_{\text{Scaled}}(\mu)=\frac{17P_{\text{CDC}}(\mu)}{12}-\frac{P^2_{\text{CDC}}(\mu)}{240}$$

The extended growth charts and tables contain entries for 0.01$^{\text{th}}$, 0.1$^{\text{th}}$, 1$^{\text{st}}$, 99$^{\text{th}}$, 99.9$^{\text{th}}$ and 99.99$^{\text{th}}$ percentiles for heights and masses in addition to entries for 3$^{\text{rd}}$ to 97$^{\text{th}}$ percentiles. The expression for 'severity of acute malnutrition' (Kamal, 2015*a*), when present, takes the form

(7) $$\textit{Severity of Acute Malnutrition}=100\left(1-\frac{P_{\text{Scaled}}(h)+P_{\text{Scaled}}(\mu)}{6}\right)\%$$

Build of a Gymnast

A child having equal contribution of brain and body functions (medium build) may be the most suitable for gymnastic activity. Build is classified as 'small, 'medium' and 'big' on the basis of sum of scaled percentiles of height and mass (Figures 5*a-f*). Note that LG had a 'medium' build, when she started gymnastics. The sport made her gain height rapidly, shifting her build to 'big' (Kamal & Khan, 2015). The children exhibiting the phenomenon of energy-channelization I, *i. e.*, those who are tall and wasted (Kamal *et al.*, 2014; 2015*a*), are, generally,



Figures 5*a-f*. From left to right, posture photographs of children exhibiting (***a***, ***b***) small build (GR**:** SGPP -KHI-20110412-02/02; age 7 *years* 6 *months* 11 *days* on May 13, 2012; sum of scaled percentiles 3.65), (***c***, ***d***) medium build (ZHZ**:** SGPP-KHI-20110412-01/01; age 6 *years* 10 *months* 27 *days* on May 13, 2012; sum of scaled percentiles 95.33) and (***e***, ***f***) big build (LG**:** SGPP-KHI-20131021-02/01; age 8 *years* 7 *months* 11 *days* on March 26, 2016; sum of scaled percentiles 174.18)

Table 8*a*. Month-wise height and mass (weight) management for a girl practicing gymnastics, LG (SGPP-KHI-20131021-02/01)

Target Date	*Height Target*		*Mass (Weight) Target*	
	cm	*ft-in*	*kg*	*lb-oz*
April 26, 2016	147.78	4 *ft* 10.18 *in*	30.93	68 *lb* 3.30 *oz*
May 26, 2016	148.28	4 *ft* 10.38 *in*	31.84	70 *lb* 3.36 *oz*
June 26, 2016	148.80	4 *ft* 10.58 *in*	32.98	72 *lb* 11.44 *oz*
July 26, 2016	149.30	4 *ft* 10.78 *in*	34.34	75 *lb* 11.49 *oz*
August 26, 2016	149.82	4 *ft* 10.99 *in*	35.71	78 *lb* 11.80 *oz*
September 26, 2016	150.34	4 *ft* 11.19 *in*	37.04	81 *lb* 10.91 *oz*

selected in the gymnastic teams. However, only the first- and the second-degree-wasted children should be allowed to participate in gymnastic activities for safety reasons (Kamal & Khan, 2015). The scaled percentiles are used to determine build of a gymnast.

Table 8*a* lists month-wise height and mass (weight) management of LG, a girl participating in gymnastics, based on Growth-and-Obesity Vector-Roadmap model (Kamal *et al.*, 2016*a*; *b*). Additional File 2 (http://www.ngds-ku.org/Papers/J48/Additional_File_2.pdf) contains detailed report of the gymnast. Flowchart of the software, which generates Vector-Roadmap, is given in Additional File 3 (http://www.ngds-ku.org/Papers/J48/Additional_File_3.pdf).

At her first checkup on November 22, 2014, LG, female (age 7 *years* 3 *months* 7 *days*), was asked to gain height and mass to achieve the values of 128.52 *cm* and 25.88 *kg*, respectively, on February 22, 2015 as suggested by Growth-and-Obesity Scalar-Roadmap Model (Kamal *et al.*, 2015*a*). At her second checkup on February 28, 2015 (age 7 *years* 5 *months* 23 *days*), she was measured to have a height of 139.92 *cm* and a mass of 25.69 *kg* — mass-put-on target slightly underachieved. Because of rapid gain of height due to gymnastics, she became severely wasted. She was, then, given targets to achieve 143.24 *cm* height and 42.39 *kg* mass on August 28, 2015, again according to the scalar model. Note that the vector model was not proposed till the end of year 2015 (Kamal *et al.*, 2016*a*; *b*). She reported for her third checkup on August 22, 2015 (age 8 *years* 7 *days*), when she was measured as having height 143.51 *cm* and mass 28.21 *kg* — height-pick-up target overachieved, whereas mass-put-on target grossly underachieved. She was, then, given targets to achieve 146.67 *cm* height and 46.92 *kg* mass on February 22, 2016. At her fourth checkup on March 26, 2016, she measured 147.255 *cm* and had a mass of 29.975 *kg*. Height gain was as per advice. However, mass-gain target again very much below the recommendation. LG's dress code 0/0.5 meant she was barefooted and examined completely undressed wearing only panties (Figures 1*a-d*). Behavior code 0 meant she was relaxed and coöperative (Kamal, 2006; Kamal *et al.*, 2002*c*). The parents received lifestyle adjustment, diet and exercise plans to achieve given targets (Table 8*b*).

