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A.P. Singh[1], K. Singh[2] and R. Kaur[3]

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Authors and affiliations
AjitPal Singh[1], Prof. & Head, Department of Anatomy, Desh Bhagat Dental College & Hospital, Desh Bhagat University, Mandi Gobindgarh (Pb.) India. Email: doctorajitpal@gmail.com
Kulvir Singh[2], Assoc. Prof. & Head, Department of Physiology, Desh Bhagat Dental College & Hospital, Desh Bhagat University, Mandi Gobindgarh (Pb.) India.
Email: kulvir.singh.hb@gmail.com
Ravneet Kaur[3], Assoc. Prof, Department of Public Health Dentistry, Desh Bhagat Dental College & Hospital, Desh Bhagat University, Mandi Gobindgarh (Pb.) India.
Email: malhi.ravneet11@gmail.com
Corresponding Author: Ajit Pal Singh, Prof. & Head, Department of Anatomy, Desh Bhagat Dental College & Hospital, Desh Bhagat University, Mandi Gobindgarh (Pb.) India. Email: doctorajitpal@gmail.com. Mobile: +91 8427338995

A Nutritional Paradox among Male Children and Adolescents of District Sri Muktsar Sahib, Punjab, India

A.P. Singh[1], K. Singh[2] and R. Kaur[3]

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ABSTRACT

Background: *Body proportional indices enable the assessment of nutritional status and provides the critical insights into an individual's overall health status. It also aids in identifying the risk of developing various non-communicable health disorders like Obesity, Hypertension, Type -II Diabetes, insulin resistance and metabolic syndrome.*

Objectives of the Study: *Present cross-sectional study is an attempt to analyse age wise trend in the nutritional status of male children and adolescents of district Sri Muktsar Sahib, Punjab.*

Methods: *A cross-sectional study was conducted among 560 males categorised into 14 age groups (5 to 18 years) and measured anthropometrically for standing height, body weight, waist and hip circumferences following the standard protocol. Body Mass Index (BMI), Waist-Hip Ratio (WHR) and Waist Height Ratio (WHtR) indices were calculated using standard formulas.*

Results: *It has been observed that the average Body Mass Index (BMI), Waist Hip Ratio (WHR) and Waist Height Ratio (WHtR) at 5 years age group is 14.1 kg/m^2, 0.90 and 0.44, respectively. Thereafter increasing trend with slight fluctuations has been found in mean values of BMI and almost decreasing trend with slight fluctuations has been observed in mean values of WHR and WHt.R in the age groups of 6 years to 18 years. Using the WHO (2000) criteria of BMI for age classification it is found that maximum number of the subjects falling in the Underweight category belongs to 8 years (65%), Healthy weight category belongs to 7 years and 13 years age groups (60%) age groups, Overweight category belongs to 18 years (20%) age group and Obese category belongs to 8 years (10%) age group.*

Conclusion

The overall findings showcase that majority of the males of district Sri Muktsar Sahib falls under the healthy category of BMI but there is very small gap exist when compared with under-weight category and are below the risk of developing metabolic syndrome. Variations observed at different age groups attributed to the socio-economic status of family, environmental exposure, physical activity, life style and food habits, geographical location and genetic make-up which may be responsible to bring out ethnic differences in body proportions during the childhood growth process.

Key Words

Nutritional Status, Body Mass Index, Waist Hip Ratio, Waist Height Ratio, Males, , Adolescents, Children, Sri Muktsar Sahib.

INTRODUCTION

In health sciences, the study of child growth and development has consistently been a key area of interest, as it serves as a powerful indicator of the health and nutritional status of populations (**Sharma, 1970**). Linear body dimensions in growing children are closely associated with structural and functional changes in the body, such as the relationship between pubertal height growth and menarcheal age in girls, or how the development of the respiratory system can influence the growth of the locomotor system (**Ellison, 1982; Papalia and Wendkos, 1989**). Body proportions show good correlation and plays remarkable role in the assessment of various epidemiological health risks at all the age groups. **Ferrie et al. (2006)** in the latest phase of the Whitehall II study (a prospective survey of the health of British civil servants) highlighted the association between trunk length and leg length to CHD (coronary heart disease). Many other studies focused on segmental lengths in relation to health **(Han et al.,1997 and Leary et al., 2007).** Today, obesity—characterized by excessive body fat—has become a leading epidemiological concern, linked to an increased risk of diabetes, cardiovascular diseases (CVDs), and coronary heart diseases (CHDs) in both youth and adults. Excess weight disrupts metabolism, impacts physical appearance, and can negatively affect mental health, leading to conditions like depression, sleep apnea, osteoarthritis, and even certain cancers later in life (**Rahman and Adjeroh, 2015**). According to a World Health Organization factsheet, approximately 462 million adults are underweight, while 1.9 billion fall into the overweight category **(WHO, 2017).** The global prevalence of overweight and obesity among preschool children has surged by 60% between 1990 and 2010, increasing from 4.2% to 6.7% (de Onis et al., 2010). This rise in childhood and adolescent overweight and obesity has been documented across both developed and developing nations (Ng et al., 2014), as well as in rural areas (Ranjani et al., 2016). While obesity rates are generally higher in adults, certain countries have experienced a faster rate of increase in children compared to adults (Popkin et al., 2006). Therefore, it is crucial to conduct studies in various regions to emphasize the severity and distinctiveness of nutritional issues. There is limited information available on body proportional indices and epidemiological markers during growth of male children and adolescents of district Sri Muktsar Sahib, Punjab. To address this knowledge gap, the present study was conducted.

