A Comparison of International and National References to the Prevalence of Stunting in Pakistani School-age Girls

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Abstract

Background: Epidemiology of stunting in <5 years old is well characterized, however its prevalence in adolescence is inconsistent in different geographical locations. We aimed to estimate the prevalence of stunting in schoolgirls of Punjab, Pakistan according to international and national references, to standardize references and devise strategies to combat stunting in adolescent girls of Punjab, Pakistan.

Methods: In this population wide cross-sectional study, 10,050 schoolgirls aged 8-16 years from 12 different districts of northern, central and southern Punjab were analysed. Prevalence of stunting was calculated by applying Centres for Disease Control and Prevention (CDC) and World Health Organisation (WHO) height-for-age references and the national reference for study population. We used Cohen's kappa statistics to analyse agreement of our data with reference values and chi square test was used as the test of trend.

Results: Marked overestimation of prevalence of stunting was observed (22.72% and 17.49% according to CDC and WHO respectively) in comparison to local reference (4.94%). There was an increasing trend of prevalence of stunting with higher age according to CDC and WHO references; however, data was comparable across all the age groups when local references were applied.

Conclusion: We recommend that prevalence of stunting in school-age girls should be determined by applying local height reference rather than international ones to plan health strategies and treatments in local population.

Background

Malnutrition is a major health care problem in developing countries like Pakistan. Stunting is one of the manifestations of chronic malnutrition and is classified according to world health organisation (WHO) expert committee report as Height-for-age Z-score ≤ -2 standard deviation (SD) from the median height of WHO reference population (1). Stunting is a collective process of diminished body growth which is predominant in early years of life i.e. before 3 years of age and continues into school age children (2) and poor cognitive abilities are highly associated with stunting (3, 4). Several factors can account for stunting such as poor nutrition, poor childcare, adverse environmental and cultural conditions, and recurrent chronic infections. Stunting leads to several adverse outcomes later in adult life and has been found to be associated with neurocognitive impairment, poor educational achievement, poor social progress, increased cardiometabolic disease risk, increased risk of obesity and adverse pregnancy outcomes in females (5–9). Furthermore, stunting is associated with increased risks of morbidity and mortality and is one of the leading causes of childhood death in developing countries. Most of the research projects and health surveys focus mainly on the prevalence of stunting and its associated factors in children under 5 years of age, however relevant data on school aged children is scarce (10–13). Recent researches in different populations provide growing body of evidence that there is a potential of catch-up growth in adolescent age among children with stunting. This catch-up linear growth can possibly lead to transition from stunted to non-stunted state during a growth phase known as the window period (14, 15). The chances of catch-up growth are increased

by adequate hygiene and nutrition, since children continuing to live in poorer/inadequate environments have limited potential for catch-up growth (16). These findings warrant the introduction of child-focussed interventions to tackle the needs of stunted children in a timely and appropriate manner.

Gender bias and female discrimination is common practice with high preference given to male over female children (17). Male children are preferably sent to better class schools for formal education and given better quality and/or amount of food than their female counterparts (18, 19), which contribute to higher prevalence of stunting in females vs. male children (20). It is highly important to identify malnutrition/stunting in young females as this is associated with problems in future pregnancies and birth of premature and low birth weight babies. The low birth weight babies born to short stature mothers are at a higher risk of stunting and have poor postnatal growth (21). On the other hand, well-nourished females face fewer problems during pregnancy and childbirth and have healthier children (22). Most of the studies conducted on Pakistani children to assess stunting have targeted paediatric population less than 5 years of age (23–26). Data about stunting in school-age children is limited (20, 27–31). An effective way to combat stunting and poor educational performance of these children is by adopting healthy lifestyle and eating habits which can have far reaching outcomes on the health of our adult population.