Growth-and-Obesity Vector-Roadmap of LG depicting her four checkups (age range**:** 7 *years* 3 *months* 7 *days* — 8 *years* 7 *months* 11 *days*) is presented, giving both CDC percentiles

Table 8*b*. Lifestyle adjustment, diet and exercise plans for LG 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); 1-2 hour fresh air exposure to uncovered skin; hair and body massage with olive oil before bathing; 8-hour, night-time, sound sleep dressed in pajama shorts only[@] (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); 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)	
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 (milk, fresh fruit, chicken and fish)	To put on mass (weight), diet plan should include milk, potato items (baked or boiled, but not fried) and protein-rich diet
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. Structured exercises, guarded-graduated[©], 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

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

[@] Sleeping in day clothes or underwear should be discouraged. In gender-segregated sleeping quarters, boys of all ıges and younger girls should be encouraged to sleep stripped-to-waist, allowing the body to breathe and ncreasing tactile stimulation (Kamal & 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 nly*, by children, *but also*, by persons of all ages, in particular, older individuals.

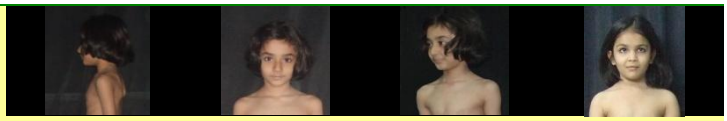
[©] Guarded-graduated exercises should contribute towards health- as well as skill-related fitness (perfor- mance :onsiderations). Such practices, also, avoid exercise-related injuries (safety considerations). 'Guarded' is related o the concept that different body ligaments are in stable equilibrium, locally, during different exercise phases ınd 'graduated' implies that sequential exercise phases are related by infinitesimal transformations (Kamal & Khan, 2013).

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

as well as scaled percentiles of height and mass (Table 8*c*). Algebraic status (pertaining-to-height) was expressed as percentage taking current-age-mid-parental height as reference, positive indica-

Table 8*c*. Growth-and-Obesity Vector-Roadmap of LG

Gender: Female ♀ • *Date of Birth* (*year-month-day*): 2007-08-15 • *Army-Cutoff Height*: 157.48 *cm* (19.36^{P})$^{¥}$
Father's Height: ♂ 167.16 *cm* • *Mother's Height*: ♀ 160.16 *cm* • *Target Height*: 157.16 *cm* (18.14^{P})