MATERIAL & METHODS

This cross-sectional study was conducted between May and July 2023, focusing on growing male children and adolescents of district Sri Muktsar Sahib, Punjab. The study involved 560 participants, divided into 14 age groups ranging from 5 to 18 years, with each group consisting of 40 subjects. Data was collected from 12 educational institutions, including schools, colleges, and academies within the district, using a cluster sampling method. Ethical approval was obtained from the Ethical Committee of Desh Bhagat University, Mandi Gobindgarh, Punjab, India (Letter No. DBU/RC/2023/2315). Age information was verified through the institutions' admission registers, and any doubtful cases were excluded. Decimal ages were calculated using the decimal age calendar method (**Tanner & Whitehouse, 1966**). Age was recorded in completed years based on institutional records. For instance, if a subject was 5 years and 5 months old, they were classified in the 5-year age group; if they were 5 years and 6 months, they were placed in the 6-year age group. Measurements of standing height, body weight, waist circumference, and hip circumference were taken for each subject following the standard protocols outlined by **Lohman et al. (1988**), using an anthropometric rod, digital weighing scale, and flexible steel tape, respectively. The collected data was entered into a computer in MS-Excel format, and statistical analysis was performed using the Statistical Package for Social Sciences (SPSS Inc; Chicago, IL, version 20.0 for Windows). Body Mass Index (BMI), Waist-Hip Ratio (WHR), and Waist-Height Ratio (WHtR) were calculated for each age group. BMI classification for age percentiles was done using growth standards developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000). Healthy children were classified as having a BMI percentile between the 5th and 85th percentiles. Children with a BMI between the 85th and 95th percentiles were considered overweight, while those at or above the 95th percentile were classified as obese (**WHO, 2000**).

RESULTS

Table 1 shows the descriptive statistics of Body Mass Index (BMI), Waist Hip Ratio (WHR) and Waist Height Ratio (WHtR) of male children and adolescents of district Sri Muktsar Sahib. It has been observed that the average Body Mass Index (BMI), Waist Hip Ratio (WHR) and Waist Height Ratio (WHtR) at 5 years age group is 14.1 kg/m^2, 0.90 and 0.44, respectively. Thereafter increasing trend with slight fluctuations has been found in mean values of BMI and almost decreasing trend with slight fluctuations has been observed in mean values of WHR and WHt.R in the age groups of 6 years to 18 years.

Further using the **WHO (2000)** criteria of BMI for age classification, cases from the present study of male children and adolescents of district Sri Muktsar Sahib have been categorized into underweight, healthy weight, overweight and obese **(Table 2)**. It is found that maximum number of the subjects falling in the Underweight category belongs to 8 years (65%) followed by 9 years (57.5%) age groups whereas only 7 years and 13 years age groups (60%) followed by 5 years and 12 years (57.5%) age groups have maximum number of the subjects in Healthy weight category of BMI classification. Maximum number of subjects in the Overweight category belongs to 18 years (20%) followed by 15 years (17.5%) and in case of Obese category maximum number of the subjects belongs to 8 years (10%) followed by 17 years (7.5%) age groups. Summing up the information, overall trend of BMI indicates that 49.2% of the subjects are having healthy weight 42.1% are underweight, 4.6% are overweight and only 3.9% are obese in the present study.