To devise appropriate interventions to combat stunting, the primary task would be to determine the prevalence of stunting and identify this high-risk paediatric population facing this condition of chronic malnutrition manifested in the form of stunting. Stunting in children ≤ 5 years of age is assessed by the universally accepted WHO height-for-age Z-score reference. However, for the school aged children and adolescents there is no consistent reference to be applied throughout the world. Two internationally accepted references i.e. CDC and WHO for estimating stunting are recommended in public health research and clinical practice. These international references are based on nearly identical criteria to determine stunting; the major difference being in categorisation of children falling in normal height or stunted category. Thus according to CDC stunting is defined as height $\leq$ 5th percentile of the reference population; according to WHO stunting is the height ≤ -2 standard deviation (SD) from the median height of the reference population. Therefore, the prevalence of stunting would vary by applying different references i.e. CDC or WHO. Few studies conducted in the school-age children to determine height status have mostly used WHO reference and have obtained variable/conflicting results (20, 28–30). These disagreements can be attributed to the differences in the population and the methodology employed to generate the height cut-offs. Therefore, to correctly categorise height status in Pakistani children, population specific height cut-offs need to be generated and validated. The recommended two references have not been applied extensively to the Pakistani school age population to study the similarities and differences in determining height status. Moreover, the local height cut-offs in comparison to these international references will help understand the degree of agreement in classifying height status among schoolgirls of Punjab, Pakistan.

Punjab is the most populous province of Pakistan and is very diverse both geographically and culturally. Measuring the prevalence of stunting in one or few district can lead to improper estimation of the problem. Therefore, the problem of stunting cannot be confronted efficiently unless regional differences are not thoroughly evaluated. Variability in the estimates of prevalence of stunting in various districts of Punjab (20, 27, 30) can be attributed to the differences in risk factors in various regions of Punjab including

climate, topography, culture, lifestyle, eating habits and the policies executed to combat malnutrition in that region. Regions with low prevalence of stunting might have policies and programmes implemented to promote hygiene, healthy eating habits, effective vaccination schedules and health awareness at the school and regional level. Moreover, low prevalence of stunting can be coupled with an average lower mean height of the locals in that region. On the other hand, higher prevalence of stunting can be the product of poor hygiene, improper diet, inadequate vaccination, lack of maternal education and inappropriate policies to improve public health in the area. Few studies conducted in Pakistani school age children to explore their height status have reported inconsistent results, thereby suggesting that the regional differences can be a contributing factor to variations in stunting (20, 27–31). However, data evaluating these regional differences is limited and no conclusion can be drawn. Highlighting the impact of these regional differences upon the prevalence of stunting will help in tackling this issue in school children in a more efficient manner by modifying the area-based programmes. We have recently generated centile curves for height and compared the percentile values of height with international references (32) but estimates of height status are not known in our study population. Moreover, the regional differences were not considered previously. In this study we aimed to fill these gaps by determining the degree of agreement of our local height-for-age cut-offs obtained from 8-16-year old schoolgirls in comparison with CDC and WHO references. We estimated height status in Punjab overall and then dissected our data in northern, central and southern Punjab. We hypothesized that the height status of our study participants is only slightly comparable with the international references and there is marked inconsistency in between various regions of Punjab.

Methods

Study group

The ethical approval of the study was obtained from The Institutional Ethical Review Committee (vide letter no UHS/ERB/22546/2014) and was conducted at the Department of Physiology & Cell Biology, University of Health Sciences, Lahore, starting in January 2015.

In this cross-sectional study, 10,050 school-age girls were recruited by using stratified multi-stage cluster sampling technique. The study participants were 8–16 years of age and were enrolled from 12 districts and 35 different public and private schools of semi-urban, urban, and rural areas of the Punjab. Province of Punjab was considered the stratum and was further subdivided into three strata i.e. northern, central, and southern Punjab due to topographical, geographical, cultural, environmental and population differences within the three regions, for the purpose of objective sampling. The three regions of Punjab vary markedly in terms of population density, therefore 1355 (13.5%) girls were recruited from northern, 6580 (65.47%) from central and 2115 (21%) from southern Punjab. From each sub-stratum identified, 12 out of 36 districts (geographical division by the Government) were selected as clusters. Districts were stratified using probability proportional to size technique taking into consideration the percentage of adolescent population in each district after obtaining information from Pakistan census bureau (33). Lists of schools were obtained from the Punjab Education Department and school names were stratified considering their urban,