Checkup	*1st*	*2nd*	*3rd*	*4th*
Photograph				
Scanned Signatures	$\mathcal{LG}$	$\mathcal{LG}$	$\mathcal{LG}$	$\mathcal{LG}$
Class and Section	II-B	II-B	III-B	III-B
Date of Checkup (*year-month-day*)	2014-11-22	2015-02-28	2015-08-22	2016-03-26
Age (*year-month-day*)	07-03-07	07-05-23	08-00-07	08-07-11
Age (*decimal years*)	7.27	7.54	8.02	8.61
Dress Code	0/0.5	0/0.5	0/0.5	0/0.5
Behavior Code	0	0	0	0
Height, *h* (*cm*)	126.96	139.92	143.51	147.255
Height (*ft-in*)	4 *ft* 1.98 *in*	4 *ft* 7.09 *in*	4 *ft* 8.50 *in*	4 *ft* 9.97 *in*
CDC Percentile-of-Height, $P_{CDC}(h)$	74.37	99.01	99.06	99.06
Scaled Percentile-of-Height, $P_{Scaled}(h)$	82.31	99.42	99.45	99.45
Estimated-Adult Height (*cm*)	167.59	180.04	180.44	180.42
Estimated-Adult Height (*ft–in*)	**5 *ft* 5.98 *in***	**5 *ft* 10.88 *in***	**5 *ft* 11.04 *in***	**5 *ft* 11.03 *in***
CA-MP (Current-Age-Mid-Parental) Height (*cm*)	118.00	119.59	122.25	125.27
Δ Height *w. r. t.* Current-Age-MP Height (*cm*)	+8.96	+20.33	+21.26	+21.99
Algebraic Status (pertaining-to-height), $STATUS_{\pm}(h)$	+7.59%	+17.00%	+17.39%	+17.55%
Qualitative Status (pertaining-to-height)	**1st-Deg Tall**	**2nd-Deg Tall**	**2nd-Deg Tall**	**2nd-Deg Tall**
CA-AC (Current-Age-Army-Cutoff) Height (*cm*)	118.26	119.86	122.53	125.56
Δ Height *w. r. t.* CA-AC Height (*cm*)	+8.70	+20.06	+20.98	+21.70
Reference Height (*cm*)	126.96	139.92	143.51	147.255
CDC Percentile-of-Reference-Height, P_{ref}	74.37	99.01	99.06	99.06
Gross Mass (*kg*)	23.66	25.69	28.21	29.975
Clothing Correction (*kg*)	0	0	0	0
Net Mass, μ (*kg*)	23.66	25.69	28.21$^{®}$	29.975$^{®}$
Net Weight (*lb-oz*)	52 *lb* 2.72 *oz*	56 *lb* 10.34 *oz*	62 *lb* 3.25 *oz*	66 *lb* 1.52 *oz*
CDC Percentile-of-Net-Mass, $P_{CDC}(\mu)$	51.31	61.58	68.54	65.29
Scaled Percentile-of-Net-Mass, $P_{Scaled}(\mu)$	61.72	71.44	77.52$^{®}$	74.73$^{®}$
Estimated-Adult Mass (*kg*)	58.62	61.76	63.88	62.89
Estimated-Adult Weight (*lb–oz*)	129 *lb* 4.04 *oz*	136 *lb* 2.73 *oz*	140 *lb* 13.64 *oz*	138 *lb* 10.62 *oz*
Height-Percentile-based-Optimal Mass, μ_{opt} (*kg*)	26.37	39.12	42.61	46.75
Δ Mass-for-Height (*kg*)	–2.71	–13.43	–14.40	–16.77
Algebraic Status (pertaining-to-mass), $STATUS_{\pm}(\mu)$	–10.28%	–34.33%	–33.80%	–35.88%
Qualitative Status (pertaining-to-mass)	**2nd-Deg Wasted**	**4th-Deg Wasted**	**4th-Deg Wasted**	**4th-Deg Wasted**
Percentile-of-*BMI*-based-Optimal-Mass, $P(\mu_{BMI})$	77.45	91.61	91.84	91.82
BMI-based-Optimal-Mass, μ_{BMI} (*kg*)	27.01	31.88	34.20	37.19
Estimated-Adult *BMI* (kg/m^2)	20.87	19.05	19.62	19.32
Nutritional Status	**Energy-Ch. I**	**Energy-Ch. I**	**Energy-Ch. I**	**Energy-Ch. I**
$P_{Scaled}(h) + P_{Scaled}(\mu)$	144.03	170.86	176.97	174.17
Build	**Medium**	**Big**	**Big**	**Big**

$^{¥}$The superscript P denotes percentile
$^{®}$Pseudo-gain of mass between 3rd and 4th checkups — mass increase from 28.21 *kg* to 29.975 *kg*; scaled percentile dropping from 77.52 to 74.73 (Kamal *et al.*, 2014)

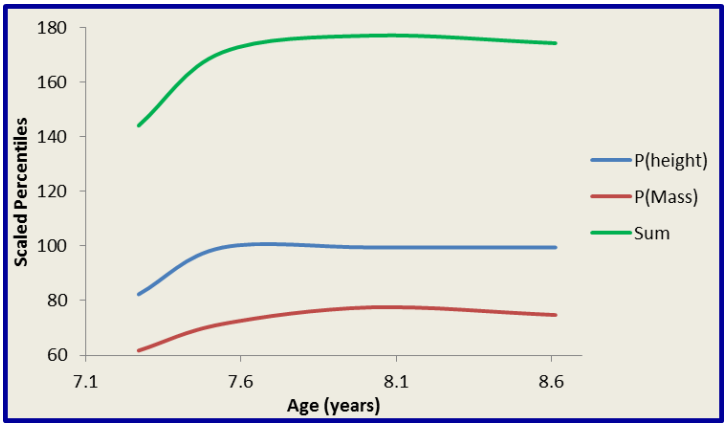


Figure 6. Time evolution of LG's height and mass scaled percentiles as well as their sum for her four checkups in the age range 7.27-8.61 *years*. Note that the gap between height and mass scaled percentiles widened at the second checkup, also indicated by Growth-and-Obesity Vector-Roadmap

ting tallness and negative stunting. Algebraic status (pertaining-to-mass) was expressed as percentage taking optimal mass as reference, positive indicating obesity and negative wasting. Qualitative statuses were assigned from algebraic statuses ($+1\% \leq STATUS_{\pm}(h) < +10\%$ 1st-degree tall; $+10\% \leq STATUS_{\pm}(h) < +20\%$ 2nd-degree tall; $-20\% \leq STATUS_{\pm}(\mu) < -10\%$ 2nd-degree wasted; $STATUS_{\pm}(\mu) < -30\%$ 4th-degree wasted). Figure 6 graphically depicts scaled height and mass percentiles for her four checkups. Height-percentile-based-optimal mass was computed by applying the condition that CDC percentile-of-optimal-mass matches with CDC percentile-of-height. *BMI*-based-optimal mass was computed in 3 steps elaborated in Kamal (2017).