DISCUSSION

To assess the antecedents of disease, morbidity, and death in adulthood, decomposing stature into its major components is proving to be a useful strategy. In present study, body proportional indices like BMI (Body Mass Index), Waist Hip Ratio (WHR), Waist-Height Ratio (WHt.R) analysis is done to assess the epidemiological risk factors in the growing male children and adolescents of district Sri Muktsar Sahib and its results are discussed as under:

Body Mass Index (BMI)

Comparing the results of BMI of the present study with other national studies (**Table 3**) indicates that mean BMI values of growing male children and adolescents of district Sri Muktsar Sahib are lower than that of Revised IAP Standards **(Khadilkar et al.,2015)**, Central Indian Population **(Thakur and Gautam, 2017)** and Haryanvi Males **(Abhilasha and Singh,2019)** whereas trend is opposite when compared with Rajasthani Boys **(Raikar et al., 2019),** Himachal Pradesh Boys **(Pathania and Biswas,2021),** West Bengal Boys **(Das et al.,2017)** and Odisha Boys **(Das and Gautam, 2022).** In comparison to Tamil Nadu Boys **(Kumaravel et al.,2014),** present study has lower mean BMI values from 5 to 12 years age groups and thereafter mean BMI values are higher than that of Tamil Nadu Boys. The **Table 4** shows the comparative analysis of present study with international studies. It has been observed that mean BMI values of the present study are lower than that of **WHO, 2006**, Pakistani Boys (**Mushtaq et al.,2012**), Greek Boys **(Bacopoulou et al. 2015**), US Males (**Cheryl et al.,2016**), Polish school children (**Natalia et al., 2019**), Argentina Boys (**Oyhenart et al.,2020**), Korean adolescents KNHANES (**Kwak et al.,2021**) at all age groups. Further using the **WHO (2000)**

criteria of BMI for age classification, cases from the present study of male children and adolescents of district Sri Muktsar Sahib have been categorized into underweight, healthy weight, overweight and obese **(Table 2)**. Findings of the study indicates that majority of the subjects are under the Healthy Weight category of classification (having BMI for age 5th to < 85th percentile) except for 8, 9 and 15-years age groups where majority of the subject have BMI for age < 5th percentile and thus considered to be Underweight. On the other hand, maximum number of overweight and obese subjects belongs to 15, 17 and 18 age groups. Variations observed in BMI among present study and other national and international populations might be due diverse socio-demographic and economic conditions. According to **Cogill (2020)** economic status is a major determinant of nutritional status of the community. Socio-cultural and economic transition can affect the nutritional standard of particularly the children and the adolescent thus there is a significant prevalence of malnutrition among the adolescent population of different Indian states.

Further it has been found that there is a positive association between body weight and dental caries in the primary and permanent dentition. Dental caries and high body mass index (BMI) constitute important health problems world-wide. According to **Ashour et al. (2018)** children who were overweight and obese were 2.9 times greater risk of developing dental caries compared to underweight and normal weight children. Recent national data from Sweden suggested a positive correlation between dental caries and BMI, and showed that obesogenic behaviour such as snacking in early childhood predicted caries development in adolescence.

Alsawat (2016) also found the positive correlation between BMI and dental caries prevalence among adult population in Saudi Arabia even after adjusting for smoking, high sugary diet, sedentary lifestyle etc. Dental caries, periodontitis, and tooth loss are typical illnesses caused by poor oral health. As both are linked to shared risk factors such diet (consumption of sugary drinks, and snacks), hereditary, socioeconomic, and lifestyle changes, recent research studies reveal that there is a considerable correlation between oral health indicators and BMI. Even study conducted among Korean population also revealed that the occurrence of periodontitis, dental caries, and tooth loss may be linked to higher BMI and inflammation also plays a pivotal role in the relationship between oral disorders and obesity (**Issrani et al.2023**).

Various studies (**Malina,1975; Malina et al.,1995 and Maia,1993**) highlighted the negative effect of overweight on physical fitness and related performance but static strength in hand grip efficiency in obese subjects tend to reflect positive effect which might be due to greater amounts of muscle mass in overweight children and adolescents similarly significantly

lower systolic and diastolic blood pressures are found in wasted males than the normal ones and cholesterol concentrations are found to be significantly higher in the overweight group. **US Department of Health and Human Services (2007)** recognized the relationship between obesity and poor self-esteem and psychosocial problems. Further using the BMI proportional index, tracked and prevent the obesity cases and updated its position in the country. Anatomically, skin thickness is affected by several factors such that age, gender and body mass index which further effects intradermal or subcutaneous injections or transdermal delivery systems clinical techniques. Sometimes issues arise in children with diabetes when subcutaneous insulin injection is mistakenly injected to muscle tissue leading to increased risk of hypoglycaemia because of altered insulin absorption **(Birkebaek et al.,1998 and Peart et al.,2007)**. Various other studies **(Bliznak and Staple,1975; Hofman et al.,2007; Gibney et al.,2010 and Ploin et al.,2011)** are associated with BMI increase and thicker dermis in both children and adults and stated increase in subcutaneous tissue thickness is obviously expected with high BMI values. **Blimkie et al. (1990)** reported the impairment of the rectus femoris muscle activation which is recruited while performing lower extremities movement patterns in adolescent boys with obesity.

