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**HEIGHT VARIANT LINKED MORPHOMETRIC ANOMALIES IN ADOLESCENT  
MALE CHILDREN IN KARAK AREA OF KHYBER PAKHTUNKHWA, PAKISTAN**

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**ABSTRACT**

**Background:** The study evaluates for causes of variant morphometry in a height affected population not yet attributed to particular factors in male adolescents of Sabirabad, Karak Khyber Pakhtunkhwa, Pakistan. **Methods:** The object subjects were categorized in moderately height affected (MhA) (n 116) and severely height affected (ShA) (n 42) along the normal height subjects (n 23). Beside height, the data of age, weight, body mass index (BMI), head circumference (HdC), upper middle arm circumference (UMAC), waist circumference (WC), hip circumference (HpC) and waist hip ratio (WHR) were obtained for comparisons along the strength of Pearson's correlation among one another in each group. Data were analysed on Minitab 18 and SPSS statistics 24. **Results:** Height was significantly 12% and 38% lower in MhA and ShA respectively compare to normal height subjects' groups. The characteristics of weight 37 and 53%; HdC 3.5 and 10%; UMAC 16 and 20%; WC 11 and 13% and HpC 15 and 21% had been significantly lower in MhA and ShA respectively compared to normal subjects. Insignificantly BMI was 8% lower and 32% greater; and WHR was unaffected and significantly 12% greater in MhA and ShA groups respectively. The normal height group projected 89% stronger and only 11% weaker correlations; moderately height affected group showed 36% stronger and 64 % weaker correlations and severely height affected subjects expressed 33% stronger and 67% weaker correlations. **Conclusion:** The data of the study provides guideline for further investigations to understand causes of height anomaly in the affected population.

**Keywords: Height anomaly, Variant morphometry, Adolescent male children,  
Inconsistent circumferences**

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## INTRODUCTION

Height variation in human is a composite result of genetic and environmental interactions. The challenges of these factors from foetal life to the culmination of growing age affect size and the associated characteristics of an individual. In a study based on the literature had attributed variability in the patterns of stature to several factors [1]. Nutritional, developmental, and genetic showed influences on height parameters of children aged 8-13 years [2]. Thus height in adolescents is the critical phase outcome of several factors participation and their interactions.

Height shows relationship with other morphological characteristics resulting the physique of a subject. Waist circumference following generalizable scaling rules had shown implications for defining body shape in populations who differ in stature [3]. Head circumference showed highly significant positive correlation with individual's height [4]. Head circumference measurements found strongly correlated with height in Turkish children aged 5-18 years [5]. Head circumference measurement, often not utilized optimally, can be a very simple tool for use by mothers and caregivers for growth monitoring at homes thereby help in early detection of growth faltering [6]. Mid upper arm circumference is a simple, low-cost, a

good and better than other anthropometric measures objective method in assessing nutritional status as observed among severely malnourished children hospitalized in rural Kenya [7].

The relationships and pattern of morphological variation also reveal the causes of possible anomalies. As the existence of a relationship between placental weight and head, parameter had been suggested of its relationship to iodine intake during pregnancy [8]. Such variations in early stages may execute as predictor of future health in adulthood. Height variation in children exhibit to be predictor of future health status as short stature had been associated with an increased risk of obesity in adults [9].

In the locality under study, the specific environment and associated natural and social characteristics have influenced the health and disease status of the population particularly of younger age affecting the stature. The study is the initial and guideline phase of larger study and includes the assessment of the specific morphological characteristics and their correlations in the adolescent male subjects of the locality.

## MATERIAL AND METHODS

### *Investigation Area*

The field study was carried out at Sabirabad of Karak District in Khyber

Pakhtunkhwa, Pakistan. The GPS coordinates of Sabirabad Township are 33° 09' 20" N and 71° 19' 19 E' and it is around 850 meters above the sea level. It comprises low hilly terrain formed of sedimentation rocks with arid landscape and very low rain fall thus population is exclusively dependent upon subsurface water. Local authorities facilitated in access to the subjects mostly at schools.

