Height of Iranian Children Age 7-18 in Comparison with WHO (2007), CDC (2000) and NCHS (1977) Global Standards: A Systematic Review and Meta-Analysis

Asou Yazdani
Ilam University of Medical Sciences

Saba Shakarami
Ilam University of Medical Sciences

Reza Najafi
Ilam University of Medical Sciences

Miremad Moafi-Madani
Ilam University of Medical Sciences

Mostafa Dianatinasab (dianati.epid@shmu.ac.ir)
Shahrood University of Medical Sciences  https://orcid.org/0000-0002-0185-5807

Kourosh Sayehmiri
Ilam University of Medical Sciences

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Height of Iranian Children Age 7-18 in Comparison with WHO (2007), CDC (2000) and NCHS (1977) Global Standards: A Systematic Review and Meta-Analysis

Asou Yazdani (1), Saba Shakarami (2), Reza Najafi (3), Miremad Moafi-Madani (4), Mostafa Dianatinasab (5*), Kourosh Sayehmiri (6*)

1 M.Sc. of Biostatistics and Member of Student Research Committee, School of Public Health, Ilam University of Medical Sciences, Ilam, Iran
2 M.Sc. of Epidemiology and Member of Student Research Committee, School of Public Health, Ilam University of Medical Sciences, Ilam, Iran
3 Pediatric Endocrinologist, Department of Pediatrics, School of Medicine, Ilam University of Medical Sciences, Ilam, Iran.
4 Medical Doctor, Mashhad University of Medical Sciences, Mashhad, Iran
5 Department of Epidemiology, Center for Health Related Social and Behavioral Sciences Research, Shahroud University of Medical Sciences, Shahroud, Iran. Email: dianatinasab@sums.ac.ir
6 Professor of Biostatistics, Psychosocial Injuries Research Center, Department of Biostatistics, Ilam University of Medical Sciences, Ilam, Iran, sayehmiri@razi.tums.ac.ir

*Corresponding author(s):
Mostafa Dianatinasab,
Department of Epidemiology, Center for Health Related Social and Behavioral Sciences Research, Shahroud University of Medical Sciences, Shahroud, Iran.
Email: dianati.epid@shmu.ac.ir
Abstract

**Background:** Growth assessment based on standardized height and weight tables and charts is an essential part of healthcare monitoring and services for children and adolescents. The present systematic and meta-analysis study aimed to determine the height of Iranian children aged 7 to 18 years and compare it with the global standards.

**Methods:** A meta-analysis was performed on all relevant studies published until November 2018. The databases Iranmedex, Magiran, SID, IranDoc, Medline, Scopus, PubMed, Science Direct, Web of Knowledge, Cochrane and Google Scholar were searched using mesh and non-mesh keywords. Findings of the reviewed studies were compiled using the random effects model. Data heterogeneity was calculated using the Q statistic and the I² index.

**Results:** 37 articles were found eligible for inclusion in the meta-analysis. The total sample size in these studies was 395,210, consisting of 189,985 males and 205,372 females. The mean height of 18-year-old Iranian girls (\( \bar{x} = 157.75, \%95CI: 156.79 \text{ to } 158.71 \)) was, respectively, 5.30, 5.38, 5.37 cm lower than the reference figures given by WHO (\( \bar{x} = 163.05 \)), CDC (\( \bar{x} = 163.13 \)), and NCHS (\( \bar{x} = 163.12 \)). Similarly, the mean height of 18-year-old Iranian boys (\( \bar{x} = 171.09, \%95CI: 169.72 \text{ to } 172.47 \)) was, respectively, 5.05, 5.09, 5.07 cm lower than the WHO (\( \bar{x} = 176.14 \)), CDC (\( \bar{x} = 176.18 \)), and NCHS (\( \bar{x} = 176.16 \)) standards.

**Conclusions:** Given the slightly different growth pattern and low mean height of Iranian girls and boys compared to the global standards, it is imperative to develop and provide more generalizable growth charts for Iranian children in order to improve the quality of growth assessment undertaken for these age groups.

**Keywords:** Stunting; Height; Growing Child; School Age; NCHS
Background

Growth assessments are an essential part of healthcare monitoring and services for children and adolescents (1-3). Height and weight measurements are highly valued because of the wealth of information they provide for studies on the growth, diet and nutrition, and health of younger people as they develop (4). Growth pattern assessments are excellent measures for multidimensional analysis of growth variations over successive generations and their relationship with the environmental factors. Such assessments are typically performed by the use of standardized height and weight charts and tables developed by the World Health Organization (WHO), United States Centers for Disease Control and Prevention (CDC), United States National Center for Health Statistics (NCHS), and other internationally accredited organizations based on the anthropometric indicators of healthy children (8).

