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THE HUNGARIAN LONGITUDINAL GROWTH STUDY: FROM BIRTH TO THE AGE OF 18 YEARS*

by
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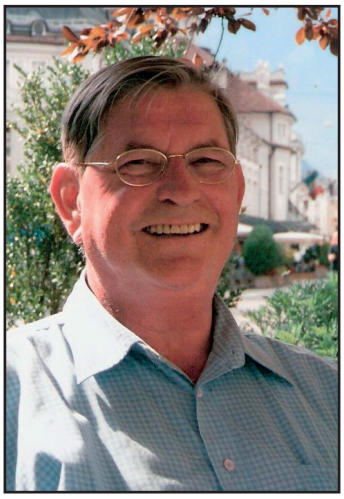
* This volume is a revised and extended English version of the book "Results of the Hungarian Longitudinal Growth Study from birth until 18 years of age" (Az Országos Longitudinális Gyermeknövekedés-vizsgálat eredményei születéstől 18 éves korig I.).

ABSTRACT

This Working Paper presents the main results of the 'Hungarian Longitudinal Growth Study'. It was the first longitudinal, nationally representative research programme in Hungary that focused on children aged between birth and 18 years of age; the number of subjects was 2,984 boys and 2,701 girls at birth, and 516 boys and 523 girls at 18 years of age. The volume is divided in four sections. The first introduces the sampling procedure and the confidence parameters of the studied anthropometric dimensions. The second represents the age-related reference values (mean, standard deviations, centiles) and growth charts (centile distribution) of body length/height, body weight, body mass index, weight-for-height, head circumference, chest circumference, abdominal circumference and skinfold measurements (triceps, subscapular, iliospinal, abdominal) between 0 and 18 years of age. The third section presents the first reference values and charts of body height velocity between three and 18 years of age. From the total sample 325 boys' and 309 girls' individual growth data (aged between three and 18 years) were used to construct these body height velocity references. The fourth section summarises the main results concerning menarcheal age in the studied representative sample. The mean age of menarche was 12.59 years (± 0.96 years SD, n: 1709 girls). By considering the mean age at peak height velocity (PHV: 8.32 cm/year) in girls, i.e. 11.2 years of age and this indicator of sexual maturation, it was possible to state that menarche occurred 16.44 months later than the mean age at PHV in girls in the sample. The differences between mature and non-mature girls (this division was made on the basis of menarche) in body height, body weight, body mass index and chest circumference, were also analysed in the last section. Printed publications arising from research results of the Hungarian Longitudinal Growth Study are listed at the end of the paper.

Keywords: longitudinal growth study, nationally representative sample, reference values, reference growth charts, body weight, body length/height, body mass index, weight-for-height, head circumference, chest circumference, skinfold measurements (triceps, subscapular, iliospinal, abdominal), body height velocity, early and late maturing growth velocity, girls' growth velocity and menarcheal age,, menarcheal age, child care, children, youth, development.

In memory of Prof. Martin van't Hof (Professor of Biostatistics, Dental School, Nijmegen University, the Netherlands; leading researcher of Euro-Growth Study Group; statistical expert of the Nestlé Research Center in Lausanne, Nestlé Nutrition), who supported the research programme by providing advice for the modelling of body height growth velocity and contributing significantly to its implementation.



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(1941–2009)

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FOREWORD

The idea of this research project, presented in this book, comes from my professor János Nemeskéri. In fact, he expected me to design and implement his envisioned 'research on 0 year olds' on a nationally representative sample, parallel to other human biological and bio-demographic studies, when he arranged a position for me at the Department of Population Statistics of the Hungarian Central Statistical Office. With this research, he was eager to prove that measuring merely body weight is insufficient for determining bodily development and nutrition at birth. He claimed that it was necessary to measure length at birth as well, applying international conventions as regards its methods and instruments. In designing the research programme it became evident that this excellent idea required considerable thought and re-conceptualisation, in order to produce results that could be utilised in the daily practice of healthcare. The research, "Medical and demographic study of pregnant women and infants", which was based on this, started in November 1979. Enrolment of pregnant women at healthcare institutions was completed on a 2% nationally representative sample by the end of 1982. On average, the pregnant women were registered in the 9–10th week of their pregnancy, and they were measured and interviewed on the 20th, 27th and 34th weeks after delivery of the child. The birth of the child marked the end of the pregnancy phase of the research, and heralded the start of measurement of infant and child development; this was entitled the Hungarian Longitudinal Growth Study. Measurements of children were taken from birth every 30 days until the age of six months, then every 60 days in the second half year of their lives, and every quarter of a year until the age of 24 months. After this, district and school nurses measured and examined children until the age of 10 each year on their birthday, and every half year between the age of 10 and 18 years.

The study was concluded in 2001 by the measurement and interview of the children born in 1983.

This internationally unique and complex research programme inspects the most important parameters of growth and development, from conception to adulthood, taking into consideration socio-demographic features of the family in doing so.

In this book we describe only a small part of the growth study. We hope to provide in-depth analysis of the results of the pregnancy and child growth study in the next volume.

Measurements of both pregnant women and children were carried out by mother and child health visitors (health visitors in short), who were prepared for these tasks during personal trainings. We are grateful for their conscientious, professional and generous work, since without their assistance this research could not have been completed.

The professional grounding and practical implementation of the research programme was funded by the Department of Maternal, Child and Youth Care of the Hungarian Ministry of Healthcare, the National Institute of Infant and Child Health (NIIC), the Hungarian Central Statistical Office (HCSO), the Department of Population Statistics of HCSO and the Hungarian Demographic Research Institute (HDRI). From these institutions we would like to express our special thanks to Dr. Imre Öry (Department Head), Dr. Attila Pintér (Chief Medical Doctor), Dr. György Vukovich (Department Head, and later Chairman of the HCSO) and Dr. János Nemeskéry (Scientific Advisor, and the initiator of this research). Furthermore, we would like to thank Dr. András Klinger (Department Head, and later Vice-Chairman of the HCSO) for his professional support from the very earliest stages of this research, Dr. Dezső Schuller (Chairman, and Chief Medical Doctor of NIIC) and Dr. Gabriella Vukovich (Vice-Chairwoman and later Chairwoman of the HCSO) for her help in completing the data recording programme. This research could not have been completed without the committed assistance of the directors of the HDRI, of which I am particularly grateful to Dr. István Monigl, Dr. Károly Miltényi, Dr. Józsefné Csernák, Dr. Tamás Faragó and Dr. Zsolt Spéder.

Gyula Simonyi's work, which included developing and updating the enormous database and preparation of the tables, is also highly appreciated.

The technical editing of this volume, including all the tables and graphs, attests to the competence of Ágnes Várnai Anek.

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Finally, I am grateful to Dr. Gyula Gyenis for scientifically reviewing the manuscript, and to Erzsébet Fanni Tóth for linguistic and stylistic review of the text.

Kálmán Joubert

INTRODUCTION

From the very start, the aim of the Hungarian Longitudinal Growth Study was to help the work of paediatricians and health visitors to assess the growth, development, and weight gain of children from birth to adulthood (until the age of 18 years) with its research findings.

The authors worked towards this aim as the research programme progressed, and they published interim results on principal body measurements as the longitudinal nature of the collection data offered increasing opportunities to study the records[1].

The period of data collection of the Hungarian Longitudinal Growth Study ended when those born in 1983 reached the age of 18 years. It was only after this that computer-assisted data analysis of the surveyed children could begin.

For the first time, this volume includes reference means and percentiles for all body measurements processed so far for the period between birth and the age of 18. These body measurements and indices are as follows: body height/body length, body mass, body mass index (BMI), body weight for body height/body length, head circumference, chest circumference, abdominal circumference, and skinfold thicknesses: in the triceps, subscapular, suprailiacal, and abdominal region. The growth rate of body height is also analysed in this volume[2].

In this volume we also publish results concerning the menarcheal age of girls, which was also included in the Hungarian Longitudinal Growth Study.

1 See the references using the results of the Hungarian Longitudinal Growth Study at the end of this volume.

2 Based on the results of the longitudinal study the project produced a CD (*KidLongi 0–18 User CD*) prepared for physicians studying the growth and development of their children patients. The programme makes the assessment and evaluation of growth and development easier and more reliable. It is available in Hungarian and English. A user guide can be downloaded from http://demografia.hu/kiadvanyokonline/index.php/kutatasijelentesek/article/view/2651/2506.

THE STUDY SAMPLING SYSTEM, ELEMENT NUMBER ALTERATIONS, AND RELIABILITY CALCULATIONS

1. GENERAL FEATURES OF THE STUDIED SAMPLE AND SOME METHODOLOGICAL CONCERNS REGARDING THE SURVEYED ANTHROPOMETRIC DATA (KÁLMÁN JOUBERT)

Proper assessment of physical development and growth of children and youth requires norms and reference data representing the entire population of a similar age from birth until adulthood.

When a child is examined, a physician can consider whether the child's body measurements correspond to the age-specific reference values.

Standards appropriate for this purpose are developed by measuring an adequate number of healthy children in each age group, and the percentiles calculated for the distribution of their sizes are plotted graphically. This is done because percentiles show the actual distribution of body measurements better than the mean and the ± standard deviation (±SD). Since growth, development and velocity are determined by numerous factors, there are efforts to provide a description of and standards for children's physical maturity by periodic cross-sectional and follow-up (longitudinal) surveys in most countries with a developed healthcare system. Given that relevant international and Hungarian literature was reviewed in detail in earlier publications (*Joubert–Gárdos 1991; Joubert–Darvay–Ágfalvi 1996)*, we will not refer to them here.

The Hungarian Longitudinal Growth Study started in 1979, under the title of the "Medical and demographic study of pregnant women and infants", which was conducted under the guidance of the authors of this chapter. The research programme performed on a 2% nationally representative sample was implemented by the initiator the Hungarian Demographic Research Institute in co-operation with the National Institute of Infant and Child Health and the HCSO Population Statistics Department.

Children in almost 120 settlements were included in this nationally representative sample. The measurements and personal data were taken by district and school nurses.

In the initial survey phase of the research programme *(Joubert-Gárdos 1991)*, pregnant women were enroled in the sample area from November 1979 to December 1982. The longitudinal growth study started with at-birth measurement of sampled pregnant women's live-born children (*Joubert–Ágfalvi 1988a, 1988b).* Measurements were repeated every 30 days until the age of six months, then every 60 days in the second half year of their lives, and every quarter of a year until the age of 24 months. After this, district and school nurses measured and examined children until the age of 10 every year on their birthday, and every half year between the age of 10 and 18.

Body measurements were recorded according to *Martin and Saller (1957),* and by taking IBP instructions *(Weiner and Lourie 1969)* into account. The training of district and school nurses, as well as regular, local supervisions were conducted by the authors themselves.

In accordance with the request of the Paediatric Professional Board of Hungary, only those born with a weight between 2500 and 4500 grams and who were not suffering from any long-lasting or severe disease that would have influenced their growth and development were included in the reference data population.

The number of children included in the survey reference sample decreased from 5685 individuals at birth (2984 boys and 2701 girls) to 1039 individuals (516 boys and 523 girls) by age 18. The periodic dropout rate and its extent is shown in *Table 1*. The uncorrected regional and national means of anthropometric data recorded until the age of 14 years correspond to nationally representative values *(see the next part of the study)*. Due to regionally characteristic dropout rates, the data became nationally representative only after weighting data from age 14.5 to 18 years . This weighting was developed by a Hungarian expert.

The following measurements were taken from birth to the age of 1[3]:

Body weight (g) (M.71.)
Body length in lying position (cm) (M.1.)
Sitting height in lying position (cm) (M.23.)
Head circumference (cm) (M.45.)
Chest circumference (cm) (M.61.)
Upper arm circumference (M.65.)
Calf circumference (cm) (M.69.)
Biacromial width (cm) (M.35.)
Bicristal width (cm) (M.40.)
Chest width (cm) (M.36.)
Humerus condylus width (mm) (IBP)
Femur condylus width (mm) (IBP)
Foot length (cm) (M.58.)
Skinfold thickness: triceps (mm) (IBP)
Skinfold thickness: subscapula (mm) (IBP)

Some measurements changed between months 15 and 24:

Foot length (M.58) was not measured

Upper extremity length (M.45.a.) and lower extremity length (M.53.) were not measured

Some measurements changed between the age of 3 and 6 years:

Instead of the upper extremity length: acromial height (M.8.) and daktylion height (M.11.) Foot length (cm) (M.58.) was measured again

Foot width (M.59.) was measured

Measurements between the ages of 7 and 18 years

Body weight (g) (M.71.)
Body height (cm) (M.I.)
Shoulder height (mm) (M.8.)
Sitting height (cm) (M.23.)
Head circumference (cm) (M.45.)
Chest circumference (cm) (M.61.)
Chest depth (cm) (M.37.)
Upper arm circumference (cm) (M.65.)
Upper arm circumference flexed (cm) (IBP)
Abdominal circumference at the navel (cm) (IBP)
Calf circumference (cm) (M.69.)
Shoulder width (cm) (M.35.)
Iliocristal width (cm) (M.40.)
Chest width (cm) (M.36.)
Humerus condylus width (mm) (IBP)
Femur condylus width (mm) (IBP)
Foot length (cm) (M.58.)
Skinfold thickness: triceps (mm) (IBP)
Skinfold thickness: subscapula (mm) (IBP)
Skinfold thickness: biceps (mm) (IBP)
Skinfold thickness: suprailiacal (mm) (IBP)

3 Codes in brackets are the Martin and Saller (1957) standards of body measurements; IBP codes are extensions of the original standard by Weiner and Lourie (1969).

Skinfold thickness: abdomen (mm) (IBP)
Skinfold thickness: calf (mm) (IBP)
Foot width (M.59.)
Head circumference (medical)

The following features of the maturation of the children were also recorded:
Menarcheal age
Sexual maturation (according to Tanner, 1962)
Eye colour
Hair colour

From the recorded anthropometric measurements in this volume, the reference means $\bar{x}$, standard deviations (SD) and reference percentiles (3rd, 10th, 25th, 50th, 75th, 90th, and 97th percentiles) of the following body measurements and indices from birth to the age of 18 years were measured and calculated for boys and girls:
Body height (body length)
Body weight
Body mass index (BMI)
Body weight for body height
Head circumference
Chest circumference
Abdominal circumference
Skinfold thickness (triceps, subscapular, suprailiacal and abdominal)

The sample size and number of performed measurements are shown in the *Table 1.1*.

The data in the table show the extent to which the number of surveyed children decreased as time progressed. It also shows the number of measurements taken for each age group. In total, anthropometric measurements of children, and data collections related to their health status, demographic and other social characteristics were conducted on 38 occasions until the age of 18 years as part of the research programme. During this period, health visitors recording the anthropometric data performed a total of 2,823,723 measurements on the surveyed children.

Table 1.1

Sample size and the number of performed measurements from birth until the age of 18 years of children in the Hungarian Longitudinal Growth Study reference population per survey period

Age	Case number (N)		No. of measure-ments	Number of performed measurements	
	Boys	Girls		Boys	Girls
At birth	2 984	2 701	15	44 760	40 515
1 month	2 949	2 662	15	44 235	39 930
2 months	2 938	2 653	15	44 070	39 795
3 months	2 927	2 622	15	43 905	39 330
4 months	2 895	2 603	15	43 425	39 045
5 months	2 869	2 577	15	43 035	38 655
6 months	2 838	2 543	15	42 570	38 145
8 months	2 809	2 519	15	42 135	37 785
10 months	2 789	2 480	15	41 835	37 200
12 months	2 807	2 495	15	42 105	37 425
15 months	2 622	2 325	15	39 330	34 875
18 months	2 597	2 294	15	38 955	34 410
21 months	2 543	2 263	15	38 145	33 945
2 years	2 585	2 304	15	38 775	34 560
3 years	2 351	2 094	17	39 967	35 598
4 years	2 397	2 127	17	40 749	36 159
5 years	2 455	2 207	17	41 735	37 519
6 years	2 469	2 209	17	41 973	37 553
7 years	2 338	2 106	25	58 450	52 650
8 years	2 313	2 082	25	57 825	52 050
9 years	2 277	2 074	25	56 925	51 850
10 years	2 223	2 022	25	55 575	50 550
10.5 years	1 697	1 560	25	42 425	39 000
11 years	1 797	1 644	25	44 925	41 100
11.5 years	1 665	1 532	25	41 625	38 300
12 years	1 750	1 618	25	43 750	40 450
12.5 years	1 604	1 501	25	40 100	37 525
13 years	1 689	1 589	25	42 225	39 725
13.5 years	1 552	1 452	25	38 800	36 300
14 years	1 612	1 530	25	40 300	38 250
14.5 years	1 165	1 138	25	29 125	28 450
15 years	1 186	1 161	25	29 650	29 025
15.5 years	837	839	25	20 925	20 975
16 years	890	882	25	22 250	22 050
16.5 years	655	631	25	16 375	15 775
17 years	692	689	25	17 300	17 225
17.5 years	485	467	25	12 125	11 675
18 years	516	523	25	12 900	13 075
Total				1 475 279	1 348 444
Sum total				2 823 723	

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2. METHODOLOGICAL COMMENTS CONCERNING THE SAMPLING SYSTEM OF THE HUNGARIAN LONGITUDINAL GROWTH SURVEY, WEIGHTING AND RELIABILITY OF THE DATA (ÖDÖN ÉLTETŐ)

The study sample

Preparations for the survey of children born between 1980 and 1983 had already started in the mid-1970s. Thus, several concepts developed before the study had commenced were adapted after implementation. A decision was also made – mainly for organisational but also for financial reasons – to extend the sample to only a few Hungarian counties, specifically 6–7 counties besides Budapest. The counties were chosen to represent one Hungarian region each, taking into account the population ratio in industrial, agricultural and other sectors, the number of children born in 1976 in a given region, their mean weight, and the ratio of infants with a birth weight below 2500 grams. In the end, the following counties (see *Table 2.1*) were sampled from the regions.

Table 2.1

The sampled counties (and Budapest) from the economically different regions of Hungary

Regions	Counties in the region	Sampled counties
South-Transdanubia	Baranya, Somogy, Tolna, Zala	Baranya
North and Central Transdanubia	Fejér, Győr, Komárom, Vas, Veszprém	Vas
North-Hungary	Borsod-Abaúj-Zemplén, Heves, Nógrád	Borsod-Abaúj-Zemplén
North-East Great Plain	Hajdú-Bihar, Szabolcs-Szatmár-Bereg	Hajdú-Bihar
South-East Great Plain	Békés, Csongrád	Csongrád
Central Great Plain	Bács-Kiskun, Jász-Nagykun-Szolnok	Jász-Nagykun-Szolnok
Central region	Pest	Pest
Budapest (capital)		Budapest (capital)

Within the selected counties settlements were stratified according to their (then) administrative status. Thus, towns with county rights and other towns and villages were distinguished. There were only four towns with county rights in the selected counties at the time of sampling. In the next step, paediatrician and school nurse districts were included in the sample by settlement type, through randomization, which meant that the starting number was always half the sampling rate. However, not all of the above-mentioned districts were eligible: districts could only be included in the sample when the district or school nurse agreed to participate, and when he or she was sufficiently prepared for the study's continuous implementation. In theory, all children born between 1980 and 1983 were enroled in the sample within the selected districts. The sample is therefore a *two-step stratified sample with group selection*. In reality, of course, not all children born between 1980 and 1983 were included in the longitudinal sample from the sample districts because participation was voluntary and not all parents gave consent.

The sample size was originally planned to represent five per cent of nurse districts, but later on it was decreased to two per cent for financial reasons. In the end, it was representative of 2.5 per cent of selected districts: 84 of the almost 3380 districts functioning in the late seventies were included in the sample. The distribution of sample districts between regions is therefore almost proportional. During enrolment, 7-8 backup districts were also selected, which could substitute for districts that dropped out.

In Budapest nine nurse districts , six districts from four county towns, 21 districts from 14 other towns, and 48 districts from 48 villages were included in the sample. As regards children born between 1980 and 1983, however, the sample is far from proportionate

both regionally and by settlement type. Moreover, in certain groups there are significant sex-related differences in the enrolment ratios. In the realised sample, the enrolment ratio of children is significantly lower than originally planned: it is hardly more than one per cent. This is partly because many parents did not want to participate in the survey, and partly because the sample is rather small with regard to the number of districts. For this reason the number of children born between 1980 and 1983 might be lower in the sampled districts than the average.

Table 2.2

Overall number of children born between 1980 and 1983, and enrolment ratios by regions, by settlement type and by sex

Region	Settlement type	Overall data			Enrolment ratios %		
		Boys	Girls	Total	Boys	Girls	Total
South-Transdanubia	TCR[a)]	4 249	4 116	8 365	0.33	0.44	0.38
	Other towns	12 091	11 616	23 707	0.94	0.89	0.92
	Village	19 707	18 819	38 526	0.73	0.79	0.77
	Total	36 047	34 551	70 598	0.75	0.78	0.76
North and Central Transdanubia	Other towns	25 321	24 368	49 689	0.78	0.82	0.80
	Village	27 064	25 799	52 863	0.57	0.49	0.53
	Total	52 385	50 167	102 552	0.67	0.65	0.66
North-Hungary	TCR	5 834	5 696	11 530	1.13	0.86	1.00
	Other towns	9 893	9 499	19 392	1.04	1.01	1.03
	Village	22 688	21 327	44 015	1.97	1.99	1.98
	Total	38 415	36 522	74 937	1.60	1.56	1.58
North-East Great Plain	TCR	6 369	5 800	12 169	0.30	0.55	0.42
	Other towns	8 478	7 884	16 362	3.59	3.17	3.39
	Village	20 300	19 703	40 003	1.75	1.72	1.73
	Total	35 147	33 387	68 534	1.93	1.86	1.90
South-East Great Plain	TCR	4 602	4 556	9 158	2.04	2.63	2.34
	Other towns	8 068	7 619	15 687	3.19	2.13	2.67
	Village	9 413	9 042	18 455	2.67	2.51	2.59
	Total	22 083	21 217	43 300	2.72	2.40	2.57
Central Great Plain	Other towns	12 673	12 126	24 799	2.18	2.16	2.17
	Village	14 787	14 288	29 075	0.49	0.43	0.46
	Total	27 460	26 414	53 874	1.27	1.23	1.25
Central region	Other towns	6 370	5 989	12 359	0.61	0.60	0.61
	Village	19 927	18 865	38 792	0.71	0.76	0.74
	Total	26 297	24 854	51 151	0.69	0.72	0.71
Hungary – total	Budapest	44 795	42 485	87 280	0.48	0.46	0.47
	TCR	21 054	20 168	41 222	0.92	1.09	1.00
	Other towns	82 894	79 101	161 995	1.56	1.40	1.48
	Village	133 886	127 843	261 729	1.18	1.15	1.16
	Total	282 629	269 597	552 226	1.16	1.11	1.14

a) TCR – town with county rights.

The initial sample structure is worth presenting in more detail, by comparing the enrolment ratios with the overall number of children born between 1980 and 1983 (*Table 2.2*). As can be seen, there are significant differences in enrolment ratios between groups. While the enrolment ratio for boys is 3.6% in the towns of the North-East Great Plain besides Debrecen, in Debrecen the same ratio for boys is 0.3%. Enrolment ratios show significant differences, not only because survey readiness differed between areas, but also because even if the distribution of the nurse districts was entirely proportionate to regions and settlement types, children's enrolment ratios fluctuated due to group selection and the different sizes of the districts. As a result, weighting had to applied for the calculations of birth data on bigger units – such as for an entire region or for a whole settlement type; weights are reciprocal values of enrolment probabilities. *Table 2.3* shows these weights by sex, settlement type, and for the counties representing the regions. Index f and l refer to the sex (f-for boys and l- for girls). As can be seen, weights fluctuate in quite a broad range (between 28 and 355).

Table 2.3

Initial s^0_{if} and s^0_{il} weights by counties, settlement types and sex

County	TCR		Other town		Village	
	s^0_{if}	s^0_{il}	s^0_{if}	s^0_{il}	s^0_{if}	s^0_{il}
Budapest	206.43	218.99	–	–	–	–
Baranya	303.50	228.67	106.06	112.78	137.81	126.3
Borsod-Abaúj-Zemplén	88.39	116.24	96.05	98.95	50.76	50.18
Csongrád	48.96	37.97	31.39	47.03	37.5	39.83
Hajdú-Bihar	335.21	181.25	27.89	31.54	57.02	58.29
Pest	–	–	163.33	166.36	140.33	131.01
Jász-Nagykun-Szolnok	–	–	45.92	46.28	205.38	230.45
Vas	–	–	127.88	121.23	175.74	203.14

Weighting of the data

In longitudinal surveys, the initial sample usually gradually decreases with the progression of time. In the present case, the initial sample of almost 6300 children also decreased to hardly more than 1150, i.e. almost to one fifth, by the end of the survey when children reached the age of 18. This is partly because not everyone originally enroled could be followed as a result of migration – for instance if the family moved to another county –, and partly because many of the original participants could not or did not want to continue participation. The extent of sample erosion varied markedly by individual county, settlement type, and even by sex. For this reason, initial weights had to be modified in order to be able to make unbiased estimates from data related to later dates. In many counties or settlement types there were no subjects enroled after the age of 14 years, or the number of samples decreased to such a degree that it is impossible to count weights as applied previously for the other age groups and thus make estimates. Therefore, after the age of 14 years weights can only be calculated for Budapest, which are applied to all of the other towns and villages.

When applying weights, we start from the usual but not entirely trivial assumption that the sample for age "t" is a random subsample of the original sample. Hence, the enrolment ratio decreases – and the weight increases – to the extent by which the sample element number decreases in the given group. More precisely, if n^t_{if} and n^t_{il} indicates the

number of boys and girls in the sample among children of "t" age in the "i" area unit (county, type of settlement), then enrolment probabilities for time "t" are:

$$f_{if}^{t} = n_{if}^{t} / n_{if}^{o} \quad f_{if}^{o} = n_{if}^{t} / N_{if} \quad \text{and} \quad f_{il}^{t} = n_{il}^{t} / n_{il}^{o} \quad f_{il}^{o} = n_{il}^{t} / N_{il}$$

and thus the weights are: $s_{if}^{t} = 1 / f_{if}^{t} = N_{if} / n_{if}^{t}$, and $s_{il}^{t} = 1 / f_{il}^{t} = N_{il} / n_{il}^{t}$

*Table 2.*4 shows the values of longitudinal weights for highlighted age groups. As the table shows, the standard deviation of weight is significantly higher for older ages than for the initial weights. Furthermore, in certain cases, weight increase is uneven with the progression of time, and sometimes a decrease is observed. Decreases are the result of migration within a county: if a child in the sample and his/her family moved from a village to a county town or to a town in the county between two sampling dates then from this date onwards the child was listed in the town sample, so the number of sample elements could even increase in the given settlement type between the two dates.