Waist-Hip Ratio (WHR) and Waist – Height Ratio (WHt.R)

In adults and children, large waist circumference is the indication of central subcutaneous and visceral fat distribution which is associated with an increased risk of CVDs, metabolic diseases, and mortality regardless of body mass index **(Savva et al., 2000; Despres et al.,2008 and Koster et al.,2008).** Waist Circumference, Waist – Hip Ratio and Waist-Height Ratio are simple, yet effective ways of measuring abdominal obesity and can be used to assess metabolic health disorders in the person of any age. Findings of the present study (**Table 1**) shows that mean WHR from 6 years to 18 years age groups is below the **WHO (2000)** cutoff points (i.e., ≥0.90 cm) for males for the risk of metabolic complications. Similarly, mean WHt.R is below the Asian cut-off of ≥0.5 for defining central obesity thus males of present study are below the risk of developing metabolic syndrome in children and adolescents (**McCarthy and Ashwell, 2006**). **Ashwell (2005)** stated waist to height ratio greater than 0.5 is an indication of excessive accumulation of upper body fat and poses a risk of developing various metabolic complications. Comparative analysis (**Table 5**) shows that mean WHR values of present study are lower than that of Pakistani Boys (**Mushtaq et al.,2012**) and Macedonian adolescents (**Bojanic et al.,2020**) and higher than that of Greek Boys (**Bacopoulou et al. 2015**) whereas in case of WHt.R, subjects of present study have lower mean WHt.R at all the age groups when compared to Bangalore Children (**Kuriyan et al.,2011**), South East Norway Children (**Fredriksen et**

al.,2018) and Macedonian adolescents (**Bojanic et al.,2020**). According to **Fadzlina et al. (2014)** gender plays a major role and is one of the factors in adolescents suffering from metabolic syndrome as obese males are more prone than females. Findings of the **Co et al. (2015)** suggested that variable prevalence has been observed in different components of the metabolic syndrome in obese adolescents. They found 75.9% of the subjects with decrease in HDL levels while 44.7% with high blood pressure and the similar outcomes are reported for the Virginia study on 3 to18 years children with obesity. Particularly in children and adolescents, waist-height ratio can be a more accurate tracking indicator of fat distribution and accumulation because it accounts for the growth in both waist circumference and stature over age. Moreover, the value of waist – height ratio is free of measurement units and is in a proximity between males and females at each age group **(Despres et al.,1990)**.

Conclusion

The outcome of the present study provides us with a comprehensive database of the health and nutritional status during growth of males of district Sri Muktsar Sahib of Punjab. Although results indicates that majority of the male population of district Sri Muktsar Sahib falls under the Healthy Category of WHO and are below the risk of developing metabolic syndrome but there is very thin line of gap do exist when compared with Underweight category. Thus, there is an immediate need of focusing on the nutritional situation of male children and adolescents of district Sri Muktsar sahib in relation to cope up with growing global health challenges in the developing world. Variations across different age groups are likely influenced by factors including socio-economic status, environmental exposure, physical activity, lifestyle, dietary habits, geographical location, and genetic makeup, which may contribute to ethnic differences in body proportions during childhood growth.

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Conflict of Interest

We confirm that there are no known conflicts of interest associated with this publication.

REFERENCES

Abhilasha and Ajitpal Singh. 2019. Body height, Body Weight, BMI of Young Haryanvi Males and Females; Comparative Anthropometric Assessment. *North States Journal of Anatomy* (Journal of North States Chapter of Anatomical Society of India).

Alswat, K., Mohamed, W., Wahab, M., Aboelil, A. 2016. The Association Between Body Mass Index and Dental Caries: Cross-Sectional Study. *J Clin Med Res*.8(2):147-152.

Ashour NA, Ashour AA, Basha S. 2018. Association between body mass index and dental caries among special care female children in Makkah City. *Ann Saudi Med*. Jan-Feb;38(1):28-35.

Ashwell M 2005. Waist to height ratio and the AshwellR shape chart could predict the health risks of obesity in adults and children in all ethnic groups. *Nutr Food Science*, 35:359-64.

Bacopoulou F , Efthymiou V, Landis G, Rentoumis A and P Chrousos GP . 2015. Waist circumference, waist-to-hip ratio and waist-to-height ratio reference percentiles for abdominal obesity among Greek adolescents, *BMC Pediatrics*, 15:50.

Birkebaek NH, Johansen A, Solvig J.1998. Cutis/subcutis thickness at insulin injection sites and localization of simulated insulin boluses in children with type 1 diabetes mellitus: need for individualization of injection technique? *Diabet Med* 15: 965–971. 2.

Blimkie CJR, Sale DG, Bar-Or O. 1990. Voluntary strength, evoked twitch contractile properties and motor unit activation of knee extensors in obese and non-obese adolescent males. Eur. J. Appl. Physiol. *Occup. Physiol*., 61, 313–318.