In Iran, as in many other countries, the lack of local standards has led to the use of standardized charts and tables of NCHS as references. Since 1978, WHO has recognized these charts, including the latest version published in 2007, as the global growth standard (11). Considering the variety of genetic, racial, geographic, economic, and social factors involved in the growth process and the fact that reference figures and natural growth patterns vary with the population, these reference charts can lead to erroneous conclusions (13). For example, various studies have shown that the average height of many countries has increased over time (19, 20). In Europe, the average height of adults has been on an increase since the middle of the nineteenth century, but while this increase has been about one centimeter per decade in northern Europe (20), it has been three centimeters per decade in southern and eastern Europe (13). In the Netherlands, the average height has increased from 165cm in 1860 to 181cm in 1990, making the Dutch the tallest nation in the world (20). This trend has also occurred in the United States, which has the world’s most racially diverse population, but the increase in height-for-age has been about 7 centimeters or 4% less than in northern Europe (19). Several anthropometric studies conducted in different parts of Iran show major discrepancies in terms of height percentiles with each other and with the global standards (2, 27-29). Therefore, a closer examination of the issue is necessary, firstly because of the role of growth factors as major metrics for long-term improvement in the public health, and secondly to illustrate the various dimensions of generational changes in growth indices (34, 35).

The growth trends in Iranian students aged 7 to 18 years have been the subject of multiple studies, most
of which have reported some differences from the global standards. However, this is the first
comprehensive meta-analysis of all studies carried out so far on this subject. In this systematic review
and meta-analysis, the authors screened and compiled the existing reports on the average height of 7 to
18-year-old Iranian boys and girls and compared the findings with the global standards so as to
contribute to the development of a clear and explicit local measure for the growth pattern assessment of
Iranian children and adolescents.

Methods

Search strategy

The review study was designed in accordance with the protocols of Systematic Review and Meta-
Analysis (PRISMA) (38). The target material was all studies published in Persian or English until
November 2018. The search was performed in national and international electronic databases including
Iranmedex, Magiran, SID, IranDoc, Medline, Scopus, PubMed, Science Direct, Web of Knowledge,
Cochrane and Google Scholar search engine. The search was conducted by two researchers (S.Sh and
A.Y) independently using identical keywords. Any disagreement was settled by the third researcher
(S.Sh) and the final consensus was reached through group discussion. For Persian databases, the
searched keywords were the Persian equivalents of height, students aged 7 to 18 years, and Iran. For
English databases, the search was performed with mesh terms: Growth Disorders, Stunting, Body
Height, Height, Length, Child, Growing Child, School Age OR 7 to 18 Years, and Iran. To expand the
search, it was repeated with a combination of mesh and non-mesh terms and AND and OR functions.
The reference list of articles was also reviewed. In the event of any ambiguity, inaccuracy, or missing
data, one of the researchers (R.N) contacted the authors via email up to two times. The bibliography of
the found articles was also manually searched to identify more possibly relevant articles (A.Y).

Screening

Inclusion and exclusion criteria

Two of the researchers (AY, KS) screened the articles based on the following inclusion criteria: 1) descriptive design, 2) the studied population being 7 to 18 years old, 3) provision of (mean ± standard
deviation) or (mean ± standard error of the mean) for the studied population, and 4) being focused on
Iran. The exclusion criteria were: 1) non-random sampling, 2) irrelevance to the subject, 3) and article’s lack of sufficient data for meta-analysis.

**Data extraction**

The quality of the articles was evaluated using the STROBE checklist (43). The authors adopted a simple procedure for quality scoring. In this procedure, two of the researchers (S.Sh and A.Y), working independently, gave each part of the checklist a score between 0 and 2, and the articles with total scores of 1-15, 16-30, and 31-44 were classified as poor, moderate and high quality respectively. The articles that earned a score of less than 16 (poor quality) were excluded from the meta-analysis process. Out of the 37 works reviewed, 33 articles, which all had a cross-sectional-observational design, were found eligible for data extraction. The required data were extracted by one of the researchers (A. Y) with the help of a prepared checklist. This checklist was designed to facilitate the organized collection of the data pertaining to the year of publication, age, gender, place of study, sample size, and mean and standard deviation (SD) for all subjects. In the cases where the standard error of the mean (SEM) was reported, the researchers converted it to the standard deviation. Stunting was defined as height-for-age shorter than 3rd percentile or 2 SD below the median of NCHS/WHO growth reference (45). Height reports of all studies were compared with the 50th percentile of the global height reference.

**Statistical analysis**

Data analysis was performed using STATA version 14.2. The results of the studies were combined using the random effects model. Data heterogeneity was measured with Q statistic and $I^2$ index. The level of significance was considered to be $P<0.05$. The analysis was performed in subgroups based on the year of publication, age, gender, study area, sample size, and mean and SD or SEM of the height. A meta-regression was also performed to determine the relationship of the reported heights with the date of report and sample size. Since the effect size was being analyzed for a normally distributed quantitative variable, the mean and standard deviation of the heights were used and the standard error of the study was obtained from the equation $\frac{\sigma^2}{n}$.

The total mean height was calculated by two methods. The first method is the weighted averaging using
the equation \[ \text{weighted mean} = \frac{\sum_{i} w_{i} \hat{y}_{i}}{\sum_{i} w_{i}} \], where \( \hat{y}_{i} \) is the effect size of study \( i \), and \( W_{i} \) is the weight of that study, which here is proportional to the size of the studied population, that is, the population of the province where the study has been conducted. The second method is the meta-analysis of fixed and random effects based on data heterogeneity. In this method, instead of the population of the province, the weights are calculated based on the sample size and the mean error of samples. In this method, the 95% confidence interval is calculated using the equation \[ \bar{y} \pm z_{\frac{a}{2}} \times \frac{s_{y}}{\sqrt{n}} \].