Table 2.4

Longitudinal sample weights by county, by types of settlement, and by sex

County	Settlement type	At the age of 2		At the age of 10		At the age of 14		At the age of 18	
		s_{if}^{0}	s_{il}^{0}	s_{if}^{0}	s_{il}^{0}	s_{if}^{0}	s_{il}^{0}	s_{if}^{0}	s_{il}^{0}
Budapest		271.48	289.01	298.63	314.70	422.59	451.97	597.27	720.08
Baranya	TCR*	708.11	457.33	303.50	171.50	326.85	171.50	–	–
	Other town	132.87	133.52	137.40	127.65	177.81	173.37	–	–
	Village	161.53	156.83	199.06	188.19	255.94	257.79	–	–
Borsod-Abaúj-Zemplén	TCR	102.35	146.05	162.06	172.61	291.70	356.00	–	–
	Other town	100.95	120.24	107.53	111.75	94.22	109.18	–	–
	Village	57.88	57.18	60.99	62.54	118.17	107.71	–	–
Csongrád	TCR	107.02	77.22	124.38	96.94	255.67	189.83	–	–
	Other town	36.67	54.81	41.37	58.61	40.95	53.28	–	–
	Village	40.40	43.06	45.92	51.08	98.05	94.19	–	–
Hajdú-Bihar	TCR	235.89	214.81	219.62	199.03	636.90	374.65	–	–
	Other town	27.09	30.09	30.17	32.18	31.40	31.54	–	–
	Község	59.01	58.12	73.02	75.49	113.41	111.32	–	–
Pest	Other town	182.00	221.81	335.26	272.23	637.00	374.31	–	–
	Village	140.33	141.84	159.42	169.95	311.36	309.26	–	–
Jász-Nagykun-Szolnok	Other town	73.25	81.38	116.27	103.64	248.49	170.79	–	–
	Village	238.50	226.79	254.95	264.59	242.41	246.34	–	–
Vas	Other town	143.06	142.50	147.22	123.07	148.08	133.15	–	–
	Village	196.12	214.99	241.64	299.99	291.01	339.46	–	–
Counties together	Other town	–	–	–	–	–	–	305.17	265.43
	Village	–	–	–	–	–	–	1106.50	846.64

a) TCR – town with county rights; lower case f refers to boys, l refers to girls.

We calculated the mean and standard deviation for several measurements and indices, both weighted and unweighted. We found that there is hardly any difference between weighted and unweighted calculated values until the age of 14, thus for further calculations related to the first 14 years we applied the unweighted method. The only exception is the estimate of the mean and percentile of the menarche age, because if we calculate them unweighted, we obtained downwards-distorted estimates. Since the sample gradually decreased, many of the girls with a relatively late menarche dropped out of the sample.

After the age of 14 years, weighting is definitely necessary, mainly because of the highly uneven decrease of the sample. Decreasing sample sizes, however, make a more detailed (per-county) demonstration of results similar to lower ages impossible; the data can only be processed as broken down by three settlement types: Budapest, towns, and villages. Longitudinal weights in this breaking down for the 14.5 to 18 year olds are demonstrated in *Table 2.5*.

Table 2.5

Longitudinal sample weights for the children aged between 14.5–18 years by sex

Area	14.5 years old	*15 years old*	*15.5 years old*	*16 years old*	*16.5 years old*	*17 years old*	*17.5 years old*	*18 years old*
Boys								
Budapest	497.73	497.73	538.28	503.32	520.88	527.00	597.27	597.27
Towns	137.68	135.53	186.96	173.83	213.83	213.45	306.63	277.94
Villages	295.55	286.69	434.69	417.09	712.16	690.13	977.27	1106.50
Girls								
Budapest	524.51	531.06	590.07	574.12	643.71	634.10	708.08	720.08
Towns	135.06	130.96	176.64	161.64	222.08	274.98	302.65	265.43
Villages	263.59	261.97	382.76	382.76	617.60	586.44	940.02	846.64

The weight numbers above show that sample sizes decreased significantly, particularly in Budapest and in the villages, towards the end of the research. For calculating national results we applied the above weights for 14.5 to 18 year olds.

Reliability of the data

When evaluating the results of any sampling exercise it is essential to have information on the reliability of the data, i.e. on the extent to which sampling error burdens the mean values of different indicators. Margins of error can be characterised as usual, with the 95 per cent confidence interval.

Based on the formula below, confidence intervals of the mean of indicator “x” can be determined as:

$$\bar{x} \pm 1.96 s_{\bar{x}}$$

where $s_{\bar{x}} = s_x / \sqrt{n}$, and “n” is the sample size in the given time, and s_x is the estimate of the standard deviation of a given “x” variable. It is usually expedient if the method of this standard deviation estimate is adjusted to the method of the sampling procedure. As indicated above, the selection procedure of the longitudinal survey sample was a two-step stratified grouped sampling. Unfortunately, error calculations cannot precisely follow the sampling procedure. Since only one county per region was included in the sample, standard deviation between primary units cannot be estimated from the sample.

Estimating the standard deviation component between the health visitor districts is equally problematic. Thus, as an approximation, we regard the sample as a stratified random sample, and standard deviations and confidence intervals of indicators are calculated accordingly. We regard regions (counties selected from the regions) and within this settlement type as strata; thus, in case of national indicators we calculate with 19 strata. We determine the indicators and the standard deviations for the two sexes separately. In *Table 2.6* we list the means of four selected measurements per county, and their 95 per cent confidence intervals for four age groups.

Table 2.6

95% confidence intervals of means $\bar{x} \pm 1.96 s_{\bar{x}}$

Counties and Budapest	Sex	0 year old	2 years old	10 years old	14 years old
		x=Body length (cm)		x=Body height (cm)	
Budapest	Boy	50.76±0.31	89.04±0.53	140.62±1.01	165.54±1.58
	Girl	50.38±0.33	87.73±0.65	140.66±1.12	162.49±1.33
Baranya	Boy	51.70±0.34	87.68±0.52	138.97±0.85	164.27±1.32
	Girl	50.95±0.30	86.58±0.59	139.20±0.92	161.85±0.93
Borsod-Abaúj-Zemplén	Boy	50.30±0.19	87.56±0.31	138.80±0.59	164.07±0.99
	Girl	49.51±0.21	86.34±0.33	138.42±0.59	160.53±0.72
Csongrád	Boy	50.10±0.20	87.80±0.32	137.77±0.65	164.39±0.80
	Girl	49.39±0.21	86.70±0.36	138.20±0.74	161.46±0.75
Hajdú-Bihar	Boy	50.25±0.19	87.52±0.25	138.72±0.48	163.79±0.73
	Girl	49.42±0.19	86.22±0.26	137.83±0.54	160.36±0.58
Pest	Boy	51.29±0.38	87.73±0.68	140.54±0.96	165.36±1.75
	Girl	50.32±0.37	86.58±0.62	139.57±1.06	161.58±1.39
Jász-Nagykun-Szolnok	Boy	50.91±0.27	88.31±0.48	139.28±1.04	164.41±1.59
	Girl	49.96±0.24	87.16±0.49	137.68±0.93	159.16±1.03
Vas	Boy	50.53±0.24	88.27±0.37	139.10±0.77	163.90±1.03
	Girl	49.90±0.24	87.27±0.35	139.81±0.73	161.24±0.75
Hungary – total	Boy	50.55±0.09	87.84±0.14	138.91±0.26	164.21±0.38
	Girl	49.80±0.09	86.66±0.14	138.64±0.27	160.91±0.30
			x=Body weight (kg)		
Budapest	Boy	3.21±0.06	12.87±0.22	35.05±1.21	55.94±2.47
	Girl	3.15±0.06	12.44±0.22	34.19±1.05	55.39±1.75
Baranya	Boy	3.33±0.06	12.76±0.19	33.74±0.83	54.02±1.77
	Girl	3.20±0.05	12.04±0.25	33.32±1.06	52.84±1.37
Borsod-Abaúj-Zemplén	Boy	3.20±0.04	12.41±0.12	33.56±0.67	52.66±1.27
	Girl	3.07±0.04	11.88±0.12	32.55±0.62	51.53±1.07
Csongrád	Boy	3.32±0.04	12.81±0.13	33.80±0.80	55.53±1.34
	Girl	3.19±0.05	12.19±0.15	33.98±0.83	54.80±1.32
Hajdú-Bihar	Boy	3.17±0.04	12.46±0.11	33.94±0.60	53.97±1.13
	Girl	3.05±0.04	11.96±0.11	32.87±0.58	51.91±0.92
Pest	Boy	3.20±0.07	12.67±0.22	33.50±1.07	55.96±2.91
	Girl	3.01±0.21	11.87±0.22	32.45±1.05	51.84±1.86
Jász-Nagykun-Szolnok	Boy	3.35±0.05	12.78±0.18	35.96±1.41	57.27±2.68
	Girl	3.16±0.05	12.15±0.18	33.32±1.15	51.53±1.52
Vas	Boy	3.32±0.05	12.55±0.15	33.36±0.83	52.79±1.34
	Girl	3.22±0.05	12.25±0.16	33.17±0.84	52.16±1.20
Hungary – total	Boy	3.26±0.02	12.61±0.05	33.94±0.30	54.24±0.56
	Girl	3.12±0.02	12.07±0.06	33.15±0.29	52.45±0.46

Table 2.6

95% confidence intervals of means $\bar{x} \pm 1.96 s_{\bar{x}}$ *(Continuation)*

Counties and Budapest	Sex	0 year old	2 years old	10 years old	14 years old
		x=Head circumference (cm)			
Budapest	Boy	33.81±0.20	48.58±0.19	52.92±0.21	54.78±0.28
	Girl	33.55±0.17	47.41±0.22	52.37±0.22	54.39±0.31
Baranya	Boy	34.04±0.19	48.55±0.19	52.84±0.19	54.72±0.23
	Girl	33.43±0.18	47.74±0.20	52.00±0.20	54.16±0.22
Borsod-Abaúj-Zemplén	Boy	33.75±0.12	48.16±0.12	52.60±0.12	54.42±0.18
	Girl	33.14±0.12	47.04±0.12	51.71±0.12	53.83±0.16
Csongrád	Boy	33.39±0.14	48.39±0.13	52.85±0.14	54.76±0.17
	Girl	32.89±0.14	47.11±0.14	52.12±0.15	54.18±0.18
Hajdú-Bihar	Boy	33.63±0.11	48.26±0.10	52.79±0.11	54.74±0.15
	Girl	33.09±0.12	47.13±0.10	51.82±0.11	54.02±0.15
Pest	Boy	33.98±0.21	48.28±0.26	53.08±0.24	55.25±0.34
	Girl	33.23±0.20	46.90±0.21	51.86±0.23	54.35±0.34
Jász-Nagykun-Szolnok	Boy	34.17±0.14	48.81±0.24	52.64±0.20	54.66±0.34
	Girl	33.45±0.14	47.58±0.22	51.71±0.19	54.09±0.27
Vas	Boy	34.15±0.16	48.42±0.15	52.82±0.15	54.86±0.19
	Girl	33.79±0.05	48.37±0.05	52.78±0.05	54.72±0.07
Hungary – total	Boy	33.23±0.05	47.22±0.05	51.92±0.06	54.11±0.07
	Girl	33.81±0.20	48.58±0.19	52.92±0.21	54.78±0.28
		x=Chest circumference (cm)			
Budapest	Boy	32.18±0.24	50.91±0.22	67.34±1.05	79.6±1.50
	Girl	31.99±0.24	49.77±0.35	66.13±1.00	83.00±1.31
Baranya	Boy	32.32±0.24	50.65±0.30	66.30±0.83	77.51±0.98
	Girl	32.09±0.22	49.56±0.30	65.62±0.94	82.04±1.16
Borsod-Abaúj-Zemplén	Boy	31.38±0.17	50.10±0.20	66.24±0.58	78.13±0.84
	Girl	31.07±0.17	49.01±0.19	64.94±0.60	81.32±0.83
Csongrád	Boy	31.52±0.16	50.18±0.20	65.89±0.66	79.00±0.83
	Girl	31.19±0.17	48.93±0.25	65.56±0.74	82.63±0.90
Hajdú-Bihar	Boy	31.91±0.15	50.58±0.17	66.48±0.52	78.23±0.71
	Girl	31.60±0.15	49.35±0.18	65.28±0.56	80.63±0.67
Pest	Boy	32.35±0.24	50.07±0.37	66.01±0.97	80.15±1.55
	Girl	31.74±0.26	48.87±0.34	64.22±0.97	79.76±1.52
Jász-Nagykun-Szolnok	Boy	32.48±0.20	51.71±0.31	68.82±1.23	80.64±1.64
	Girl	31.90±0.20	50.32±0.32	66.05±1.07	81.90±1.24
Vas	Boy	32.58±0.21	50.03±0.23	65.77±0.69	77.94±0.87
	Girl	32.11±0.21	48.97±0.27	64.84±0.75	78.88±0.86
Hungary – total	Boy	31.95±0.11	50.44±0.09	66.42±0.20	78.56±0.23
	Girl	31.60±0.11	49.26±0.09	65.28±0.21	81.11±0.22

In case of means related to aggregates, we apply standard deviation formulas for stratified samples. For instance, in the case of data from the above tables, settlement types are the strata. In case of national means related to settlement types, counties are regarded as strata. Thus, we finally calculate the variance of means related to a specific age "t", and for example for villages, with the following formula:

$$\sigma^2\left[\bar{\bar{Y}}_r^t(k)\right]=\sum_{i=1}^{7}\left[W_r^t(k)\right]^2\sigma^2\left[\bar{\bar{Y}}_r^t(k)\right] \text{ and } \sigma^2\left[\bar{\bar{Y}}_l^t(k)\right]=\sum_{i=1}^{7}W_l^{t\,2}(k)\sigma^2\left[\bar{\bar{Y}}_l^t(k)\right],$$

where $\sigma^2\left[\bar{\bar{Y}}_{jf}^{t}(k)\right]=\frac{1}{\left(n_f^t\right)^2\left(n_f^t-1\right)}\sum_{h=1}^{n_{jf}^t}\left(y_{ihjf}^t-\bar{y}_{jf}^t\right)^2$ is the variance within counties for the age of "t" for boys, and by writing an index "l" instead of "f" for girls, where W^t_{jf} and W^t_{jl} are the relative weight of the "I"[th] county in the basic population for boys and girls.

Table 2.7 contains half of the confidence intervals of the means related to the 14.5 to 18 years olds for variables in *Table 2.6*, completed with BMI values. In line with the above statements, this table shows data broken down only according to settlement type.

Table 2.7

95% confidence intervals of means (Half length of the confidence interval)

Settlements	Sex	Age (year)							
		14.5	15	15.5	16	16.5	17	17.5	18
		Body height							
Budapest	boy	0.017	0.014	0.015	0.014	0.015	0.015	0.013	0.013
	girl	0.015	0.015	0.016	0.016	0.017	0.017	0.018	0.018
Towns	boy	0.006	0.006	0.006	0.006	0.007	0.006	0.007	0.007
	girl	0.005	0.004	0.005	0.005	0.006	0.005	0.007	0.008
Villages	boy	0.007	0.007	0.008	0.008	0.010	0.010	0.011	0.011
	girl	0.005	0.005	0.007	0.007	0.008	0.008	0.010	0.009
Hungary total	boy	0.004	0.004	0.005	0.004	0.005	0.005	0.005	0.005
	girl	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005
		Body weigth							
Budapest	boy	2.73	2.55	2.59	2.35	2.40	2.57	2.41	2.43
	girl	1.94	1.93	2.01	1.98	2.02	2.05	2.30	2.43
Towns	boy	0.84	0.84	0.99	0.92	1.10	1.03	1.17	1.11
	girl	0.66	0.67	0.77	0.72	0.87	0.81	0.96	0.87
Villages	boy	1.07	1.06	1.22	1.17	1.39	1.39	1.47	1.56
	girl	0.89	0.90	1.08	1.07	1.43	1.36	1.88	1.75
Hungary total	boy	0.65	0.64	0.74	0.69	0.79	0.78	0.84	0.83
	girl	0.52	0.52	0.60	0.58	0.72	0.67	0.88	0.82
		Head circumference							
Budapest	boy	0.30	0.30	0.32	0.28	0.26	0.26	0.29	0.28
	girl	0.33	0.33	0.31	0.31	0.32	0.32	0.33	0.32
Towns	boy	0.11	0.12	0.14	0.13	0.16	0.15	0.18	0.17
	girl	0.11	0.11	0.13	0.12	0.16	0.14	0.18	0.16
Villages	boy	0.16	0.16	0.19	0.18	0.22	0.22	0.29	0.29
	girl	0.14	0.13	0.16	0.16	0.19	0.19	0.21	0.20
Hungary total	boy	0.09	0.09	0.11	0.10	0.12	0.11	0.14	0.13
	girl	0.08	0.08	0.10	0.09	0.11	0.11	0.12	0.11

Table 2.7

95% confidence intervals of means (Half length of the confidence interval) (Continuation)

Settlements	Sex	Age (year)							
		14.5	15	15.5	16	16.5	17	17.5	18
		Chest circumference							
Budapest	boy	1.75	1.61	1.70	1.52	1.50	1.60	1.79	1.57
	girl	1.52	1.53	1.85	1.84	1.84	1.57	1.69	1.68
Towns	boy	0.58	0.57	0.64	0.60	0.71	0.68	0.78	0.76
	girl	0.56	0.55	0.61	0.58	0.67	0.65	0.79	0.73
Villages	boy	0.77	0.78	0.86	0.83	1.02	0.98	1.08	1.14
	girl	0.78	0.75	0.91	0.88	1.13	1.09	1.38	1.30
Hungary total	boy	0.45	0.45	0.50	0.47	0.54	0.52	0.59	0.57
	girl	0.45	0.43	0.51	0.48	0.58	0.54	0.67	0.61
		BMI							
Budapest	boy	0.74	0.71	0.70	0.63	0.65	0.69	0.65	0.65
	girl	0.58	0.58	0.59	0.58	0.61	0.61	0.74	0.76
Towns	boy	0.23	0.23	0.28	0.26	0.32	0.29	0.33	0.32
	girl	0.23	0.23	0.27	0.25	0.30	0.28	0.32	0.29
Villages	boy	0.31	0.31	0.35	0.33	0.41	0.40	0.45	0.48
	girl	0.31	0.30	0.35	0.35	0.44	0.42	0.56	0.53
Hungary total	boy	0.18	0.18	0.21	0.19	0.23	0.22	0.24	0.24
	girl	0.18	0.18	0.20	0.19	0.23	0.22	0.27	0.26

Methods used for the statistical analyses

When analysing data, our goal is simple: we wish to make the strongest possible conclusion from limited data. To do this we need to overcome at least one serious problem: differences can be obscured by biological variability and experimental imprecision. This makes it difficult to distinguish real differences from random variability. Statistical analyses are therefore necessary when observed differences are small compared to experimental imprecision and biological variability. Nevertheless, in many fields, we cannot avoid large amounts of variability yet care about relatively small differences. Statistical methods are necessary to draw valid conclusions from such data. In the case of our study, when sample sizes seem to be sufficiently high – and the sample sizes in this survey may be considered large enough even taking into account decreases during the survey – then the significance of differences of the means can be tested with the so-called *asymptotic z-test.* If a sample is large enough then the distribution of the mean will approximate the normal distribution well, and thus the variable

$$z = \frac{\bar{y} - \bar{x}}{\sqrt{\frac{s_y^2}{n_y} + \frac{s_x^2}{n_x}}}$$

follows a standard N(0,1) normal distribution with a good approximation, in case the H_0 hypothesis is valid, i.e. the two means are equal. Based on the table of the standard normal distribution function we can decide whether the value “z” we obtained based on the sample data can be regarded as significant, or at what level can it be regarded as significant.

We should, however, pay attention to the fact that the condition of applying the z-test is that the two means to be tested should derive from independent samples taken from two distributions of identical standard deviations. If we have several samples and we want to study the significance of the difference of several means then the analysis of variance described in the next section should be performed first, to decide whether the means in question can be considered as originating from independent samples taken from the same population. This is the situation, for example, when we want to test the difference of the county means. If we have several independent samples from the same population then one or two significant differences between the means may arise as a result of random effect. So, in such a case, we first have to test whether the hypothesis that the samples arise from an identical distribution is valid, or whether it should be rejected with an *analysis of variance*. During the analysis we applied the z-test only within the given regional units to study the significance of differences between boys' and girls' means, because they theoretically derive from different distributions. There are usually no significant differences regarding the standard deviations, so their populational equality can generally be assumed. The results of z-tests for the different indicators for 0 to 14 year-olds are shown in *Table 2.8*, and those for 14.5 to 18 year olds are shown in *Table 2.9*. In the tables *** indicates that the obtained z-value is significant at a level of at least p<0.001; ** if it is significant at a level of p<0.01; and *, if the level of significance is p<0.05.

Table 2.8

Differences of basic physical characteristics between the sexes in various ages (age 0 to 14 years) tested by a z-test (z-values)

Counties and Budapest	Age (year)			
	0	2	10	14
	x=Body length (cm)		x=Body height (cm)	
Budapest	1.66	3.06**	–0.05	4.24***
Baranya	3.24***	2.74**	–0.36	2.93**
Borsod-Abaúj-Zemplén	5.54***	5.24***	0.89	5.69***
Csongrád	4.80***	4.48***	–0.85	5.22***
Hajdú-Bihar	6.01***	6.94***	2.41**	15.36***
Pest	3.56***	2.46**	1.33	3.31***
Jász-Nagykun-Szolnok	5.16***	3.28***	2.25**	5.42***
Vas	3.65***	3.82***	–1.30	4.08***
Hungary – total	11.87***	11.73***	1.42	13.47***
		Body weight		
Budapest	0.93	2.70**	1.05	1.65*
Baranya	3.17***	3.89***	0.61	1.03
Borsod-Abaúj-Zemplén	4.31***	6.05***	2.17**	1.33
Csongrád	4.14***	6.17***	–0.31	0.76
Hajdú-Bihar	4.54***	6.42***	2.51**	2.78**
Pest	3.86***	5.03***	1.37	2.34**
Jász-Nagykun-Szolnok	5.11***	4.87***	2.84**	3.65***
Vas	2.85**	2.75**	0.31	0.69
Hungary – total	907.57***	13.65***	3.65***	4.84***

Table 2.8

Differences of basic physical characteristics between the sexes in various ages (age 0 to 14 years) tested by a z-test (z-values) (Continuation)

Counties and Budapest	Age (year)			
	0	2	10	14
	Head circumference			
Budapest	1.95*	7.89***	30.48***	1.83*
Baranya	4.60***	5.77***	6.02***	3.54***
Borsod-Abaúj-Zemplén	7.00***	12.84***	10.29***	4.87***
Csongrád	4.95***	13.10***	7.15***	4.59***
Hajdú-Bihar	6.51***	15.03***	12.06***	6.74***
Pest	5.11***	8.03***	7.15***	3.66***
Jász-Nagykun-Szolnok	7.20***	7.49***	6.52***	2.55**
Vas	4.34***	10.37***	7.03***	3.84***
Hungary – total	14.56***	29.26***	21.66***	11.69***
	Chest circumference			
Budapest	1.10	4.38***	1.63	3.19***
Baranya	1.38	5.03***	1.07	–5.85***
Borsod-Abaúj-Zemplén	2.50**	7.76***	3.07***	–5.29***
Csongrád	2.75**	7.65***	0.65	–5.80***
Hajdú-Bihar	3.65***	77.89***	3.10***	–9.87***
Pest	3.34***	4.64***	2.55**	0.35
Jász-Nagykun-Szolnok	4.02***	6.11***	3.34***	–1.21
Vas	3.14***	5.76***	1.75*	–1.51
Hungary – total	6.90***	18.39***	5.93***	–10.17***

Table 2.9

Differences in basic physical characteristics between the sexes at various ages (age 14.5 to 18) tested by a z-test (z-values)

Settlement type	Age (year)							
	14.5	15	15.5	16	16.5	17	17.5	18
	Body height							
Budapest	4.37***	5.60***	7.18***	7.30***	7.88***	9.65***	10.53***	11.35***
Towns	Each value is significant at p<0.001 level							
Villages	Each value is significant at p<0.001 level							
Hungary – total	Each value is significant at p<0.001 level							
	Body weigth							
Budapest	2.71**	3.65***	3.85***	4.93***	5.01***	5.59***	7.09***	6.70***
Towns	Each value is significant at p<0.001 level							
Villages	Each value is significant at p<0.001 level							
Hungary – total	Each value is significant at p<0.001 level							

Table 2.9

Differences in basic physical characteristics between the sexes at various ages (age 14.5 to 18) tested by a z-test (z-values) (Continuation)

Settlement type	Age (year)							
	14.5	15	15.5	16	16.5	17	17.5	18
	Head circumference							
Budapest	2.79**	3.15***	2.94***	3.25***	3.73***	3.47***	4.17***	4.39***
Towns	Each value is significant at p<0.001 level							
Villages	Each value is significant at p<0.001 level							
Hungary – total	Each value is significant at p<0.001 level							
	Chest circumference							
Budapest	–0.83	–0.59	–0.88	–0.43	0.40	0.34	1.63	1.07
Towns	–5.80***	–4.76***	–4.06***	–2.76**	–0.64	0.1	0.25	0.78
Villages	–3.44***	–3.26***	–2.48**	–2.96**	–2.60**	–2.47**	–2.70**	–2.40**
Hungary – total	–6.01***	–5.26***	–4.39***	–3.97***	–2.89**	–1.70*	–1.67*	–1.53

As can be seen from the above tables, boys' and girls' means differ significantly among 0 to 14 year olds in the majority of counties and indicators, yet non-significant differences can also be seen. Thus, body height is usually not significantly different for 10 year old boys and girls. However, body weight is not significantly different in the two sexes among ten year olds in five counties. Moreover, in four counties it is not significantly different among the 14 year olds either. There are non-significant z values even for chest circumference, like in Budapest and Baranya county for the 0 and 10 year-olds, and for the older age group boys' and girls' chest circumference is not significantly different in Csongrád county. In case of 14 year olds, no significant sex-related differences are observed for this measurement in the last three counties.

There are significant sex-related differences for 14.5 to 18-year-olds in the majority of cases, and this is partly the result of higher sample sizes of the merged groups. However, the BMI values of boys and girls are not significantly different. Furthermore, in Budapest there is no sex-related significant difference for chest circumference. For those older than 16, this measure is not significantly different in towns either.

As stated earlier, if we break the population down to several groups and want to study the significance of differences between means obtained, then we can only do this by pairs if the total group means show a significant deviation. Thus, the hypothesis that different group means derive from samples taken from the same population is to be rejected. The so-called analysis of variance procedure serves to verify this latter hypothesis. During this analysis we assume that sample elements are independent in the different groups: they originate from normal distributions of identical standard deviations, and the H_o null hypothesis to be verified is that the means are also identical. Data show that assuming equal standard deviations is entirely well-grounded: there are no significant differences between counties within a sex in the standard deviations of a given indicator. The analysis of variance is based on the fact that the square difference sum related to the entire population, Q, can be broken down into two sums from which one, Q_1, characterises difference between a group (in our case counties) means, while the other, Q_2, characterises differences within a group. Formulas are the following:

$$Q_1 = \sum_{j=1}^{8} n_j \left(\bar{x}_j - \bar{x}\right)^2$$

$$Q_2 = \sum_{j=1}^{8} \sum_{i=1}^{n_j} \left(x_{ij} - x_j\right)^2$$

and $Q = Q_1 + Q_2 = \sum_{j=1}^{8} \sum_{i=1}^{n_j} \left(x_{ij} - \bar{x}\right)^2$,

where n_j is the number of observations in group (county) "j", and their sum is "n". If the null hypothesis is valid then both $s_1^2 = Q_1/7$ and $s_2^2 = Q_2/n-8$ are undistorted estimates for the unknown σ^2 variance of the population. Equality of the variance estimates above can be tested by the $F = s_1^2/s_2^2$ statistics of F(7, n-8) distribution. If the obtained F value is bigger than the critical value of the F distribution function with 7 and n-8 freedoms of degree, then the null hypothesis has to be rejected, i.e. county means originate from samples taken from populations with non-identical means.