#### *Sampling Strategy*

The population data collected was sorted in three categories. The first category comprised of subjects for normal height. Second category included the defined short stature (severely height affected) subjects. Third category included subjects distinctly separate from second category and had been termed as moderate height affected group.

The morphometric data included height, age, weight, head circumference, middle arm circumference, body mass index, waist circumference, hip circumference and waist hip ratio. The sample size of most severely height affected included 42, moderately affected 116 and 23 randomly picked participants from normal height subjects.

#### *Procedures for Morphometric Data*

Weight was measured using floor type weighing scale to the nearest 0.5Kg. Height was obtained with measuring tape applied to the wall with readings to the nearest 0.2cm. Head circumference was taken

through the middle of the forehead around the head. Hip circumference was measured with tape passing through the most of the prominent part of the buttocks. Waist circumference was taken at the level of umbilicus with normal breathe out. Formulae were employed for obtaining BMI and WHR [10, 11].

#### *Statistical Methods*

Descriptive statistics were obtained for each parameter and unpaired Student t test was applied for comparisons in-between two groups. The level of statistical significance was  $p \leq 0.05$ . Pearson Correlation Test was performed and correlation strength was followed as in 'Biostatistics Series Module 6: Correlation and Linear Regression [12]. Software named 'Statistical Package for Social Sciences (SPSS) version 24' and 'Minitab version 18' were used.

## **RESULTS**

#### *Height*

The average height was  $1.48 \pm 0.042$ ,  $1.271 \pm 0.014$  and  $0.917 \pm 0.037$ m in the normal, moderately (MhA) and severely height affected subjects (ShA) respectively. In comparison to normal subjects, the height was 12.5 and 38.3% significantly lower in both MhA and ShA groups respectively. The MhA were 28.3% significantly taller than the ShA subjects (Fig. 1).

#### *Age*

The average age in the normal, moderately and severely affected height subjects was observed at  $11.70 \pm 0.55$ ;  $10.23 \pm 0.13$  and  $13.1 \pm 1.7$  years respectively. The comparing groups were in closer age ranges, however ShA were 12 % greater and MhA were about 12 % lower in age compare to the subjects of normal height (**Fig. 1**).

#### *Weight*

The mean weight was  $39.7 \pm 3.1$ ,  $24.77 \pm 0.6$  and  $18.6 \pm 2.7$  Kg in the normal, MhA and ShA subjects respectively. In comparison to normal subjects, the weight was 37.6% and 53.1% significantly lower in MhA and ShA groups respectively. In MhA weight was 33.17% significantly taller than the ShA (**Fig. 1**).

#### *Head Circumference*

The mean head circumference was  $52.46 \pm 0.28$ ,  $50.60 \pm 0.19$  and  $47.05 \pm 0.89$  cm in the normal, MhA and ShA respectively. In comparisons to normal height, MhA and ShA were insignificantly 3.5% and 10.3% significantly lower respectively. The MhA had significantly 9.4% greater value than ShA (**Fig. 2**).

#### *Upper Middle Arm Circumference*

The average upper middle arm circumference was  $20.75 \pm 0.74$ ,  $17.33 \pm 0.016$  and  $16.46 \pm 0.70$  cm in the normal, MhA and ShA respectively. In comparison to normal MhA and ShA were significantly 20.67% and 16.48% lower respectively and

difference between MhA and ShA was insignificant (**Fig. 2**).

#### *Body Mass Index*

The body mass index was  $17.20 \pm 0.47$ ,  $17.54 \pm 0.92$  and  $22.8 \pm 4.9$  in the normal, MhA and ShA respectively. In comparisons to normal insignificantly 8.4% lower in MhA and 32.55% higher in ShA. The MhA showed 30.96% insignificant lower value than ShA (**Fig. 2**).

#### *Waist Circumference*

The average waist circumference was  $64.41 \pm 1.9$ ,  $56.79 \pm 0.51$  and  $55.8 \pm 2.4$  cm in the normal, MhA and ShA respectively. In comparisons to the normal, the values were significantly 11.8% and 13.3% lower in MhA and ShA respectively. The difference between MhA and ShA was insignificant (**Fig. 3**).