Reports containing information given in Tables 8*a-c* are handed over to each student of gymnastics, whose checkup is conducted. Mother, accompanied by father, is requested to come to school/SF-Growth-and-Imaging Laboratory and discuss the report. We follow 'Disclosure and Regret Model', in which any mistake in report is immediately notified to the parents with regrets, which is adapted from University of Michigan Health System's 'Disclosure, Apology and Offer Model' (Simmons, 2016).

DISCUSSION

There is a dire need to streamline various definitions of childhood obesity (Kamal, 2016) so that one arrives at a mathematical criterion requiring a child to lose net weight within a span of half-a-year (Kamal, 2017). Such a criterion should be validated based on anthropometric data collected locally (Kamal *et al.*, 2017*b*). The power of mathematics (Kamal, 2008) should be employed, *not only*, to generate guidelines to maintain optimal weight-for-height of gymnasts (Kamal, 2015*c*) and prevent spinal injuries (Kruse & Lemmen, 2009), *but also*, to generate builds (Kamal & Khan, 2015) and somatotypes (Raković *et al.*, 2015), so that classroom sections and gymnastic teams could be formed according to build (Kamal, 2015*d*). This may be achieved by following a structured routine of physical and psychological examinations combined with fitness testing to generate 'objective data' (physical findings, Growth-and-Obesity Vector-Roadmaps) along with the 'subjective data' (history — parents, pregnancy, birth, infancy and early childhood as well as the most-recent history, in the physical, the psychological, the academic and the social domains) to chart a course-of-action for the long-term health

protection of a gymnast (Bates, 1991). The importance of medical selection and orientation in gymnastics cannot be overemphasized (Alexescu *et al.*, 2014). It is recommended that the medical orientation of a gymnast should go through the stages of sport medical anamnesis (general anamnesis and gymnastic-specific anamnesis), somatoscopic and somatometric exams (assisted by clinical photographs on which square grids are superimposed, moiré fringe topography, rasterstereography, dotted-rasterstereography) and physical-quality assessment.

3-D movements of gymnasts may be analysed by adapting mathematical framework used in the telemetry techniques for tracking rocket maneuvers as well as robotic-arm control (Kamal, 2015*b*). Hiley & Yeadon (2015) describe optimal technique, variability and control in gymnastics. Gymnastic moves are learnt and refined within constraints on anatomical limits, coördination precision, flexibility and strength as well as mechanical limitations of a given movement. Achieving constant success is of greater importance as compared to some biomechanical measure of movement.

CONCLUSION

This work described fitness testing, psychological and physical examinations of primary-school students participating in gymnastic activities with a focus to generate Growth-and-Obesity Roadmaps, which included statuses (pertaining-to-height) and (pertaining-to-mass), nutritional status, build based on scaled percentiles adjusted for the Pakistani population. In addition, mathematical-statistical definitions of normal, early, delayed, excessively delayed, excessively early and precarious puberty are given and approximate Tanner scores related to various stages of puberty (prepubertal, peripubertal, pubertal, adolescent and adult). Application of these concepts is expected to improve the overall health of young gymnasts in turn contributing to improvement of their performance.

References

Akram, M. & Kamal, S. A. (1991, April 16-20). Role of moiré fringe topography in the skeletal examination of school athlete. In**:** *The International Congress and Exposition on Sports Medicine and Human Performance*, p. 2, Vancouver, Canada, abstract#36**:** http://www.ngds-ku.org/pub/confabst0.htm#C36:

Alexander, M. M. & Brown, M. S. (1979). *Pediatric History Taking and Physical Diagnosis for Nurses*, 2nd Ed. p. 41, New York, United States**:** McGraw-Hill

Alexescu, T., Negrean, V. Handru, M., Tanţău, A. & Para, I. (2014). The importance of medical selection and orientation in sports. *Palestrica of the Third Millennium — Civilization and Sport*, 15 (3), 238-245

Ayatollahi, S. M. T., Dolatabadi, E. & Ayatollahi, S. A. R. (2002). Age at menarche in Iran. *Annals of Human Biology*, 29 (4), 355-362

Bates, B. (1991). *A Guide of Physical Examination and History Taking*, 5th Ed. p. 637, Philadelphia, United States**:** Lippincott

Behrman, R. E. & Vaughan III, V. C. (1983). *Nelson Textbook of Pediatrics*, 12th Ed. pp. 40-42, Philadelphia, United States**:** Saunders

Caroll, M. E. & Manners, H. K. (2003). *Gymnastics* 7-11**:** *A Session-by-Session Approach to Key Stage* 2, pp. 2-5; chapter 1**:** Introduction — Key Stage 2, e-Ed. London, UK**:** The Falmer Press & Philadelphia, Pennsylvania, United States**:** Taylor & Francis

Ferholt, J. D. L. (1980). *Clinical Assessment of Children***:** *A Comprehensive Approach to Primary Pediatric Care*, pp. 184-225; chapter 9**:** The Art of the Physical Examination, Philadelphia, United States**:** Lippincott