F-values of the analysis of variance in the age groups of 0 to 14 year olds are shown in *Table 2.10*.

Table 2.10

Differences between county means of various physical characteristics by sex: results of the analysis of variance (F values)

Observed variable	Sex	Age (year)			
		0	2	10	14
Body height	Boy	16.90***	5.56***	4.86***	259.46***
	Girl	18.36***	5.19***	5.19***	4.00***
Body weight	Boy	9.35***	60.37***	2.70**	3.38***
	Girl	9.88***	4.76***	1.87	3.20***
Head circumfrence	Boy	14.35***	6.20***	2.92***	3.14***
	Girl	11.78***	10.15***	7.67***	3.66***
Chest circumfrence	Boy	22.64***	16.31***	4.58***	3.16***
	Girl	16.92***	11.32***	1.65	7.38***

As can be seen, except for the county means of body weight and chest circumference of 10 year old girls, there are highly significant differences between the county means in all cases. It is thus possible to compare the differences of these means by pairs with the z-test described in section 4.1.

Summary of the statistical methods and sampling system

Sample selection was performed with a stratified two-step grouped sampling. The seven regions of the country were represented in the sample by seven counties and Budapest. In the second step nurse districts were selected, and from the selected districts theoretically all children born between 1980 and 1983 were enroled in the sample. Participation in the survey was voluntary and many did not enrol in the initial sample. Approximately 2.5 per cent of nurse districts, i.e. 84 districts, and 1.1 per cent of children born between 1980 and 1983, i.e. 5685 children, were included in the initial sample. Children's enrolment ratios varied between 0.3 and 3.6 by regions, settlement types and sex. The sample decreased year by year at a different rate, but even after 18 years, data for 1150 children were included in the survey. Due to the significant initial non-response and subsequent sample erosion, theoretically the different indicators could have been estimated only from a weighted sample. Calculations on several estimates performed with and without weighting showed, however, that up to the age of 14 there was hardly any difference between values calculated weighted and unweighted, so for the first 14 years we usually applied unweighted estimates. From the age of 14 weighting was necessary due to the decreasing sample sizes. Furthermore, from this age onwards data could be presented as broken down by the three main settlement types only, i.e. to Budapest, towns, and villages. Nevertheless, only the national data can be regarded as reference data. Reliability of the estimates obtained from the sample was tested by calculating 95 per cent confidence intervals, and the significance of the difference between the two means was tested by the so-called asymptotic z-test. Analysis of variance was employed in order to see whether the application of the z-test was justified.

3. AGE-RELATED MEAN VALUES AND PERCENTILES OF SELECTED BODY MEASUREMENTS (KÁLMÁN JOUBERT, SAROLTA DARVAY, ANNAMÁRIA ZSÁKAI, RÓZSA ÁGFALVI)

One important objective of the Hungarian Longitudinal Growth Study was to develop and publish age-related national reference values for the most important body measurements.

As stated in the section on sampling, the data recorded up to the age of 14 are national reference values without any corrections. Due to regional differences in drop out ratios, data on subjects between the age of 14.5 and 18 years need to be corrected with weights in order to become national reference values.

The results in the tables and figures published in this volume are calculated from data weighted according to the requirements, so *means and percentiles published from birth to the age of 18 years are national reference values.*

Here we have to note that as written in the titles of tables and figures: the published study results refer to the so-called "reference data population". In accordance with the request of the Paediatric Professional Board, only those children who were born with a body weight between 2500 and 4500g, and who were neither suffering from any diseases influencing growth and development, nor from other lasting diseases, were included in the "reference population". As such, 2984 boys and 2701 girls were included in the so-called reference data population at birth. By the age of 18, we could take measurements of 516 boys and 523 girls of those originally enroled.

Ever since the first results were published, Hungarian paediatricians and health visitors have been using these reference values (means, percentiles), which were based on the body measurements recorded during the longitudinal child growth survey, and performed on a nationally representative sample (*Joubert–Ágfalvi 1988a, 1988b, Joubert–Darvay–Ágfalvi 1993a, 1993b, 1996a, 1996b; Darvay–Ágfalvi-Joubert 1997; Joubert–Darvay–Ágfalvi 2003; 2005).*

In the following section, we present the reference-means $\overline{x}$, standard deviations (SD), and reference percentiles (3rd, 10th, 25th, 50th, 75th, 90th and 97th percentiles) of selected body measurements and calculated values from the anthropometric sizes, which were recorded during the survey from birth to the age of 18 years for boys and girls: body height (body length), body weight, body mass index (BMI), body weight for body height, head circumference, chest circumference, abdominal circumference, and skinfolds measured in the triceps, subscapular, suprailiacal, and abdominal region.

Before presenting the anthropometric measurements listed above in tables and figures, we provide a precise description of the given sizes.

Body length and body height

From birth to the age of two years, children's *body length* is measured on an infant-length measuring board in a supine position.

From the age of three onwards, *body height* is measured in standing position with an anthropometer. The head of the child standing barefoot is in a straight position – but not too tense – and set to the Frankfurt horizontal plane. The feet are kept in an open position in front, and in a not entirely closed position at the back.

The reference values for children's body height (body length) are found in *Tables 3.1* and *3.2.* Reference percentiles curves for ages 0 to 36 months are shown in *Figures 3.1* and *3.2*, while reference percentiles for the body height values for ages two to 18 are shown in *Figures 3.3* and *3.4*.

Body weight

A child's body weight (body mass) is measured with ten-gram precision in infancy, always at the same time of the day, preferably in the morning, while the child is naked or wearing just a pair of short trousers.

Children's body weight reference values are found in *Tables 3.3* and *3.4*. Reference percentiles for 0 to 36 months of age are shown in *Figures 3.5* and *3.6*, while reference curves for two to 18 years of age are found in *Figures 3.7* and *3.8*.

The surveyed child's body height (body length) and body weight values are marked in the percentile graph from time to time, or these values are compared to values in the tables, so the actual growth and development data of the child can easily be examined and evaluated.

Weight-for-height

Reference values of weight-for-height (length) provide age-independent figures to evaluate the status of the infant and child in terms of nutritional and physical development. Weight-for-height is a frequently applied indicator despite the distortive effect of age independence.

Reference means and reference percentiles of body weight related body height (body length) are presented in *Tables 3.5* and *3.6*. Corresponding reference percentile curves for 0 to 2 years of age are shown in *Figures 3.9* and *3.10*, and for two to ten years of age in *Figures 3.11* and *3.12*. They provide information on mean body weight and body weight percentiles per body height (body length) in centimetres. The figures were modeled by fitting a fifth degree polynomial based on data referring to the period from birth to the age of 14. Values are presented from birth to the age of 18.

Comparison of the two biological parameters should aid evaluation of the status of physical development of the child, even if evaluation of reference values obtained for an age was not straightforward.We present two examples to study this relationship.

A four-year-old boy is 108.2cm and 14.5kg. According to his age, both of his measurements are *appropriate and within range for the age* (body mass is above the 10th percentile, and body height is below the 90th percentile). Examining the child's body-mass-body-length relationship based on the weight-for-height percentile figure, we can state that the intersection point of the two co-ordinates is well below the 3rd percentile, and the *child is therefore underweight compared to his body height (weight-deficient).*

A five-year-old boy's body height is 105.4cm and his body weight is 21.9kg, so both measurements are *appropriate and within range for the age.* The child's body-weight-for-body-height percentile figure (*Figure 3.11*) shows that his *body mass is larger compared to his body height:* the child is *overweight (has significant body weight excess).*

Based on the weight-for-height value, the *child's nutritional condition corresponds to his/her body height* between the 25th and 75th percentile. Between the 25th and 10th, as well as 75th and 90th percentile, the child's *nutritional condition is adequate for his/her body height.* Between the 3rd and 10th percentile the *child's nutritional condition as compared to his/her body height is less than adequate.* Between the 90th and 97th percentile the child is *better fed than adequate.* Below the 3rd percentile the *child is underweight as compared to his/her body height, i.e. thin (weight-deficient).* Above the 97th percentile, the *child is overweight as compared to his/her body height (has a significant body weight excess).*

Body mass index (BMI)

The *body mass index* (BMI) shows the relationship between body weight and body height, by providing the number of body weight kilograms per 'square metre' of body height: BMI= body mass (kg)/body height^2 (m^2).

BMI is suitable for determining the status of overweight or obese, because it has a strong correlation with body weight (Pearson's R=0.84), though its correlation with body height is weak (R=0.20) (*Bodzsár 1991).*

To define the extent of obesity, WHO recommendations (1998) are usually taken into account: –18.49 underweight (weight-deficient); 18.5–24.9 adequate nutritional condition (normal weight); 25.0–29.9 overweight (pre-obesity); 30.0–39.9 real overweight (obese); and BMI of 40.0 and higher values fall under the category of pathological overweight (obesity) (WHO TRS 1995).

Evaluation of a child's nutritional condition based on BMI may be performed only by applying the corresponding age-related BMI reference percentiles. The calculated BMI of the studied child is evaluated in the standard manner, after taking BMI percentile bands into account (see the evaluation described for body weight for body height).

Besides these features, BMI is widely suitable for screening overweight and obesity in childhood, with the method evaluated by *Cole et al. (2000)*. It can be used easily because it is simple, and the necessary sizes are widely available (*Gyenis et al. 2004*).

The 85th percentile curves of BMI as the cut-off values for screening overweight in childhood were estimated according to the recommendations of Cole and his colleagues (2000). By comparing the percentile distributions of children's BMI from different populations, Cole and his colleagues (2000) found that the 85th percentile of BMI coincides with the adult cut-off point for overweight (25kg/m^2) at the age of 18 years in both sexes.

In some cases, however, BMI only provides information on whether the studied individual has a body mass surplus compared to his/her body height. It does not offer information about whether the body mass excess is primarily made up of muscle or adipose tissue.

Head circumference

When measuring head circumference the steel measuring tape is held around the child's head in such a way that it passes through the glabella landmark point at the front, through the opistocranion landmark point at the back, and over the maximum bulge of the occiput.

Reference means and reference percentiles of head circumference are shown in *Tables 3.9* and *3.10*. Reference percentile curves of head circumference for 0 to 36 months of age can be seen in *Figures 3.17* and *3.18*, while reference curves for two to 18 years are shown in *Figures 3.19* and *3.20*.

Chest circumference

The steel measuring tape is placed directly under the lower shoulder blade angles at the back, then after leading it around the chest it is placed precisely above the areola of the mamillas. The measurement is taken following exhalation of a relaxed inhalation.

The chest circumference size of the examined child can be evaluated based on the reference data in *Tables 3.11* and *3.12*, or by using the reference percentile curves. Reference percentiles for 0 to 36 months can be seen in *Figures 3.21* and *3.22*, while reference curves for two to 18 years are shown in *Figures 3.23* and *3.24*.

Abdominal circumference at the navel

The steel measuring tape is led around at the height of the navel so that the tape also runs in a horizontal position at the level of the navel at the back. This size is only measured from the age of seven.

Tables 3.13 and *3.14*, as well as *Figures 3.25* and *3.26* contain the reference data for abdominal circumference.

The not entirely regular shape of the percentile curves led us to correct for the unevenness by fitting a 2nd degree polynomial. The connected values can be seen in *Tables 3.15* and *3.16*. Percentiles curves drawn by the 2nd degree polynomial are shown in *Figures 3.27* and *3.28*.

Skinfold thicknesses (triceps, subscapula, abdomen, and iliospinale)

In order to judge the health status of a child, it is important to evaluate nutritional condition besides measuring the body mass, body height, and establishing the weight-for-height (length) relationship and calculating BMI. One important tool for this is measurement and evaluation of the thickness of the subdermal connective tissue, so-called skinfolds in different body areas.

We measure the *triceps* skinfold on the dorsal surface of the upper arm, at half the distance between the acromion and the elbow (it is expedient to mark it with a dermograph), so that the longitudinal axis of the raised skinfold overlaps with the upper arm longitudinal axis.

We measure the *subscapular* skinfold at approximately two fingers' distance under the scapular point, so that the skinfold axis closes an approximately 45º angle with the body's axis of symmetry.

We measure the *abdominal* skinfold 5cm left of the navel on the stomach, the axis of the skinfold is horizontal.

We measure the skinfold at the *iliospinale* (*spina iliaca anterior superior*) above the anterior, the downward-bending angle of the winged upper portion of the ileum.

These measurements were taken on the left side of the body with a Lange-type skinfold-caliper.

From our reference data population we compiled the tables containing the reference mean $\bar{x}$, the standard deviation (SD), and the reference percentiles (*Tables 3.17–3.24*) for data on the *triceps, subscapular, iliospinale and abdominal skinfolds*. According to international practice, percentiles pooled from the total values of the four skinfolds can be seen in *Tables 3.25* and *3.26*. Values in the tables are provided in millimetres. Skinfold thickness reference percentiles are found in *Figures 3.29–3.38*. Future analysis of skinfold measurements will include plotting the percentile curves on a logarithmic scale for international comparability.

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Table 3.1

Reference means and percentiles of body length/height from birth to the age of 18 years (boys)

Age	Case number (N)	Mean $\bar{x}$ (cm)	SD	Percentiles (cm)						
				3	10	25	50	75	90	97
At birth	2 984	50.82	2.18	47.00	48.20	49.51	50.72	52.14	53.65	55.09
1 month	2 949	54.08	2.22	50.02	51.24	52.68	54.10	55.55	57.03	58.55
2 months	2 938	57.44	2.34	53.08	54.45	56.00	57.60	59.05	60.40	62.02
3 months	2 927	60.74	2.42	56.03	57.60	59.10	60.85	62.40	63.80	65.17
4 months	2 895	63.55	2.49	58.62	60.35	62.00	63.70	65.30	66.62	68.20
5 months	2 869	66.06	2.55	61.00	62.80	64.51	66.10	67.75	69.11	70.72
6 months	2 838	68.19	2.55	63.00	64.80	66.38	68.00	69.70	71.10	72.70
8 months	2 809	71.02	2.63	66.10	68.00	69.50	71.10	72.85	74.40	76.20
10 months	2 789	73.63	2.68	68.58	70.56	72.04	73.81	75.60	77.20	79.15
12 months	2 807	76.28	2.76	71.09	72.99	74.56	76.40	78.12	79.79	81.80
15 months	2 622	79.52	2.98	74.07	76.01	77.74	79.57	81.51	83.19	85.20
18 months	2 597	82.44	3.19	76.60	78.60	80.65	82.60	84.55	86.45	88.45
21 months	2 543	85.21	3.44	78.88	81.08	83.28	85.36	87.38	89.50	91.60
2 years	2 585	87.98	3.60	81.09	83.35	85.68	87.90	90.00	92.17	94.45
3 years	2 351	96.39	4.06	89.02	91.31	93.83	96.36	99.01	101.50	104.15
4 years	2 397	103.06	4.25	95.18	97.90	100.26	103.20	106.06	108.55	111.50
5 years	2 455	109.74	4.66	101.06	103.82	106.68	109.76	112.90	115.65	118.50
6 years	2 469	116.26	4.95	107.10	110.05	113.03	116.30	119.40	122.52	125.47
7 years	2 338	122.70	5.27	112.50	115.98	119.15	122.48	125.92	129.15	132.45
8 years	2 313	128.35	5.61	117.94	121.31	124.60	128.44	132.07	135.45	139.00
9 years	2 277	133.79	5.99	122.47	126.34	129.75	133.99	137.73	141.45	145.26
10 years	2 223	138.99	6.34	127.22	131.14	134.91	139.09	143.08	147.41	151.15
10.5 years	1 697	141.77	6.38	129.95	133.60	137.44	141.75	145.96	150.06	154.00
11 years	1 797	144.46	6.68	132.25	136.05	139.99	144.58	148.69	153.05	157.16
11.5 years	1 665	147.35	6.90	134.85	138.59	142.57	147.32	152.05	156.19	160.16
12 years	1 750	150.37	7.26	137.37	141.15	145.37	150.38	155.22	159.60	164.06
12.5 years	1 604	153.57	7.70	139.81	143.70	148.47	153.51	159.00	163.44	168.24
13 years	1 689	157.06	7.95	142.45	146.80	151.95	157.05	162.43	167.65	172.15
13.5 years	1 552	160.64	8.13	145.10	150.00	155.30	160.40	166.48	171.03	175.40
14 years	1 612	164.20	8.09	148.15	153.25	158.96	164.30	169.85	174.36	178.65
14.5 years	1 165	167.16	7.95	151.35	157.00	162.00	167.50	172.70	177.00	181.40
15 years	1 186	169.93	7.57	154.90	160.50	165.00	170.00	175.15	179.30	183.90
15.5 years	837	171.92	7.23	158.00	163.10	167.30	172.00	176.80	181.20	185.50
16 years	890	173.66	6.93	160.20	165.20	169.10	173.50	178.30	182.50	186.70
16.5 years	655	174.69	6.74	162.10	166.60	170.20	174.60	179.55	183.50	187.90
17 years	692	175.72	6.66	163.65	167.90	171.25	175.50	180.40	184.40	188.50
17.5 years	485	176.44	6.23	164.95	169.15	172.20	176.00	180.70	185.00	188.75
18 years	516	176.92	6.22	165.58	169.93	172.93	176.45	180.80	185.20	189.10

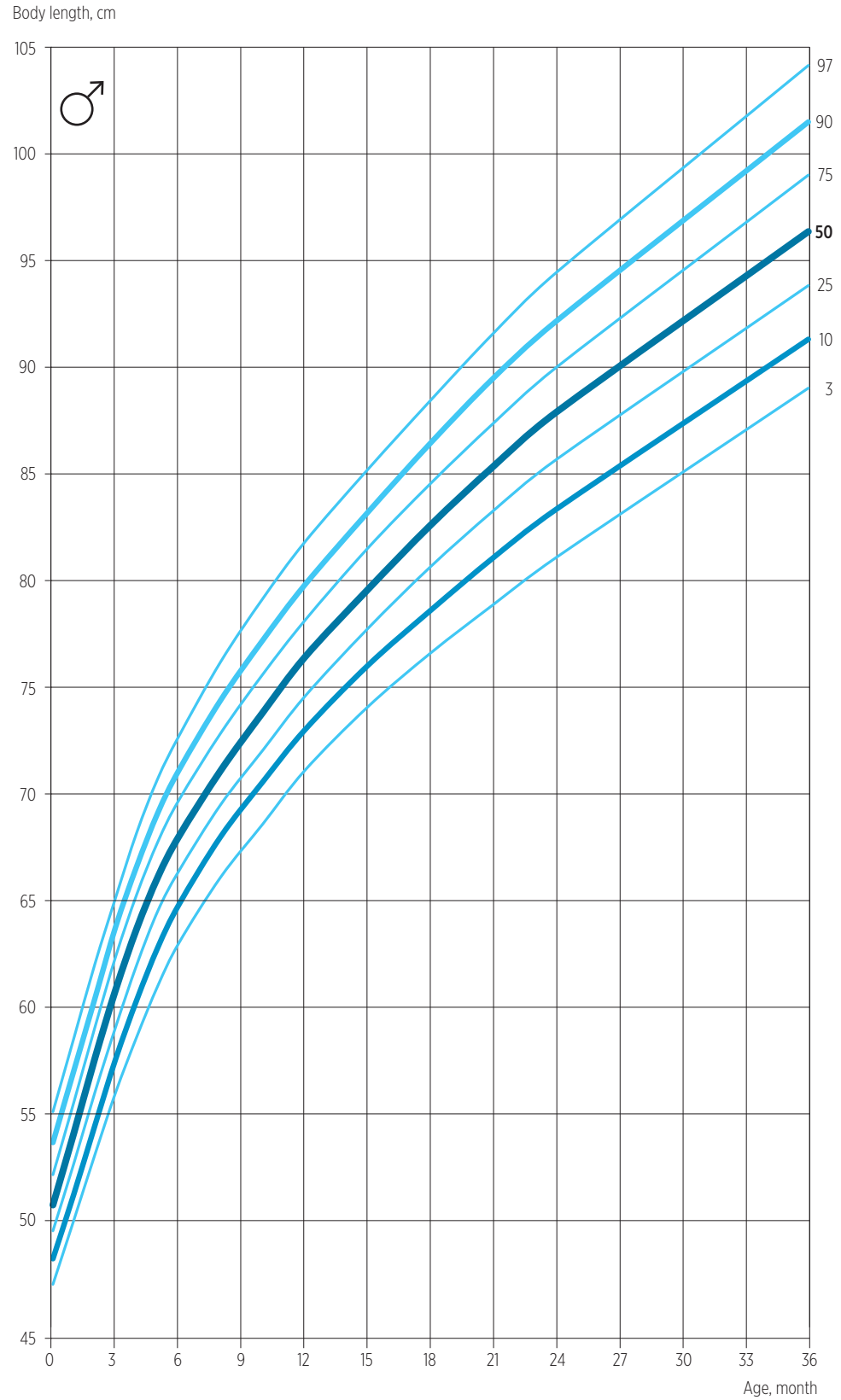
Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.2

Reference means and percentiles of body length/height from birth to the age of 18 years (girls)

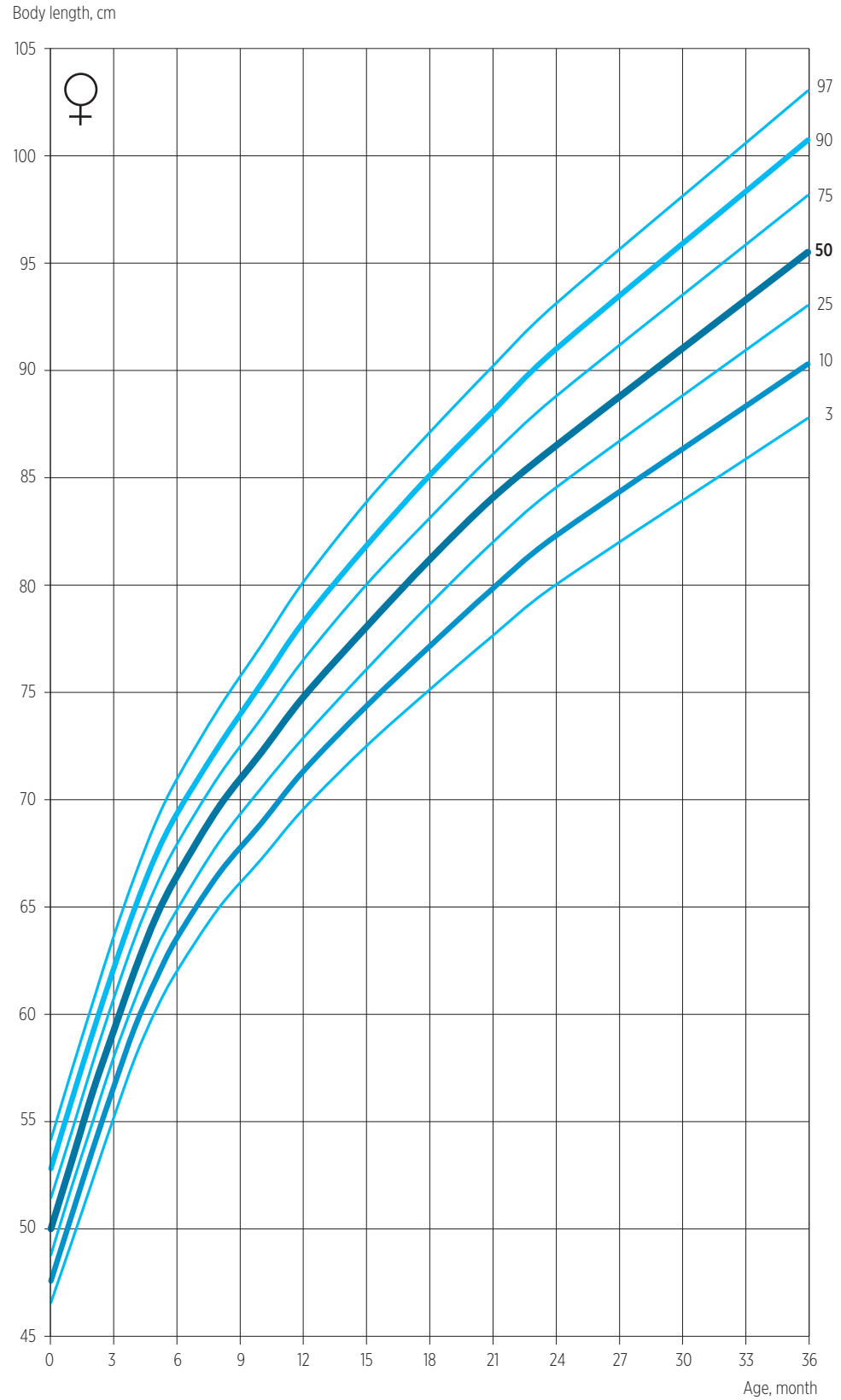
Age	Case number (N)	Mean $\bar{x}$ (cm)	SD	Percentiles (cm)						
				3	10	25	50	75	90	97
At birth	2 701	50.15	2.07	46.60	47.61	48.82	50.04	51.48	52.85	54.20
1 month	2 662	53.30	2.06	49.45	50.70	52.03	53.22	54.59	56.06	57.45
2 months	2 653	56.42	2.15	52.35	53.77	55.05	56.45	57.80	59.20	60.60
3 months	2 622	59.48	2.25	55.25	56.68	58.07	59.30	60.80	62.20	63.70
4 months	2 603	62.15	2.28	58.00	59.45	60.72	62.10	63.60	65.00	66.50
5 months	2 577	64.52	2.35	60.24	61.67	63.06	64.56	66.00	67.45	69.00
6 months	2 543	66.60	2.45	62.05	63.60	64.90	66.48	67.96	69.39	71.00
8 months	2 519	69.42	2.50	65.00	66.60	68.05	69.70	71.15	72.55	74.30
10 months	2 480	72.03	2.59	67.25	68.92	70.56	72.22	73.81	75.42	77.20
12 months	2 495	74.76	2.68	69.58	71.35	72.90	74.80	76.53	78.30	80.16
15 months	2 325	78.09	2.96	72.52	74.38	76.09	78.07	80.04	81.85	83.88
18 months	2 294	81.15	3.18	75.14	77.16	79.12	81.20	83.13	85.12	87.12
21 months	2 263	84.02	3.37	77.65	79.85	82.00	84.08	86.10	88.10	90.20
2 years	2 304	86.88	3.54	80.03	82.31	84.55	86.50	88.80	91.00	93.12
3 years	2 094	95.56	4.08	87.80	90.32	93.05	95.53	98.18	100.75	103.05
4 years	2 127	102.31	4.25	94.50	97.01	99.80	102.60	105.28	108.20	110.90
5 years	2 207	109.07	4.67	100.37	103.24	106.15	109.17	112.15	115.11	118.02
6 years	2 209	115.55	4.96	106.23	109.30	112.31	115.61	118.83	122.05	125.19
7 years	2 106	122.00	5.29	112.02	115.36	118.40	121.90	125.46	128.61	132.16
8 years	2 082	127.64	5.64	117.20	120.50	124.04	127.58	131.28	135.00	138.50
9 years	2 074	133.15	5.98	121.95	125.68	129.28	133.17	137.22	140.74	144.72
10 years	2 022	138.84	6.51	126.80	130.75	134.64	138.80	143.08	147.06	151.20
10.5 years	1 560	142.06	6.68	129.45	133.50	137.65	142.21	146.44	150.57	154.60
11 years	1 644	145.48	6.97	132.52	136.44	140.85	145.60	150.13	154.37	158.40
11.5 years	1 532	148.83	7.18	135.50	139.50	144.11	149.02	153.62	158.14	162.14
12 years	1 618	152.01	7.10	138.75	142.50	147.36	152.25	156.91	161.08	165.04
12.5 years	1 501	154.82	6.93	141.80	145.55	150.23	155.13	159.58	163.52	167.35
13 years	1 589	157.33	6.65	144.87	148.60	153.05	157.55	162.02	165.78	169.52
13.5 years	1 452	159.41	6.36	147.56	151.23	155.33	159.70	163.82	167.54	171.22
14 years	1 530	161.07	6.12	149.70	153.30	157.17	161.17	165.30	168.90	172.67
14.5 years	1 138	162.26	6.15	151.00	154.60	158.50	162.40	166.50	170.20	173.90
15 years	1 161	163.38	6.09	152.00	155.70	159.60	163.50	167.70	171.30	174.95
15.5 years	839	164.22	5.98	152.80	156.40	160.40	164.40	168.70	172.35	175.90
16 years	882	164.92	6.16	153.38	157.10	161.00	165.20	169.40	173.10	176.70
16.5 years	631	165.61	6.02	153.65	157.50	161.60	165.80	170.00	173.70	177.40
17 years	689	165.96	6.03	154.10	158.00	162.00	166.40	170.60	174.30	177.95
17.5 years	467	166.75	6.09	154.40	158.50	162.50	166.90	171.00	174.80	178.40
18 years	523	167.20	6.13	154.80	159.00	163.10	167.50	171.40	175.10	178.70

Based on the reference data of the Hungarian Longitudinal Growth Study.