semi-urban and rural status. The grades were chosen from the selected list of schools based upon the age criterion of our study population. From the selected grades the students were selected randomly. During this study a due consideration and importance was given to ethics and privacy rights of the study participants. Prior to data collection the parents were informed about the data collection protocols and procedures and informed written consent was obtained from the parents/guardians of the girls participating in the study. Normal and healthy girls were recruited for this study and those having any past medical history or suffering from metabolic syndrome (like Prader-willi syndrome) or not willing to participate were excluded. To ensure the exact age, the date of birth of each participant was obtained from the school register. The age of the subjects was then calculated from the date of sampling in exact day/month/year. The study population was divided into 12 monthly 9 groups. However, for the analysis and documentation purposes the ages were truncated to full years: thus: for example, 10 years refers to participants aged between 9.5–10.49 years. In the present study we have not stratified our study population based upon the socio-economic status, however the data includes participants from all classes. Therefore, we are confident that the socio-economic class will have little/no effect on our pooled data. The demographic data about the girls was obtained by filling in the questionnaires one to two days prior to our visit to the school for data collection.

Anthropometric measurements

Anthropometric measurements were recorded for everyone by trained personnel following CDC's recommendations given in anthropometry procedures manual 2007 by National Health and Nutrition Examination Survey (NHANES) (34). The assistants in data collection belonged to the medical field and were given extensive training previously to ensure the data quality. The anthropometric measurements comprised recording of height, done in all the subjects.

The same equipment was used to obtain anthropometric data from all the participating subjects for quality assurance. All the measurements were done from eight to eleven in the morning during the school timings with due permission from the principal/dean of the participating school.

Standing Height is the measurement of maximum vertical size of the body and was measured with a portable stadiometer (SECA 217, SECA, USA), consisted of a vertical stand and an adjustable headpiece. Height was measured to the nearest of 0.1 cm. stadiometer was calibrated with a set of predefined lengths to ensure accuracy. While recording the standing height, correct body posture was attained.

Statistical analysis

All data entry and analysis were performed using SPSS Version 15.0 (SPSS Inc. Chicago IL, United States, 2009). The graphs and figures were prepared by using GraphPad Prism version 8.0.0 for windows, GraphPad software, san Diego, California, USA. 'n' represents the number of study participants and values above and below 4SD were considered outliers and not included in the analysis. The outliers were identified from the z-score plot of the parameter under consideration and excluded from the dataset. We applied

World Health Organisation (WHO) 2007 (35), Centres for Disease Control and Prevention (CDC) 2000 (36) and the study population cut-offs to express Height-for-age z-scores and classify stunting among children and adolescent girls of the Punjab. Stunting is classified based upon WHO 2007 reference with height ≥ -2 SD from the median height of the reference population (35) and height $\geq$ 5th percentile of the reference population according to CDC 2000 reference (36). We also obtained height reference cut-offs from our study population by using Height-for-age ≥ -2 SD $\geq$ 2SD as stunted and normal height, respectively. To obtain comparable data across references applied we compared the data of our study group of girls 8–16 years with age and sex matched values obtained from the two international references and then applied cut-offs obtained from our data and estimated height status in our study group. We first calculated the crude prevalence of stunted and normal height girls for the pooled data to determine overall prevalence in the province and then in all the three substrata i.e. northern, central, and southern Punjab individually. We utilised Cohen's *k* statistic to assess the agreement in classification of stunting between the international references CDC, WHO and our study population Height-for-age cut-offs. *k* $\geq$ 0.6 was defined as the poor agreement, 0.6 to $<$ 0.8 as moderate agreement and $\geq$ 0.9 as excellent agreement (37). Chi square test was used as a test of trend to compare differences in the prevalence of stunting between the groups under study, *p*-values $\leq$ 0.05 was considered statistically significant.

