ABSTRACT

Background: Evaluation of children’s anthropometrics poses challenges due to age-related changes. The main focus is on height and weight. However, since weight is height-dependent, body mass index (BMI) is the best surrogate measurement of adiposity. Israel has not developed national growth tables; therefore, researchers and clinicians utilize either World Health Organization (WHO) or U.S. Centers for Disease Control and Prevention (CDC) tables as benchmarks.

Objectives: To evaluate the anthropometrics of Israeli children benchmarked by CDC and WHO tables.

Methods: A retrospective review was conducted of the 1987–2003 birth cohort (age 4–18 years) from Clalit Health Services databases. Anthropometrics were retrieved twice: at study entry and one year later. We evaluated them as separate cohorts. Gender-specific age-matched median height and BMI were compared with CDC and WHO height and BMI tables.

Results: The study consisted of 15,650, mean age at study entry 9.5 years (range 4–18). Gender-specific median heights of the Israeli children were similar to CDC and WHO values at younger ages, but were slightly shorter than the age-matched CDC and WHO toward the age of final height in both cohorts. However, gender-specific median BMI was considerably and statistically significant higher compared to CDC and WHO values consistently along the entire age range in both cohorts.

Conclusions: Israeli children were slightly shorter toward the age of final height, compared to WHO and CDC. However, BMI in Israeli children was significantly higher compared to the CDC and WHO consistently along the age range, which raises an alarm regarding obesity patterns.

KEY WORDS: body mass index (BMI), growth, height, obesity, standard deviation score (SDS)

Do Israeli Children's Anthropometrics Comply with World Health Organization and U.S. Centers for Disease Control and Prevention Height and Body Mass Index Tables?

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Evaluating children’s anthropometrics is a complicated process because all measurements should be related to age and gender. We focused on height and weight; however, weight is height-dependent and vice versa [1]. Therefore body mass index (BMI), which is widely accepted as the best surrogate measure of adiposity, is calculated [2]. Longitudinal growth is a multi-factorial process in which the main contributors are genetics (parental height) [3], health status, and environmental factors [4-6]. BMI is also related to genetics but also directly dependent on lifestyle, especially intake and output of calories. Obesity, which is known to be a factor that increases morbidity and mortality [7,8], has become epidemic among children and raises the attention and concern of health authorities [9-12].

Israel health authorities did not develop national growth tables; hence, researchers and clinicians evaluate height, weight, and BMI relative to U.S. Centers for Disease Control and Prevention (CDC) or World Health Organization's (WHO) growth tables [13,14]. BMI in American children is known to be relatively high and pose an emerging health problem in the United States [9,10,15,16].

Previous publications have evaluated and validated the applicability of WHO and CDC to the evaluation of Israeli children [17]. The Israel Ministry of Health official site presents the WHO growth tables [18]. Others have evaluated the appropriateness of U.S. and international BMI-for-age references to define adiposity among Israeli school children [19].

The aim of this study was to evaluate the anthropometry (height and BMI) of an Israeli population sample benchmarked (gender and age matched) by the CDC and WHO.

PATIENTS AND METHODS

The population sample was based on Clalit Health Services (Israel's largest health services provider) anonymous database
samples, approved by Clalit’s institutional review board (IRB) with a waiver from signed consent. This population sample is of a single health care provider, although Clalit insures 5 million members (approximately 55% of the entire Israeli population) under Israel’s National Health Insurance Law. Originally, the sample population served as a control group to assess growth in children with attention deficit hyperactivity disorder prior to treatment.

INCLUSION CRITERIA
The reference population included a 1987–2013 birth cohort of children 4–18 years of age on study entry, during 2003–2017. The study entry date was randomly sampled from available anthropometric measurement data.

Each child’s anthropometrics were retrieved twice: first at study entry and second and second one year later (depending on availability of retrievable anthropometrics). We evaluated these groups as two comparable cohorts; cohort 1 (first measurement) and cohort 2 (second measurement).

EXCLUSION CRITERIA
Individual heights or BMI values < -4 standard deviation score (SDS), or > +4 SDS were considered as most likely measurement or documentation error and were excluded.