Based on the reference data of the Hungarian Longitudinal Growth Study.

Figure 3.1
Reference percentiles of body length/height from birth to the age of 3 years (boys)



Based on the reference data of the Hungarian Longitudinal Growth Study.
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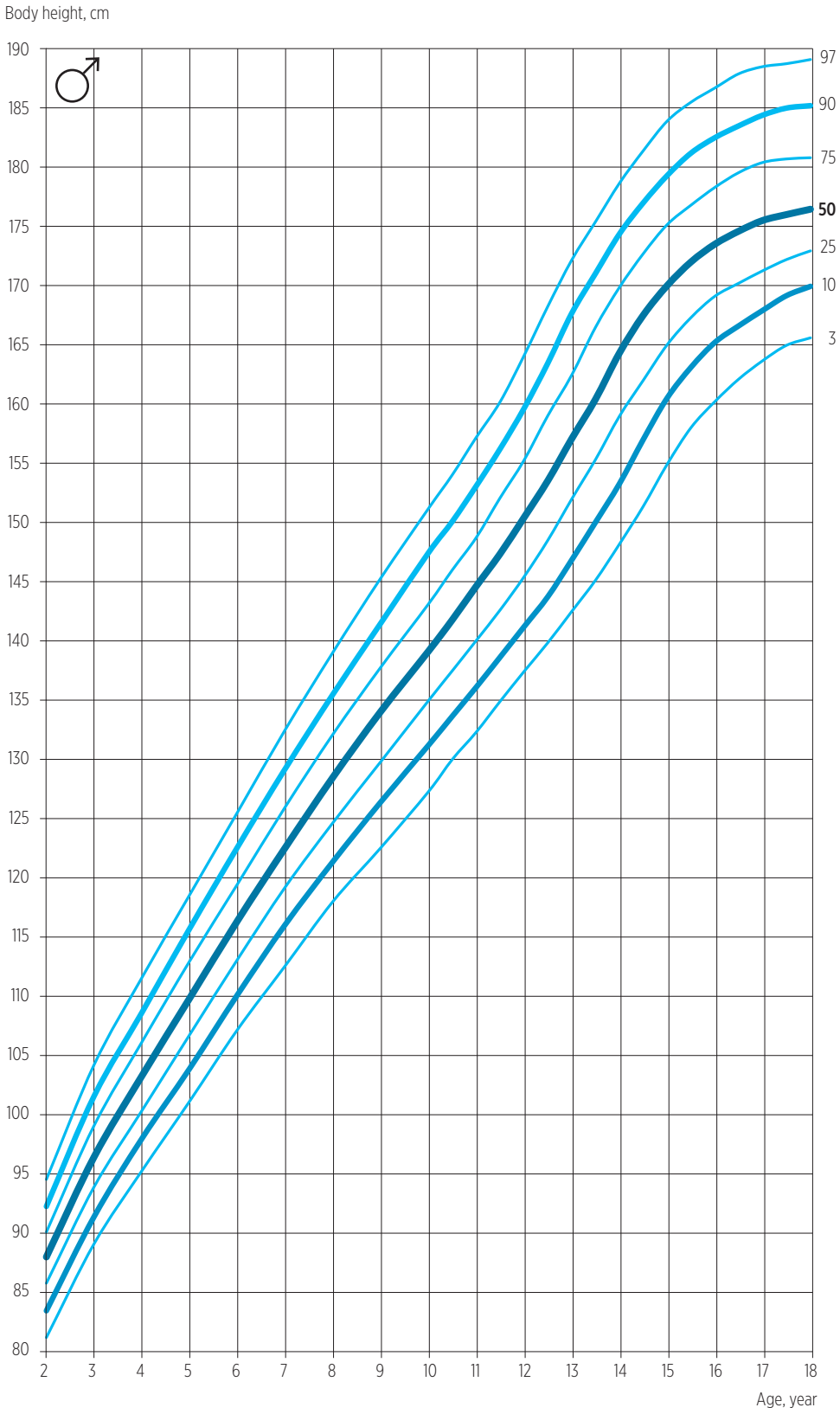
Figure 3.2
Reference percentiles of body length/height from birth to the age of 3 years (girls)



Based on the reference data of the Hungarian Longitudinal Growth Study.
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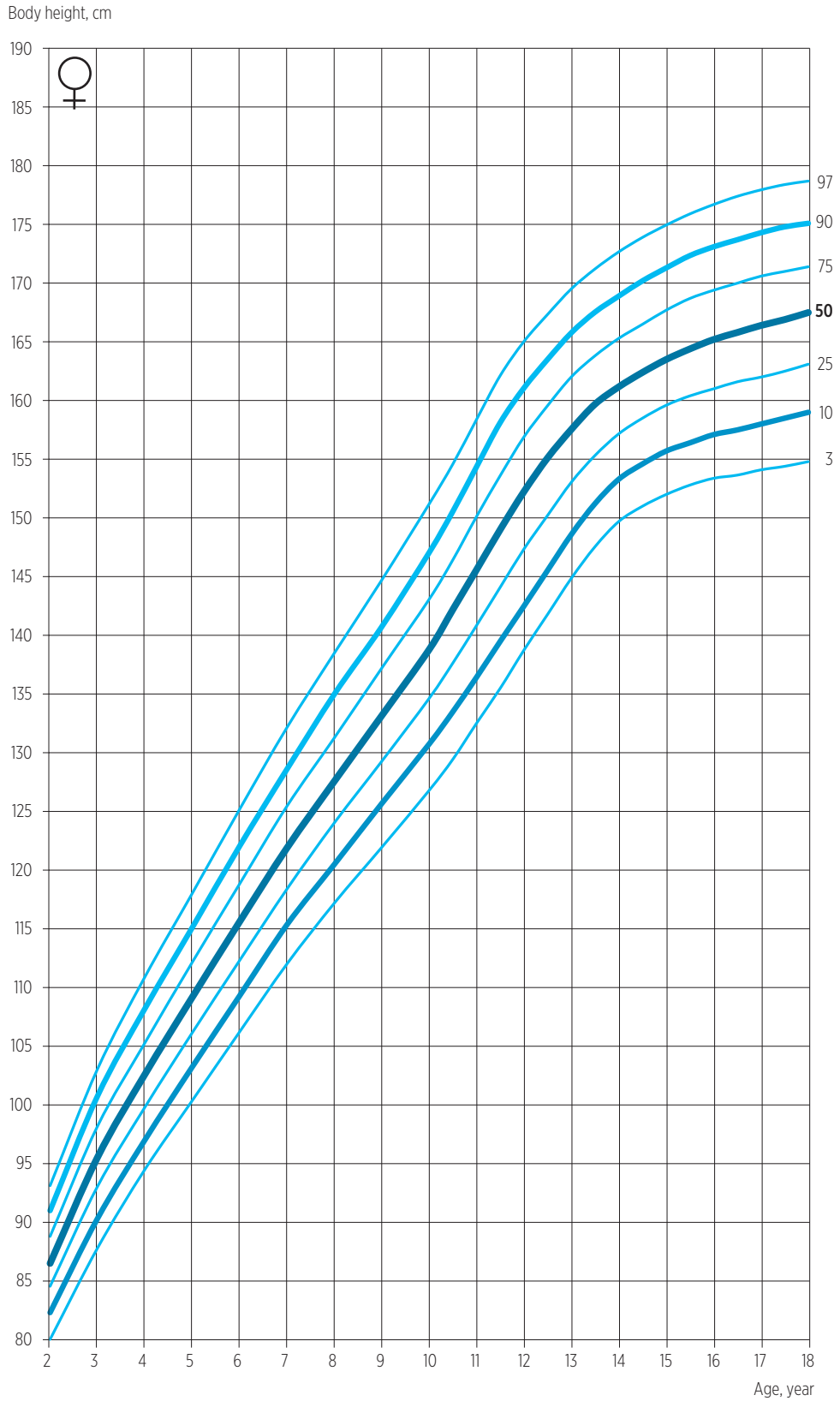
Figure 3.3
Reference percentiles of body length/height from the age of 2 to 18 years (boys)



Based on the reference data of the Hungarian Longitudinal Growth Study.
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Figure 3.4
Reference percentiles of body length/height from the age of 2 to 18 years (girls)

Table 3.3

Reference means and percentiles of body weight from birth to the age of 18 years (boys)

Age	Case number (N)	Mean $\bar{x}$ (cm)	SD	Percentiles (kg)						
				3	10	25	50	75	90	97
At birth	2 990	3.31	0.42	2.52	2.73	3.00	3.30	3.60	3.88	4.17
1 month	2 949	4.09	0.49	3.24	3.52	3.82	4.15	4.50	4.80	5.12
2 months	2 939	5.05	0.57	4.00	4.31	4.67	5.01	5.42	5.75	6.12
3 months	2 929	5.92	0.64	4.70	5.07	5.51	5.90	6.32	6.70	7.14
4 months	2 898	6.67	0.71	5.35	5.75	6.20	6.65	7.10	7.50	8.03
5 months	2 874	7.30	0.76	5.90	6.32	6.78	7.30	7.78	8.26	8.80
6 months	2 842	7.84	0.82	6.35	6.79	7.25	7.81	8.34	8.83	9.40
8 months	2 815	8.64	0.92	7.02	7.50	8.00	8.60	9.25	9.81	10.45
10 months	2 793	9.35	0.99	7.55	8.10	8.69	9.31	10.01	10.60	11.31
12 months	2 810	10.01	1.07	8.07	8.69	9.29	9.95	10.70	11.32	12.10
15 months	2 625	10.73	1.15	8.65	9.39	10.00	10.69	11.50	12.20	13.00
18 months	2 600	11.41	1.24	9.23	10.00	10.65	11.36	12.25	13.00	13.85
21 months	2 546	12.04	1.33	9.72	10.55	11.25	11.98	12.93	13.76	14.67
2 years	2 590	12.66	1.43	10.19	10.99	11.78	12.55	13.58	14.45	15.49
3 years	2 353	14.82	1.84	11.93	12.70	13.60	14.70	15.95	17.02	18.61
4 years	2 398	16.68	2.17	13.21	14.19	15.20	16.49	17.99	19.31	21.47
5 years	2 455	18.79	2.70	14.91	16.00	17.01	18.51	20.03	22.00	24.58
6 years	2 469	21.24	3.41	16.48	17.70	19.00	20.60	22.98	25.18	28.82
7 years	2 335	24.07	4.19	18.19	19.90	21.21	23.31	25.99	29.21	33.66
8 years	2 306	27.12	5.17	20.03	22.01	23.78	26.01	29.19	33.62	39.51
9 years	2 275	30.42	6.31	22.30	24.32	26.29	29.02	32.70	38.52	45.98
10 years	2 223	34.05	7.65	24.49	26.71	29.01	32.20	36.73	44.30	53.23
10.5 years	1 691	36.11	8.42	25.82	28.03	30.36	33.93	39.20	47.60	57.11
11 years	1 794	38.24	9.26	27.00	29.48	32.02	35.80	42.03	50.95	61.03
11.5 years	1 662	40.61	10.06	28.30	31.00	33.83	37.76	45.02	54.46	64.97
12 years	1 750	43.00	10.73	29.62	32.50	35.65	40.08	48.00	57.74	68.60
12.5 years	1 604	45.73	11.33	31.00	34.26	37.88	42.90	51.09	61.06	72.10
13 years	1 688	48.58	11.79	32.80	36.16	40.21	45.99	54.20	64.35	75.40
13.5 years	1 550	51.52	12.09	34.70	38.51	43.01	49.32	57.42	67.30	78.20
14 years	1 616	54.33	12.23	36.65	41.00	45.99	52.35	60.20	69.97	80.55
14.5 years	1 166	56.95	11.89	39.01	43.78	48.90	55.12	62.90	72.41	82.60
15 years	1 189	59.55	11.90	41.68	46.36	51.65	57.62	65.15	74.65	84.65
15.5 years	837	61.60	11.57	44.20	49.04	53.95	59.65	66.95	76.50	86.50
16 years	890	63.49	11.34	46.48	51.36	56.05	61.50	68.78	78.20	88.00
16.5 years	654	65.35	11.45	48.78	53.10	57.62	63.35	70.45	79.90	89.20
17 years	692	66.72	11.38	50.58	54.80	59.22	64.96	72.06	81.12	90.28
17.5 years	485	67.88	10.49	52.05	55.93	60.30	66.30	73.38	82.20	91.30
18 years	516	68.65	10.68	52.95	56.97	61.49	67.35	74.32	83.00	92.00

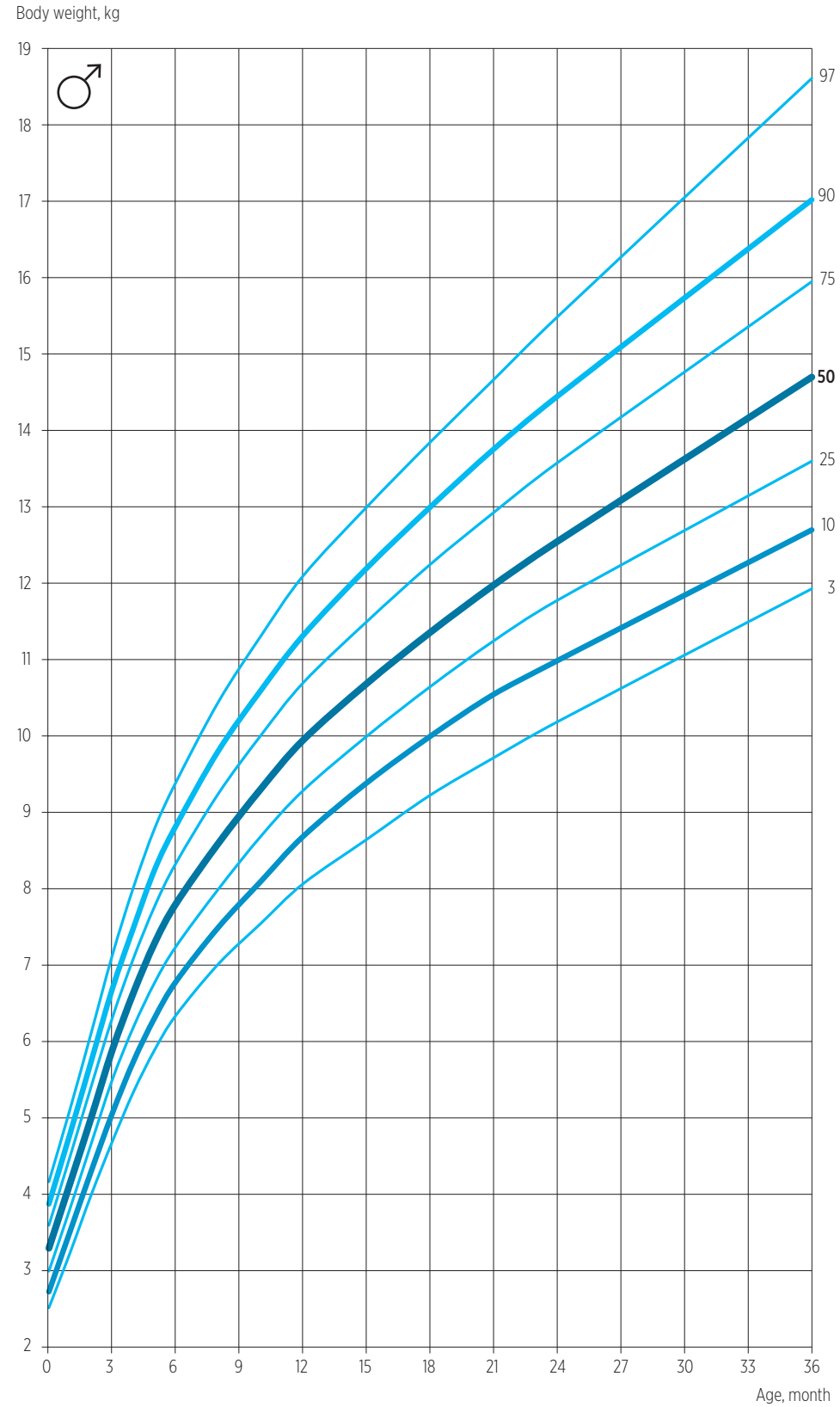
Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.4

Reference means and percentiles of body weight from birth to the age of 18 years (girls)

Age	Case number (N)	Mean $\bar{x}$ (cm)	SD	Percentiles (kg)						
				3	10	25	50	75	90	97
At birth	2 703	3.20	0.39	2.49	2.70	2.90	3.15	3.40	3.60	3.9
1 month	2 662	3.89	0.44	3.12	3.40	3.65	3.95	4.22	4.50	4.82
2 months	2 654	4.72	0.49	3.80	4.10	4.40	4.73	5.05	5.37	5.70
3 months	2 622	5.49	0.58	4.47	4.80	5.10	5.48	5.86	6.25	6.63
4 months	2 604	6.18	0.64	5.06	5.40	5.74	6.15	6.60	7.01	7.46
5 months	2 579	6.77	0.70	5.55	5.93	6.30	6.75	7.23	7.70	8.19
6 months	2 546	7.29	0.76	5.99	6.37	6.75	7.23	7.75	8.25	8.80
8 months	2 522	8.06	0.84	6.62	7.05	7.46	8.00	8.60	9.20	9.80
10 months	2 483	8.76	0.92	7.10	7.61	8.10	8.70	9.36	10.00	10.63
12 months	2 496	9.42	1.01	7.60	8.16	8.70	9.30	10.01	10.77	11.44
15 months	2 326	10.15	1.10	8.25	8.85	9.45	10.12	10.86	11.60	12.40
18 months	2 293	10.85	1.21	8.85	9.50	10.10	10.80	11.60	12.42	13.28
21 months	2 262	11.49	1.31	9.35	10.10	10.70	11.46	12.29	13.20	14.17
2 years	2 307	12.15	1.41	9.82	10.56	11.25	12.04	13.00	13.95	15.00
3 years	2 094	14.37	1.84	11.35	12.30	13.16	14.10	15.32	16.68	18.00
4 years	2 127	16.30	2.20	12.80	13.90	14.90	16.01	17.60	19.15	21.00
5 years	2 206	18.43	2.77	14.35	15.50	16.70	18.08	19.85	21.81	24.35
6 years	2 209	20.84	3.48	15.92	17.22	18.51	20.29	22.51	24.88	28.15
7 years	2 102	23.56	4.25	17.65	19.10	20.68	22.80	25.48	28.35	32.65
8 years	2 077	26.50	5.17	19.50	21.09	23.01	25.49	28.80	32.77	37.99
9 years	2 071	29.71	6.12	21.48	23.32	25.49	28.49	32.39	37.70	44.00
10 years	2 023	33.33	7.22	23.52	25.85	28.48	31.95	36.60	42.70	50.01
10.5 years	1 560	35.46	7.74	24.70	27.29	30.20	34.00	39.01	45.42	53.03
11 years	1 642	38.07	8.53	25.90	29.02	32.03	36.60	41.80	48.50	56.15
11.5 years	1 532	40.68	9.23	27.55	30.80	34.05	39.20	45.05	51.80	59.50
12 years	1 615	43.42	9.62	29.50	32.90	36.53	42.07	48.05	55.30	62.80
12.5 years	1 494	45.96	9.67	31.55	34.98	39.06	44.80	50.90	58.30	66.20
13 years	1 589	48.50	9.65	33.95	37.38	41.67	47.20	53.20	60.95	69.10
13.5 years	1 450	50.70	9.62	36.25	39.80	44.01	49.30	55.30	63.16	71.50
14 years	1 526	52.60	9.59	38.63	42.02	45.98	51.20	57.02	64.97	73.30
14.5 years	1 137	54.05	9.35	40.40	43.90	47.85	52.85	58.50	66.50	75.00
15 years	1 160	55.44	9.61	41.65	45.35	49.50	54.20	59.74	67.73	76.25
15.5 years	840	56.78	9.35	42.76	46.60	50.80	55.38	60.85	68.75	77.50
16 years	883	57.42	9.21	43.65	47.65	51.85	56.28	61.85	69.68	78.60
16.5 years	634	58.27	9.55	44.35	48.40	52.65	56.96	62.80	70.45	79.60
17 years	692	58.71	9.39	44.98	49.00	53.30	57.50	63.40	71.18	80.35
17.5 years	465	59.63	9.57	45.45	49.60	53.75	57.99	63.90	71.75	81.00
18 years	520	60.10	9.38	45.94	50.05	54.25	58.34	64.20	72.30	81.50

Based on the reference data of the Hungarian Longitudinal Growth Study.



Based on the reference data of the Hungarian Longitudinal Growth Study.
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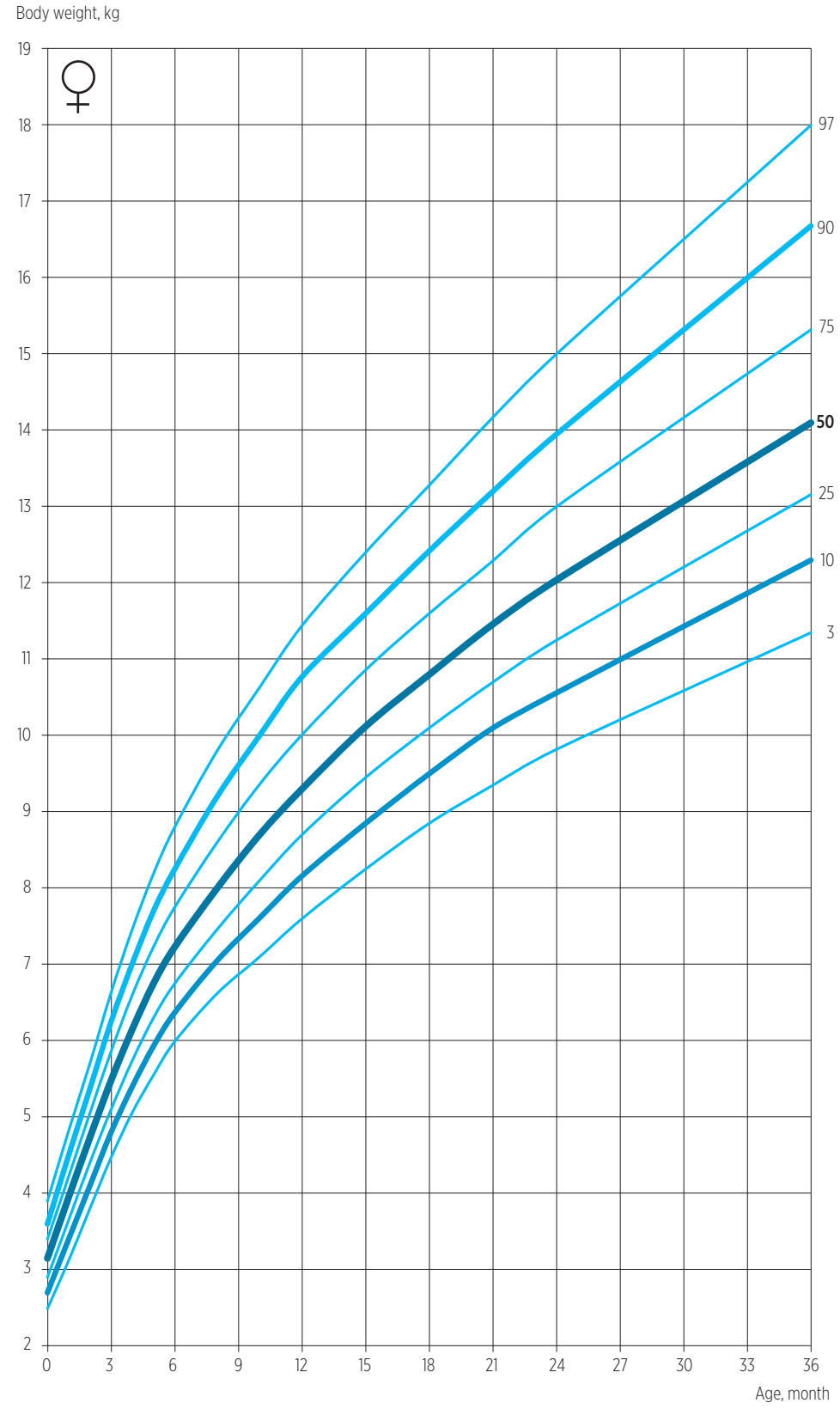
Figure 3.5
Reference percentiles of body weight from birth to the age of 3 years (boys)