#### *Hip Circumference*

The mean hip circumference was  $75.8 \pm 2.7$ ,  $65.42 \pm 0.62$  and  $59.3 \pm 2.9$  cm the normal, MhA and ShA respectively. Comparisons to the normal values were 15.85% and 21.76% lesser in MhA and ShA respectively. The MhA also exhibited significantly 10.32% greater value than ShA (**Fig. 3**).

#### *Waist Hip Ratio*

The average WHR was  $0.855 \pm 0.012$ ,  $0.865 \pm 0.007$  and  $0.9554 \pm 0.0089$  in the normal, MhA and ShA respectively. In comparison to the normal ShA was significantly, 11.7% greater and the

remaining comparisons were insignificantly statistically.

### **Correlations in Morphometric Characteristics**

Correlation has been worked out among the various morphometric characteristics within the normal height, moderately height affected and severely height affected subjects. The trends of the correlation has been compared within the height assorted groups (**Table 1**).

#### *Height*

Height predicted strong correlation with all the remaining characteristic studied in the normal height group. However in moderately height affected group except weight showing strong correlation the rest in this group, and all in severely affected groups showed comparatively weaker comprising a few of good, some fair and largely poor correlations.

#### *Age*

Age also predicted stronger correlations with all remaining parameters measured in the normal height group compare to the moderately and severe height affected subjects. In normals two showed good along stronger for the rest, in moderately affected there were good, one fair and three poor and in severely affected except one fair and the rest were poor correlated.

#### *Weight*

In weight except two parameters those projected good otherwise the rest showed

strong correlations in the normal group. In the other two compareable groups correlations were same i.e. strong, one good and the remaining fair and mostly poorly correlated.

#### *Waist Circumference*

In waist except WHR projected weaker correlations in all categories, head circ showed good and the rest exhibited strong correlations in the normals. UMAC also projected strong correlation in severely affected subjects.

#### *Hip Circumference*

Hip circ projected strong correlation with UMAC in all the heights categories. Two parameter showed good and the rest projected strong correlations. Except one in height affected groups correlation were weaker compare to normals.

#### *Waist Hip Ratio*

It exhibited inverse correlation with all the rest of parameters. Height only showed strong otherwise good with the most and fair with two parameters in the normals. In height affected groups the correlations are weaker than the normals.

#### *Upper Middle Arm Circumference*

Most parameters projected strong correlation with UMAC however with WHR and head circumference exhibited good correlation in the normals. Strong correlations had been observed of UMAC with weight, waist,, hip circ and BMI in height affected groups also.

Body Mass Index

Except in WHR and head circumference the correlation is fair otherwise with all the rest of the parameters it projected as strong correlation. All the parameter with one exception showed weaker correlations in the height affected groups compared to the normals.

Overview of the Strength of Correlations in Different Height Related Groups

Correlation of nine parameters in each of the three height related groups projected 36 results. In the normal height group of 36 correlations 23 strong, 09 good and 4 fair were expressed. In moderately height affected group of total 36 correlations 6 strong, 7 good, 4 fair and 19 poor shown. Thus, marked differences in correlations strength in various height related groups had been observed (Table 2).