DEFINITIONS
Height and weight measurements on their respective dates were retrieved from individual patient electronic medical records, considered as a reliable source. The clinical guideline policy of Clalit Health Services is to measure height and weight of all children at least twice during childhood. Each primary pediatrician and pediatric nurse at a Clalit clinic uses a standard medical weight and height scale to routinely measure and document in the electronic medical record.

BMI was calculated from child’s height and weight, which were usually measured simultaneously.

Age was calculated from the respective date of birth and at measurement date.

We defined “final height” as height at age of 17 for girls and at age of 19 for boys. Given boys age range at study entry was taken at 4–18 years of age, final height of boys was derived from cohort 2.

ANALYSIS
Gender-specific median height curves were calculated by age and presented at half-year intervals.

We used two comparisons tables:
• CDC gender-specific median height and median BMI by age
• WHO gender-specific median height and median BMI by age

Statistical analyses were performed using IBM Statistical Package for the Social Sciences statistics software, version 25 (SPSS, IBM Corp, Armonk, NY, USA).

Standard statistical methods were used to summarize the data. Nominal scale variables were analyzed by frequencies and percentages, and continuous variables were analyzed by means, standard deviation, and medians. All comparisons were 2-sided. P values < 0.05 were considered statistically significant.

The null hypothesis was that our Israeli population sample is not different from the CDC and WHO median curves.

To evaluate differences between the Israeli children versus CDC curves we defined curves as different when ≥ 50% of the age-matched differences between the Israeli children and CDC were statistically significant. We defined similar as when < 50% of the age-matched differences between the Israeli children and CDC were statistically significant.

RESULTS
The population sample included of 15,650/16,240 children (after and before exclusion respectively). The cumulative distribution by age is presented in Figure 1 and presents a considerable and similar representation though not identical by age.

The distribution by district and by socioeconomic category is shown in Table 1.

The population characteristics of first measurement cohort and second measurement cohort are presented in Table 2, which shows diversity in socioeconomic status and wide geographical distribution.

Figures 1A and 1B demonstrate gender-specific median height curves by age in the Israeli sample for each Israeli cohort and the respective CDC and WHO median curves. The CDC curve was nearly identical to that of the WHO for each gender. Height curves of the Israeli girls show increases in height with age, with growth velocity deceleration at 11.5–13.5 years of age [Figure 1A]. Height curves of the Israeli boys show similar increases in height with age, including a growth velocity deceleration...
Figure 1. Israeli sample median height and BMI curves by gender, and by cohort, compared to the respective U.S. Centers for Disease Control and Prevention (CDC) and World Health Organization (WHO) curves

BMI = body mass index
The obesity trend among children is a worldwide concern. Obesity in American children is well known and accordingly poses an emerging health problem in the US [9,10,15,16]. Previous studies have evaluated obesity in Israeli children and its association with potential morbidity but none have shown alarming results [20,21].

**Table 2. Descriptive statistics: Israeli children sample at study entry, by gender**

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>N=7594 (48.5%)</td>
<td>N=8054 (51.5%)</td>
</tr>
<tr>
<td>Year of study entry, range</td>
<td>2003–2017</td>
<td>2003–2017</td>
</tr>
<tr>
<td>Age at height measurement (range)</td>
<td>9.1 years (4–18)</td>
<td>9.2 years (4–18)</td>
</tr>
<tr>
<td>Height, median</td>
<td>132.0 cm</td>
<td>132.0 cm</td>
</tr>
<tr>
<td>Height SDS, median</td>
<td>-0.10</td>
<td>-0.12</td>
</tr>
<tr>
<td>BMI, median</td>
<td>16.9</td>
<td>17.2</td>
</tr>
<tr>
<td>BMI SDS, median</td>
<td>+0.15</td>
<td>+0.22</td>
</tr>
</tbody>
</table>

BMI = body mass index, SDS = standard deviation score

**DISCUSSION**

We evaluated whether Israeli children's anthropometrics were similar to the most frequently used reference tables, namely the CDC and WHO height and BMI tables [17,19]. Israeli children's height is slightly shorter, and became noticeably shorter toward age of final height compared to the references.