Based on the reference data of the Hungarian Longitudinal Growth Study.
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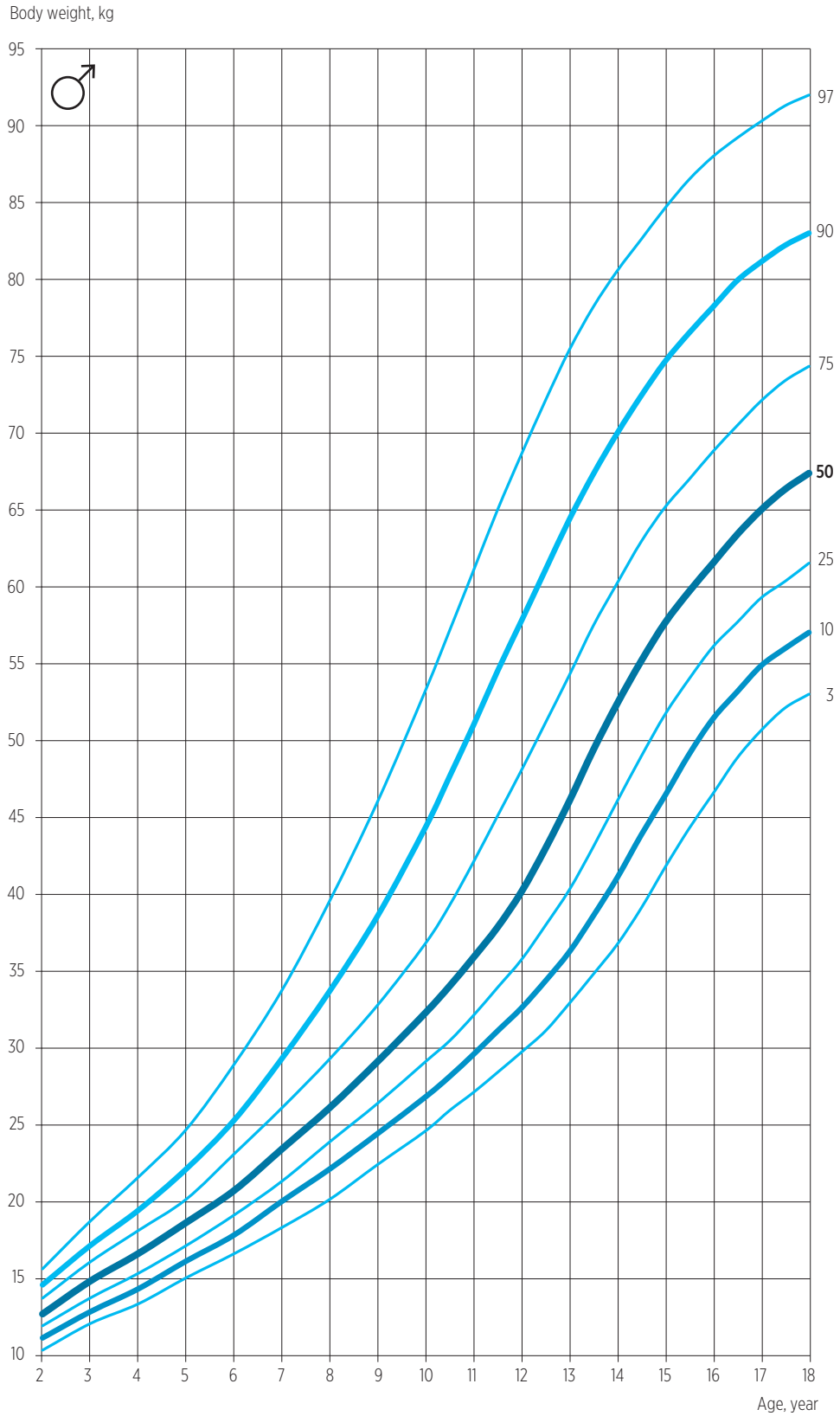
Figure 3.6
Reference percentiles of body weight from birth to the age of 3 years (girls)



Based on the reference data of the Hungarian Longitudinal Growth Study.
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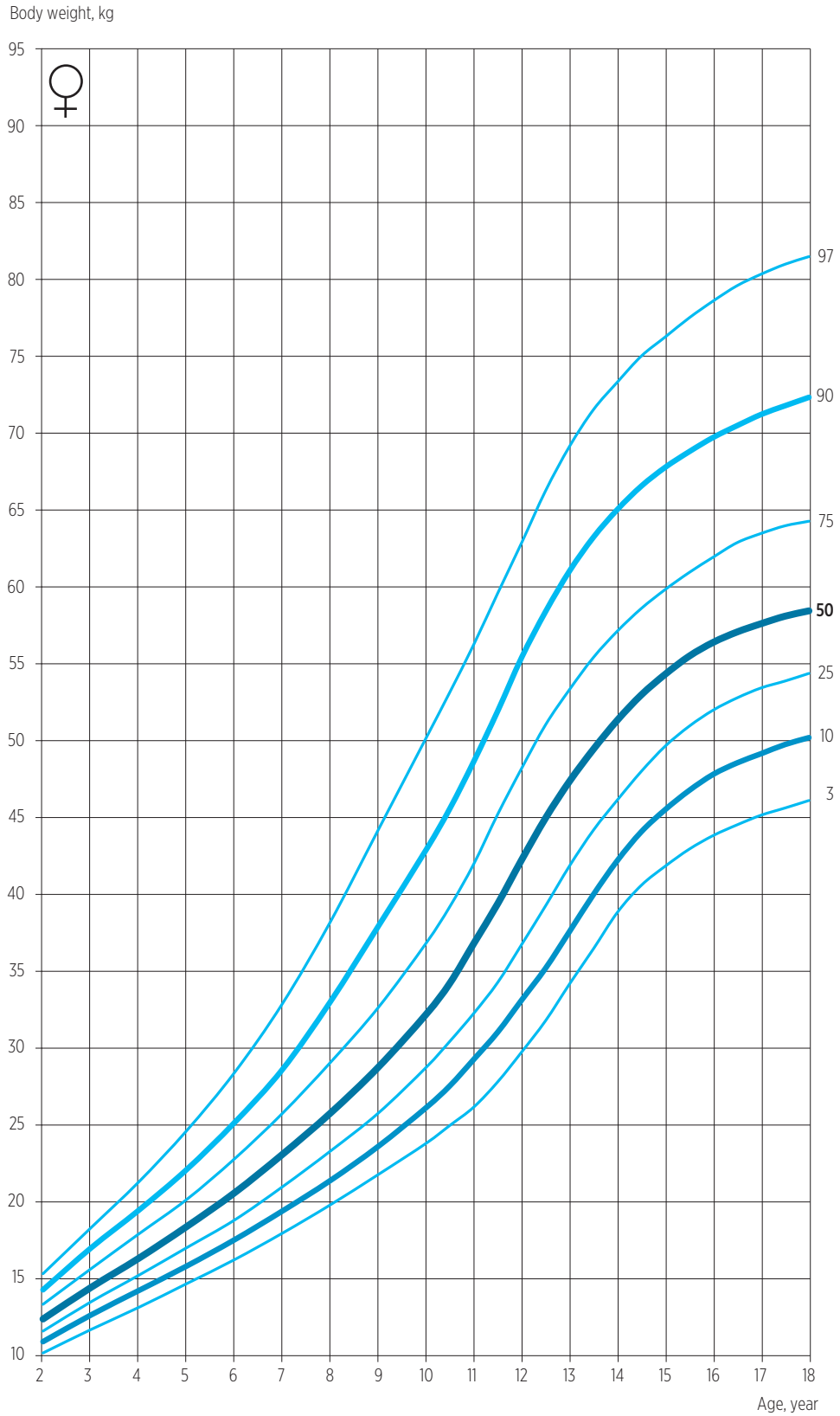
Figure 3.7
Reference percentiles of body weight from the age of 2 to 18 years (boys)



Based on the reference data of the Hungarian Longitudinal Growth Study.

Figure 3.8
Reference percentiles of body weight from the age of 2 to 18 years (girls)

Table 3.5

Change of weight-for-height/length mean and percentiles from birth to the age of 18 years (boys)

Body height/ length) (cm)	Case number (N)	Mean $\bar{x}$ (kg)	SD	Percentiles (kg)						
				3	10	25	50	75	90	97
47	156	2.79	0.20	2.50	2.54	2.62	2.80	2.95	3.07	3.22
48	316	2.96	0.26	2.55	2.65	2.80	2.94	3.10	3.32	3.50
49	517	3.12	0.28	2.65	2.75	2.90	3.10	3.30	3.45	3.67
50	716	3.32	0.33	2.80	2.92	3.10	3.30	3.50	3.70	4.00
51	767	3.48	0.35	2.90	3.05	3.25	3.45	3.65	3.90	4.20
52	808	3.73	0.39	3.05	3.25	3.45	3.73	3.95	4.20	4.45
53	908	3.96	0.44	3.11	3.45	3.70	3.95	4.20	4.50	4.90
54	899	4.22	0.50	3.40	3.65	3.90	4.18	4.50	4.80	5.27
55	840	4.43	0.50	3.50	3.90	4.12	4.40	4.70	5.05	5.45
56	877	4.75	0.55	3.85	4.10	4.40	4.70	5.05	5.40	5.90
57	875	4.99	0.58	3.95	4.30	4.65	5.00	5.30	5.65	6.15
58	917	5.25	0.58	4.25	4.58	4.90	5.20	5.60	5.95	6.35
59	908	5.54	0.58	4.60	4.90	5.15	5.50	5.80	6.20	6.70
60	953	5.79	0.59	4.80	5.09	5.40	5.75	6.10	6.55	6.90
61	972	6.07	0.57	5.10	5.38	5.66	6.03	6.40	6.80	7.25
62	1054	6.35	0.63	5.30	5.60	5.96	6.30	6.70	7.10	7.60
63	1079	6.57	0.60	5.60	5.88	6.14	6.50	6.90	7.32	7.75
64	1155	6.85	0.62	5.85	6.15	6.40	6.80	7.20	7.62	8.00
65	1183	7.08	0.62	6.00	6.35	6.68	7.00	7.50	7.90	8.31
66	1128	7.34	0.65	6.20	6.55	6.90	7.30	7.70	8.15	8.65
67	1145	7.58	0.64	6.50	6.80	7.15	7.55	8.00	8.40	8.87
68	1215	7.87	0.69	6.65	7.02	7.40	7.85	8.30	8.80	9.20
69	1105	8.10	0.71	6.90	7.20	7.60	8.07	8.55	9.00	9.45
70	1085	8.40	0.74	7.10	7.50	7.90	8.40	8.85	9.35	9.90
71	994	8.69	0.73	7.30	7.80	8.20	8.69	9.20	9.60	10.05
72	1088	8.90	0.80	7.50	7.90	8.34	8.90	9.40	10.00	10.45
73	1017	9.20	0.80	7.85	8.20	8.65	9.15	9.70	10.25	10.83
74	1074	9.48	0.82	8.02	8.50	8.90	9.45	10.00	10.50	11.13
75	956	9.67	0.84	8.27	8.65	9.01	9.65	10.15	10.80	11.40
76	1050	9.99	0.86	8.50	8.97	9.40	10.00	10.50	11.10	11.70
77	846	10.18	0.89	8.70	9.10	9.60	10.05	10.70	11.36	12.15
78	995	10.44	0.93	8.85	9.30	9.80	10.40	11.00	11.61	12.20
79	879	10.73	0.93	9.20	9.60	10.05	10.66	11.30	12.00	12.70
80	897	10.89	0.93	9.20	9.80	10.30	10.80	11.50	12.10	12.80
81	826	11.06	0.96	9.50	9.95	10.40	11.00	11.60	12.40	13.00
82	923	11.37	0.99	9.70	10.20	10.70	11.30	12.00	12.70	13.20
83	890	11.58	0.99	9.90	10.40	10.90	11.50	12.20	13.00	13.60
84	863	11.72	1.04	10.00	10.50	11.00	11.60	12.30	13.00	13.90
85	731	11.98	1.02	10.10	10.80	11.30	12.00	12.60	13.20	14.00
86	753	12.29	1.02	10.60	11.00	11.60	12.20	13.00	13.60	14.40
87	653	12.44	1.06	10.50	11.00	11.70	12.40	13.00	13.90	14.50
88	565	12.66	1.04	10.80	11.40	12.00	12.60	13.30	14.00	14.90
89	537	12.97	1.19	11.00	11.60	12.20	12.80	13.70	14.50	15.20
90	486	13.21	1.23	11.30	12.00	12.50	13.00	14.00	14.70	15.80
91	352	13.47	1.15	11.70	12.00	12.70	13.50	14.10	15.00	15.80
92	337	13.67	1.10	12.00	12.50	13.00	13.50	14.20	15.00	16.00

Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.5

Change of weight-for-height/length mean and percentiles from birth to the age of 18 years (boys) (Continuation)

Body height/ length) (cm)	Case number (N)	Mean $\bar{x}$ (kg)	SD	Percentiles (kg)						
				3	10	25	50	75	90	97
93	268	13.98	1.33	11.70	12.50	13.10	14.00	14.80	15.50	16.80
94	311	14.23	1.34	12.00	12.50	13.30	14.10	15.00	15.50	17.00
95	336	14.48	1.26	12.20	13.00	13.70	14.30	15.10	16.00	17.00
96	300	14.64	1.22	12.50	13.00	13.90	14.80	15.50	16.20	16.60
97	310	15.05	1.30	13.00	13.50	14.00	15.00	15.60	16.80	18.00
98	404	15.24	1.36	12.80	13.60	14.20	15.00	16.00	17.00	18.00
99	379	15.50	1.40	13.00	14.00	14.60	15.30	16.40	17.40	18.50
100	349	15.75	1.37	13.50	14.00	15.00	15.60	16.50	17.50	18.50
101	310	16.15	1.58	14.00	14.50	15.20	16.00	16.90	17.80	19.20
102	360	16.32	1.49	13.50	14.50	15.20	16.30	17.20	18.20	19.00
103	389	16.67	1.59	14.00	14.80	15.50	16.50	17.50	19.00	20.00
104	349	17.03	1.54	14.20	15.10	16.00	17.00	18.00	19.00	20.20
105	399	17.27	1.66	14.80	15.20	16.00	17.00	18.20	19.20	20.50
106	365	17.49	1.51	15.00	15.80	16.50	17.50	18.20	19.10	21.40
107	348	17.93	1.66	15.30	16.00	16.80	17.80	19.00	20.00	21.50
108	362	17.96	1.75	15.00	16.00	17.00	18.00	19.00	20.00	22.00
109	362	18.61	1.99	15.80	16.50	17.30	18.40	19.50	21.00	23.00
110	381	18.85	1.77	16.10	16.80	17.50	18.80	20.00	21.00	22.00
111	365	19.31	1.90	16.20	17.10	18.00	19.00	20.10	21.50	23.30
112	392	19.67	2.05	16.50	17.50	18.10	19.50	20.70	22.20	24.00
113	397	19.94	2.11	16.50	17.50	18.60	19.90	21.00	22.00	25.00
114	369	20.31	2.22	16.80	18.00	19.00	20.00	21.50	22.80	25.30
115	387	20.61	1.97	17.50	18.30	19.20	20.30	21.60	23.30	25.00
116	374	21.08	2.23	17.90	18.50	19.70	21.00	22.20	23.50	25.00
117	372	21.60	2.22	18.00	19.20	20.00	21.20	22.80	24.20	26.30
118	410	21.81	2.14	18.60	19.60	20.20	21.50	23.00	24.50	26.80
119	401	22.52	2.69	19.00	19.80	20.70	22.00	23.70	26.00	29.50
120	375	22.71	2.75	18.60	20.00	21.00	22.40	24.00	26.00	29.20
121	368	23.27	2.94	19.20	20.20	21.50	22.70	24.50	26.50	30.00
122	370	23.45	2.38	20.00	21.00	22.00	23.00	24.50	26.30	29.00
123	407	24.22	2.68	20.00	21.50	22.50	24.00	25.40	27.40	29.50
124	410	24.76	2.74	20.50	21.80	23.00	24.50	26.00	28.30	30.50
125	441	25.39	3.55	20.50	22.00	23.30	25.00	26.50	29.20	34.00
126	394	25.78	3.02	21.60	22.50	23.80	25.30	27.00	29.50	33.00
127	453	26.35	3.42	21.70	23.00	24.00	25.80	28.00	30.00	35.00
128	418	26.83	3.39	22.80	23.60	25.00	26.00	28.00	31.00	35.30
129	465	27.48	3.21	23.00	24.00	25.20	27.00	29.00	31.80	35.00
130	436	28.30	3.93	23.00	24.00	26.00	27.70	30.00	33.00	38.50
131	411	28.75	4.11	23.50	24.70	26.00	28.10	30.30	33.30	38.00
132	463	29.32	3.98	24.00	25.20	26.90	28.60	31.00	34.00	38.00
133	471	29.82	4.03	25.00	26.00	27.00	29.00	31.50	35.00	40.00
134	481	30.23	4.19	24.80	26.00	27.70	29.50	32.00	35.00	40.50
135	535	31.35	4.48	25.10	27.00	28.50	30.20	33.00	37.50	43.50
136	504	31.92	4.89	26.00	27.50	29.00	30.90	33.60	37.50	44.00
137	515	32.24	4.86	25.70	27.50	29.20	31.20	34.00	38.00	44.50
138	528	32.71	4.56	26.50	28.00	29.90	32.00	34.50	38.00	43.00

Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.5

Change of weight-for-height/length mean and percentiles from birth to the age of 18 years (boys) (Continuation)

Body height/ length) (cm)	Case number (N)	Mean $\overline{x}$ (kg)	SD	Percentiles (kg)						
				3	10	25	50	75	90	97
139	555	33.71	5.16	26.50	28.70	30.50	32.60	36.00	39.80	46.60
140	641	34.42	5.39	27.50	29.20	31.00	33.10	36.20	41.00	48.30
141	530	35.12	5.63	27.80	29.50	31.50	33.80	37.50	42.30	49.70
142	571	35.71	5.52	28.50	30.00	32.00	34.50	38.00	43.20	50.00
143	578	36.41	5.72	29.00	31.00	32.50	35.20	39.00	43.70	49.40
144	574	37.44	6.02	29.70	31.50	33.30	36.00	40.00	46.00	53.00
145	578	38.19	6.22	30.00	32.10	33.80	37.00	40.60	46.00	54.10
146	502	38.76	6.27	31.00	32.50	35.00	37.00	41.20	47.00	56.00
147	560	39.51	6.45	30.60	32.80	35.00	38.00	43.00	48.50	55.20
148	583	40.72	6.90	31.50	33.70	35.70	39.00	44.50	50.80	57.70
149	535	41.56	7.14	32.50	34.20	36.80	39.80	44.60	51.50	60.00
150	563	42.00	7.45	32.00	34.20	36.80	40.20	45.80	52.20	60.00
151	495	43.35	7.66	33.20	35.90	38.00	41.50	47.00	53.00	62.30
152	498	44.68	8.18	33.70	36.90	39.00	42.50	48.10	57.00	66.00
153	486	45.21	7.71	35.00	36.90	39.60	43.40	49.50	55.50	64.00
154	479	46.06	8.05	34.90	37.50	40.10	44.10	50.10	57.90	66.00
155	487	46.44	7.86	35.50	38.30	41.00	45.00	50.00	57.20	65.20
156	452	47.91	8.68	36.50	39.10	42.10	46.00	51.50	59.80	69.70
157	437	49.11	9.11	37.60	39.20	43.00	46.50	53.50	62.40	69.10
158	476	50.00	9.10	37.60	40.10	43.60	48.00	55.00	63.00	71.00
159	398	51.34	9.40	39.00	42.00	45.20	49.00	55.50	64.50	76.40
160	454	51.44	9.49	39.10	42.50	45.00	49.00	55.00	64.50	75.40
161	403	53.47	9.83	39.50	42.50	46.40	51.80	58.50	68.50	75.20
162	406	53.27	9.05	40.60	44.00	47.00	52.00	57.00	63.50	75.20
163	442	54.78	9.38	43.00	45.00	48.20	53.00	58.50	66.00	78.70
164	402	55.63	9.27	43.00	46.00	49.00	54.00	60.00	68.50	78.90
165	429	55.63	8.80	43.60	46.20	49.80	54.00	60.00	67.20	78.00
166	362	57.18	9.46	45.00	46.70	50.90	55.70	61.40	68.00	82.20
167	412	58.63	9.48	45.80	48.70	52.00	57.00	63.00	70.00	82.20
168	489	59.14	9.84	47.20	49.30	52.20	57.00	63.00	74.00	85.00
169	481	60.55	10.06	47.20	51.00	54.00	58.00	64.00	75.50	84.20
170	441	60.45	8.99	48.00	51.40	55.00	59.00	64.50	71.00	82.20
171	443	63.17	10.98	50.20	52.00	55.50	60.70	68.00	78.70	94.80
172	442	64.56	11.58	51.40	53.80	56.50	62.00	69.00	80.10	98.00
173	461	64.44	11.45	50.50	54.00	57.00	61.50	68.00	80.50	90.00
174	402	64.43	10.84	50.60	54.00	57.80	62.30	68.10	77.50	88.50
175	413	66.47	9.42	54.00	56.40	60.00	64.50	70.50	80.00	88.20
176	313	64.89	8.48	52.10	55.50	58.70	63.80	69.50	75.00	86.00
177	316	66.71	9.77	52.20	56.80	60.50	64.80	70.60	79.80	89.00
178	329	68.08	9.16	54.00	58.00	62.00	66.50	72.90	80.10	88.00
179	235	69.51	9.93	55.20	59.50	63.00	68.00	73.00	81.00	95.90
180	227	71.01	10.40	56.00	59.50	64.70	69.00	75.00	85.00	98.00
181	191	70.20	9.09	56.90	60.10	65.00	68.20	74.40	81.10	94.50
182	147	71.44	11.17	58.00	61.00	64.20	69.50	76.00	84.10	98.30
183	132	73.18	10.87	58.50	62.00	65.00	71.00	78.50	92.50	96.80
184	101	74.68	12.85	58.00	60.50	65.00	70.80	81.50	95.20	105.20

Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.6

Change of weight-for-height/length mean and percentiles from birth to the age of 18 years (girls)

Body height/ length) (cm)	Case number (N)	Mean $\bar{x}$ (kg)	SD	Percentiles (kg)						
				3	10	25	50	75	90	97
47	237	2.83	0.25	2.50	2.55	2.65	2.80	2.95	3.14	3.35
48	409	2.97	0.28	2.53	2.62	2.79	2.95	3.12	3.30	3.60
49	592	3.13	0.34	2.60	2.75	2.92	3.10	3.30	3.50	3.77
50	696	3.32	0.30	2.78	2.92	3.12	3.30	3.50	3.70	3.90
51	784	3.49	0.33	2.86	3.10	3.27	3.48	3.70	3.93	4.15
52	814	3.73	0.41	3.00	3.25	3.48	3.70	3.97	4.20	4.50
53	834	3.95	0.45	3.10	3.45	3.70	3.95	4.18	4.47	4.82
54	868	4.18	0.46	3.39	3.65	3.90	4.15	4.45	4.75	5.10
55	814	4.42	0.48	3.45	3.85	4.12	4.42	4.70	5.00	5.25
56	880	4.71	0.51	3.85	4.10	4.35	4.65	5.00	5.31	5.70
57	837	4.89	0.50	3.95	4.30	4.55	4.90	5.20	5.51	5.85
58	901	5.19	0.54	4.35	4.60	4.85	5.10	5.50	5.87	6.35
59	949	5.46	0.51	4.62	4.85	5.10	5.41	5.75	6.10	6.45
60	998	5.72	0.60	4.80	5.10	5.35	5.65	6.02	6.43	6.85
61	978	5.94	0.58	5.00	5.30	5.56	5.90	6.25	6.69	7.08
62	1037	6.21	0.57	5.25	5.52	5.85	6.15	6.50	6.95	7.45
63	1087	6.45	0.56	5.52	5.80	6.05	6.40	6.80	7.20	7.60
64	1120	6.71	0.59	5.75	6.00	6.30	6.65	7.05	7.51	7.95
65	1085	6.95	0.62	5.90	6.23	6.55	6.90	7.30	7.71	8.30
66	1053	7.19	0.62	6.15	6.44	6.80	7.15	7.55	8.00	8.45
67	962	7.43	0.68	6.30	6.60	6.98	7.35	7.88	8.36	8.79
68	1006	7.68	0.68	6.55	6.85	7.20	7.65	8.06	8.60	9.10
69	997	8.02	0.71	6.80	7.15	7.50	8.00	8.50	8.95	9.50
70	942	8.27	0.73	7.00	7.35	7.75	8.25	8.75	9.20	9.80
71	845	8.47	0.74	7.22	7.55	8.00	8.44	9.00	9.45	9.93
72	960	8.77	0.76	7.45	7.88	8.24	8.70	9.22	9.80	10.25
73	893	9.03	0.76	7.70	8.10	8.50	9.00	9.50	10.00	10.50
74	866	9.26	0.82	7.90	8.25	8.70	9.20	9.80	10.30	11.00
75	820	9.50	0.83	8.10	8.50	9.00	9.40	10.00	10.50	11.25
76	835	9.72	0.89	8.25	8.60	9.10	9.60	10.20	10.80	11.65
77	677	9.98	0.86	8.50	9.00	9.30	9.90	10.50	11.10	11.89
78	822	10.19	0.93	8.70	9.10	9.60	10.10	10.70	11.40	12.20
79	756	10.43	0.92	8.90	9.30	9.80	10.30	11.00	11.70	12.30
80	761	10.63	0.96	9.00	9.50	10.00	10.60	11.20	11.90	12.60
81	679	10.77	0.98	9.10	9.60	10.10	10.70	11.30	12.00	12.80
82	734	11.01	0.94	9.50	10.00	10.40	11.00	11.50	12.10	13.00
83	707	11.30	0.99	9.70	10.10	10.60	11.20	12.00	12.60	13.50
84	714	11.50	1.00	10.00	10.30	10.80	11.40	12.00	12.80	13.50
85	671	11.72	1.04	10.00	10.50	11.00	11.60	12.30	13.00	13.80
86	582	11.92	1.00	10.20	10.70	11.20	12.00	12.50	13.10	13.90
87	538	12.14	1.08	10.40	10.90	11.50	12.00	12.80	13.50	14.10
88	410	12.53	1.06	10.70	11.30	11.80	12.50	13.10	14.00	14.60
89	363	12.77	1.27	10.80	11.30	12.00	12.70	13.50	14.40	15.00
90	304	12.95	1.18	11.00	11.50	12.00	13.00	13.80	14.50	15.10
91	263	13.27	1.24	11.00	12.00	12.50	13.10	14.00	14.80	16.00
92	248	13.44	1.25	11.10	12.00	12.50	13.50	14.20	15.00	16.00

Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.6

Change of weight-for-height/length mean and percentiles from birth to the age of 18 years (girls) (Continuation)