With these explanations, the mathematical formulation of the fixed and random models can be written as follows:

\[ \hat{y} = \frac{\sum_{i} \hat{y}_{i} w_{i}}{\sum_{i} w_{i}} \text{ with } w_{i} = \frac{1}{v_{i}} \]

where

\[ \hat{y}_{i} = \text{value of the parameter in study } i \]

\[ v_{i} = \text{variance of the parameter in study } i \]

\[ \hat{y} = \text{point estimate of the parameter after combining the results of all studies} \]

According to the above formula, the parameter estimate is equal to the weighted sum of parameter values reported in different studies. In this formula, the weight of each study is inversely proportional to the variance of the parameter in that study. In case of using the inverse variance, the weight of each study will be directly proportional to the inverse variance.

In the fixed model, it is assumed that \( \hat{y}_{i} \) follows a normal distribution, or:

\[ \hat{y}_{i} \approx N (y, v_{i}) \]

This means that the observations made in the studies have a normal distribution with a fixed mean \( y \) for the entire population) and a variance of \( v_{i} \). In the random model, it is assumed that:

\[ \hat{y}_{i} \approx N (y, v_{i}) \text{ and } y_{i} \approx N (y, v_{i}) \]

This means that the observations made in each study follow a normal distribution with a mean equal to
the mean in the same population \( (y_i) \), and the parameters in different populations have a normal
distribution with a mean equal to that parameter in all populations \((y)\) and a variance of \(\tau^2\). Hence, the
observed differences have two origins \((\tau^2, \nu)\). Heterogeneity across studies was evaluated by using the
Q statistics at the \( P < 0.10 \) level of significance. We also calculated the \( I^2 \) statistic, which describes the
total variation across studies attributable to heterogeneity rather than chance; an \( I^2 \) value greater than
50% indicates at least moderate heterogeneity and potential publication bias was assessed by visual
inspection of Begg’s funnel plots.

**Results**

In the initial systematic search, a total of 528 articles were identified. Of these, 215 articles were
duplicates and 191 were irrelevant, hence leaving 122 articles eligible for full-text review. After this
review, 37 of these articles were excluded because of inconsistency in terms of target population, 28
were excluded because of missing data, and 17 were excluded because of not meeting the
inclusion/exclusion criteria. The remaining 40 articles were subjected to quality evaluation and 37 of
them were found eligible for inclusion in the final analysis (Figure 1).

The total sample size of the 37 articles included in the meta-analysis was 395,210, of which 189,985
were male and 205,372 were female. These studies were published in Iran between 1991 and 2017. The
profile of the studies included in the meta-analysis is presented in Table 1.

As shown in Figure 2, the mean height of 18-year-old Iranian girls was 157.75 cm (95% confidence
interval: 156.156 – 158.72) and for boys, this figure was 171.09 (95% confidence interval: 169.72-172.47). The lowest and highest heights reported for 18-year-old Iranian girls were related to, respectively,
the study of Mostafa Hosseini (1991) (5), which reported an average height of 153 cm (confidence
interval: 152.89-153-10) for Iranians girls across the country, and the study of Akhi (2007) (34), which
reported an average height of 161 cm (confidence interval: 160.72-161.26) for the city of Sari,
Mazandaran (A). For 18-year-old Iranian boys, The lowest and highest reported heights were in,
respectively, the study of Mohsen Hosseini (2017) (49), which reported an average height of 164 cm
(confidence interval: 163.89-164.10) for Isfahan, and the study of Mehporvar (2015) (47), which
reported an average of 174.44 cm (confidence interval: 174-174.87) for Yazd (B).

According to the results presented in Figure 3, the mean height of Iranian girls and boys is lower than
the global standards. The results also show that Iranian girls and boys in the age group of 7 to 12 years
are only slightly shorter than the global references, but this difference widens from the age of 14 in girls
and 13 in boys. For example, Table 2 shows that at the age of 12, Iranian girls are 4.00, 4.25, and 3.96
cm shorter than the WHO, NCHS and CDC standards, but at the age of 16, this difference widens to
5.11, 5.10, and 5.14 cm, respectively, and remains the same at least until the age of 18 years. For Iranian
boys, the difference from the WHO, NCHS and CDC standards is 5.40, 5.76, and 5.44 cm at the age of
13, slightly changes to 5.20, 5.74, and 5.63 cm at the age of 16 and remains the same at least until the
age of 18. In other words, these differences from the global standards vary with the gender. For girls,
the difference starts at the age of 12 and reaches a maximum of about 5 cm at the age of 18. But for
boys, the difference from the global standards remains almost constant as they go through childhood
and adolescence.