The Israeli girl height curves of both cohorts were different versus the CDC. Table 3 shows that the density of statistically significant differences in age-matched increases with age. The two girl cohorts (first and second measurements) were similar between the groups. Similarly, the Israeli boy height curves of both cohorts were different versus the CDC. Table 3 shows that the density of statistically significant increases in age-matched increases with age. The two Israeli boy cohorts were similar. Figure 2 shows that given the large number of measurements, differences between Israeli children height may be statistically significant different than CDC and WHO, despite being less considerable clinically.

Israeli boy BMI curves of both cohorts were visually different than the CDC. However in the two boy cohorts BMI curves were similar between the groups. Similarly, Israeli girl BMI curves of both cohorts were visually different than the CDC. However, BMI curves were similar between the two girl cohorts.

The obesity trend among children is a worldwide concern. Obesity in American children is well known and accordingly pose an emerging health problem in the US [9,10,15,16]. Previous studies have evaluated obesity in Israeli children and its association with potential morbidity but none have shown alarming results [20,21].
LIMITATIONS

Registry is a legitimate data source for research but includes limitations that should be considered. The data were sampled from a single healthcare provider (Israel's largest) that may not precisely represent the entire population. We cannot exclude the possibility that children who were either overweight or of short stature were over-represented due to more frequent visits and repeated measurements, while children with normal anthropometrics were less frequently measured. However, we believe that the large size of the cohort included in this study compensates for most limitations.

CONCLUSIONS

Our findings are disturbing because they show that Israeli children already present a concern for obesity. Given the importance and the consistency of the findings in which BMI starts to diverge early along the curve in Israeli children, we find it to be our responsibility to share these alarming findings and insights with the pediatric and public health communities.

The disturbing findings justify the need to design a broader, nationwide research tool to validate (or negate) these findings. We advise the pediatric associations within the public health services of the Ministry of Health to consider developing national growth curves.

### Table 3. Age-matched statistically significant differences between height of the Israeli children versus the CDC and between the two Israeli cohorts

<table>
<thead>
<tr>
<th>Age, years</th>
<th>Statistical significant difference in age-specific boys BMI (#)</th>
<th>Statistical significant difference in age-specific girls BMI (#)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cohort 1 vs. CDC</td>
<td>Cohort 2 vs. CDC</td>
</tr>
<tr>
<td>4</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>4.5</td>
<td>#</td>
<td>#</td>
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<tr>
<td>5</td>
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<td>5.5</td>
<td>#</td>
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<tr>
<td>6</td>
<td>#</td>
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<td>6.5</td>
<td>#</td>
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<td>7</td>
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<td>7.5</td>
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<td>10.5</td>
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<td>#</td>
</tr>
<tr>
<td>18</td>
<td>#</td>
<td>#</td>
</tr>
<tr>
<td>Rate</td>
<td>19/29 (66%)</td>
<td>19/27 (70%)</td>
</tr>
</tbody>
</table>

BMI = body mass index, CDC = U.S. Centers for Disease Control and Prevention
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REFERENCES

Capsule
Mutations in emerging variants
The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) spike protein mediates host cell entry and contains key epitopes for antibody binding. Emerging SARS-CoV-2 variants, which seem to have originated in immunocompromised patients with prolonged infections, have mutations in the spike protein. Some of these mutations recur in independent lineages and some may compensate for deleterious effects of others and thereby arise together. In a perspective, McCormick and colleagues discussed emerging variants and mutations that may reduce antibody-mediated neutralization of the virus and, potentially, vaccine efficacy.

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Eitan Israeli

Capsule
Separating microbes and cancers
The role of microorganisms in causing and sustaining cancers has been in dispute for centuries. Through the lens of gut- and tumor-associated microbes, Sepich-Poore and colleagues reviewed current understanding of the microbiota in cancer, building a “microbiially conscious” framework. The authors argue that humans should be considered as a meta-organism, but how our microbiota influences cancer is still not well understood mechanistically. Nevertheless, advances in microbiome research are improving the understanding of immunoncology and driving new diagnostic and therapeutic approaches.

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Eitan Israeli