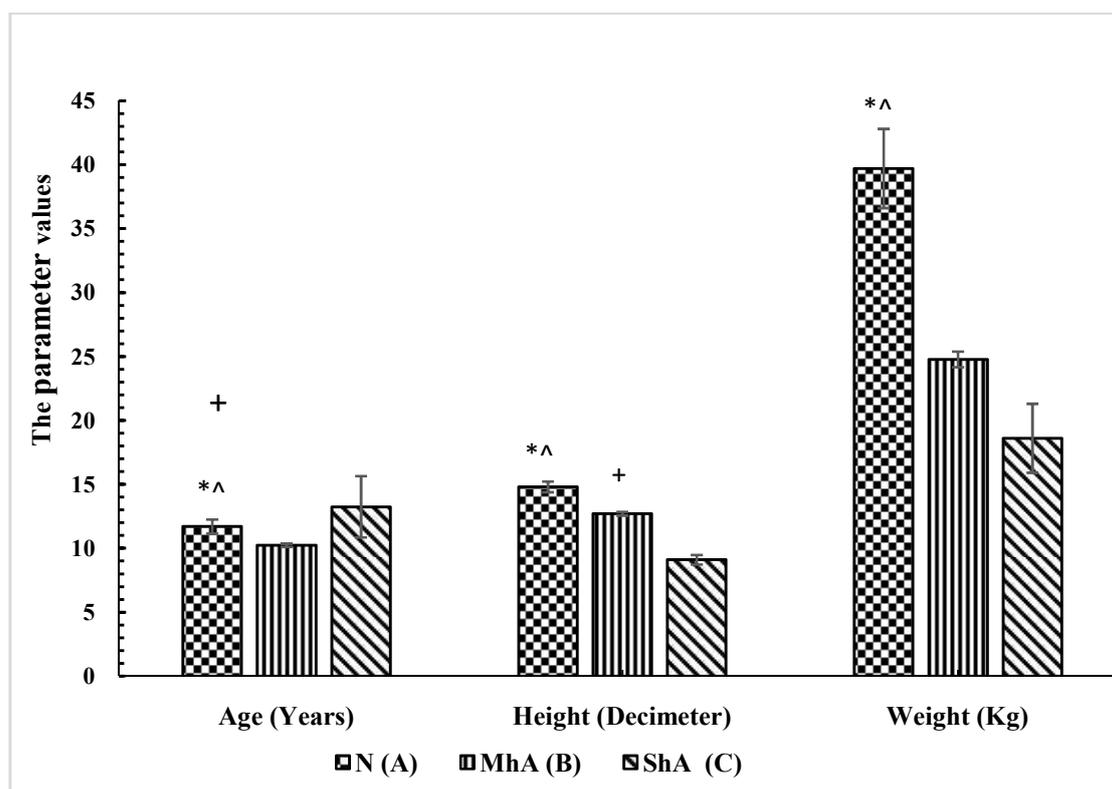


Fig 1: The average age, height and weight in different comparing groups of normal {(N), (A)} and moderately {(MhA), (B)} and severely {(ShA), (C)} height affected population. Statistically significant (P < 0.05) \*Between A & B; ^between A & C and +between B & C