Bliznak J and Staple TW.1975. Roentgenographic measurement of skin thickness in normal individuals. *Radiology* 116: 55–60.

Bojanic D, Ljubojevic M, Krivokapic D, Gontarev S. 2020 . Waist circumference, waist-to-hip ratio, and waist-to-height ratio reference percentiles for abdominal obesity among Macedonian adolescents. *Nutr Hosp*., 27;37(4):786-793.

Cheryl D. Fryar MSPH, Qiuping Gu MD and Cynthia LO. 2016 . Anthropometric Reference Data for Children and Adults: United States, 2011–2014. Vital and Health Statistics, Series 3, Number 39. Hyattsville, Maryland August 2016, DHHS Publication No. 2016–1604.

Co J, Jeffrey J, Emmett M, Modak A, Sondike SB . 2015 . Obe sity, Hypertension and Metabolic Syndrome in Children in West Virginia. *W V Med J*.,111(4):20-2, 24. PMID: 26242028.

Cogill B. 2020. Anthropometric indicators measurement guide 2003. Available at https://www.fhi360.org/. Accessed on 27 April, 2020.

Das D and Gautam RK .2022. Growth and Nutritional status among adolescents of Dongria Kondh- A PVTG of Niyamgiri Hills of Odisha, India. *Human Biology Review*, 11(1), 54-65.

Das S, Ghritlahre M,Tiwari B and Bose K .2017.Assessment of Nutritional Status among 2 to 12 Years Children of Two Districts in West Bengal, India. *J Life Science*, 9(2): 118-125 .

de Onis M, Blossner M, Borghi E .2010 . Global prevalence and trends of overweight and obesity among preschool children. *Am J Clin Nutr*, 92: 1257-1264.

Despres JP, Lemieux I, Bergeron J, Pibarot P, Mathieu P, Larose E, et al. 2008. Abdominal obesity and the metabolic syndrome: contribution to global car diometabolic risk. *Arterioscler Thromb Vasc Biol*.,28(6):1039-49. DOI: 10.1161/ATVBAHA.107.159228.

Despres JP, Moorjani S, Lupien PJ, Tremblay A, Nadeau A, Bouchard C. 1990. Regional distribution of body fat, plasma lipopro teins, and cardiovascular disease. *Arteriosclerosis*.,10: 497–511.

Ellison PT.1982. Gender-Specific Growth Patterns for Stature, Sitting Height and Limbs Length in Croatian Children and Youth (3 to 18 Years of Age), Coll. *Antropol*. 27 1: 321–334.

Fadzlina AA, Harun F, Nurul Haniza MY, et al. 2014. Metabolic syndrome among 13 year old adolescents: Prevalence and risk factors. *BMC Public Health*, 14(Suppl 3):S7. doi: 10.1186/1471-2458-14-S3-S7.

Ferrie JE, Langenberg C, Shipley MJ, Marmot MG. 2006. Birth weight, components of height and coronary heart disease: evidence from the Whitehall II study. *Int J Epidemiol* 35:1532–42.

Fredriksen PM, Skår A and Mamen A .2018 . Waist circumference in 6–12-year-old children: The Health Oriented Pedagogical Project (HOPP).Scandinavian *Journal of Public Health*, 2018; 46 (Suppl 21): 12–20.

Gibney MA, Arce CH, Byron KJ, Hirsch LJ .2010 . Skin and subcutaneous adipose layer thickness in adults with diabetes at sites used for insulin injections: implications for needle length recommendations. *Curr Med Res Opin* 26: 1519– 1530.

Han TS, Hooper JP, Morrison CE, Lean ME .1997. Skeletal proportions and metabolic disorders in adults. *Eur J Clin Nutr*., 51:804–9.

Hofman PL, Lawton SA, Peart JM, Holt JA, Jefferies CA, et al. 2007. An angled insertion technique using 6-mm needles markedly reduces the risk of intramuscular injections in children and adolescents. *Diabet Med* 24: 1400– 1405.

Issrani R, Reddy J, Bader AK, Albalawi RFH, Alserhani EDM, Alruwaili DSR, Alanazi GRA, Alruwaili NSR, Sghaireen MG, Rao K .2023. Exploring an Association between Body Mass Index and Oral Health-A Scoping Review. *Diagnostics* (Basel). 13(5):902.

Khadilkar V, Yadav S, Agrawal KK, Tamboli S, Banerjee M, Cherian A, Goyal JP, Khadilkar A, Kumaravel V, Mohan V, Narayanappa D, Ray I and Yewale V. 2015. Revised IAP Growth Charts for Height, Weight and Body Mass Index for 5- to 18-year-old Indian Children. *Indian Pediatr*; 52 : 47-55.