Results

The mean age of 10,050 schoolgirls included in this study was 12.7 ± 2.29 years (Mean $\pm$ SD). The overall prevalence of stunting in the study population using two international references is described in Fig. 1. Overall, the percentages of girls with normal height in different age groups under study was quite similar (77.28% and 82.51% respectively). Overall, the prevalence of stunted girls in our study cohort was 22.72%, 17.49% according to CDC and WHO respectively). The prevalence of stunting was similar for younger girls (8, 9 years) according to CDC and WHO, higher among girls of 10–12 years according to WHO as compared to CDC and highest among girls of 13–16 years of age according to CDC as compared to WHO reference (Table 1, Fig. 1). When we applied the local Height-for-age cut-offs obtained from our study population a significantly higher percentage of the girls had normal height (95.06%, *p* $<$ 0.05, Table 1). Overall prevalence of stunting was markedly lower (4.94%, *p* $<$ 0.05, Fig. 1) in all the age groups in comparison with CDC and WHO references. However, among the 8-year-old girls' prevalence of stunting was comparable according to all the three references applied. A notable finding was the increasing trend of prevalence of stunting with increasing age when CDC and WHO references were applied. However, no such trend was observed when the local cut-offs applied (Fig. 1) as the prevalence of stunting was found to be comparable across all the age groups studied. We compared the height values obtained from our cumulative study cohort with CDC and WHO references and then used kappa correlation to assess the degrees of agreement between these references and local reference. There was poor agreement between the local reference in comparison with CDC and WHO ($\kappa = 0.163, 0.325$ respectively) references.

Table 1

Prevalence of stunting by applying height-for-age specific cut-offs from CDC, WHO and the study group in the girls of Punjab; (n = 10,050).

CDC reference										
Height status categories	8 y	9 y	10 y	11 y	12 y	13 y	14 y	15 y	16 y	Overall
No. of children	29	65	64	129	191	332	465	488	520	2283
< 5th percentile										
% Stunting	6.30	10.73	7.54	13.16	14.89	20.65	30.71	34.25	39.25	22.72
No. of children	431	541	785	851	1092	1276	1049	937	805	7767
> 5th percentile										
% Normal	93.70	89.27	92.46	86.84	85.11	79.35	69.29	65.75	60.75	77.28
WHO reference										
No. of children < 2SD	24	63	100	200	225	260	279	274	333	1758
% Stunting	5.22	10.40	11.78	20.41	17.54	16.17	18.43	19.23	25.13	17.49
No. of children > 2SD	436	543	749	780	1058	1348	1235	1151	992	8292
% Normal	94.78	89.60	88.22	79.59	82.46	83.83	81.57	80.77	74.87	82.51
Study group reference										
No. of children < 2SD	14	22	35	47	73	100	70	63	72	496
% Stunting	3.04	3.63	4.12	4.80	5.69	6.22	4.62	4.42	5.43	4.94
No. of children > 2SD	446	584	814	933	1210	1508	1444	1362	1253	9554
% Normal	96.96	96.37	95.88	95.20	94.31	93.78	95.38	95.58	94.57	95.06

To explore the region-specific differences, we sub-categorised the data according to three regions of Punjab i.e. northern, central and southern Punjab. The height status of the girls differed across the study population subgroups when CDC, WHO and local Height-for-age cut-offs were applied. In northern Punjab

(n = 1335), accumulative estimates for percentage of girls of all age groups with normal height were variable when the two references were applied (78.52%, 81.18; according to CDC and WHO respectively) with the highest percentage found when local cut-offs were applied (93.54%, $p \leq 0.05$; Table 2, Fig. 2). Overall estimates of stunted girls in northern Punjab were found to be quite in an agreement when these two cut-offs were applied (21.48% and 18.82% according to CDC and WHO references respectively). When the individual age groups were assessed, similar percentage of girls were stunted for ages 8 and 9 years according to CDC and WHO references (4.38% and 6.43% for CDC and WHO respectively). Girls of ages 10–12 years were more stunted according to WHO (9.55%, 24.48% and 28.66% respectively) as compared to CDC reference (5.06%, 13.29% and 25.61% respectively), 13-16-year-old girls had a higher prevalence of stunting according to CDC (32.37%, 38%, 32.90% and 36.52% respectively) as compared to WHO reference [26.59%, 24.67%, 16.77% and 27.83% respectively (Table 2. Figure 2)]. Overall stunting prevalence in northern Punjab had an agreement across the studied age groups when the two international references were applied. However, the prevalence of stunting was significantly lower with local cut-offs (6.46%, $p \leq 0.05$) in comparison to the two international references, with highest prevalence among the 12- and 13-year-old-girls (12.20%, 15.61% girls stunted respectively).