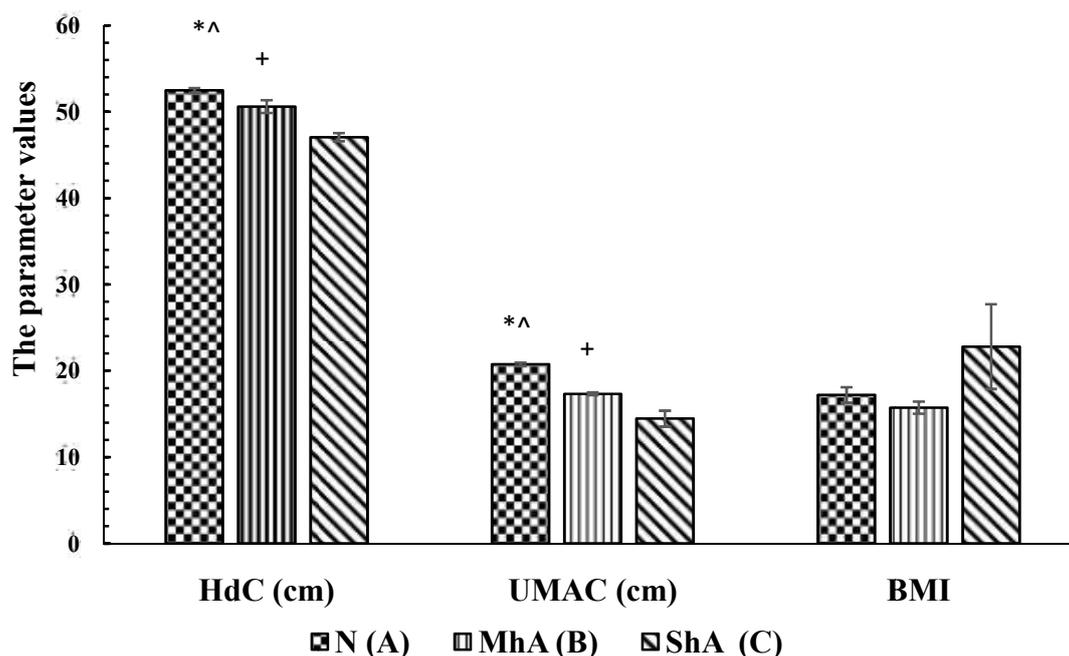


Fig 2: The average Head Circumference (HdC), Upper Middle Arm (UMAC) and Body Mass Index (BMI) of normal {(N), (A)} and moderately {(MhA), (B)} and severely {(ShA), (C)} height affected population. Statistically significant (P =<0.05) \*Between A& B; ^between A & C and +between B & C

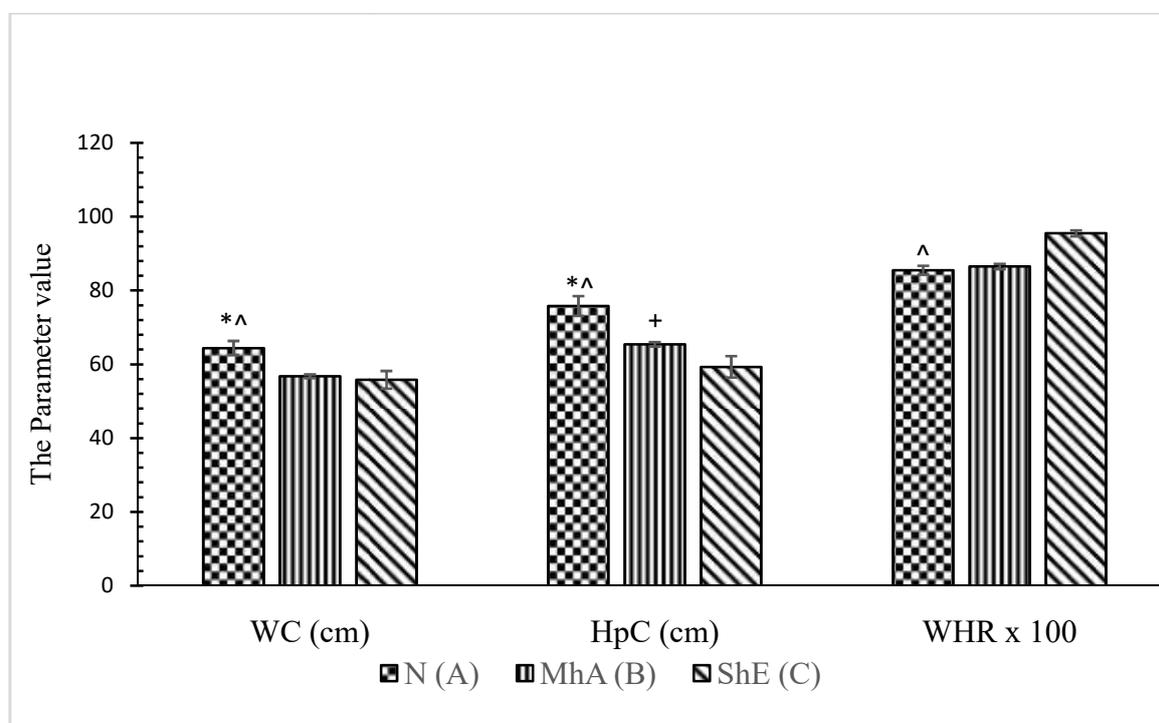


Fig 3: The average Waist Circumference (WC), Hip circumference (HpC), Waist Hip Ratio (WHR) of normal {(N), (A)} and moderately {(MhA), (B)} and severely {(ShA), (C)} height affected population. Statistically significant (P =<0.05) \*Between A& B; ^between A & C and +between B & C