According to the results of meta-regression analysis, the final height of 18-year-old Iranian girls and
boys has not significantly changed with the year of the study. No statistically significant difference was
observed in this regard for boys (P = 0.20) or girls (P = 0.11) (Table 3). Figure 4 shows meta-regression
analysis of random effects model of the mean height of 18-year-old Iranian girls and boys

The results of Table 4 show that among 18-year-old girls of different ethnicities, those belonging to
Kurd and Baluch ethnicities have respectively the highest (159.27 cm) and lowest (155.33 cm) mean
height. Similarly, among 18-year-old boys, those belonging to Kurd and Baluch ethnicities have the
highest (173.72 cm) and lowest (170.03 cm) mean height.

Although the funnel plot was slightly asymmetric, after using the trim-and-fill method, visual inspection
of Begg’s funnel plot did not identify substantial asymmetry for WD studies. Figures not presented here
to save the limited space.

Discussion

To the best of our knowledge, this is the first systematic review and meta-analysis on the height of Iranians aged 7 to 18 years in comparison with WHO, NCHS, and CDC standards. In this study, the growth patterns of Iranian girls and boys were found to be different from the reference patterns. Meta-analysis of studies conducted on 398,758 male and female students showed that Iranian girls of age 10 to 13 are averagely taller than Iranian boys of the same age, but this relation reverses at higher ages. The same trend is present in the WHO standard, but in CDC and NCHS, it starts from the age of 11 instead of 10. In the previous studies, this trend has been attributed to the earlier onset of puberty in girls (50).

Research has shown that the mean age of menarche in Iran is lower than in developed countries (51). For example, the mean age of menarche is 12.43 in the United States (52), 13.1 in Norway (53), 12.27 in Indonesia (54), 12.6 in Colombia (55) and 12.4 in Mexico (56). It is widely known that there are major differences in the age of menarche in different countries and different raced, but the specific reasons for these differences are still not well understood (57). Besides race, multiple factors including biological, social, nutritional, geographical and lifestyle conditions may affect the age of menarche, but overall, early or late onset of menarche cannot be attributed any one factor (58, 59).

Since the meta-analysis showed that the average height of Iranian girls and boys exhibit an almost uniform pattern from the age of 16 to 18, the mean height at the age of 18 was chosen for the final comparison with the global standards. In this comparison, it was found that the mean height of 18-year-old Iranian girls is, respectively, 4.67, 4.75, and 4.74 cm lower than the WHO, CDC, and NCHS standards. For 18-year-old Iranian boys, the mean height is 4.58, 4.62, and 4.60 cm lower than the WHO, CDC and NCHS standards. In these findings, the mean heights of Iranian girls and boys of all ages were closer to the WHO figures than to other standards. The results also showed a 13.18 cm difference in the mean height of Iranian boys and girls at the age of 18, whereas this difference is respectively 13.09, 13.05 and 13.04 cm in WHO, CDC, and NCHS standards.

According to the results of the meta-analysis, the weighted means of the height of Iranian girls and boys of all ages were also lower than the reference standards. All meta-analyses are based on the assumption
that sampling has been random and not stratified. For example, if a study has taken a sample of 500 people from Ilam province, which has a population of 600,000 people, and another study has taken a sample of 500 people from Tehran province, which has a population of 12 million people, then in meta-analysis, weighting to studies is based on inverse variance and sample size we do not give weight to studies base of province population of studies, when we pooled studies we give same weight to all of provinces. But in weighting mean method we use of structure, stratify sampling and population of provinces and sample size of studies accounted in the total mean. As a result, this weighted mean is more accurate than the other mean discussed above. The weighted mean height of 18-year-old Iranian girls was found to be 3.40, 3.48, 3.47 cm lower than the WHO, CDC and NCHS standards. For 18-year-old Iranian boys, the weighted mean of the height was 3.76, 3.80, 3.78 cm lower than the WHO, CDC and NCHS standards, respectively. The weighted mean height of girls and boys at the age of 18 was closer to the WHO reference values than to other standards, nevertheless, there is a substantial difference between the growth trends of Iranian girls and boys and those of the global standards.

The above findings are consistent with the results of Ulijaszek et al. (2001), which after studying the mean height of 7-year-old students in numerous studies, reported that the mean height of Asian populations is approximately 1.0-1.7 cm lower than that of other demographic groups in Europe, Africa, North America, and South America (60). A study conducted on students aged 6 to 16 in Sagamu, Nigeria, showed that the mean height of these students was lower than the WHO and CDC references and generally closer to the former than the latter (61). The findings of the present work are also in agreement with the reports of studies conducted in Italy, Turkey and Saudi Arabia, which showed that, for most ages, stature growths were lower than the reference figures (62-64). A study on the growth of Nigerians aged 1 to 20 also showed that the 50th percentile of children growth chart was lower than that of WHO/FAO standard (65). On the other hand, these findings were inconsistent with the results of a study by Razzaghy et al. (2006), which reported that the height of Iranian boys aged 6 to 15 are comparable to the CDC figures and local standards are only needed for girls of 6 to 17 years old (6). The results are also inconsistent with the findings of Bener et al. (2005) and Fuiano et al. (2005) (66, 67).