Goldbloom, R. B. (1992). *Pediatric Clinical Skills*, pp. 31-35. New York, United States**:** Churchill Livingstone

Hiley, M. & Yeadon, M. R. (2015). Optimal technique, variability and control in gymnastics. In**:** *Sports Performance* (Ed. K. Kanosue), pp. 293-304. Waseda University

Joseph, L. H. (1949, March-April). Gymnastics in the pre-revolutionary eighteenth century, *CIBA Symposia*, 1054-1060

Kamal, S. A. (2006, May 23). Manual for Anthropometric Measurements. The-NGDS-Pilot-Project-e-Publication, Karachi, Pakistan**:** University of Karachi; full text (version 9.11; release date**:** April 7, 2016)**:** http://www.ngds-ku.org/ngds_folder/M02.pdf

Kamal, S. A. (2008, December 20-23). Role of mathematics in sports sciences and technologies. In**:** *The Thirty-Fifth All Pakistan Science Conference* (*Genomics for Health and Prosperity*), p. 75, Karachi, Pakistan**:** University of Karachi; *Karachi University Journal of Science*, 36 (1&2), 5; abstract#72**:** http://www.ngds-ku.org/Presentations/Sports.pdf

Kamal, S. A. (2009, December 16, 17). Mathematics of experimentation. In**:** *The National Conference on Physics and the World of Today*, pp. 9, 10, Karachi, Pakistan**:** Department of Physics, University of Karachi (Prof. Dr. Muhammed Rafi and Prof. Dr. Muhammed Razi Hussain memorial lecture); abstract#10**:** http://www.ngds-ku.org/Presentations/Physics2.pdf

Kamal, S. A. (2010, March 22). Mathematics in the life sciences. In**:** *The First National Conference on Mathematical Sciences (CMS 2010)*, p. 19, Karachi, Pakistan**:** Department of Mathematics, University of Karachi (the Syed Firdous memorial lecture); abstract#10**:** http://www.ngds-ku.org/Presentations/Firdous.pdf

Kamal, S. A. (2011, May 9, 10). Anthromathematics**:** A new branch of mathematics. In**:** *The Sixth Symposium on Computational Complexities, Innovations and Solutions* (*CCIS 2011*), pp. 13, 14, Abbotabad, KP, Pakistan**:** The COMSATS Institute of Information Technology (keynote lecture); abstract#1**:** http://www.ngds-ku.org/Presentations/Anthromath.pdf

Kamal, S. A. (2015*a*). Acute malnutrition in a child suffering from cardiac problems. *International Journal of Biology and Biotechnology*, 12 (4), 381-391; full text**:** http://www.ngds-ku.org/Papers/J40.pdf

Kamal, S. A. (2015*b*, December 28-30). US-childhood-obesity problem**:** Solutions proposed in Pakistan. In**:** *The First International Conference on Life Sciences* (*Emerging Trends in Biological Sciences and Genomics*), pp. 8, 9, Karachi, Pakistan**:** M. A. H. Qadri Biological Research Center, University of Karachi (invited lecture); abstract**:** http://www.ngds-ku.org/Presentations/Childhood-Obesity.pdf

Kamal, S. A. (2015*c*). Optimal-mass management in obese children. *International Journal of Biology and Biotechnology*, 12 (3), 381-391; full text**:** http://www.ngds-ku.org/Papers/J38.pdf

Kamal, S. A. (2015*d*, September 2). Research empowering teaching for community development**:** An example from sport-mathematics research. In**:** *The Second Educational Conference on Educational Challenges of the Pakistani Children in the Twenty-First Century*, p. 1, Karachi, Pakistan**:** Faculty of Education, University of Karachi (keynote lecture); abstract#1**:** http://www.ngds-ku.org/Presentations/Research-Teaching-ComDev.pdf

Kamal, S. A. (2016, November 14). Streamlining various definitions of childhood obesity. In**:** *Nutrition and Health for Better Living* (*seminar on the occasion of the World Diabetes Day*), p. 1, Karachi, Pakistan**:** University Scholars Forum, University of Karachi, Karachi (concluding talk); abstract**:** http://www.ngds-ku.org/Presentations/Childhood-Obesity-Definitions.pdf

Kamal, S. A. (2017). In search of a definition of childhood obesity. *International Journal of Biology and Biotechnology*, 14 (1), 49-67; full text**:** http://www.ngds-ku.org/Papers/J45.pdf

Kamal, S. A., Alam, S. J. & Firdous, S. (2002*a*, June 22). A precedence graph for the physical examination of children. In**:** *The National Telemedicine Conference Pakistan* 2002, p. 2, Islamabad, Pakistan**:** Technology Resource Mobilization Unit (TreMU), Ministry of Science and Technology, Government of Pakistan; abstract**:** http://www.ngds-ku.org/pub/confabst.htm#C51:

Kamal, S. A., Alam, S. J. & Firdous, S. (2002*b*, May 31, June 1). An influence graph for the physical examination of children. In**:** *The Aga Khan University PGME Conference***:** *Complexity Science and Health Care*, p. 2, Karachi, Pakistan**:** The Aga Khan University (poster presentation); abstract**:** http://www.ngds-ku.org/pub/confabst.htm#C50:

Kamal, S. A., Ansari, S. A. & Jamil, S. S. (2015*a*). Generating and validating Growth-and-Obesity Roadmaps for the Pakistani children. *International Journal of Biology and Biotechnology*, 12 (1), 47-61; full text**:** http://www.ngds-ku.org/Papers/J35.pdf

Kamal, S. A., Ansari, S. A. & Sarwar, M. (2017*a*). Medical criteria for induction into the Armed Forces of Pakistan**:** Cutoff heights for still-growing youth. *Pakistan Armed Forces Medical Journal*, 67 (3), (in press); full text**:** http://www.ngds-ku.org/Papers/J47.pdf

Kamal, S. A., Burki, S. & Jamil, S. S. (2013*a*, September 4, 5). Optimal-weight management through diet, exercise and lifestyle adjustment. In**:** *The First Conference on Anthromathematics in the Memory of* (*Late*) *Syed Firdous* (*ANTHROMATHEMATICS 2013*), p. 9, Karachi, Pakistan**:** Department of Mathematics, University of Karachi and Hyderabad, Pakistan**:** Government College; abstract #Anthro13-03**:** http://www.ngds-ku.org/Presentations/Optimal_Weight.pdf

Kamal, S. A., Firdous, S. & Alam, S. J. (2002*c*, June 22). The NGDS Pilot Project**:** A software to analyze growth of a child (a telemedicine perspective). In**:** *The National Telemedicine Conference Pakistan* 2002, p. 2, Islamabad, Pakistan**:** Technology Resource Mobilization Unit (TreMU), Ministry of Science and Technology, Government of Pakistan; full text**:** http://www.ngds-ku.org/Papers/C52.pdf

Kamal, S. A., Haider, A. & Sarwar, M. (2013*b*, September 4, 5). Rasterstereography in scoliosis detection and management. In**:** *The First Conference on Anthromathematics in the Memory of* (*Late*) *Syed Firdous* (*ANTHROMATHEMATICS 2013*), p. 10, Karachi, Pakistan**:** Department of Mathematics, University of Karachi and Hyderabad, Pakistan**:** Government College; abstract#Anthro13-04**:** http://www.ngds-ku.org/Presentations/Rasterstereography.pdf

Kamal, S. A., Jamil, N. & Khan, S. A. (2011). Growth-and-Obesity Profiles of children of Karachi using box-interpolation method. *International Journal of Biology and Biotechnology*, 8 (1), 87-96; full text**:** http://www.ngds-ku.org/Papers/J29.pdf

Kamal, S. A. & Jamil, S. S. (2012). A method to generate Growth-and-Obesity Profiles of children of still-growing parents. *International Journal of Biology and Biotechnology*, 9 (3), 233-255 (delayed puberty due to vigorous gymnastic routines discussed on page 238); full text**:** http://www.ngds-ku.org/Papers/J30.pdf

Kamal, S. A. & Jamil, S. S. (2014). KJ-regression model to evaluate optimal masses of extreme cases. *International Journal of Biology and Biotechnology*, 11 (4), 623-648; full text**:** http://www.ngds-ku.org/Papers/J34.pdf

Kamal, S. A., Jamil, S. S. & Razzaq, U. A. (2014). Stunting induced by wasting — wasting induced by stunting**:** A case study. *International Journal of Biology and Biotechnology*, 11 (1), 147-153; full text**:** http://www.ngds-ku.org/Papers/J32.pdf

Kamal, S. A. & Khan, S. A. (2013, September 4, 5). Fitness for primary-school children. In**:** *The First Conference on Anthromathematics in the Memory of* (*Late*) *Syed Firdous* (*ANTHROMATHEMATICS 2013*), p. 24, Karachi, Pakistan**:** Department of Mathematics, University of Karachi and Hyderabad, Pakistan**:** Government College; abstract#Anthro13-18**:** http://www.ngds-ku.org/Presentations/Fitness.pdf

Kamal, S. A. & Khan, S. A. (2014). Primary-physical-education practices in Pakistan and England**:** Health and safety perspectives. *International Journal of Biology and Biotechnology*, 11 (2&3), 401-419; full text**:** http://www.ngds-ku.org/Papers/J33.pdf

Kamal, S. A. & Khan, S. A. (2015). Hairstyle, footwear and clothing for gymnastic activities in the primary-school setting. *Pamukkale Journal of Sport Sciences*, 6 (3), 29-45; full text**:** http://www.ngds-ku.org/Papers/J37.pdf