Table 2

Prevalence of stunting by applying height-for-age specific cut-offs from the CDC, WHO and the study group in the girls of northern Punjab; (n = 1355).

CDC reference										
Height status categories	8 y	9 y	10 y	11 y	12 y	13 y	14 y	15 y	16 y	Overall
No. of children < 5th percentile	6	9	9	19	42	56	57	51	42	291
% Stunting	4.38	6.43	5.06	13.29	25.61	32.37	38.00	32.90	36.52	21.48
No. of children > 5th percentile	131	131	169	124	122	117	93	104	73	1064
% Normal	95.62	93.57	94.94	86.71	74.39	67.63	62.00	67.10	63.48	78.52
WHO reference										
No. of children < 2SD	6	9	17	35	47	46	37	26	32	255
% Stunting	4.38	6.43	9.55	24.48	28.66	26.59	24.67	16.77	27.83	18.82
No. of children > 2SD	131	131	161	108	117	127	113	129	83	1100
% Normal	95.62	93.57	90.45	75.52	71.34	73.41	75.33	82.23	72.17	81.18
Study group reference										
No. of children < 2SD	0	3	6	2	20	27	13	9	2	82
% Stunting	0.00	2.14	3.37	1.40	12.20	15.61	8.67	5.81	6.67	6.46
No. of children > 2SD	137	137	172	141	144	146	137	146	28	1188
% Normal	100.00	97.86	96.63	98.60	87.80	84.39	91.33	94.19	93.33	93.54

Estimates of girls with normal height in the central Punjab region ($n = 6580$) were comparable to two international references applied (75.71%, 81.53% according to CDC and WHO references respectively) and the highest prevalence of girls with normal height was found with the local cut-offs (94.95%, $p \leq 0.05$, Table 3, Fig. 3). Overall estimates of stunting were very high when the two references applied, with the highest prevalence obtained with CDC reference (24.29%, 18.47% according to CDC and WHO respectively, Fig. 3). When CDC and WHO were assessed for all the age groups individually, girls of 8 and 9 years had almost similar prevalence of stunting, higher prevalence was found in age groups 10–12 years according to WHO as compared to CDC and stunting was more prevalent in age groups 13–16 years of age according to CDC as compared to WHO (Fig. 3). Markedly low estimates of stunting were observed in all the age groups when local cut-offs were applied (5.05%, $p \leq 0.05$) in comparison to CDC and WHO. Generally, among the girls of central Punjab a trend of increasing prevalence of stunting was observed with increasing age according to CDC and WHO references. However, when local cut-offs were applied the estimates for stunting among the girls across all the age groups analysed was comparable.

Table 3

Prevalence of stunting by applying height-for-age specific cut-offs from the CDC, WHO and the study group in the girls of central Punjab; (n = 6580).

CDC reference										
Height status categories	8 y	9 y	10 y	11 y	12 y	13 y	14 y	15 y	16 y	Overall
No. of children < 5th percentile	19	38	46	96	122	217	326	354	380	1598
% Stunting	8.23	11.41	9.94	15.14	14.66	19.93	31.80	35.54	38.89	24.29
No. of children > 5th percentile	212	295	417	538	710	872	699	642	597	4982
% Normal	91.77	88.59	90.06	84.86	85.34	80.07	68.20	64.46	61.11	75.71
WHO reference										
No. of children < 2SD	15	37	71	139	144	170	195	201	243	1215
% Stunting	6.49	11.11	15.33	21.92	17.31	15.61	19.02	20.18	24.87	18.47
No. of children > 2SD	216	296	392	495	688	919	830	795	734	5365
% Normal	93.51	88.89	84.67	78.08	82.69	84.39	80.98	79.82	75.13	81.53
Study group reference										
No. of children < 2SD	12	14	27	40	46	55	46	47	23	310
% Stunting	5.19	4.20	5.83	6.31	5.53	5.05	4.49	4.72	4.31	5.05
No. of children > 2SD	219	319	436	594	786	1034	979	949	511	5827
% Normal	94.81	95.80	94.17	93.69	94.47	94.95	95.51	95.28	95.69	94.95