Body height/ length) (cm)	Case number (N)	Mean $\bar{x}$ (kg)	SD	Percentiles (kg)						
				3	10	25	50	75	90	97
93	256	13.75	1.16	11.70	12.20	13.00	13.70	14.50	15.20	16.00
94	293	14.02	1.55	11.80	12.40	13.00	14.00	14.90	15.50	17.00
95	309	14.21	1.27	12.00	12.60	13.50	14.10	15.00	16.00	16.70
96	287	14.61	1.40	12.10	13.00	13.50	14.50	15.50	16.40	17.50
97	287	14.84	1.37	12.50	13.20	14.00	14.80	15.50	16.80	17.70
98	313	15.04	1.37	12.80	13.50	14.10	15.00	15.80	16.70	17.50
99	275	15.25	1.44	13.00	13.50	14.30	15.00	16.00	17.20	18.00
100	292	15.67	1.49	13.30	14.00	14.60	15.50	16.50	17.50	18.50
101	327	15.80	1.41	13.00	14.20	15.00	15.60	16.70	17.50	18.80
102	360	16.11	1.47	14.00	14.50	15.00	16.00	17.00	18.00	19.00
103	328	16.59	1.67	13.80	14.80	15.50	16.50	17.50	18.60	20.20
104	314	16.85	1.54	14.50	15.00	15.90	16.80	17.80	18.60	20.10
105	323	17.08	1.57	14.50	15.40	16.00	17.00	18.00	19.00	20.50
106	309	17.29	1.73	14.60	15.00	16.00	17.00	18.50	19.50	21.00
107	330	17.60	1.85	15.00	15.50	16.20	17.50	18.80	20.00	22.00
108	333	18.12	1.90	15.00	16.00	17.00	18.00	19.10	20.50	22.10
109	349	18.40	1.98	15.80	16.20	17.00	18.00	19.40	20.80	23.00
110	370	18.77	1.92	16.00	16.70	17.50	18.50	19.50	21.00	23.50
111	299	18.99	2.31	16.00	16.80	17.50	18.60	20.00	21.50	24.00
112	343	19.45	2.03	16.00	17.00	18.00	19.30	20.50	22.00	24.00
113	333	19.63	2.11	16.30	17.40	18.30	19.50	20.50	22.20	24.20
114	323	20.25	2.47	16.90	17.80	18.60	20.00	21.50	23.00	25.00
115	371	20.74	2.49	17.30	18.00	19.00	20.20	22.00	23.40	27.30
116	336	20.86	2.29	17.30	18.00	19.20	20.50	22.00	24.00	26.00
117	337	21.50	2.79	18.00	18.80	19.70	21.00	22.80	25.00	28.00
118	340	21.72	2.48	18.00	19.20	20.00	21.40	22.90	25.00	26.60
119	354	22.08	2.64	18.50	19.20	20.00	21.90	23.50	25.70	28.50
120	378	22.55	2.47	19.00	19.80	21.00	22.20	24.00	26.00	27.50
121	348	23.26	2.98	19.30	20.20	21.30	22.80	24.50	27.00	29.60
122	385	23.66	2.74	19.50	20.50	22.00	23.00	25.00	27.20	30.00
123	360	24.11	3.52	20.00	20.50	22.00	23.50	25.30	28.10	32.50
124	336	24.65	3.27	20.00	21.10	22.50	24.00	26.20	28.80	31.50
125	389	25.25	3.58	20.40	21.70	23.00	24.50	27.00	30.00	33.30
126	379	25.28	3.19	21.00	22.00	23.00	24.70	27.00	29.50	32.60
127	371	26.08	3.38	21.00	22.50	24.00	25.50	28.00	30.50	33.90
128	382	26.54	3.51	22.00	23.00	24.20	26.00	28.30	31.00	33.00
129	406	27.06	3.54	22.00	23.50	24.60	26.30	28.70	32.00	36.00
130	394	28.07	4.09	22.50	24.00	25.20	27.00	29.90	33.50	39.00
131	386	28.12	3.99	22.50	24.00	25.30	27.50	30.00	33.00	38.50
132	387	29.15	4.73	23.10	25.00	26.00	28.00	31.00	35.00	40.00
133	366	29.20	3.84	23.70	25.00	26.30	28.80	31.10	34.90	38.00
134	415	29.69	4.21	24.30	25.10	27.00	28.90	32.00	35.00	40.00
135	439	31.06	4.49	25.20	26.50	28.00	30.00	33.00	37.00	42.00
136	404	31.85	5.18	25.00	26.50	28.20	30.70	34.50	39.50	44.10
137	417	31.75	4.93	25.20	27.00	28.50	30.90	34.00	38.00	43.00
138	438	32.52	4.83	26.00	27.00	29.00	31.50	35.00	38.50	44.00

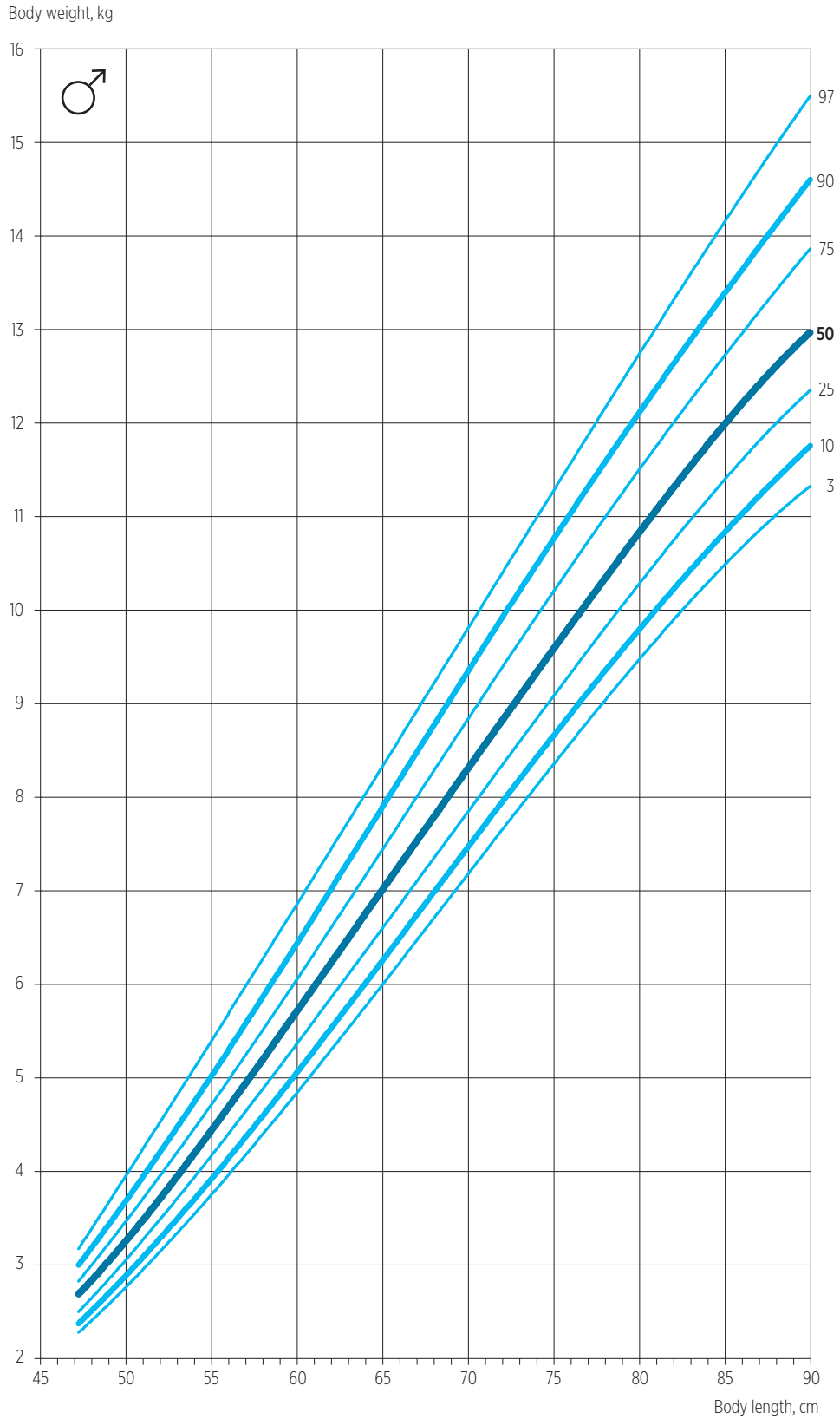
Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.6

Change of weight-for-height/length mean and percentiles from birth to the age of 18 years (girls) (Continuation)

Body height/ length) (cm)	Case number (N)	Mean $\bar{x}$ (kg)	SD	Percentiles (kg)						
				3	10	25	50	75	90	97
139	433	33.28	5.26	26.50	27.80	30.00	32.10	35.50	40.00	46.30
140	476	33.94	4.81	27.00	29.00	30.50	33.00	36.50	40.20	45.30
141	432	34.71	5.71	28.00	29.00	31.00	33.10	37.50	42.00	47.50
142	475	35.92	5.70	28.00	30.00	32.00	34.80	38.50	44.00	50.50
143	447	36.25	5.91	28.50	30.00	32.20	34.50	39.30	44.00	49.80
144	446	37.20	6.34	28.70	31.00	33.00	35.80	40.40	45.30	51.60
145	485	38.13	6.25	29.50	31.50	33.80	37.00	41.30	46.20	53.90
146	448	38.80	6.51	30.00	32.00	34.20	37.50	41.80	47.50	55.40
147	495	40.03	6.69	31.10	33.00	35.30	38.50	43.50	48.90	55.00
148	486	40.46	7.47	31.20	33.50	35.50	38.60	44.00	49.00	58.30
149	482	41.01	6.97	31.00	33.50	36.20	40.00	44.90	49.60	55.50
150	547	43.05	7.17	32.70	35.00	38.00	41.50	47.50	53.50	58.20
151	489	44.14	8.05	33.50	36.00	38.50	42.50	48.50	54.30	63.50
152	575	45.62	8.61	34.00	36.40	39.70	43.80	50.10	57.00	65.00
153	599	46.05	7.76	34.90	37.70	40.30	45.00	49.50	57.50	64.20
154	589	47.16	8.15	35.00	38.10	41.60	45.70	51.30	58.50	65.60
155	648	48.82	8.63	36.50	39.20	42.10	47.00	54.00	62.10	66.50
156	663	50.41	9.44	37.50	40.30	43.70	48.80	54.80	64.20	73.00
157	655	50.47	8.04	38.10	41.80	45.00	49.00	54.30	61.00	68.50
158	846	51.60	8.31	39.00	42.00	46.00	50.30	56.20	62.30	70.30
159	694	52.04	8.82	40.00	42.60	46.00	50.10	56.00	65.00	74.00
160	780	53.00	8.48	41.00	43.50	47.30	51.40	57.00	65.10	72.60
161	661	53.40	8.50	41.10	44.20	48.00	51.80	57.00	66.00	73.90
162	717	54.93	8.85	43.00	45.30	49.00	53.50	59.00	66.00	76.50
163	767	55.29	8.14	43.80	46.80	50.00	54.10	58.50	66.00	75.50
164	690	55.76	8.05	43.50	47.00	50.90	54.50	59.00	65.60	75.70
165	686	56.30	7.64	45.00	47.50	51.50	55.30	60.00	65.20	73.90
166	494	57.36	9.33	45.60	48.00	51.10	55.00	62.00	68.50	80.40
167	545	58.44	8.67	46.00	49.50	53.00	56.50	62.40	70.00	76.20
168	504	59.80	8.18	48.00	51.50	54.90	58.00	63.00	70.00	82.00
169	415	59.74	7.51	48.20	51.60	55.00	59.00	63.20	67.80	80.00
170	386	60.79	8.08	49.00	52.00	55.50	60.00	64.50	72.00	80.00
171	244	61.77	8.49	50.00	53.00	56.00	60.00	65.00	73.10	85.00
172	231	63.18	10.08	51.00	53.50	56.00	60.00	67.70	78.00	88.00
173	174	63.77	11.06	50.00	53.50	57.00	61.20	66.80	75.00	96.00
174	119	63.83	11.63	52.50	54.10	56.50	62.00	66.00	75.10	92.50
175	108	65.13	11.39	50.00	55.30	57.40	63.00	70.00	78.00	90.00

Based on the reference data of the Hungarian Longitudinal Growth Study.



Based on the reference data of the Hungarian Longitudinal Growth Study.
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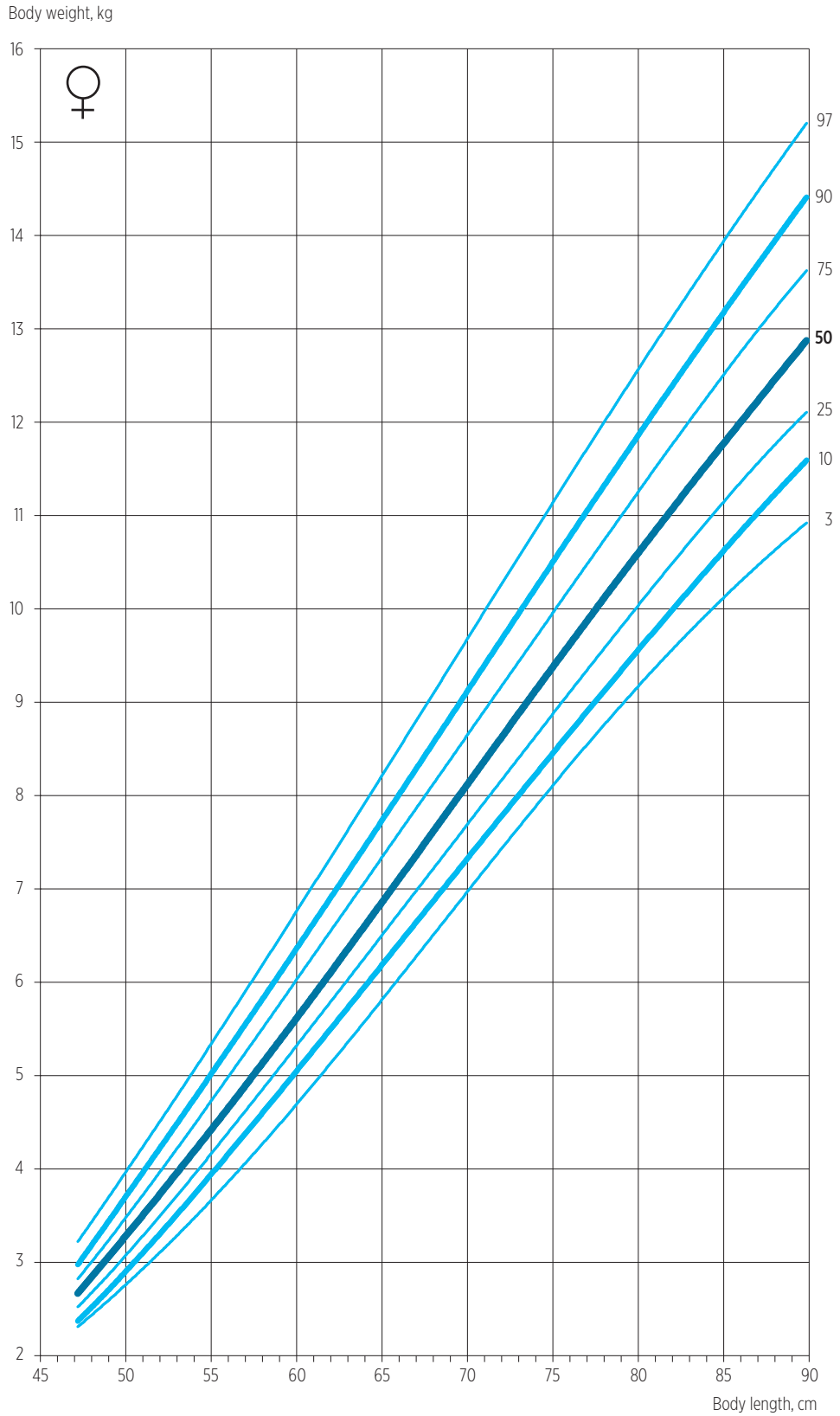
Figure 3.9
Percentiles of weight-for-length from birth to the age of 2 years (boys)



Based on the reference data of the Hungarian Longitudinal Growth Study.
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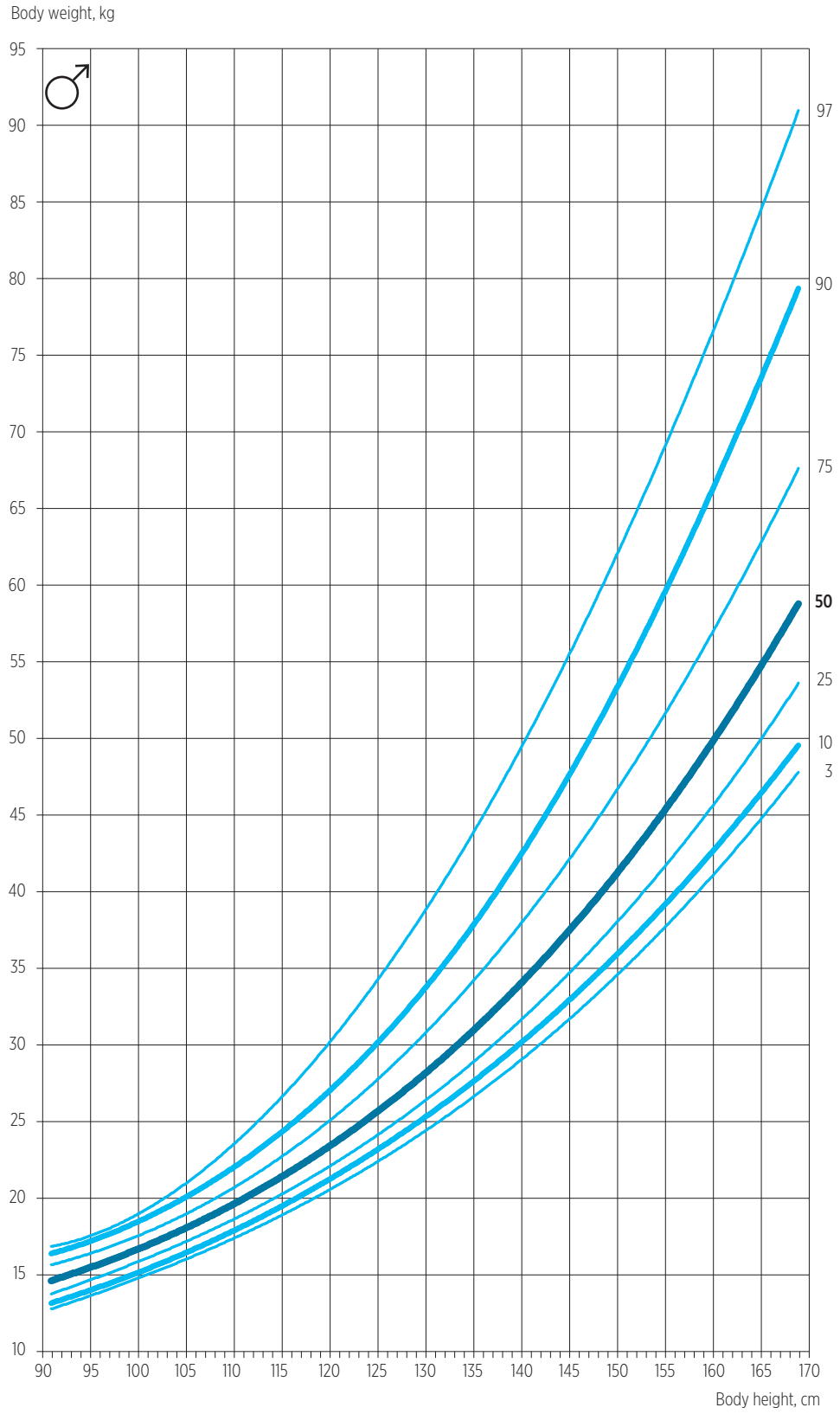
Figure 3.10
Percentiles of weight-for-length from birth to the age of 2 years (girls)



Based on the reference data of the Hungarian Longitudinal Growth Study.
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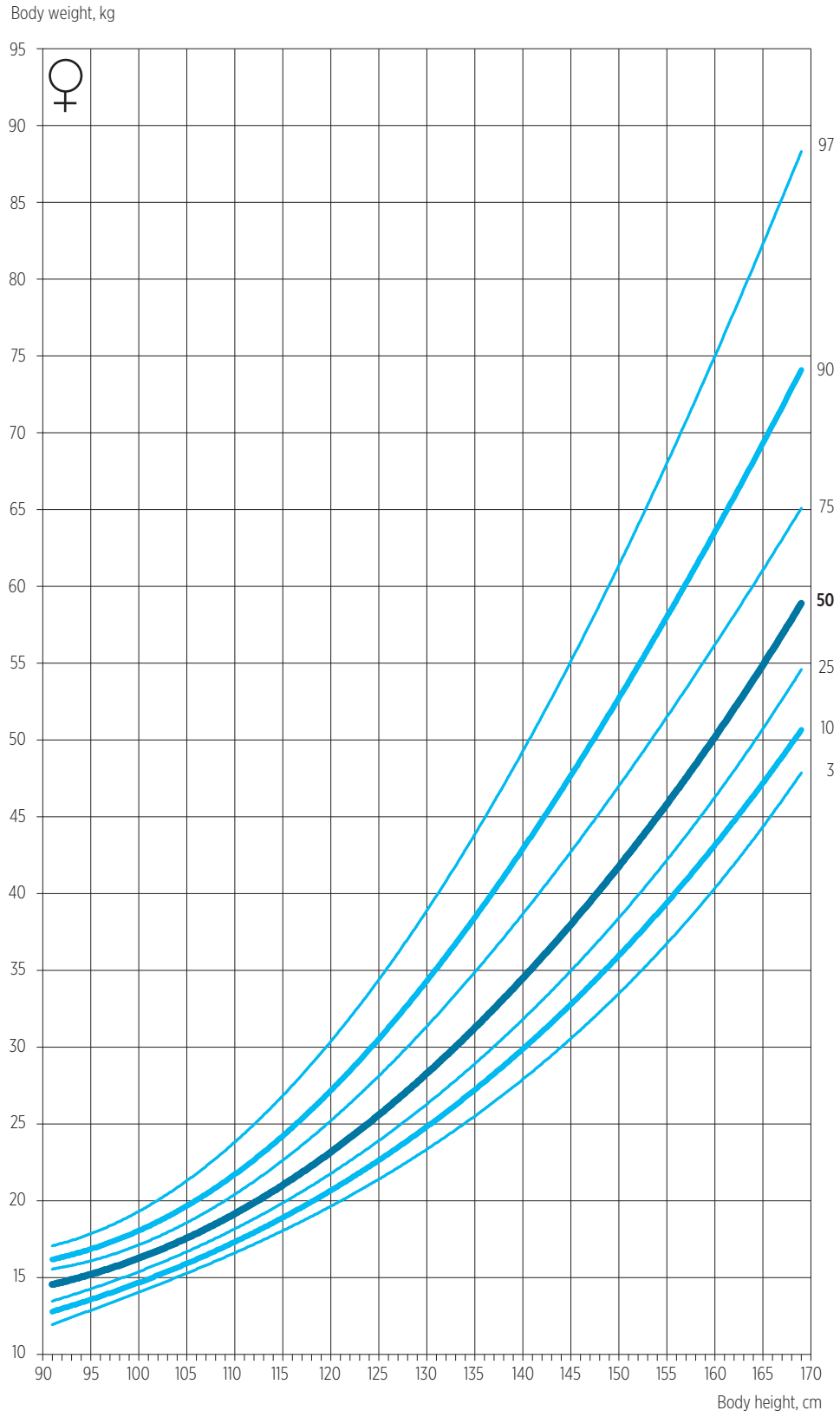
Figure 3.11

Percentiles of weight-for-height from the age of 2 to 14 years (boys) Percentiles of weight-for-length from birth to the age of 2 years (girls)



Based on the reference data of the Hungarian Longitudinal Growth Study.