These inconsistencies can be attributed to the populations studied in those works. For example, the study
of Razzaghy was conducted on the children of school age in Tehran, which can be hardly generalized to the entire population of Iranian children and adolescents. It should also be noted that the growth rate of girls and boys in different regions is a function of numerous factors. In this regard, some studies have suggested that children who enjoy a better social and economic status are taller than others (45, 68). In another study, race was highlighted as a key factor for the height of children and statistically significant differences were shown between the growth curves of black and white people (69). However, several studies have questioned the role of race in growth indices. For example, Droomers et al. (1995) showed that Indonesian children with high socioeconomic status had higher height and weight than American children (70). Also, the results of a systematic study showed that in low-income and middle-income countries, children living in urban areas are taller than their rural peers (70). The role of health services, education level, and nutritional diet on the height is also well recognized (68). A number of studies have also underscored the role of genetic and environmental factors such as malnutrition, growth retardation, and infection as factors influencing the anthropometric indices in developing countries (71, 72).

The comparison of height indices of Iranian boys and girls with their European and American peers shows significant discrepancies, which can be attributed to differences in environmental, socio-economic, educational, lifestyle, and diet factors. Considering the significant difference between the mean heights of Iranian girls and boys and the global standards, it can be stated that these standards, which are based on the population of American children, are ill-suited for the population of Iranian children and adolescents (71). Because of genetic, economic, social and cultural differences, the existing criteria, which are mostly based on the population of people living in advanced Western nations, cannot be valid for all countries across the world. In addition, relying on the growth indicators designed based on non-local populations may lead to false diagnoses of underweight and short stature (49). The use of global standards can also have secondary effects such as the promotion of ill-fitting ergonomic designs for chairs and tables, which may increase the prevalence of musculoskeletal problems in the local population (73). The results of this study provide evidence in support of the notion that regional growth standards should be developed according to racial, genetic, and geographical specification of each country so that they could be relied upon for use in local studies on health or growth disorders.
The main limitation of this study was the skewed geographical distribution of the reviewed studies, which was reflected in the fact that some provinces had multiple representatives while others had no representative in the analyzed data. The main strength of this work is the large size of the compiled sample, which makes the findings more generalizable for the broader population of Iranian children and adolescents. The findings of this research are based on a sample of about 398,000 people living in different cities across Iran, and considering that height is a quantitative variable, this sample can be considered large enough for reasonable generalization of the results to the whole country. Hence, this is the most accurate estimate of the height status of Iranian girls and boys in different age groups from 7 to 18. The results of this meta-analysis are also consistent with the findings of a study conducted in 2015 by Mehrparvar (46, 47), which is currently the largest nation-wide anthropometry study carried out on six major ethnicities of Iran (Kurd, Lor, Turk, Arab, Persian, and Baluch).

Conclusion

Given the different growth pattern and low mean height of Iranian girls and boys compared to the global standards, the use of these reference charts for Iranian children and adolescents may lead to erroneous conclusions. Therefore, development and promotion of regional growth charts for Iranian children and adolescents seem necessary for reliable evaluation of growth trends and more effective health policy planning in relation to these age groups.

Abbreviations

World Health Organization (WHO), United States Centers for Disease Control and Prevention (CDC), United States National Center for Health Statistics (NCHS), protocols of Systematic Review and Meta-Analysis (PRISMA), standard deviation (SD), standard error of the mean (SEM).

Declarations

Ethics approval and consent to participate

The research proposal was approved by the Ethics Committee affiliated with Ilam University of Medical Sciences. This is a systematic review study then no ethical approval or consent to
participate is applicable to this study.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors stated no conflict of interest.

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Authors’ contributions

All authors contributed extensively to the work presented in this paper. AY and MD designed the study. SS, RN, and KS conceived the study. MM, AY, and SS created and performed the literature search strategy. AY built the data extraction file, AY and SS performed the data extraction and MD and KS supervised the process. MD and KS performed the statistical analyses, and all authors interpreted the data. MM and RN drafted and revised the manuscript, and all the other authors contributed substantially to the writing and revising of the manuscript. All authors have read and approved the final version of the manuscript.

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Table 1: Profile of the studies included in the quantitative meta-analysis.