Koster A, Leitzmann MF, Schatzkin A, Mouw T, Adams KF, van Eijk JT, et al. 2008. Waist circumference and mortality. *Am J Epidemiol*.,167(12):1465-75. DOI: 10.1093/aje/kwn079.

Kuriyan R, Thomas T, Lokesh DP, Sheth NR, Mahendra A, Joy R, Sumithra S, Bhat S and Kurpad AV.2011. Waist Circumference and Waist for Height Percentiles in Urban South Indian Children Aged 3-16 Years. *Indian Paediatrics*, 48; 765-771.

Kwak BO, Lim J, Chung S .2021. Body Shape Indices in Adolescents Based on the 2009–2012 Korea National Health and Nutrition Examination Survey. *Children* 2021, 8, 894.

Leary S, Davey Smith G, Ness A.2007. ALSPAC Study Team. Smoking during pregnancy and components of stature in offspring. *Amer Jour Hum Biol*.,18:502–12.

Lohman TG, Roche AF, and Marforell ER.1988.. Anthropometric Standardization Reference Manual. Human Kinetics: Campaign, IL.

Maia JAR.1993. Abordagem antropobiológica da selecção em desporto. Estudo multivariado de indicadores biosociais da selecção em ande bolistas dos dois sexos dos 13 aos 16 anos. (Anthropological approach to sports selection. (A multivariate study of biosocial indi cators in handball players of both sexes aged 13–16 y.) Doctoral dissertation. University of Porto, Portugal, 1993 (in Portuguese).

Malina RM .1975. Anthropometric correlates of strength and motor performance. *Exerc Sports Sci Rev*., 3:249–74.

Malina RM, Beunen GP, Claessens A, et al. 1995. Fatness and physical fit ness of girls 7 to 17 years. *Obes Res*.,3: 221–31.

McCarthy HD and Ashwell M .2006. A study of central fatness using waist-to-height ratios in UK children and adolescents over two decades supports the simple message-keep your waist circumference to less than half your height. *Int J Obes*., 30(6):988-92. DOI: 10.1038/sj.ijo.0803226.

Mushtaq MU, Gull S, Mushtaq K, Abdullah HM et al. (2012). Height, weight and BMI percentiles and nutritional status relative to the international growth references among Pakistani school-aged children. *BMC Pediatrics* 2012 12:31.

Natalia NS, Aleksandra G & Slawomir K (2019). Mid-upper arm circumference and body mass index as different screening tools of nutritional and weight status in Polish schoolchildren across socio-political changes. *Scientific Reports*, 9:12399; https://doi.org/10.1038/s41598-019-48843-5.

Ng M, Fleming T, Robinson M et al. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: A systematic analysis for the global burden of disease study 2013. *Lancet*, 384(9945): 766-781.

Oyhenart EE , Torres MF, Luis MA , Garraza M , Navazo B , Quintero FA ,Cesani MF (2020). Body composition in relation to nutritional status and socio-environmental conditions in schoolchildren living in the urban periphery of La Plata, Argentina, *Archivos Latinoamericanos De Nutrición*, 7 (2):81-94.

Papalia DE and Wendkos SO (1989). Human development. McGraw-Hill, Baskerville.

Pathania NS and Biswas R (2021).Assessment of nutritional status of adolescent school going boys of Himachal Pradesh. International Journal of Community Medicine and Public Health Pathania NS et al. *Int J Community Med Public Health*. 2021 Oct;8(10):4960-4966.

Peart JM, Holt JA, Jefferies CA, et al. (2007) .An angled insertion technique using 6-mm needles markedly reduces the risk of intramuscular injections in children and adolescents. *Diabet Med* 24: 1400– 1405.

Ploin D, Schwarzenbach F, Dubray C, Nicolas JF, Goujon C, et al. (2011). Echographic measurement of skin thickness in sites suitable for intradermal vaccine injection in infants and children. *Vaccine* 29: 8438–8442.

Popkin BM, Conde W, Hou N, Monteiro C 2006. Is there a lag globally in overweight trends for children compared with adults? *Obesity,*14: 1846-1853.

Rahman SA, Adjeroh D (2015). SurfaceBased Body Shape Index and Its Relationship with All-Cause Mortality. *PLoS ONE* 10(12): e0144639. doi:10.1371/journal.pone.0144639.

Raikar KJ, Maaheraa A, Sobti S (2019). A study of anthropometric parameters of school children: a cross-sectional study in Rajasthan. *Int J Community Med Public Health*, 6:1499-504.

Ranjani H, Mehreen TS, Pradeepa R, Anjana RM, Garg R, Anand K, Mohan V 2016. Epidemiology of childhood overweight and obesity in India: A systematic review. *Indian J Med Res*, 143: 160-174.