Figure 3.12
Percentiles of weight-for-height from the age of 2 to 14 years (girls)birth to the age of 2 years (girls)

Table 3.7

Change of body mass index (BMI) reference mean and percentiles from birth to the age of 18 years (boys)

Age	Case number (N)	Mean $\bar{x}$ (kg/m²)	SD	Percentiles (kg/m²)							
				3	10	25	50	75	85	90	97
At birth	2 984	12.80	1.22	10.73	11.34	12.02	12.77	13.54	13.98	14.30	15.03
1 month	2 949	13.95	1.22	11.75	12.43	13.12	13.89	14.73	15.18	15.51	16.40
2 months	2 938	15.29	1.32	12.93	13.67	14.44	15.25	16.10	16.62	16.96	17.80
3 months	2 927	16.04	1.41	13.63	14.33	15.10	15.96	16.90	17.45	17.84	18.74
4 months	2 895	16.50	1.45	14.04	14.78	15.55	16.40	17.37	17.93	18.36	19.42
5 months	2 869	16.71	1.46	14.20	14.95	15.72	16.64	17.65	18.15	18.56	19.56
6 months	2 838	16.85	1.48	14.29	15.09	15.84	16.80	17.76	18.29	18.66	19.73
8 months	2 809	17.13	1.51	14.56	15.24	16.09	17.07	18.06	18.65	19.02	20.08
10 months	2 789	17.24	1.50	14.69	15.39	16.21	17.17	18.17	18.73	19.14	20.16
12 months	2 807	17.19	1.49	14.64	15.40	16.17	17.07	18.11	18.73	19.13	20.27
15 months	2 622	16.97	1.48	14.51	15.19	15.95	16.83	17.83	18.48	18.91	20.01
18 months	2 597	16.78	1.48	14.30	15.05	15.77	16.69	17.64	18.28	18.66	19.84
21 months	2 543	16.57	1.48	14.06	14.84	15.58	16.45	17.45	18.04	18.49	19.56
2 years	2 585	16.35	1.48	13.88	14.64	15.37	16.18	17.21	17.79	18.25	19.40
3 years	2 351	15.93	1.44	13.51	14.30	15.00	15.82	16.72	17.27	17.62	18.93
4 years	2 397	15.67	1.48	13.26	13.99	14.71	15.55	16.46	17.00	17.46	18.82
5 years	2 455	15.56	1.58	13.08	13.83	14.54	15.39	16.32	16.94	17.42	18.89
6 years	2 469	15.66	1.80	13.12	13.77	14.52	15.38	16.48	17.13	17.67	19.62
7 years	2 335	15.91	1.99	13.17	13.88	14.62	15.56	16.67	17.59	18.27	20.66
8 years	2 306	16.37	2.29	13.44	14.16	14.93	15.91	17.19	18.33	19.12	21.96
9 years	2 274	16.89	2.61	13.65	14.37	15.25	16.32	17.71	19.14	20.20	23.81
10 years	2 222	17.50	2.96	13.85	14.65	15.58	16.78	18.60	20.47	21.40	25.33
10.5 years	1 689	17.83	3.16	13.97	14.85	15.72	17.00	19.08	20.93	22.05	26.35
11 years	1 794	18.17	3.32	14.20	14.94	15.94	17.30	19.59	21.36	22.61	26.66
11.5 years	1 662	18.54	3.48	14.30	15.16	16.17	17.59	20.16	21.77	23.43	27.32
12 years	1 749	18.85	3.57	14.40	15.34	16.36	17.83	20.48	22.14	23.89	27.86
12.5 years	1 601	19.22	3.62	14.66	15.69	16.70	18.29	20.89	22.48	24.18	28.34
13 years	1 687	19.52	3.58	14.95	15.83	17.06	18.68	21.00	22.80	24.51	28.45
13.5 years	1 549	19.79	3.54	15.19	16.28	17.43	18.92	21.28	23.08	24.61	28.92
14 years	1 611	20.00	3.51	15.34	16.50	17.66	19.23	21.42	23.33	24.62	29.06
14.5 years	1 166	20.28	3.37	15.81	16.82	18.02	19.58	21.57	23.56	24.72	29.06
15 years	1 188	20.52	3.36	16.08	17.15	18.35	19.76	21.92	23.75	24.76	29.09
15.5 years	837	20.75	3.27	16.45	17.60	18.59	20.13	21.93	23.92	24.88	28.84
16 years	890	20.99	3.18	16.81	17.85	18.95	20.33	22.30	24.05	24.86	28.63
16.5 years	654	21.35	3.30	17.11	18.01	19.15	20.71	22.53	24.16	25.39	29.39
17 years	692	21.57	3.24	17.28	18.29	19.38	20.97	22.81	24.23	25.87	29.37
17.5 years	485	21.76	3.01	17.64	18.45	19.70	21.22	23.11	24.28	26.02	29.01
18 years	516	21.90	3.11	17.66	18.45	19.88	21.41	23.12	24.29	26.26	29.24

Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.8

Change of body mass index (BMI) reference mean and percentiles from birth to the age of 18 years (girls)

Age	Case number (N)	Mean $\bar{x}$ (kg/m²)	SD	Percentiles (kg/m²)							
				3	10	25	50	75	85	90	97
At birth	2 701	12.71	1.15	10.67	11.27	11.93	12.67	13.45	13.90	14.23	14.97
1 month	2 661	13.69	1.15	11.57	12.28	12.90	13.67	14.43	14.85	15.19	15.92
2 months	2 653	14.83	1.21	12.68	13.37	13.98	14.77	15.60	16.08	16.47	17.24
3 months	2 622	15.52	1.34	13.26	13.91	14.62	15.41	16.35	16.88	17.23	18.19
4 months	2 602	16.00	1.37	13.73	14.39	15.08	15.87	16.82	17.35	17.77	18.72
5 months	2 577	16.26	1.42	13.92	14.59	15.31	16.12	17.09	17.68	18.10	19.19
6 months	2 543	16.43	1.45	14.05	14.70	15.44	16.29	17.29	17.92	18.37	19.34
8 months	2 519	16.72	1.47	14.26	14.95	15.73	16.62	17.63	18.24	18.63	19.69
10 months	2 480	16.88	1.48	14.31	15.12	15.89	16.79	17.80	18.37	18.73	19.89
12 months	2 495	16.84	1.50	14.32	15.05	15.83	16.73	17.73	18.30	18.73	19.94
15 months	2 325	16.64	1.48	14.23	14.88	15.63	16.51	17.48	18.12	18.55	19.76
18 months	2 292	16.47	1.50	14.06	14.71	15.46	16.35	17.31	17.96	18.40	19.52
21 months	2 261	16.26	1.49	13.85	14.53	15.22	16.12	17.11	17.74	18.12	19.31
2 years	2 303	16.09	1.48	13.71	14.31	15.10	15.99	16.94	17.51	17.95	19.12
3 years	2 094	15.71	1.50	13.28	14.00	14.77	15.61	16.57	17.15	17.54	18.80
4 years	2 127	15.54	1.56	13.10	13.81	14.51	15.39	16.40	16.94	17.42	18.72
5 years	2 206	15.44	1.68	13.01	13.61	14.32	15.26	16.28	16.94	17.39	19.17
6 years	2 209	15.55	1.88	12.88	13.61	14.32	15.25	16.42	17.16	17.88	19.74
7 years	2 102	15.75	2.08	12.91	13.62	14.41	15.38	16.64	17.62	18.34	20.53
8 years	2 077	16.18	2.34	13.18	13.84	14.63	15.68	17.18	18.36	19.24	21.49
9 years	2 071	16.65	2.58	13.34	14.05	14.86	16.07	17.86	19.16	20.02	22.65
10 years	2 022	17.18	2.84	13.49	14.32	15.25	16.52	18.54	19.89	21.08	24.10
10.5 years	1 555	17.47	2.97	13.74	14.54	15.48	16.72	18.74	20.32	21.38	24.76
11 years	1 641	17.87	3.13	13.88	14.75	15.74	17.13	19.24	20.84	22.05	25.40
11.5 years	1 531	18.24	3.26	14.05	14.96	16.03	17.54	19.63	21.36	22.53	26.28
12 years	1 614	18.68	3.29	14.38	15.33	16.42	18.08	20.09	21.74	22.96	26.70
12.5 years	1 494	19.07	3.27	14.65	15.71	16.80	18.42	20.55	22.10	23.31	26.96
13 years	1 586	19.52	3.26	15.05	16.10	17.29	18.91	21.05	22.44	23.89	27.26
13.5 years	1 448	19.89	3.25	15.48	16.59	17.73	19.21	21.34	22.75	24.28	27.77
14 years	1 525	20.22	3.25	15.83	16.80	18.03	19.60	21.62	23.05	24.57	27.70
14.5 years	1 137	20.52	3.22	16.22	17.20	18.39	19.84	21.87	23.33	24.93	28.09
15 years	1 160	20.77	3.32	16.28	17.48	18.66	20.15	22.07	23.58	25.09	28.32
15.5 years	840	21.04	3.15	16.74	17.88	18.93	20.45	22.46	23.81	25.18	28.92
16 years	883	21.09	3.07	16.80	17.98	19.09	20.49	22.50	24.03	25.05	28.77
16.5 years	633	21.25	3.11	16.94	18.04	19.23	20.68	22.45	24.22	25.32	29.25
17 years	691	21.32	3.11	16.98	18.22	19.38	20.61	22.58	24.39	25.06	29.25
17.5 years	465	21.48	3.08	17.31	18.38	19.46	20.82	22.67	24.54	25.58	28.97
18 years	520	21.56	3.05	17.61	18.45	19.54	20.84	22.87	24.67	25.80	29.01

Based on the reference data of the Hungarian Longitudinal Growth Study.

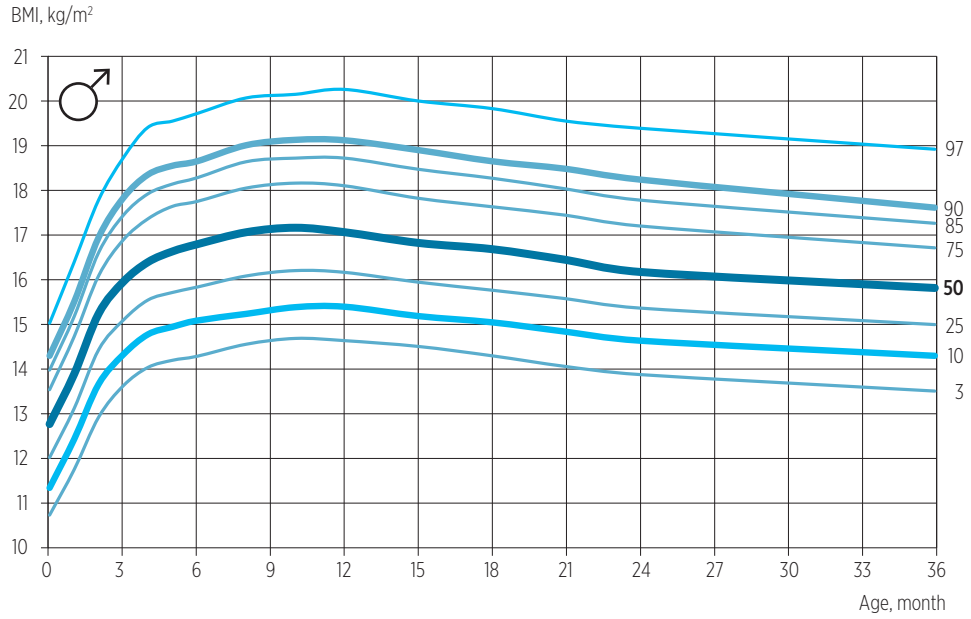


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Figure 3.13
Reference percentiles of body mass index (BMI) from birth to the age of 3 years (boys)

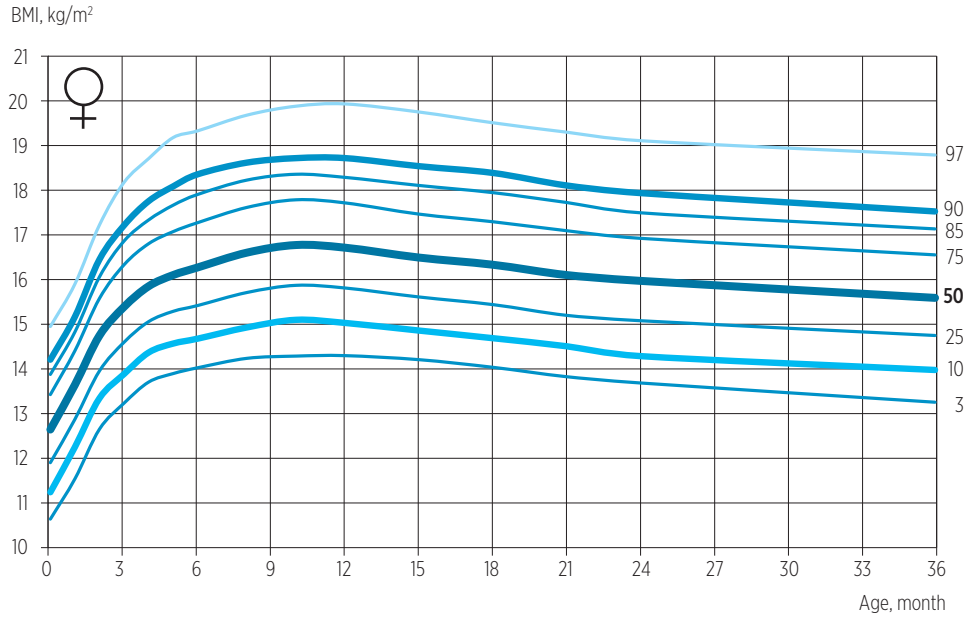

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Figure 3.14
Reference percentiles of body mass index (BMI) from birth to the age of 3 years (girls)

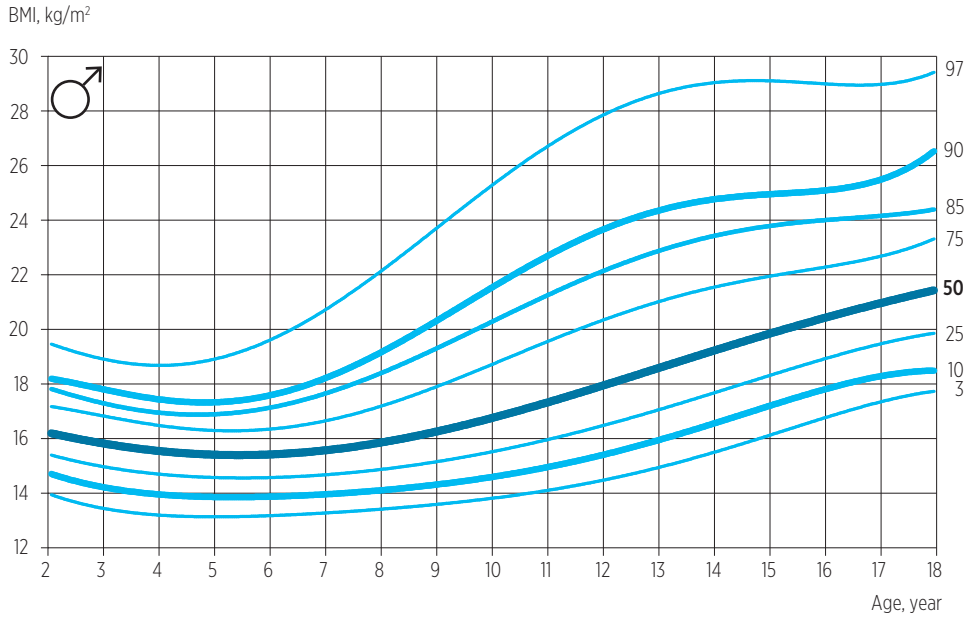

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Figure 3.15
Reference percentiles of body mass index (BMI) from the age of 2 to 18 years (boys)

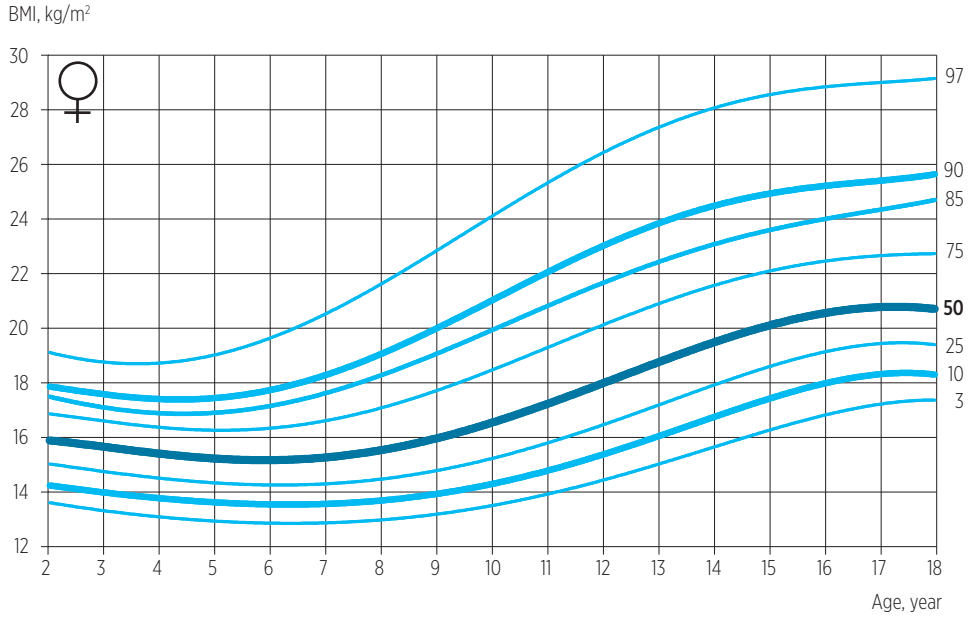

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Figure 3.16
Reference percentiles of body mass index (BMI) from the age of 2 to 18 years (girls)

Table 3.9

Reference means and percentiles of head circumference from birth to the age of 18 years (boys)

Age	Case number (N)	Mean $\bar{x}$ (cm)	SD	Percentiles (cm)						
				3	10	25	50	75	90	97
At birth	2 986	33.94	1.37	31.10	32.08	33.06	34.02	35.00	35.69	36.54
1 month	2 948	36.12	1.38	33.30	34.24	35.12	36.09	37.05	37.90	38.70
2 months	2 938	37.99	1.37	35.14	36.11	37.06	38.00	38.90	39.60	40.33
3 months	2 928	39.52	1.34	36.85	37.82	38.76	39.55	40.42	41.07	41.89
4 months	2 897	40.76	1.34	38.15	39.14	40.03	40.86	41.69	42.38	43.12
5 months	2 871	41.86	1.35	39.29	40.26	41.09	41.98	42.80	43.51	44.25
6 months	2 840	42.76	1.35	40.15	41.10	41.96	42.84	43.65	44.41	45.18
8 months	2 813	43.93	1.42	41.35	42.29	43.16	44.10	44.95	45.73	46.53
10 months	2 789	44.93	1.39	42.35	43.26	44.14	45.05	45.95	46.70	47.60
12 months	2 800	45.84	1.38	43.17	44.08	44.95	45.84	46.71	47.53	48.40
15 months	2 612	46.67	1.41	44.03	44.92	45.77	46.60	47.56	48.40	49.26
18 months	2 584	47.33	1.42	44.80	45.66	46.50	47.35	48.23	49.11	50.04
21 months	2 529	47.89	1.44	45.42	46.26	47.10	47.93	48.87	49.76	50.58
2 years	2 578	48.41	1.44	45.92	46.70	47.53	48.37	49.28	50.12	50.95
3 years	2 345	49.42	1.37	46.97	47.71	48.53	49.47	50.28	51.07	51.94
4 years	2 383	50.09	1.37	47.60	48.37	49.20	50.11	51.00	51.83	52.60
5 years	2 432	50.71	1.33	48.20	49.03	49.85	50.73	51.58	52.34	53.10
6 years	2 445	51.23	1.30	48.77	49.55	50.40	51.23	52.06	52.83	53.58
7 years	2 315	51.60	1.29	49.22	49.98	50.78	51.56	52.51	53.20	54.03
8 years	2 290	51.99	1.30	49.56	50.36	51.15	51.95	52.91	53.62	54.52
9 years	2 256	52.40	1.32	49.92	50.73	51.54	52.40	53.25	54.05	55.02
10 years	2 203	52.82	1.36	50.30	51.09	51.94	52.81	53.73	54.55	55.55
10.5 years	1 683	53.13	1.43	50.48	51.32	52.08	53.05	54.00	54.86	55.85
11 years	1 788	53.34	1.46	50.72	51.54	52.29	53.29	54.25	55.19	56.17
11.5 years	1 657	53.60	1.48	50.95	51.77	52.55	53.55	54.55	55.49	56.47
12 years	1 745	53.80	1.50	51.15	52.01	52.75	53.77	54.78	55.74	56.75
12.5 years	1 600	54.05	1.50	51.35	52.21	53.00	54.00	55.05	56.00	57.04
13 years	1 682	54.28	1.52	51.54	52.42	53.26	54.25	55.32	56.30	57.32
13.5 years	1 547	54.53	1.52	51.72	52.61	53.47	54.49	55.55	56.50	57.56
14 years	1 608	54.74	1.57	51.85	52.81	53.68	54.72	55.73	56.74	57.82
14.5 years	1 166	54.95	1.61	52.03	52.97	53.92	54.94	55.94	56.95	58.03
15 years	1 189	55.17	1.65	52.20	53.18	54.10	55.13	56.10	57.16	58.20
15.5 years	837	55.37	1.66	52.41	53.37	54.30	55.27	56.28	57.30	58.34
16 years	889	55.53	1.62	52.60	53.58	54.50	55.50	56.44	57.50	58.50
16.5 years	653	55.76	1.64	52.85	53.80	54.72	55.65	56.60	57.68	58.69
17 years	692	55.86	1.63	53.03	54.00	54.88	55.82	56.74	57.84	58.82
17.5 years	485	56.03	1.62	53.30	54.25	55.10	55.96	56.90	58.00	59.00
18 years	516	56.12	1.61	53.52	54.46	55.26	56.10	57.06	58.15	59.10

Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.10

Reference means and percentiles of head circumference from birth to the age of 18 years (girls)

Age	Case number (N)	Mean $\bar{x}$ (cm)	SD	Percentiles (cm)						
				3	10	25	50	75	90	97
At birth	2 696	33.43	1.29	31.01	31.81	32.58	33.50	34.24	35.04	35.90
1 month	2 663	35.40	1.31	33.00	33.78	34.54	35.51	36.22	37.04	37.95
2 months	2 654	37.12	1.27	34.55	35.52	36.28	37.07	37.95	38.70	39.48
3 months	2 622	38.54	1.27	36.04	37.00	37.80	38.56	39.38	40.05	40.95
4 months	2 605	39.72	1.27	37.25	38.15	39.02	39.76	40.54	41.23	42.05
5 months	2 579	40.76	1.28	38.36	39.21	40.05	40.81	41.57	42.25	43.10
6 months	2 546	41.67	1.30	39.18	40.00	40.85	41.61	42.42	43.20	44.00
8 months	2 522	42.81	1.34	40.32	41.15	42.04	42.85	43.69	44.54	45.34
10 months	2 483	43.80	1.35	41.28	42.15	43.03	43.85	44.65	45.53	46.35
12 months	2 493	44.71	1.34	42.12	43.02	43.82	44.64	45.50	46.31	47.23
15 months	2 316	45.53	1.35	43.05	43.90	44.69	45.53	46.38	47.21	48.15
18 months	2 284	46.18	1.38	43.66	44.55	45.35	46.15	47.05	47.97	48.96
21 months	2 254	46.74	1.36	44.23	45.05	45.92	46.77	47.63	48.55	49.52
2 years	2 302	47.29	1.38	44.73	45.57	46.39	47.23	48.09	49.04	49.93
3 years	2 090	48.33	1.29	45.97	46.70	47.52	48.28	49.12	50.00	50.81
4 years	2 118	49.05	1.28	46.65	47.52	48.23	49.04	49.93	50.69	51.53
5 years	2 189	49.68	1.29	47.24	48.04	48.93	49.70	50.54	51.28	52.10
6 years	2 193	50.23	1.29	47.80	48.58	49.48	50.21	51.06	51.82	52.56
7 years	2 068	50.66	1.24	48.33	49.06	49.90	50.65	51.51	52.23	53.03
8 years	2 044	51.08	1.26	48.73	49.54	50.30	51.05	51.95	52.69	53.52
9 years	2 040	51.52	1.28	49.12	49.95	50.70	51.54	52.36	53.13	54.02
10 years	1 996	51.97	1.31	49.55	50.40	51.15	52.03	52.85	53.72	54.60
10.5 years	1 542	52.32	1.38	49.75	50.66	51.43	52.30	53.11	54.06	54.96
11 years	1 637	52.62	1.41	50.00	50.95	51.71	52.56	53.45	54.42	55.31
11.5 years	1 531	52.89	1.44	50.23	51.20	51.99	52.88	53.76	54.72	55.60
12 years	1 616	53.17	1.45	50.50	51.47	52.25	53.13	54.05	55.03	55.93
12.5 years	1 494	53.45	1.46	50.78	51.71	52.55	53.39	54.38	55.30	56.17
13 years	1 584	53.69	1.46	51.02	52.00	52.78	53.65	54.65	55.55	56.45
13.5 years	1 447	53.97	1.47	51.22	52.21	53.05	53.90	54.86	55.81	56.72
14 years	1 523	54.15	1.47	51.40	52.38	53.22	54.08	55.05	56.00	56.96
14.5 years	1 139	54.28	1.48	51.60	52.55	53.40	54.23	55.15	56.15	57.14
15 years	1 162	54.48	1.48	51.75	52.70	53.52	54.37	55.29	56.30	57.32
15.5 years	839	54.59	1.47	51.90	52.82	53.65	54.53	55.43	56.40	57.45
16 years	883	54.72	1.47	52.03	52.94	53.82	54.67	55.55	56.50	57.60
16.5 years	630	54.85	1.50	52.15	53.05	53.92	54.80	55.67	56.58	57.75
17 years	691	54.92	1.47	52.30	53.18	54.04	54.93	55.78	56.65	57.87
17.5 years	467	55.08	1.48	52.48	53.35	54.18	55.05	55.85	56.70	57.97
18 years	522	55.17	1.45	52.65	53.50	54.30	55.17	55.95	56.82	58.07

Based on the reference data of the Hungarian Longitudinal Growth Study.

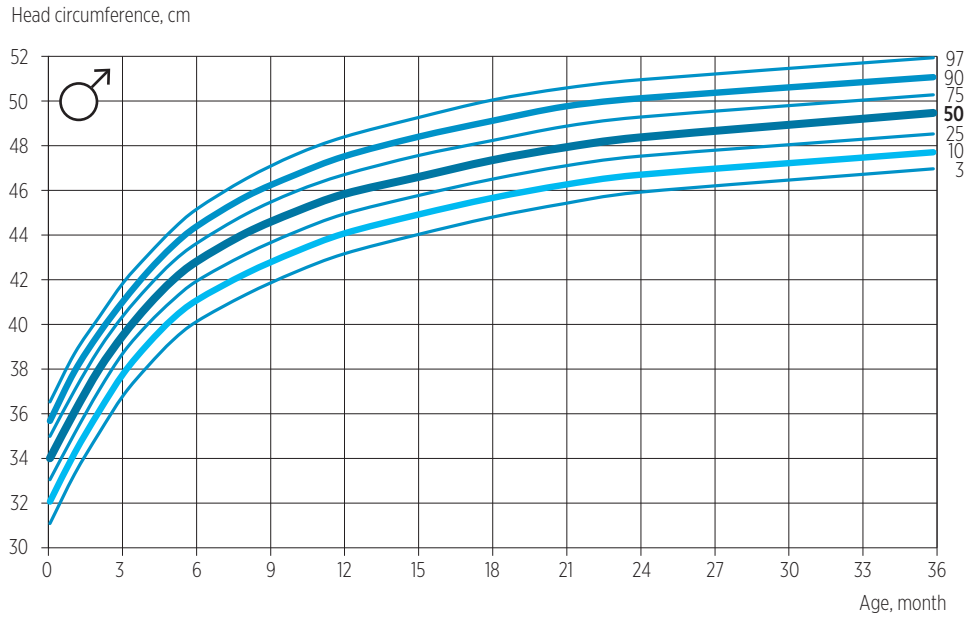

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Figure 3.17

Reference percentiles of head circumference from birth to the age of 3 years (boys)

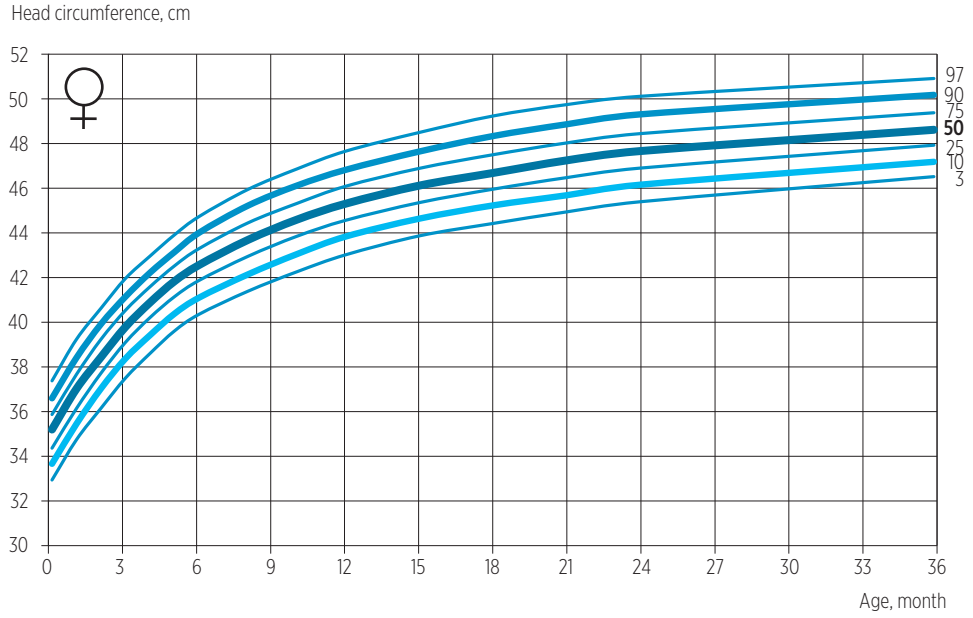

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Figure 3.18

Reference percentiles of head circumference from birth to the age of 3 years (girls)