| ROW | Study                        | Year | Area       | N     |
|-----|------------------------------|------|------------|-------|
| 1   | Mohammad K. (2)              | 1991 | Iran       | 7872  |
|     |                              |      |            | 7896  | 15768 |
| 2   | Hosseini M. (5)              | 1991 | Iran       | 11175 |
|     |                              |      |            | 11174 | 22349 |
|     | (Rural, Urban)               |      |            |       |
| 3   | Ayaatollahi S M T A. (7)     | 1989 | Shiraz     | 642   |
|     |                              |      |            | 565   | 1207  |
| 4   | Motie Langarodi H. (10)      | 1992 | Ghazvin    | 1103  |
|     |                              |      |            | 1113  | 2236  |
| 5   | Aminorroaya M. (15, 16)      | 1997 | Esfahan    | 4150  |
|     |                              |      |            | 4386  | 8536  |
| 6   | Ershadi A. (17)              | 1998 | Kashan     | -     |
|     |                              |      |            | 8093  | 8093  |
| 7   | Ahmadi A. (21)               | 1998 | Kerman     | 3287  |
|     |                              |      |            | 3419  | 6706  |
| 8   | Mohammad K. (2)              | 1999 | Iran       | 8904  |
|     |                              |      |            | 8880  | 17784 |
| 9   | Hosseini M. (5)              | 1999 | Iran       | 12598 |
|     |                              |      |            | 12598 | 25196 |
|     | (Rural, Urban)               |      |            |       |
| 10  | Hajian K. (25)               | 2000 | Babol      | 498   |
|     |                              |      |            | 500   | 994   |
| 11  | Montazerifar F. (30)         | 2000 | Zahedan    | -     |
|     |                              |      |            | 1404  | 1404  |
| 12  | Ebrahimzadeh S. (32)         | 2000 | Mashahad   | 334   |
|     |                              |      |            | 338   | 672   |
|   | Ebrahimzadeh S. (1) | 2001 | Shiraz     | Mashhad | Uromieh | 5808 | 5657 | 11465 |
|---|---------------------|------|------------|---------|---------|------|------|-------|
| 14 | Taheri F.(3)        | 2004 | Birjand    | -       | 1020    | 1020 |
| 15 | Razaghi Azar M. (6) | 2003 | Tehran     | 1512    | 1407    | 2919 |
| 16 | Noghizadeh A. (9)   | 2005 | Ardabil    | 3998    | -       | 3998 |
| 17 | Taghavi N. (12)     | 2005 | Shahrood   | 1234    | 990     | 2224 |
| 18 | Tartibian B. (14)   | 2005 | Uromieh    | -       | 1522    | 1522 |
| 19 | S.M.T A.(18)        | 2006 | Shiraz     | 1141    | 1064    | 2205 |
| 20 | Sohrabi A.(22)      | 2007 | Zahedan    | 34229   | 29551   | 63780|
| 21 | Akhi O.(23)         | 2007 | Sari       | -       | 1233    | 1233 |
| 22 | Shidfar F. (24)     | 2007 | Babol      | -       | 609     | 609  |
| 23 | Nemati A. (26)      | 2008 | Ardabil    | -       | 3741    | 3741 |
| 24 | Habibi E. (31)      | 2009 | Esfahan    | 493     | 489     | 982  |
| 25 | Hafezi R.(33)       | 2010 | Iran       | 1015    | 1015    | 2030 |
| 26 | Mozafari H.(36)     | 2011 | Yazd       | 1080    | 1080    | 2160 |
| 27 | Safari F. (37)      | 2011 | Ghazvin    | -       | 2181    | 2181 |
| 28 | Fakharzadeh L. (39) | 2011 | Abadan     | 1064    | 1076    | 2140 |
| 29 | Mirmohammadi S.J.(40)| 2011 | Iran       | 14924   | 14964   | 30092|
| 30 | Mirmohammadi S.J.(41)| 2012 | Iran       | 6471    | 6287    | 12731|
| 31 | Shahin M.(42)       | 2012 | Ghaenat    | 3200    | -       | 3200 |
| 32 | Baghianimoghadam.(28)| 2012 | Yazd       | 960     | 961     | 1921 |
| 33 | Heydari ST.(44)     | 2014 | Jahrom     | 492     | 500     | 992  |
| 34 | Mehrparvar AH. (46) | 2015 | Iran       | 3590    | 3884    | 7410 |
| 35 | Mehrparvar AH. (47) | 2015 | Iran       | 4703    | 4773    | 9476 |
| 36 | Hosseini M. (48)    | 2016 | Iran       | 6669    | 6451    | 13120|
| 37 | Hosseini S M.(49)   | 2017 | Esfahan    | 23070   | 30751   | 53839|
Table 2: Comparison of the mean height of Iranian girls and boys aged 7 to 18 years with the global standards

| Age (Year) | Gender | Children and adolescents 7 to 12 years old in Iran | *Mean Height length (cm) | Weight % 95 CI | Height length (cm) |WHO | CDC | NCHS |
|-----------|--------|--------------------------------------------------|--------------------------|----------------|-------------------|-----|-----|-----|
| 7         | Male   | 119.30                                            | 117.33                   | 121.27         | 119.36            | 121.73 | 122.03 | 121.76 |
|           | Female | 118.86                                            | 115.92                   | 121.80         | 118.54            | 120.81 | 121.76 | 121.49 |
| 8         | Male   | 124.63                                            | 122.71                   | 126.55         | 124.96            | 127.26 | 128.12 | 127.87 |
|           | Female | 124.24                                            | 121.50                   | 126.99         | 123.80            | 126.55 | 127.82 | 127.58 |
| 9         | Male   | 130.90                                            | 127.08                   | 132.10         | 130.11            | 132.56 | 133.73 | 133.51 |
|           | Female | 129.84                                            | 127.11                   | 132.57         | 129.36            | 132.49 | 133.13 | 132.92 |
| 10        | Male   | 135.05                                            | 133.21                   | 136.90         | 135.40            | 137.77 | 138.82 | 138.61 |
|           | Female | 135.59                                            | 132.93                   | 138.25         | 134.91            | 138.63 | 138.21 | 137.98 |
| 11        | Male   | 139.96                                            | 138.01                   | 141.90         | 139.54            | 143.11 | 143.73 | 143.52 |
|           | Female | 141.72                                            | 138.99                   | 144.45         | 140.98            | 144.99 | 144.26 | 143.97 |
| 12        | Male   | 144.73                                            | 142.24                   | 147.22         | 143.75            | 149.08 | 149.30 | 149.04 |
|           | Female | 147.23                                            | 143.95                   | 150.50         | 146.40            | 151.23 | 151.48 | 151.19 |
| 13        | Male   | 150.64                                            | 147.52                   | 153.75         | 149.02            | 156.04 | 156.40 | 156.08 |
|           | Female | 151.74                                            | 148.57                   | 154.92         | 151.31            | 156.37 | 157.34 | 157.15 |
| 14        | Male   | 157.29                                            | 153.87                   | 160.70         | 155.84            | 163.18 | 164.14 | 163.84 |
|           | Female | 154.93                                            | 152.39                   | 157.47         | 154.68            | 159.78 | 160.47 | 160.39 |
| 15        | Male   | 163.53                                            | 160.21                   | 166.85         | 162.50            | 168.95 | 170.13 | 169.94 |
|           | Female | 156.45                                            | 154.39                   | 158.52         | 156.21            | 161.66 | 161.89 | 161.85 |
| 16        | Male   | 167.87                                            | 165.18                   | 170.55         | 167.56            | 172.89 | 173.61 | 173.50 |
|           | Female | 157.40                                            | 155.83                   | 158.97         | 157.05            | 162.51 | 162.50 | 162.54 |
### Table 3: Meta-regression analysis of random effects of the mean height of 18-year-old Iranian girls and boys