Kamal, S. A., Manzoor, C. M. S. & Khan, S. A. (2013*c*, September 4, 5). Diet-based interventions and vitamin-D deficiency. In**:** *The First Conference on Anthromathematics in the Memory of* (*Late*) *Syed Firdous* (*ANTHRO-MATHEMATICS 2013*), p. 14, Karachi, Pakistan**:** Department of Mathematics, University of Karachi and Hyderabad, Pakistan**:** Government College; abstract#Anthro13-08**:** http://www.ngds-ku.org/Presentations/VitaminD.pdf

Kamal, S. A., Manzoor, C. M. S. & Khan, S. A. (2013*d*, September 4, 5). Increasing height through diet, exercise and lifestyle adjustment. In**:** *The First Conference on Anthromathematics in the Memory of* (*Late*) *Syed Firdous* (*ANTHROMATHEMATICS 2013*), p. 18, Karachi, Pakistan**:** Department of Mathematics, University of Karachi and Hyderabad, Pakistan**:** Government College; abstract#Anthro 13-12**:** http://www.ngds-ku.org/Presentations/Height_Management.pdf

Kamal, S. A., Naz, A. A. & Ansari, S. A. (2016*a*). Growth-and-Obesity Vector-Roadmaps of the Pakistani children. *International Journal of Biology and Biotechnology*, 13 (4), 651-671; full text**:** http://www.ngds-ku.org/Papers/J43.pdf

Kamal, S. A., Naz, A. A. & Ansari, S. A. (2017*b*). Possible validation of mathematical definition of childhood obesity based on anthropometric data collected during 1998-2013. *International Journal of Biology and Biotechnology*, 14 (2), 219-235; full text**:** http://www.ngds-ku.org/Papers/J46.pdf

Kamal, S. A., Naz, A. A., Musafar S. & Ansari, S. A. (2016*b*, February 12, 13). Growth-and-Obesity Vector-Roadmaps generated using enhanced anthropometric instruments. In**:** *The Karachi Physics Society First National Conference on Multi-Disciplinary Topics in Physics*, Karachi, Pakistan**:** Department of Physics, University of Karachi (invited lecture); abstract#IT-04**:** http://www.ngds-ku.org/Presentations/Vector.pdf

Kamal, S. A., Rajput, M. K. & Ansari, S. A. (2016*c*). Gait analysis of 7-10-*year*-old children of Karachi from nutritional-status perspective. *International Journal of Biology and Biotechnology*, 13 (1), 13-25; full text**:** http://www.ngds-ku.org/Papers/J41.pdf

Kamal, S. A., Raza, S. K. & Sarwar, M. (2016*d*). Mathematical modeling of scoliosis indicators in growing children. *International Journal of Biology and Biotechnology*, 13 (3), 471-484; full text**:** http://www.ngds-ku.org/Papers/J42.pdf

Kamal, S. A., Razzaq, U. A. & Jamil, S. S. (2013*e*, September 4, 5). Importance of standardization of anthropometric protocols. In**:** *The First Conference on Anthromathematics in the Memory of* (*Late*) *Syed Firdous* (*ANTHROMATHEMATICS 2013*), p. 12, Karachi, Pakistan**:** Department of Mathematics, University of Karachi and Hyderabad, Pakistan**:** Government College; abstract#Anthro13-06**:** http://www.ngds-ku.org/Presentations/Anthropometry.pdf

Kamal, S. A., Sarwar, M. & Raza, S. K. (2013*f*, September 4, 5). Moiré fringe topography in scoliosis detection and management. In**:** *The First Conference on Anthromathematics in the Memory of* (*Late*) *Syed Firdous* (*ANTHROMATHEMATICS 2013*), p. 16, Karachi, Pakistan**:** Department of Mathematics, University of Karachi and Hyderabad, Pakistan**:** Government College; abstract#Anthro13-10**:** http://www.ngds-ku.org/Presentations/Moire.pdf

Kamal, S. A., Sarwar, M. & Razzaq, U. A. (2013*g*, September 4, 5). Cumulative-Scoliosis-Risk Weightage (CSRW) — Designing preventive strategies. In**:** *The First Conference on Anthromathematics in the Memory of* (*Late*) *Syed Firdous* (*ANTHROMATHEMATICS 2013*), p. 11, Karachi, Pakistan**:** Department of Mathematics, Univer-sity of Karachi and Hyderabad, Pakistan**:** Government College; abstract#Anthro13-05**:** http://www.ngds-ku.org/Presentations/CSRW.pdf

Kamal, S. A., Sarwar, M. & Razzaq, U. A. (2015*b*). Effective decision making for presence of scoliosis. *International Journal of Biology and Biotechnology*, 12 (2), 317-328; full text**:** http://www.ngds-ku.org/Papers/J36.pdf

Kamal, S. A., Sultan, F. & Jamil, S. S. (2013*g*, September 4, 5). Sensitivity and specificity of screening tests. In**:** *The First Conference on Anthromathematics in the Memory of* (*Late*) *Syed Firdous* (*ANTHROMATHEMATICS 2013*), p. 13, Karachi, Pakistan**:** Department of Mathematics, University of Karachi, and Hyderabad, Pakistan**:** Government College; abstract#Anthro13-07**:** http://www.ngds-ku.org/Presentations/Screening.pdf