**Table 1: Correlations among various morphometric parameters' in normal and variedly height affected subjects, Height, Age, Weight, Waist Circumference (Waist Circ) , Hip Circumference (Hip Circ), Waist Hip Ratio (WHR), Head circumference (Head Circ), Upper Middle Arm Circumference (UMAC) and Body Mass Index (BMI). Degree of correlation (r-value): >0.7 strong; <0.7 – .0.5 good; <0.5 – >0.3 fair; <0.3 poor**

Base Parameter	Correlated Parameter	Correlation Status: r values with strength of correlations		
		Normal Population n 23	Moderately Affected n 116	Severely Affected n 42
Height	Age	0.962 (Strong)	0.423 (Fair)	0.150 (Poor)
	Weight	0.961 (Strong)	0.710 (Strong)	0.448 (Fair)
	Waist Circ	0.881 (Strong)	0.560 (Good)	0.646 (Good)
	Hip Circ	0.952 (Strong)	0.696 (Good)	0.682 (Good)
	WHR	-0.608 (Strong) Inverse	-0.257(Poor) Inverse	-0.559 (Good) Inverse
	Head Circ	0.711 (Strong)	0.105 (Poor)	0.075 (Poor)
	UMAC	0.880 (Strong)	0.505 (Good)	0.624 (Good)
	BMI	0.760 (Strong)	-0.394 (Fair) Inverse	-0.164 (Poor) Inverse
Age	Weight	0.927 (Strong)	0.554 (Good)	0.115 (Poor)
	Waist Circ	0.835 (Strong)	0.571 (Good)	0.019 (Poor)
	Hip Circ	0.923 (Strong)	0.556 (Good)	0.122 (Poor)
	WHR	-0.621 (Good) Inverse	0.017 (Poor)	-0.386 (Fair) Inverse
	Head Circ	0.679 (Good)	0.136 (Poor)	-0.074 (Poor) Inverse
	UMAC	0.844 (Strong)	0.363 (Fair)	0.232 (Poor)
	BMI	0.753 (Strong)	0.122 (Poor)	0.198 (Poor)
Weight	Waist	0.937 (Strong)	0.817 (Strong)	0.690 (Good)
	Hip Circ	0.985 (Strong)	0.923 (Strong)	0.696 (Good)
	WHR	-0.590 (Good) Inverse	-0.255 (Poor) Inverse	-0.397 (Fair) Inverse
	Head Circ	0.667 (Good)	0.206 (Poor)	0.269 (Fair)
	UMAC	0.950 (Strong)	0.727 (Strong)	0.653 (Good)
	BMI	0.890 (Strong)	0.278 (Poor)	0.767 (Strong)
Waist Circ	Hip Circ	0.937 (Strong)	0.873 (Strong)	0.974 (Poor)
	WHR	-0.362 (Fair) Inverse	0.134 (Poor)	-0.483 (Fair) Inverse
	Head Circ	0.548 (Good)	0.224 (Poor)	0.346 (Fair)
	UMAC	0.914 (Strong)	0.675 (Good)	0.917 (Strong)
	BMI	0.880 (Strong)	0.291 (Poor)	0.353 (Fair)
Hip Circ	WHR	-0.614 (Good) Inverse	-0.290 (Poor)(Inverse)	-0.654 (Good) Inverse
	Head Circ	0.587 (Good)	0.188 (Poor)	0.316 (Fair)
	UMAC	0.960 (Strong)	0.804 (Strong)	0.946 (Strong)
	BMI	0.898 (Strong)	0.235 (Poor)	0.338 (Fair)
WHR	Head Circ	-0.436 (Fair) Inverse	0.132 (Poor)	-0.190 (Poor) Inverse
	UMAC	-0.570 (Good) Inverse	-0.324 (Fair) (Inverse)	-0.661 (Good) Inverse
	BMI	-0.47 (Fair) Inverse	0.008 (Poor)	-0.062 (Poor) Inverse
Head Circ	UMAC	0.527 (Good)	0.188 (Poor)	0.374 (Fair)
	BMI	0.448 (Fair)	0.088 (Poor)	0.143 (Poor)
BMI	UMAC	0.924 (Strong)	0.198 (Poor)	0.326 (Fair)