| Variables          | Year | Cons |
|--------------------|------|------|
| Mean height of 18 years old boys |      |      |
| Coef.              | 0.084 | 1.066 |
| Std.Err.           | 0.064 | 129.322 |
| t                  | 1.310 | 0.010 |
| P>|t|               | 0.205 | 0.994 |
| Mean height of 18 years old girl |      |      |
| Coef.              | 0.812 | -5.298 |
| Std.Err.           | 0.048 | 98.224 |
| t                  | 1.660 | -0.050 |
| P>|t|               | 0.113 | 0.958 |

#### Table 4: Comparison of the mean height of 18-year-old Iranian girls and boys based on ethnicity

| Age (Year) | Gender | Mean height length (cm) in difference ethnic | Mean Height length (cm) |
|------------|--------|---------------------------------------------|--------------------------|
|            |        | Persian | Kurd | Turk | Lor | Arab | Balouch | Unknow | Maximum | Minimum |
| 7          | Male   | 119.29  | 118.94 | 119.79 | 118.57 | 123.11 | 119.09 | 118.63 | 123.11 | 118.63 |
|            | Female | 118.86  | 119.36 | 118.68 | 118.81 | 120.95 | 119.03 | 118.52 | 120.95 | 118.52 |
| 8          | Male   | 124.77  | 124.67 | 124.63 | 123.90 | 128.29 | 124.10 | 123.84 | 128.29 | 123.84 |
|            | Female | 124.60  | 124.00 | 123.96 | 123.55 | 127.55 | 124.93 | 122.72 | 127.55 | 122.72 |
| 9          | Male   | 129.71  | 130.61 | 130.31 | 129.56 | 134.78 | 130.48 | 129.33 | 134.78 | 129.33 |
|            | Female | 129.86  | 129.99 | 130.50 | 128.77 | 133.11 | 130.91 | 128.61 | 133.11 | 128.61 |

* Calculated based on weighted mean in Iran
|    | Male     | Female    | Male     | Female    | Male     | Female    |
|----|----------|-----------|----------|-----------|----------|-----------|
| 10 | 134.63   | 135.35    | 134.85   | 135.15    | 139.60   | 139.60    |
|    | 137.87   | 136.78    | 136.18   | 134.70    | 138.81   | 138.81    |
|    | 139.46   | 140.44    | 143.00   | 139.61    | 143.46   | 139.03    |
|    | 141.77   | 143.16    | 143.92   | 140.54    | 144.54   | 140.15    |
|    | 144.08   | 145.60    | 146.61   | 149.25    | 142.54   | 144.26    |
|    | 146.78   | 149.99    | 148.81   | 150.71    | 146.55   | 145.56    |
|    | 144.48   | 152.44    | 153.09   | 150.79    | 156.39   | 149.76    |
|    | 151.55   | 154.37    | 153.12   | 152.08    | 153.74   | 150.04    |
|    | 156.76   | 159.62    | 159.98   | 158.03    | 160.87   | 154.06    |
|    | 154.64   | 157.20    | 156.34   | 155.62    | 155.93   | 153.17    |
|    | 162.79   | 165.95    | 165.78   | 163.16    | 166.11   | 160.82    |
|    | 156.10   | 158.45    | 157.38   | 157.11    | 156.60   | 154.31    |
|    | 167.52   | 170.76    | 168.62   | 167.83    | 170.32   | 165.40    |
|    | 157.03   | 158.99    | 158.99   | 157.51    | 157.40   | 156.18    |
|    | 170.30   | 172.77    | 171.05   | 170.75    | 173.55   | 168.05    |
|    | 157.88   | 159.44    | 159.24   | 157.46    | 157.57   | 156.02    |
|    | 170.35   | 173.72    | 172.02   | 171.85    | 172.26   | 170.03    |
|    | 157.91   | 159.27    | 158.29   | 158.04    | 158.67   | 155.33    |
| 18 | 170.70   | 172.77    | 171.05   | 170.75    | 173.55   | 168.05    |
|    | 157.88   | 159.44    | 159.24   | 157.46    | 157.57   | 156.02    |
|    | 170.35   | 173.72    | 172.02   | 171.85    | 172.26   | 170.03    |
|    | 157.91   | 159.27    | 158.29   | 158.04    | 158.67   | 155.33    |