Karlberg, J. P. E. (1987). Modeling of Human Growth. *PhD Dissertation*, University of Göteborg, Göteborg, Sweden

Karlberg, J. P. E., Tsang, K. & Lui, W. F. (1998). Clinical research practice. *Journal of Paediatrics*, *Obstetrics and Gynaecology* (*Hong Kong Edition*), 24 (2), 5-8

Kruse, D. & Lemmen, B. (2009). Spine injuries in the sport of gymnastics. *Current Sports Medicine Reports*, 8 (1), 20-28

Magarey, A. M., Bouton, T. J. C., Chatterton, B. E., Schultz, C., Nordin, B. E. C. & Cockington, R. A. (1999). Bone growth from 11 to 17 years**:** Relationship to growth, gender and changes with pubertal status including timing of menarche. *Acta Paediatrica*, 88 (2), 139-146

Malina, R. M. & Bielicki, T. (1996). Retrospective longitudinal growth study of boys and girls active in sport. *Acta Paediatrica*, 85 (5), 570-576

Raković, A., Savanović,, V., Stanković, D., Pavlović, R., Simeonov, A. & Petković, E. (2015). Analysis of the elite athletes' somatotypes. *Acta Kinesiologica*, 9 (supplement 1), 47-53

Rumball, J. S. & Leburn, C. M. (2004). Preparticipation physical examination**:** Selected issues for the female athlete. *Clinical Journal of Sport Medicine*, 14 (3), 153-160

Simmons, A. (2016, October). That is an awful idea. *Reader's Digest (Asia)*, 109 (643), 76-80 (to stem malpractice suits, hospitals should admit their mistakes)

Straker, L., Howie, E. K., Cliff, D. P., *et al.* (2016). Australia and other nations are failing to meet sedentary behaviour guidelines for children**:** Implications and a way forward. *Journal of Physical Activity and Health*, 13 (2), 177-188

Tanner, J. (1962). Growth at Adolescence. Oxford, UK**:** Blackwell Scientific Publications

Tanner, J. M., Goldstein H. & Whitehouse, R. H. (1970). Standards for children's height at ages 2-9 years allowing for height of parents. *Archives of Disease in Childhood*, 45 (244), 755-762

Wasim, M., Kamal, S. A. & Shaikh, A. (2013). A security system employing edge-based rasterstereo-graphy. *International Journal of Biology and Biotechnology*, 10 (4), 613-630; full text**:** http://www.ngds-ku.org/Papers/J31.pdf

*Informed Consent and Confidentiality Standards***:** G Family was invited to come to SF-Growth-and-Imaging Laboratory after the Project Director received completed and duly signed (by both parents and the participating child) Informed Consent Form, named as 'The SGPP Participation Form' — page 11 of Additional File 1. To safeguard G Family's privacy, the photographs, included in LG's Growth-and-Obesity Vector-Roadmap and in Figure 1, do not show the actual child, whose profile is presented. In addition, family label (G) and initials of child

(LG) are different from first letters in the actual names (according to our group's confidentiality standards). Same holds for the case numbers appearing in this paper. These are different from the numbers entered in reports given to parents. Further, in place of scanned signatures, initials are given, again, to protect privacy. For school checkups, 'Informed Consent Form', employed opt-in policy — page 5 of Additional File 1.

*Additional Resources***:** *Additional File* 1 (http://www.ngds-ku.org/papers/J48/Additional_File_1.pdf) contains virtual tour of the SF-Growth-and-Imaging Laboratory as well as description of the institutional review process, the NGDS checkups on school premises and the SGPP checkups in the SF Laboratory. *Additional File* 2 (http://www.ngds-ku.org/Papers/J48/Additional_File_2.pdf) contains proposed report of Growth-and-Obesity Vector-Raodmap. At the end of report, summary of history, physical examination and clinical photographs of LG are included. Pages 7-10 give color codes used in report as well as coördinate-plane and Venn-diagrammic representations of nutritional-status classification. *Additional File* 3 compares severity of acute malnutrition computed using CDC and scaled percentiles (http://www.ngds-ku.org/Papers/J48/Additional_File_3.pdf), illustrating the case history of GR, an acutely malnourished child. In addition, assigned build is compared based on CDC and scaled percentiles. Flowchart of the software is placed on page 6.

*Authors' Note***:** Laura Clinton, Physical Education Teacher in East Anglia, England had extensive dialogue with SAK regarding pre-participation and end-of-the-term physical examinations. The software used to generate Growth-and-Obesity Roadmaps was generated by Shakeel Ahmed Ansari, PhD Candidate, Department of Physics, University of Karachi. Thanks are, also, due to Dr. Yasmin Ansar Rizvi, Medical Officer, University-of-Karachi Clinic, for convincing SAK to recommend banning carbonated drinks (*cf.* diet plans for children). No potential conflict of interest is identified for this work.