Table 2: Ssummary of the Strength of Pearson’s Correlations in the Different Height Related Groups

Height Groups	Total	Strong	% of Total	Good	% of Total	Fair	% of Total	Poor	% of Total
Normal	36	23	63.88	9	25	4	11.11	0	0
Moderately affected	36	6	16.66	7	19.44	4	11.11	19	52.77
Severly Affected	36	3	8.33	9	25	11	30.55	13	36.11

**DISCUSSION**

Three groups of varied height had been justified in the study as the moderately height affected group was significantly 12.5% shorter and of severely affected significantly 38.5% shorter compare to the normal height group. In general, in adolescent phase height correlates with the age of the subjects. Maximum height, in the study, of the normal height group remained within an average age of 11.7 years. Severely height affected subjects were shortest despite averagely about one and half year older than the normal subjects group. The moderately affected subjects’ height had also been lower compare to the controls. Undoubtedly thus warranted that adolescents of the studied population included moderately affected and severely height affected subjects along of normal height.

Morphometric features of weight, head circumference, upper middle arm circumference, waist circumference, and hip circumference were measured significantly reduced in moderately height affected group; whereas in the severely height affected group these morphometric characteristics were significantly and

markedly lower compare to the normal height group. It appears that the factors of growth are being compromised affecting height and other related parameters in adaptations during growth. There are however variations in degree of effects in relationships of various parameters within each height group. The patterns of the effects had been elaborated based on Pearson’s correlations.

Pearson’s correlation co-efficient were obtained and those showed variedly strong, good, fair and poor correlations among the various parameters within each of a group. The strength of correlation of the comparing parameters of a group has demonstrated variations in the expression among the different height related groups. Thus, capricious patterns of strength of correlations among the height-based groups further strengthen the idea that there are pertinent basis for the variation in the height of the population studied.

Several studies have reported on such correlations as head circumference showed highly significant positive correlation with individual's height [4]. Another found that head circumference measurements were strongly correlated with height, weight and

waist circumference [5]. A strong correlation between arm span and height in all age groups to the extent that arm span could be used instead of height as an alternative in the conventional body mass index in elderly persons [13].

The impact of morphometric studies are of significance and could be taken as first step in identifying the variability in studies of diversity, health related concerns and adaptability in a population. Studies in children and adolescents showed that weight to height ratio (WHtR) similarity to both BMI and WC being useful for identifying those with increased cardio metabolic risk. It is expected that prospective studies might confirm the usefulness of WHtR for predicting comorbidities of obesity in children and adolescents [14, 15]. The value of MUAC was projected useful tool as a marker of malnutrition [16] and used as an appropriate rapid diagnostic method to identify malnourished children in managing nutritional rehabilitation programs [17]. Reduced head size in malnutrition could effect on brain and development [18] thus altering the status of correlation with other parameters.

In the present study the normal height group projected 89 % the stronger and only 11% the weaker correlations; moderately height affected group showed 36% the stronger and 64 % weaker correlations and

severely height affected subjects expressed 33% stronger and 67% weaker correlations (Table 3). Thus there is an evident pattern of far greater occurrence of the stronger correlations among the most morphometric features in the normal group and shifting to the weaker correlations gradually in the moderate and severely height affected groups. In severely height affected group there was far greater incidence of weaker to the total correlations. The shifting pattern of correlations from normal height to the affected reveals of diverse adaptabilities among the different height groups.

The literature report of such predictions in various studies. Military recruits height data available of 18<sup>th</sup> and 19 century have shown that their height was shorter than of the recent times as recruited from the lower socioeconomic class thus poor health and nutrition would have contributed in their poor growth [19]. Growth hormone undoubtedly is the principal factor of influencing the growth including height, as there is increased production of GH during middle and late puberty [20]. Thyroid hormone has direct effect on chondrocytes and osteoblasts through expression of thyroid hormone receptors thus affecting the head dimensions [21]. To ascertain the causes of the height anomaly in the population of the study the morphometric studies provide necessary guidelines for further investigations.

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