In southern Punjab, 81.37% and 86.38% girls had normal height according to CDC and WHO respectively (Table 4, Fig. 4). However, the highest percentage of girls (96.82%) with normal height was obtained when local cut-offs of height were applied. Accumulative prevalence of stunting was very high across the two

references applied with highest prevalence reported when CDC reference applied (18.63%, 13.62% according to CDC and WHO respectively; Fig. 4). Next, we investigated the prevalence of stunting among the girls of each age group. In the younger age groups i.e. 8–10 years data according to CDC and WHO was comparable. In 11 and 12-year-old girls of southern Punjab, lower prevalence of stunting seen with CDC as compared to WHO and from ages 13–16 years, a higher prevalence found with CDC as compared to WHO reference (Fig. 4). When the local cut-offs were employed, strikingly low prevalence of stunting was found in the girls of southern Punjab (3.18%; $p \leq 0.05$) as compared to CDC and WHO in all the age groups overall with comparable values seen in the individual age groups. When CDC and WHO references were applied an increasing trend in the prevalence of stunting was observed with increasing age in the study participants (Fig. 4). When the three regions of Punjab were compared for height status by applying local height-for-age cut-offs, the highest prevalence of stunting was observed among the girls belonging to northern Punjab and the lowest prevalence among the girls of southern Punjab (Fig. 5).

Table 4

Prevalence of stunting by applying height-for-age specific cut-offs from the CDC, WHO and the study group in the girls of southern Punjab; (n = 2115).

CDC reference										
Height status categories	8 y	9 y	10 y	11 y	12 y	13 y	14 y	15 y	16 y	Overall
No. of children < 5th percentile	4	18	9	14	27	59	82	83	98	394
% Stunting	4.35	13.53	4.33	6.90	9.41	17.05	24.19	30.29	42.06	18.63
No. of children > 5th percentile	88	115	199	189	260	287	257	191	135	1721
% Normal	95.65	86.47	95.67	93.10	90.59	82.95	75.81	69.71	57.94	81.37
WHO reference										
No. of children < 2SD	3	17	12	26	34	44	47	47	58	288
% Stunting	3.26	12.78	5.77	12.81	11.85	12.72	13.86	17.15	24.89	13.62
No. of children > 2SD	89	116	196	177	252	302	292	227	175	1827
% Normal	96.74	87.22	94.23	87.19	88.15	87.28	86.14	82.85	75.11	86.38
Study group reference										
No. of children < 2SD	2	5	2	5	7	18	11	7	6	63
% Stunting	2.17	3.76	0.96	2.46	2.44	5.20	3.24	2.55	6.06	3.18
No. of children > 2SD	90	128	206	198	280	328	328	267	93	1918
% Normal	97.83	96.24	99.04	97.54	97.56	94.80	96.76	97.45	93.94	96.82

Discussion

In this study a large population of Punjabi school going children and adolescent girls ($n = 10,050$) of ages 8–16 years have been analysed for anthropometric measurements. We found very high prevalence of stunting with notable discrepancies in prevalence assessed by using two international height references. Prevalence of stunting was highest with CDC as compared to WHO reference and study population reference. Overall, the two international references for height-for-age showed a moderate degree of agreement among themselves when they were applied to estimate stunting (Fig. 1). Markedly, we found a poor agreement when the two references i.e. CDC and WHO were compared with the height-for-age cut-offs of study population. The results of present study highlight the importance of choice of references used to estimate the height status of children and adolescents to determine stunting, as it can significantly impact the strategies implemented by policy makers to address this abnormality. An appropriate assessment of stunting can also affect the decision of paediatricians to treat such a condition as now there is growing evidence that catch-up growth is possible till 15 years of age (14), thereby children can be stunted during early adolescence and can recover also by the use of timely strategies.