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|     | Male     | Female    | Male     | Female    | Male     | Female    |
|-----|----------|-----------|----------|-----------|----------|-----------|
| 11  | 139.73   | 139.60    | 139.46   | 139.60    | 139.03   | 139.03    |
|     | 135.78   | 135.15    | 134.85   | 134.85    | 134.22   | 134.22    |
|     | 141.77   | 141.54    | 140.44   | 140.44    | 140.15   | 140.15    |
|     | 144.08   | 142.54    | 145.60   | 145.60    | 142.26   | 142.26    |
|     | 146.78   | 145.56    | 149.99   | 149.99    | 149.25   | 149.25    |
|     | 144.48   | 149.76    | 152.44   | 152.44    | 142.54   | 142.54    |
|     | 151.55   | 149.76    | 154.37   | 154.37    | 150.47   | 150.47    |
|     | 156.76   | 150.04    | 159.62   | 159.62    | 150.72   | 150.72    |
|     | 154.64   | 153.17    | 157.20   | 157.20    | 154.22   | 154.22    |
|     | 162.79   | 160.82    | 165.95   | 165.95    | 153.17   | 153.17    |
|     | 156.10   | 154.31    | 158.45   | 158.45    | 154.31   | 154.31    |
|     | 167.52   | 165.40    | 170.76   | 170.76    | 153.17   | 153.17    |
|     | 157.03   | 158.18    | 158.99   | 158.99    | 158.99   | 158.99    |
|     | 170.30   | 168.05    | 172.77   | 172.77    | 158.04   | 158.04    |
|     | 157.88   | 156.02    | 159.44   | 159.44    | 157.73   | 157.73    |
|     | 170.35   | 170.03    | 173.72   | 173.72    | 159.44   | 159.44    |
|     | 157.91   | 155.33    | 159.27   | 159.27    | 170.03   | 170.03    |

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Figure 1

Diagram of meta-analysis in accordance with PRISMA
### Figure 2

Estimation of the mean height of 18-year-old Iranian girls and boys based on the date of the study

| Study ID | ES (95% CI) | Weight |
|----------|-------------|--------|
| Heydari ST. (2014) | 159.60 (159.10, 160.10) | 4.72 |
| Mehrparvar AH. (2015) | 158.67 (158.29, 159.05) | 4.74 |
| Mehrparvar AH. (2015) | 159.09 (158.72, 159.46) | 4.75 |
| Mehrparvar AH. (2015) | 158.44 (158.08, 158.80) | 4.75 |
| Mehrparvar AH. (2015) | 160.19 (159.78, 160.60) | 4.74 |
| Mehrparvar AH. (2015) | 159.27 (158.86, 159.68) | 4.74 |
| Mehrparvar AH. (2015) | 155.15 (154.81, 155.49) | 4.75 |
| Akhi O. (2007) | 161.00 (160.73, 161.27) | 4.76 |
| MontazeriFar F. (2000) | 155.50 (155.19, 155.81) | 4.76 |
| Nemati A. (2008) | 158.20 (157.94, 158.46) | 4.76 |
| Aminorroaya A. (1997) | 159.00 (158.82, 159.18) | 4.77 |
| Hosseini M. (2016) | 159.60 (159.44, 159.76) | 4.77 |
| Mohamad K. (1991) | 155.00 (154.87, 155.13) | 4.78 |
| Arshadi A. (1998) | 158.40 (158.27, 158.53) | 4.78 |
| Mohamad K. (1999) | 158.00 (157.88, 158.12) | 4.78 |
| Hoseini M. (1991) | 157.00 (156.89, 157.11) | 4.78 |
| Hoseini M. (1991) | 153.00 (152.89, 153.11) | 4.78 |
| Hoseini M. (1999) | 159.00 (158.90, 159.10) | 4.78 |
| Hoseini M. (2008) | 157.00 (156.90, 157.10) | 4.78 |
| Mirmohammadi SJ. (2011) | 158.00 (157.92, 158.08) | 4.78 |
| Hosseini S M. (2017) | 153.80 (153.72, 153.88) | 4.78 |
| Overall (I-squared = 99.9%, p = 0.000) | 157.75 (156.79, 158.72) | 100.00 |

**NOTE:** Weights are from random effects analysis
Figure 3

Comparison of the mean height of Iranian girls and boys during growth with the global standards
Figure 4

Random effects model of the mean height of 18-year-old Iranian girls and boys. Larger circles represent larger sample sizes. Width of the diagram represents the distance.

Supplementary Files

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