Savva SC, Tornaritis M, Savva ME, Kourides Y, Panagi A, Silikiotou N, et al. (2000). Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. *Int J Obes Relat Metab Disord*.;24:1453–8.

Sharma JC (1970) . Physical growth and development of the Maharashtrians. (Ethnographic and Folk Culture Society, Lucknow.

Tanner JM and Whitehouse RH (1966). Notes on the use of height and weight standard charts. London: Creasey, Hertford.

Thakur R and Gautam RK (2017). Pre and post pubertal growth difference among boys and girls of 5-18 years of age: A cross-sectional study among central Indian Population. *Human Biology Review*, 6 (2), 164-187.

US Department of Health and Human Services (2007) . The problem of overweight in children and adolescents: the surgeon general's call to action to prevent and decrease overweight and obesity. http://www.surgeongeneral.gov/ topics/obesity/call to action/fact_adolescents.htm. Accessed July 17, 2007.

WHO (2000). Obesity: Preventing and managing the global epidemic. World Health Organisation Technical Report Series No.894:58-60.

WHO (2006) Multicentre Growth Reference Study Group. Assessment of differences in linear growth among populations in the WHO Multicentre Growth Reference Study. *Acta Paediatr Suppl* 2006; 450:56–65.

World Health Organization (WHO). 2017. The Double burden of malnutrition; Brief Policy. World Health Organization, Geneva.

Table 1 : Descriptive Statistics of Body Mass Index (BMI), Waist Hip Ratio (WHR) and Waist Height Ratio (WHtR) of male children and adolescents of district Sri Muktsar Sahib, Punjab.

Age Group (In Years)	BMI (kg/m^2)		WHR		WHtR	
	Mean	SD	Mean	SD	Mean	SD
5	14.1	1.55	0.90	0.04	0.44	0.02
6	13.2	1.82	0.89	0.08	0.43	0.02
7	13.5	1.39	0.85	0.06	0.41	0.03
8	14.1	2.89	0.83	0.06	0.39	0.03
9	14.1	1.20	0.82	0.04	0.39	0.03
10	14.9	2.60	0.83	0.03	0.40	0.03
11	15.8	2.81	0.82	0.04	0.40	0.03
12	16.0	2.40	0.82	0.10	0.40	0.03
13	16.8	2.94	0.81	0.05	0.39	0.04
14	17.3	3.03	0.79	0.05	0.39	0.05
15	18.2	3.86	0.79	0.05	0.40	0.05
16	18.4	3.65	0.78	0.04	0.39	0.04
17	20.5	5.10	0.78	0.05	0.41	0.04
18	20.7	3.95	0.80	0.06	0.42	0.06

Table 2: WHO (2000) classification of Body Mass Index (BMI) for age of male (N=40) children and adolescents of district Sri Muktsar Sahib, Punjab.

Age Group (In Years)	Underweight	Healthy Weight	Overweight	Obese
	(BMI for age < 5th percentile)	(BMI for age 5th to < 85th percentile)	(BMI for age 85th to < 95th percentile)	(BMI for age ≥95th percentile)
5	14 (35%)	23 (57.5%)	01 (2.5%)	02 (5%)
6	18 (45%)	21 (52.5%)	-	01 (2.5%)
7	16 (40%)	24 (60%)	-	-
8	26 (65%)	10 (25%)	-	04 (10%)
9	23 (57.5%)	17 (42.5%)	-	-
10	16 (40%)	21 (52.5%)	02 (5%)	01 (2.5%)
11	13 (32.5%)	22 (55%)	03 (7.5%)	02 (5%)
12	15 (37.5%)	23 (57.5%)	-	02 (5%)
13	14 (35%)	24 (60%)	-	02 (5%)
14	18 (45%)	19 (47.5%)	01 (2.5%)	02 (5%)
15	20 (50%)	12 (30%)	07 (17.5%)	01 (2.5%)
16	17 (42.5%)	22 (55%)	-	01 (2.5%)
17	13 (32.5%)	20 (50%)	04 (10%)	03 (7.5%)
18	13 (32.5%)	18 (45%)	08 (20%)	01 (2.5%)

Table 3: Comparative Analysis of Body Mass Index (BMI – Kg/m^2) of male children and adolescents of present study with other National and International Studies.