Even though recently there is growing evidence regarding the catchup growth possibilities in early adolescent period, data highlighting the prevalence of stunting in Pakistani adolescent population is very limited. Mostly stunting had been considered and studied in early childhood i.e. less than five years of age. Few studies conducted to estimate stunting in the school age children have applied WHO or CDC reference of height-for-age and found inconsistent results which reduces their usefulness in categorising height status in local population (20, 27–31, 38). We have tackled this problem in this study by applying two international and one local height cut-off reference to the overall Punjab and its regional population to allow a thoughtful comparison between studies regarding prevalence of stunting.

Moreover, when WHO standards were applied to our Pakistani school age children there was an overestimation of prevalence of stunting (20, 28). We have found the similar trend in our data when CDC and WHO references were applied to determine height status in our study population. There was an increasing trend of stunting with increasing ages in the schoolgirls when CDC and WHO references were used, however prevalence of stunting was comparable across all the age groups when study population cut-offs were applied. Additionally, we also found significant differences in stunting prevalence when we applied these references to the school age girls belonging to different regions of Punjab.

In the present study we found approximately 5% stunting overall in the schoolgirls of Punjab, which is partly in agreement with a previous study where they found 8% of children were stunted (28), but is in contrast to other studies which show stunting prevalence of 16% (6–12 years) (20), 16.7% & 14.3% [5–14 years; according to National Health Survey of Pakistan (NHSP) and Karachi surveys respectively] (38), 15.2% (5–14 years) (27), 45.2% (4–12 years), 36% (6–12 years) (30) and 35% (5–10 years) (31) among school children from various regions of the country. In these previous studies the study population (range = 5–14 yrs) was younger than the present study (8–16 years) and with smaller sample sizes (range $n = 200$ –2072) than ours ($n = 10,050$). In these previous studies, only WHO reference was applied while ignoring CDC for estimating stunting prevalence. Moreover, we have also observed that when we applied WHO reference for height the overall prevalence of stunting was 17.49%, which is largely in agreement with the stunting prevalence reported in previous studies as 16% (20), 15.2% (27), 16.7% & 14.3% (38) conducted among

school age children of rural Sindh, southern Punjab, NHSP and Karachi surveys respectively. Therefore, lower prevalence of stunting in our study cohort as compared to previous studies could be due to the WHO reference applied to estimate stunting. Unfortunately, there is no study available in literature from local population where indigenous/local height cut-off reference to define height status have been employed, rendering it impossible to compare estimates of stunting prevalence obtained by our local cut-offs with previous data. The prevalence of stunting as reported in few previous studies conducted on Pakistani school age children showed higher values and inconsistent results and differed from our study estimates (20, 27, 30, 31, 38).

We also noticed significant differences in the estimates of stunting when school going girls of northern, central and southern Punjab were compared (Figs. 2, 3, 4 & 5). Highest prevalence of stunting was found to be present among the northern Punjab schoolgirls (6.46%, $p \leq 0.05$; Fig. 5) and lowest prevalence was estimated among the girls of southern Punjab (3.18%, $p \leq 0.05$; Fig. 5). When we further explored the age wise differences in the stunting prevalence among northern Punjab schoolgirls, a strikingly notable finding was the very high stunting estimates of 12.20% and 15.61% among the age groups 12 and 13 years respectively (Fig. 2). The most likely explanation of this region-specific inconsistency could possibly be the differences in socio-economic status, maternal education status, provision of health facilities, heterogeneous nature of population, diverse cultural practices, variable food habits, level of child's growth and development associated with this chronic malnutrition condition manifested in the form of stunting (39). The identification of these regional differences in the prevalence of stunting especially in adolescent girls is extremely important to target the high prevalence areas with the implementation of programs to prevent complications such as poor obstetrical outcomes, obesity and neurological disorders.

