Europe-specific percentile reference values for anthropometric body composition indices and for markers of insulin resistance in children of the IDEFICS study

Consensus Workshop on the Metabolic Syndrome in Childhood
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on behalf of the IDEFICS consortium
Anthropometric percentiles
In order to characterise the nutritional status in children with obesity or wasting conditions, European anthropometric reference values for body composition measures beyond the body mass index (BMI) are needed.

Differentiated assessment of body composition in children has long been hampered by the lack of appropriate references.

The aim of our study is to provide percentiles for body composition indices in normal weight European children, based on the IDEFICS cohort (Identification and prevention of Dietary- and lifestyle-induced health Effects in Children and infantS).

Based on the paper:
The two authors share a near identical body-mass index (BMI), but as dual X-ray absorptiometry imagery shows that is where the similarity ends. The first author (figure, right) has substantially more body fat than the second author (figure, left). Lifestyle may be relevant: the second author runs marathons whereas the first author's main exercise is running to beat the closing doors of the elevator in the hospital every morning.

The contribution of genes to such adiposity is yet to be determined, although the possible relevance of intrauterine under-nutrition is supported by the first author's low birthweight. The image is a useful reminder of the limitations of BMI as a measure of adiposity across populations.
Table 3: Sample size and percentage values of percentiles of waist circumference by age and sex

<table>
<thead>
<tr>
<th>Sex</th>
<th>Age</th>
<th>n</th>
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<td>75.7</td>
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US (NHANES) vs. IDEFICS/European percentiles
(boys; 50th, age 5,7,10 yr)

Percentile Curves for Waist Circumference in 2-20 Year Old Males (NHANES III)

93rd percentile curve passes through 102 cm at 18 years

52.8 vs. 52.0
56.4 vs. 54.9
63.3 vs. 59.2

US (NHANES) vs. IDEFICS/European percentiles (girls, 50th, age 5, 7, 10 yr)

Percentile Curves for Waist Circumference in 2-20 Year Old Females (NHANES III)

- 86th percentile curve passes through 88 cm at 18 years
- 52.5 vs. 51.3
- 55.9 vs. 53.9
- 63.2 vs. 59.5

Flow chart of the inclusion criteria of 2.0-10.9 year old normal weight children

16,228 2.0-10.9 yr old children from T₀ survey

18,745 2.0-10.9 yr old children participated in the whole survey

2,517 2.0-10.9 yr old children from T₁ survey

Exclusion of 5,915 overweight, obese and underweight children based on Cole & Lobstein’s IOTF criteria

12,830 2.0-10.9 yr old normal weight children were included
Numbers of 2.0-10.9 year old normal weight children included in the analyses of anthropometric measures, stratified by sex and country

<table>
<thead>
<tr>
<th>Sex</th>
<th>BMI</th>
<th>Waist circumference</th>
<th>Neck circumference</th>
<th>Triceps skinfold</th>
<th>Subscapular skinfold</th>
<th>Body fat mass</th>
<th>Biceps skinfold</th>
<th>Supra-iliac skinfold</th>
<th>Sum of skinfolds</th>
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<td>5,798</td>
<td>5,768</td>
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<td>1,650</td>
<td>1,624</td>
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<td>1,614</td>
<td>2</td>
<td>1</td>
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<td>1,573</td>
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<td>Total</td>
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<td>11,893</td>
<td>11,845</td>
<td>8,177</td>
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</table>

1: Sample size also for waist-to-height ratio
2: Sample size also for fat mass index
Percentile curves of body mass index in normal weight European girls and boys.
Percentile curves of body fat mass in normal weight European girls and boys
Percentile curves of fat mass index in normal weight European children girls and boys.
Percentile curves of waist circumference in normal weight European girls and boys.
Sensitivity analysis: percentile curves of waist circumference in girls and boys based on all children and for normal weight children only.
Percentile curves of waist-to-height ratio in normal weight European girls and boys

Girls

Boys

Age (y)

Waist to height ratio

P99
P97
P90
P75
P50
P25
P10
P3
P1

P99
P97
P90
P75
P50
P25
P10
P3
P1

Sixth Framework Programme
Percentile curves of neck circumference in normal weight European girls and boys
Percentile curves of biceps skinfolds in normal weight European girls and boys
Percentile curves of triceps skinfold in normal weight European girls and boys
Percentile curves of subscapular skinfolds in normal weight European girls and boys.