Age Group (In Years)	PRESENT STUDY	Revised IAP Standards, 2015 *(Khadilkar et al.,2015)*	Central Indian Population *(Thakur and Gautam, 2017)*	Tamil Nadu Boys *(Kumaravel et al.,2014)*	West Bengal Boys *(Das et al.,2017)*	Rajasthani Boys *(Raikar et al.,2019)*	Haryanvi Males *(Abhilasha and Singh,2019)*	Himachal Pradesh Boys *(Pathania and Biswas,2021)*	Odisha Boys *(Das and Gautam,2022)*
5	14.1	14.7	15.3	14.4	14.0	12.1	16.1	-	-
6	13.2	14.9	16.5	14.3	13.6	11.2		-	-
7	13.5	15.1	18.3	14.7	13.8	12.0	18.3	-	-
8	14.1	15.5	19.5	15.1	13.9	12.0		-	-
9	14.1	15.9	21.9	15.4	14.0	12.6	20.8	-	-
10	14.9	16.4	24.8	15.5	14.1	13.1		-	14.5
11	15.8	17.0	27.4	16.4	14.5	12.9	21.9	-	14.6
12	16.0	17.7	30.7	16.8	14.9	13.4		-	15.4
13	16.8	18.2	33.8	16.7	-	14.1	22.0	-	16.7
14	17.3	18.7	37.3	17.1	-	14.6		-	17.6
15	18.2	19.3	40.0	17.8	-	15.6	22.5	18.7	19.0
16	18.4	19.9	46.3	18.7	-	16.8		18.9	18.9
17	20.5	20.5	51.1	19.4	-	-	24.2	19.7	19.7
18	20.7	21.1	52.0	19.8	-	-		-	19.8

Table 4 : Comparative Analysis of Body Mass Index (BMI – Kg/m^2) of male children and adolescents of present study with other International Studies.

Age Group (In Years)	PRESENT STUDY	WHO, 2006	Pakistani Boys *(Mushtaq et al.,2012)*	Greek Boys *(Bacopoulou et al. 2015)*	US Males *(Cheryl et al.,2016)*	Polish school children *(Natalia et al.,2019)*	Argentina Boys *(Oyhenart et al.,2020)*	Korean adolescents KNHANES *(Kwak et al.,2021)*
5	14.1	16.2	15.2	-	16.1	-	16.8	-
6	13.2	16.3	15.3	-	16.0	-	17.1	-
7	13.5	16.5	15.5	-	16.2	16.1	17.9	-
8	14.1	15.7	16.1	-	16.6	17.1	18.7	-
9	14.1	16.1	16.4	-	17.1	17.8	19.4	-
10	14.9	16.4	17.2	-	17.9	18.3	19.9	19.4
11	15.8	17.0	16.5	-	20.5	18.7	20.7	19.4
12	16.0	17.6	16.1	21.0	19.2	19.2	21.0	20.3
13	16.8	18.3	-	21.4	21.0	20.0	-	20.4
14	17.3	19.1	-	21.1	21.2	20.5	-	21.1
15	18.2	19.8	-	21.9	22.0	21.2	-	20.9
16	18.4	20.6	-	22.4	22.9	22.1	-	22.2
17	20.5	21.2	-	22.6	23.6	22.5	-	22.4
18	20.7	21.8	-	-	24.6	23.0	-	21.8

Table 5 : Comparative Analysis of Waist – Hip Ratio (WHR) and Waist – Height Ratio (WHt.R) of male children and adolescents of present study with other International Studies.

Age Group (In Years)	Waist – Hip Ratio (WHR)				Waist – Height Ratio (WHt.R)			
	PRESENT STUDY	Pakistani Boys *(Mushtaq et al.,2012)*	Greek Boys *(Bacopoulou et al. 2015)*	Macedonian adolescents *(Bojanic et al.,2020)*	Dist. Sri Muktsar Sahib *(Present Study)*	Bangalore Children *(Kuriyan et al.,2011)*	South East Norway Children *(Fredriksen et al.,2018)*	Macedonian adolescents *(Bojanic et al.,2020)*
5	0.90	0.89	-	-	0.44	0.48	-	-
6	0.89	0.89	-	-	0.43	0.47	0.46	-
7	0.85	0.88	-	-	0.41	0.46	0.46	-
8	0.83	0.88	-	-	0.39	0.45	0.45	-
9	0.82	0.88	-	-	0.39	0.45	0.46	-
10	0.83	0.88	-	-	0.40	0.44	0.46	-
11	0.82	0.88	-	0.84	0.40	0.43	0.45	0.46
12	0.82	0.87	0.72	0.82	0.40	0.43	0.46	0.45
13	0.81	-	0.72	0.81	0.39	0.43	-	0.43
14	0.79	-	0.71	0.81	0.39	0.43	-	0.44
15	0.79	-	0.70	0.83	0.40	0.43	-	0.45
16	0.78	-	0.70	0.84	0.39	0.44	-	0.44
17	0.78	-	0.67	0.84	0.41	-	-	0.45
18	0.80	-	-	0.81	0.42	-	-	0.45