This study emphasizes the importance of comparing internationally used references when applied to paediatric population and their degree of agreement with the study population own cut-offs. The need to generate population specific height references has been highlighted because of variations in height pattern among pre-adolescent and adolescent children especially 7–18 years of age (40). This comprehensive meta-analysis of mean height and pattern of linear growth of populations across the world shows that it is not justifiable to use a single reference throughout the globe to estimate height status, especially for the Asians (40). There are huge differences between the height status of adolescents belonging to different populations, thereby suggesting variations in growth pattern depending upon the genetic and environmental factors which exist in between these populations (41). This suggests the dire need to establish population specific references, which are difficult to validate as there is no gold standard available for comparison for this purpose. Moreover, for the authenticity of the population specific cut-offs, longitudinal studies with comprehensive application of references are required to be considered suitable for application especially in terms of predicting adverse health consequences in adulthood. There is very limited data available to assess the adult health status after applying local references. Although there exists a unanimous consensus for the application of standards to estimate stunting in the younger age groups i.e. till 5 years of age, height-for-age reference values have not been specified for the young adolescent group, thereby rendering it impossible to obtain consistent results regarding the prevalence of stunting among school age children.

This study has certain limitations. First, it is a cross-sectional study and stunting prevalence was estimated at one time point. Longitudinal studies are recommended to determine the trends in height status in our population, to generate population specific references and to determine the health outcomes of stunting in adults. Second this study includes only school age girls, we need to generate height reference data also for boys. Third, the study participants are the schoolgirls belonging to the province of Punjab. This study needs to be expanded to encompass data from all the four provinces of Pakistan.

Conclusions

We report marked differences in the estimation of stunting prevalence among 8-16-year-old schoolgirls of Punjab after applying CDC, WHO and study population own height references. When data was further dissected deeply, region wise differences also existed in the prevalence of stunting across all the age groups studied. When CDC and WHO references were applied there was a remarkable overestimation of stunting observed in our study cohort in comparison to study population own references and there was an increasing trend of stunting prevalence with increasing age of the girls. Our study highlights the importance of generating population specific height reference to determine and monitor stunting in adolescents. The estimation of stunting should be consistent throughout the population to implement appropriate health policies to combat with this nutritional problem in our school age population.

Abbreviations

CDC: Centres for disease control and prevention

WHO: World health organization

IREC: Institutional ethical review committee

NHANES: National health and nutrition examination survey

Declarations

Ethics approval and consent to participate:

The study was approved by the institutional ethical review committee of University of Health sciences, Lahore. An informed written consent was obtained from the parents or legal guardians of schoolgirls participated in this study.

Consent for publication:

Not applicable.

Availability of data and materials:

Data is included in the form of supplementary tables in the manuscript. The datasets analysed in this study are available from corresponding author upon reasonable request.

Competing interests:

The authors have no competing interests to declare in relation to the work presented here.

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Author's contributions:

Conception and design: AK

Analysis, statistical evaluation and interpretation of data: AK

Drafting of the manuscript: AK & RQ

Critical revision of the article for important intellectual content: AK & RQ

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Figures

Figure 1 **Prevalence of stunting in
three regions of Punjab together**

Figure 1

Age related prevalence of stunting in schoolgirls 8-16 years using the height-for-age references of CDC 2000 (dashed line), WHO 2007 (dotted line) and study group (solid line) in Punjab (n=10050).

Figure 2 Prevalence of stunting in northern Punjab

Figure 2

Age related prevalence of stunting in schoolgirls 8-16 years using the height-for-age references of CDC 2000 (dashed line), WHO 2007 (dotted line) and study group (solid line) in Punjab (n=10050).

Figure 3 Prevalence of stunting in central Punjab

Figure 3

Age related prevalence of stunting in schoolgirls 8-16 years using the height-for-age references of CDC 2000 (dashed line), WHO 2007 (dotted line) and study group (solid line) in central Punjab (n=6580).

Figure 4 Prevalence of stunting in southern Punjab

Figure 4

Age related prevalence of stunting in schoolgirls 8-16 years using the height-for-age references of CDC 2000 (dashed line), WHO 2007 (dotted line) and study group (solid line) in southern Punjab (n=2115).

Figure 5 Prevalence of stunting according to international and local height-for-age cut-offs in northern, central, southern and overall Punjab

Figure 5
Prevalence of stunting in schoolgirls 8-16 years according to Height-for-age cut-off values of international and national references in the Punjab and its three regions.

Supplementary Files

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