**Girls**

- **P99**
- **P97**
- **P90**
- **P75**
- **P50**
- **P25**
- **P10**
- **P3**
- **P1**

**Boys**

- **P99**
- **P97**
- **P90**
- **P75**
- **P50**
- **P25**
- **P10**
- **P3**
- **P1**

**Subscapular skinfold (mm)**

**Age (y)**

- 2
- 4
- 6
- 8
- 10
Percentile curves of suprailiac skinfold in normal weight European girls and boys
Percentile curves of sum of skinfolds in normal weight European girls and boys
The presented percentile curves may aid a differentiated assessment of total and abdominal adiposity in European children.
Percentiles of markers of insulin resistance in pre-pubertal normal-weight European children from the IDEFICS cohort
Aim

- To present age- and sex-specific reference values of markers of insulin resistance (IR) for preadolescent children:
  - Insulin
  - Glucose
  - HOMA-IR (homeostasis model assessment to quantify IR).
  - HbA1c (glycosylated haemoglobin)

→ To provide a basis for early detection of metabolic diseases
Study population

- Children who participated in at least one wave of the IDEFICS surveys
- Normal weight and without diabetes (self-reported)
- 3 to 10.9 years old
- Availability of biological markers

→ 7,074 children (of a total of 18,745 IDEFICS children)
Blood samples and biomarkers

- Blood withdrawal after an overnight fast → Exclusion of some children due to unclear fasting status
- Fractioning of blood at local survey centres
- Freezing of blood fractions at -80°C and shipping on dry ice to a central lab
- Standardised laboratory measurements
  - Glucose by point-of-care testing (Cholestech LDX*)
  - Insulin and HbA1c in central laboratory (accredited according to ISO 15189)

Statistical analysis

- Percentile curves were calculated as a function of age stratified by sex using the ‘Generalised Additive Model for Location Scale and Shape’ (GAMLSS).

- The final models used
  - Box–Cox t (BCT) distribution for **insulin** and **HOMA-IR** (modelling $\mu$ as a cubic spline depending on age, $\log(\sigma)$ as a linear function of age, and $\nu$ and $\tau$ as constants).
  - Lognormal distribution for **glucose** (considering $\mu$ as a linear function of age and $\log(\sigma)$ as a constant).
  - BCT distribution for **HbA1c** (modelling $\mu$ as a cubic spline depending on age, $\log(\sigma)$ and $\nu$ as a linear function of age and $\tau$ as constant).
Reference limit for adults: <174 pmol/l (<25 mIU/l)*

*Roche Diastics. Insulin immunoassay package insert. ms_12017547122
HOMA percentiles

Reference limit for adults: < 2*

Glucose percentiles

Reference limit for adults: 5.6 mmol/l (100 mg/dl)*

HbA1c percentiles

Reference range for adults: 20 - 42 mmol/mol (4.0 – 6.0 %)

Results

- Levels of insulin, fasting glucose and HOMA-IR show a continuously increasing trend with age while HbA1c shows an upward trend only beyond the age of 8 years.

- Insulin and HOMA-IR values are higher in girls of all age groups, whereas glucose values are slightly higher in boys and HbA1c values don’t differ between the sexes.

- Reference values for adults are only of limited use for paediatric practice as most biological markers in children rise with age.
Strengths and limitations

Strengths
- Large prospective European study, standardised survey protocol, focus on young children

Limitations
- No assessment of pubertal stage
Conclusions

- Reference percentiles for markers of insulin resistance were modeled on the basis of the so far largest dataset of healthy preadolescent children.
Thank you for your attention!

Also many thanks to

- The IDEFICS children and their parents for their participation
- Timm Intemann for his enduring help with the GAMLSS modelling
- Ina Alvarez for technical support
- The European Community and the Volkswagen Foundation for funding
Children with normal weight (defined by Cole, WHO or CDC) and children of all weight groups
Sensitivity analysis glucose

Children with normal weight (defined by Cole, WHO or CDC) and children of all weight groups