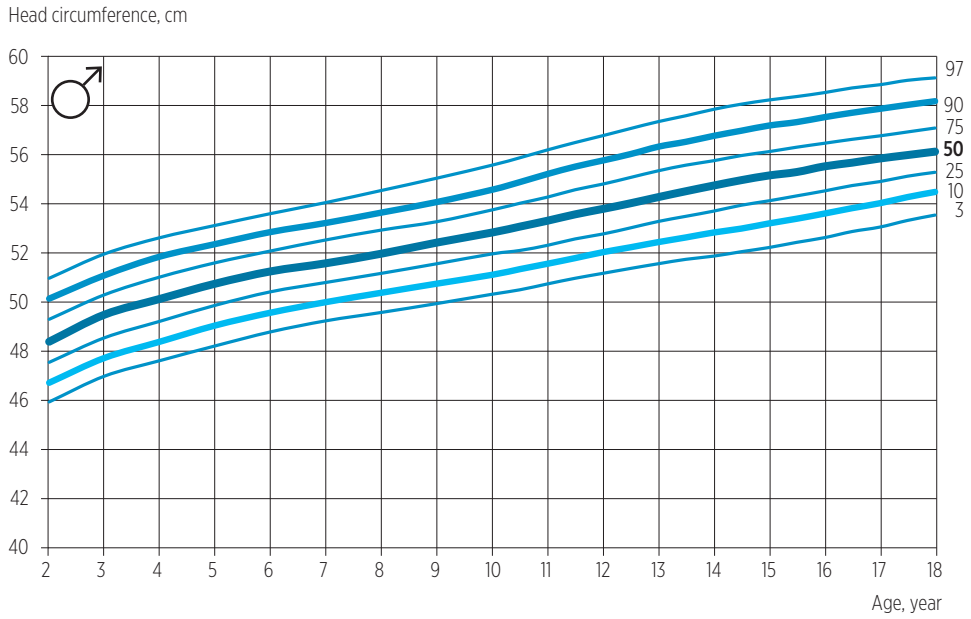

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Figure 3.19

Reference percentiles of head circumference from the age of 2 to 18 years (boys)

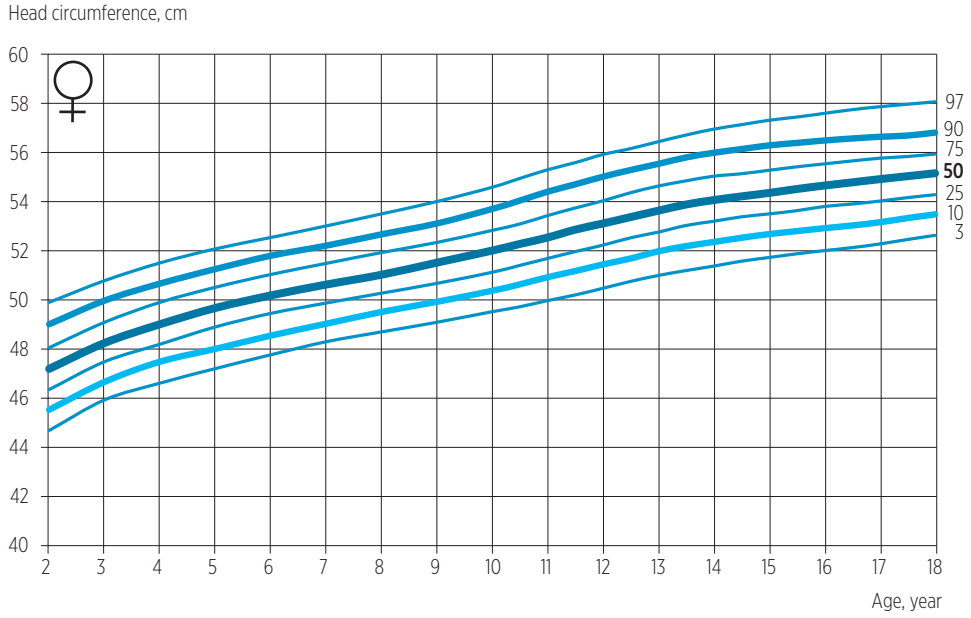

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Figure 3.20

Reference percentiles of head circumference from the age of 2 to 18 years (girls)

Table 3.11

Reference means and percentiles of chest circumference from birth to the age of 18 years (boys)

Age	Case number (N)	Mean $\bar{x}$ (cm)	SD	Percentiles (cm)						
				3	10	25	50	75	90	97
At birth	2 982	32.14	1.74	29.01	30.01	31.01	32.09	33.25	34.31	35.54
1 month	2 949	34.95	1.84	31.52	32.55	33.75	35.02	36.12	37.22	38.31
2 months	2 939	37.40	1.93	33.77	35.02	36.09	37.43	38.70	39.96	41.03
3 months	2 927	39.35	1.94	35.61	37.01	38.06	39.51	40.56	41.77	43.03
4 months	2 895	40.83	1.98	37.05	38.36	39.58	40.97	42.06	43.22	44.55
5 months	2 873	42.07	2.03	38.30	39.57	40.80	42.06	43.40	44.57	46.02
6 months	2 841	43.14	2.05	39.36	40.56	41.80	43.06	44.47	45.70	47.08
8 months	2 812	44.53	2.18	40.76	42.02	43.14	44.51	45.97	47.28	48.82
10 months	2 790	45.81	2.17	42.02	43.18	44.38	45.78	47.15	48.62	50.10
12 months	2 804	46.94	2.17	43.10	44.24	45.40	46.82	48.18	49.80	51.19
15 months	2 612	47.99	2.15	44.29	45.38	46.50	47.95	49.35	51.01	52.28
18 months	2 583	48.86	2.19	45.14	46.20	47.35	48.78	50.26	52.00	53.30
21 months	2 528	49.67	2.27	45.92	47.00	48.15	49.54	51.10	52.78	54.13
2 years	2 569	50.50	2.33	46.42	47.59	48.80	50.17	51.78	53.50	54.91
3 years	2 346	51.90	2.55	47.90	49.02	50.28	51.76	53.26	55.16	56.95
4 years	2 391	53.52	2.67	49.20	50.42	51.80	53.24	55.04	57.00	58.65
5 years	2 448	55.16	3.01	50.51	51.78	53.15	54.90	56.89	58.76	61.05
6 years	2 460	57.00	3.47	52.02	53.20	54.75	56.59	58.76	61.03	64.47
7 years	2 331	59.25	4.20	53.50	55.01	56.56	58.54	61.06	63.95	68.59
8 years	2 307	61.56	4.90	55.01	56.73	58.52	60.79	63.43	67.11	73.08
9 years	2 272	63.97	5.64	56.54	58.55	60.38	63.00	66.06	70.74	78.05
10 years	2 219	66.52	6.60	58.11	60.23	62.39	65.04	69.03	75.10	83.04
10.5 years	1 695	67.97	6.98	59.02	61.22	63.43	66.20	70.60	77.55	85.64
11 years	1 790	69.35	7.26	60.04	62.22	64.56	67.54	72.26	79.73	87.70
11.5 years	1 655	70.82	7.47	61.03	63.23	65.93	68.97	74.05	81.58	89.70
12 years	1 736	72.22	7.56	62.00	64.49	67.06	70.34	75.67	83.22	91.09
12.5 years	1 589	73.69	7.67	62.88	65.65	68.29	72.03	77.57	85.02	92.35
13 years	1 667	75.35	7.74	64.09	66.94	69.86	73.90	79.54	86.74	93.51
13.5 years	1 525	76.83	7.59	65.30	68.21	71.37	75.56	81.22	88.12	94.95
14 years	1 580	78.64	7.49	66.77	70.00	73.31	77.60	83.15	89.60	96.33
14.5 years	1 161	80.74	8.19	68.07	71.74	75.26	79.61	84.90	91.18	98.00
15 years	1 186	82.30	8.28	69.47	73.24	77.01	81.29	86.23	92.64	99.50
15.5 years	833	83.56	7.70	71.22	74.94	78.56	82.74	87.51	93.76	100.55
16 years	888	84.68	7.49	72.90	76.30	79.84	84.04	88.75	94.77	101.46
16.5 years	655	86.21	7.54	74.30	77.77	81.14	85.08	90.07	95.90	102.30
17 years	692	87.08	7.59	75.62	79.00	82.20	86.02	91.07	96.70	103.20
17.5 years	485	88.00	7.09	77.00	80.03	83.29	86.86	92.08	97.39	103.72
18 years	516	88.53	7.09	77.96	80.71	84.10	87.60	92.65	97.78	104.15

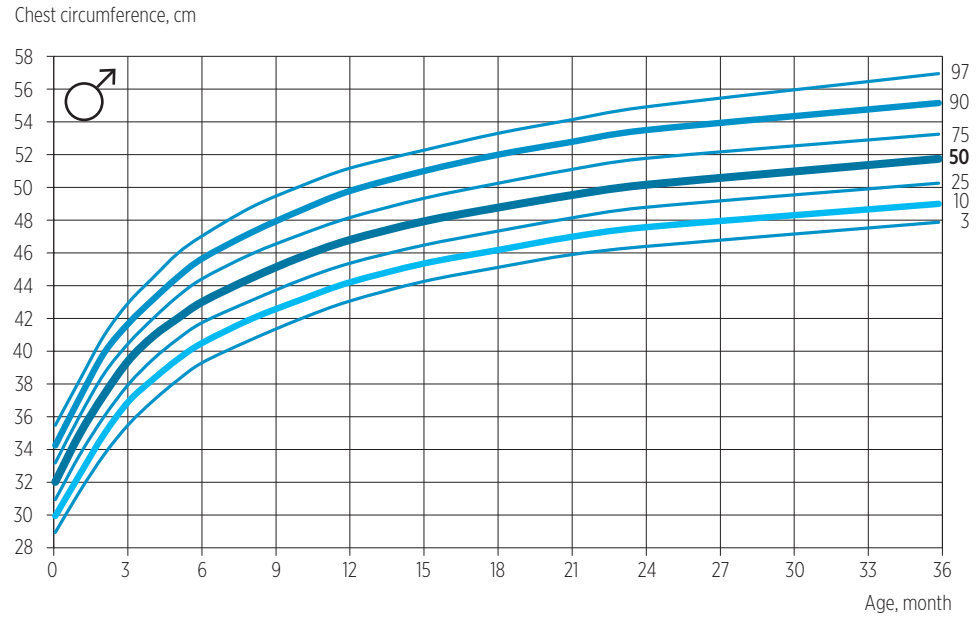
Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.12

Reference means and percentiles of chest circumference from birth to the age of 18 years (girls)

Age	Case number (N)	Mean $\bar{x}$ (cm)	SD	Percentiles (cm)						
				3	10	25	50	75	90	97
At birth	2 694	31.88	1.65	28.90	29.81	30.71	31.90	33.03	34.04	35.18
1 month	2 662	34.46	1.70	31.35	32.34	33.26	34.38	35.55	36.73	38.00
2 months	2 653	36.66	1.73	33.45	34.47	35.52	36.59	37.85	39.02	40.09
3 months	2 620	38.43	1.79	35.08	36.11	37.25	38.47	39.62	40.74	41.96
4 months	2 604	39.85	1.86	36.40	37.50	38.71	39.95	41.05	42.21	43.40
5 months	2 577	41.08	1.91	37.58	38.70	39.95	41.10	42.29	43.53	44.70
6 months	2 544	42.16	1.95	38.48	39.65	40.88	42.08	43.35	44.55	45.80
8 months	2 519	43.48	2.01	39.83	41.04	42.32	43.56	44.91	46.04	47.37
10 months	2 481	44.73	2.03	41.05	42.29	43.57	44.75	46.08	47.27	48.67
12 months	2 490	45.82	2.04	42.09	43.27	44.48	45.75	47.04	48.35	49.80
15 months	2 316	46.83	2.07	43.16	44.32	45.55	46.82	48.12	49.54	51.06
18 months	2 283	47.69	2.11	44.06	45.12	46.36	47.65	49.08	50.55	52.08
21 months	2 250	48.48	2.23	44.84	45.92	47.10	48.45	49.88	51.53	53.06
2 years	2 292	49.34	2.30	45.32	46.53	47.74	49.09	50.60	52.25	53.88
3 years	2 085	50.77	2.49	46.69	48.00	49.12	50.56	52.22	54.02	56.02
4 years	2 117	52.39	2.75	47.95	49.27	50.56	52.09	54.02	55.66	58.04
5 years	2 194	54.04	3.13	49.34	50.72	52.05	53.77	55.71	57.75	60.40
6 years	2 199	55.81	3.58	50.55	52.04	53.52	55.23	57.71	60.00	63.65
7 years	2 085	57.86	4.31	51.88	53.33	55.04	57.09	59.89	63.09	67.30
8 years	2 062	60.09	4.95	53.09	54.96	57.01	59.20	62.06	66.51	71.07
9 years	2 058	62.59	5.73	54.70	56.62	58.93	61.51	65.09	70.20	75.95
10 years	2 007	65.37	6.61	56.57	58.55	61.01	64.12	68.58	74.57	81.06
10.5 years	1 560	67.07	6.81	57.62	59.64	62.22	65.64	70.57	76.72	83.12
11 years	1 640	69.14	7.27	58.80	61.09	63.85	67.82	73.12	79.38	85.55
11.5 years	1 526	71.10	7.61	60.02	62.50	65.48	70.03	75.52	81.62	88.07
12 years	1 609	73.37	7.90	61.45	64.06	67.38	72.49	78.07	84.10	90.12
12.5 years	1 489	75.41	7.93	62.90	65.89	69.57	74.62	80.52	86.11	92.14
13 years	1 567	77.50	7.69	64.44	67.95	72.00	77.02	82.53	88.13	93.80
13.5 years	1 429	79.35	7.52	66.28	70.06	74.08	78.94	84.36	89.80	95.45
14 years	1 497	81.21	7.22	68.36	72.20	76.07	80.67	86.08	91.35	97.10
14.5 years	1 138	83.01	8.04	70.28	73.85	77.56	82.14	87.66	92.90	98.78
15 years	1 161	84.21	7.92	72.09	75.25	78.80	83.56	88.73	94.09	100.20
15.5 years	839	85.34	7.72	73.80	76.62	80.06	84.60	89.66	95.07	101.30
16 years	882	86.00	7.58	75.03	77.79	81.05	85.63	90.40	95.92	102.22
16.5 years	633	87.18	7.55	76.00	78.72	81.90	86.61	91.14	96.52	103.16
17 years	691	87.62	7.57	76.65	79.45	82.50	87.33	91.78	97.20	104.07
17.5 years	466	88.32	7.61	77.09	80.05	82.92	87.92	92.44	97.80	104.85
18 years	522	88.74	7.54	77.21	80.20	83.25	88.25	93.00	98.40	105.30

Based on the reference data of the Hungarian Longitudinal Growth Study.



Based on the reference data of the Hungarian Longitudinal Growth Study.
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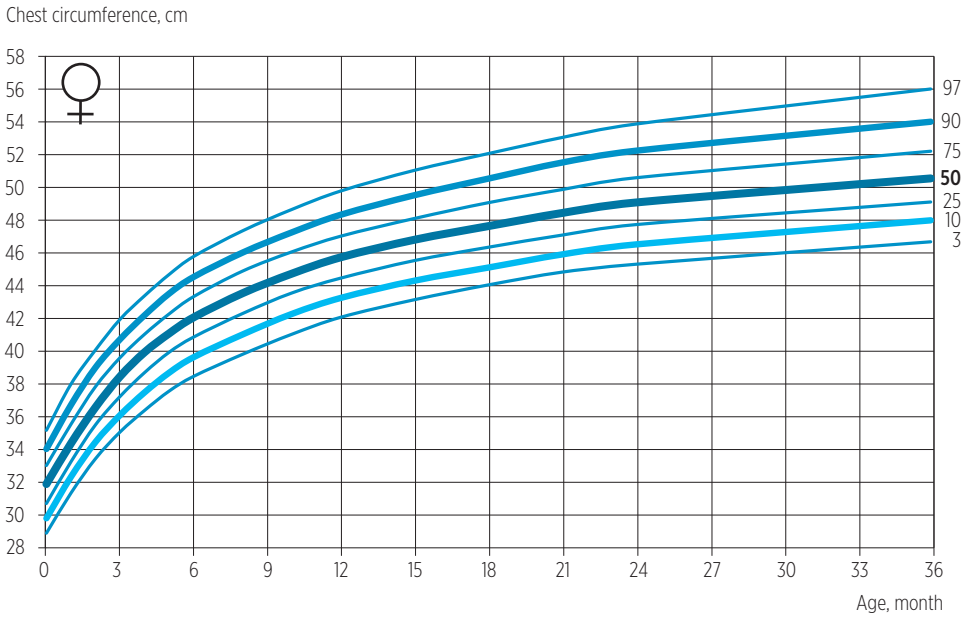
Figure 3.21

Reference percentiles of chest circumference from birth to the age of 3 years (boys)



Based on the reference data of the Hungarian Longitudinal Growth Study.
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Figure 3.22

Reference percentiles of chest circumference from birth to the age of 3 years (girls)

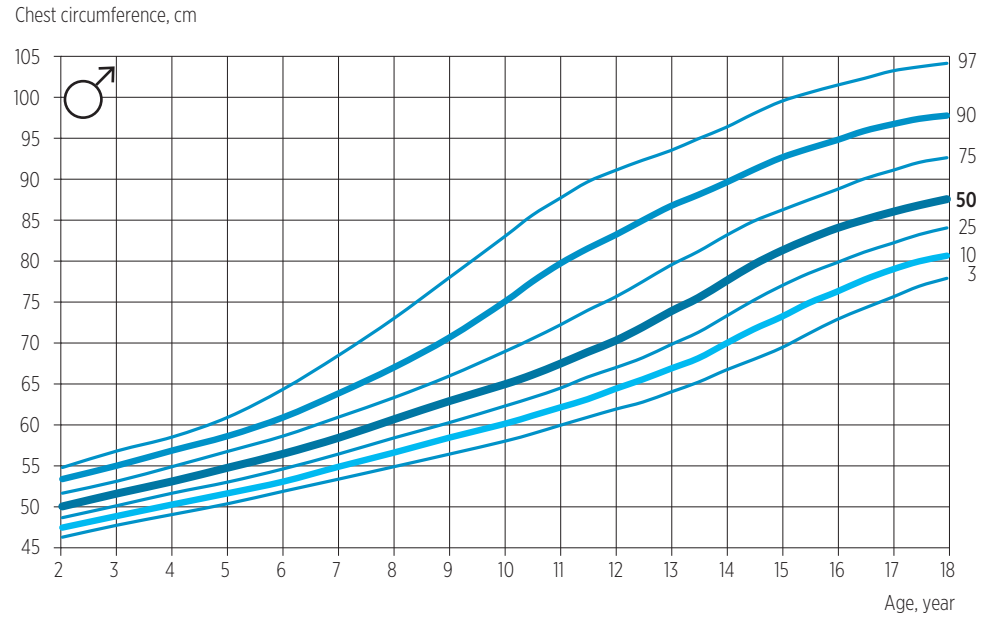

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Figure 3.23

Reference percentiles of chest circumference from the age of 2 to 18 years (boys)

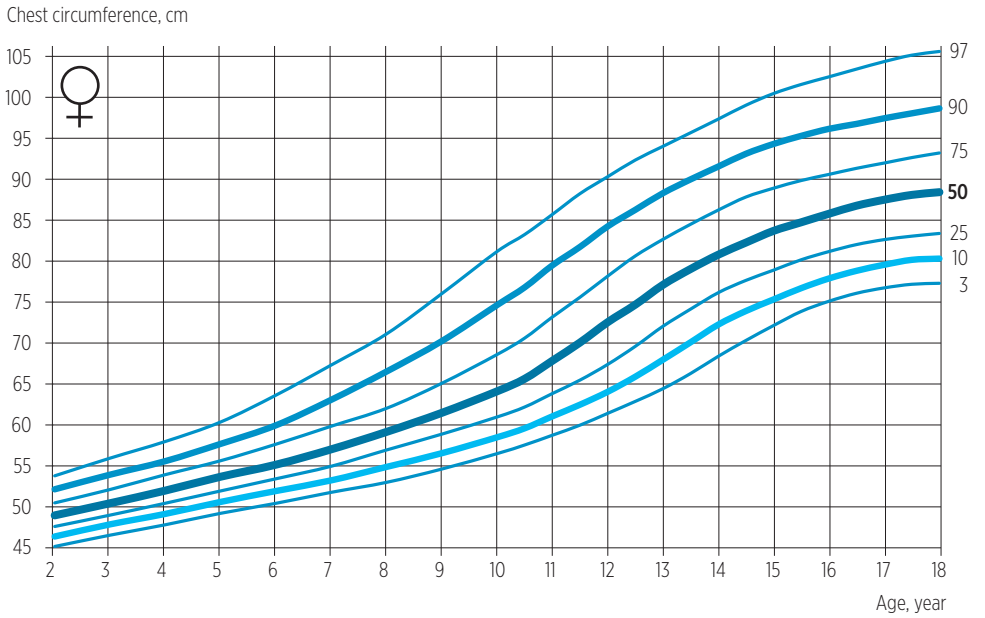

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Figure 3.24

Reference percentiles of chest circumference from the age of 2 to 18 years (girls)

Table 3.13

Reference means and percentiles of abdominal circumference from the age of 7 to 18 years (boys)

Age (year)	Case number (N)	Mean $\bar{x}$ (cm)	SD	Percentiles (cm)						
				3	10	25	50	75	90	97
7	2 321	55.51	5.09	48.06	50.04	52.04	55.01	58.02	62.04	68.05
8	2 279	57.73	5.37	50.04	52.03	54.04	57.01	60.04	65.07	71.04
9	2 229	59.92	5.91	52.00	54.01	56.02	59.02	62.06	68.10	75.07
10	2 140	62.02	6.34	53.02	55.04	58.01	61.02	65.04	72.01	77.12
10.5	1 608	63.10	6.40	54.02	56.03	59.01	62.02	66.08	73.04	78.11
11	1 683	64.26	6.57	55.01	57.03	60.01	63.03	67.12	74.11	80.01
11.5	1 538	65.19	6.66	55.06	58.02	60.06	64.06	69.04	76.01	80.10
12	1 605	66.31	6.63	56.03	59.01	62.01	65.06	70.07	76.11	82.01
12.5	1 458	67.36	6.66	57.04	60.00	63.00	66.08	71.11	78.00	82.06
13	1 526	68.46	6.57	58.02	61.02	64.02	68.01	73.03	78.08	83.02
13.5	1 391	69.54	6.27	59.04	62.03	65.05	69.04	74.02	78.12	83.02
14	1 452	70.78	6.17	60.05	63.05	66.11	70.08	75.05	79.12	84.04
14.5	1039	72.20	6.00	61.90	65.10	68.00	71.50	76.00	80.60	84.80
15	1074	73.30	6.20	63.00	66.00	69.00	72.50	77.00	82.00	86.10
15.5	764	74.30	5.90	64.30	67.50	70.00	73.50	77.80	83.00	86.90
16	824	75.10	6.20	65.20	68.00	70.60	74.20	78.80	84.10	88.80
16.5	608	75.90	6.10	66.10	69.00	71.50	75.00	79.50	85.00	89.20
17	641	76.40	6.10	66.00	69.00	72.00	75.60	80.30	85.00	90.00
17.5	459	77.20	6.10	67.00	70.00	72.60	76.30	81.00	86.00	90.00
18	484	77.40	6.10	67.20	70.10	73.00	77.00	81.50	86.00	90.10

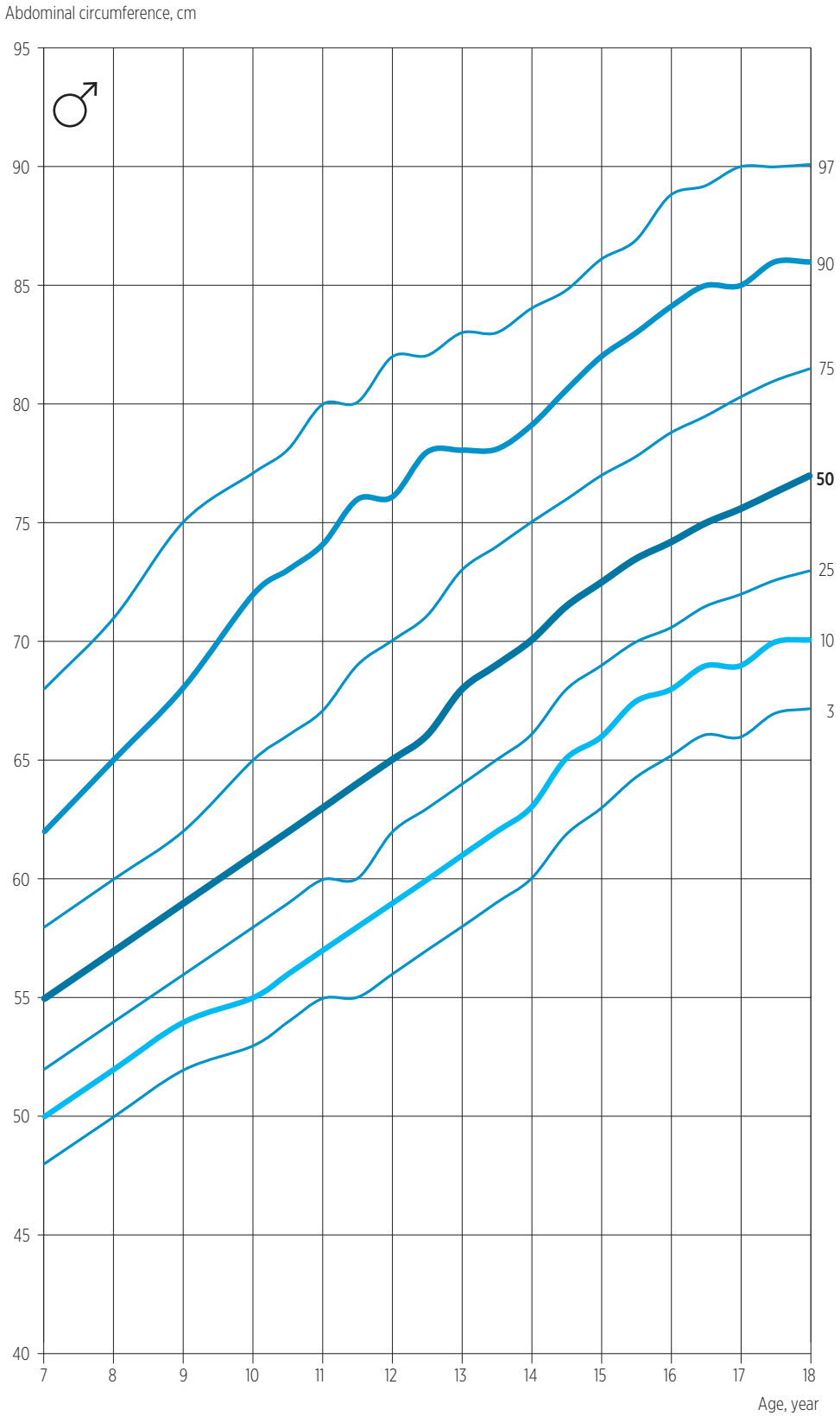
Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.14

Reference means and percentiles of abdominal circumference from the age of 7 to 18 years (girls)

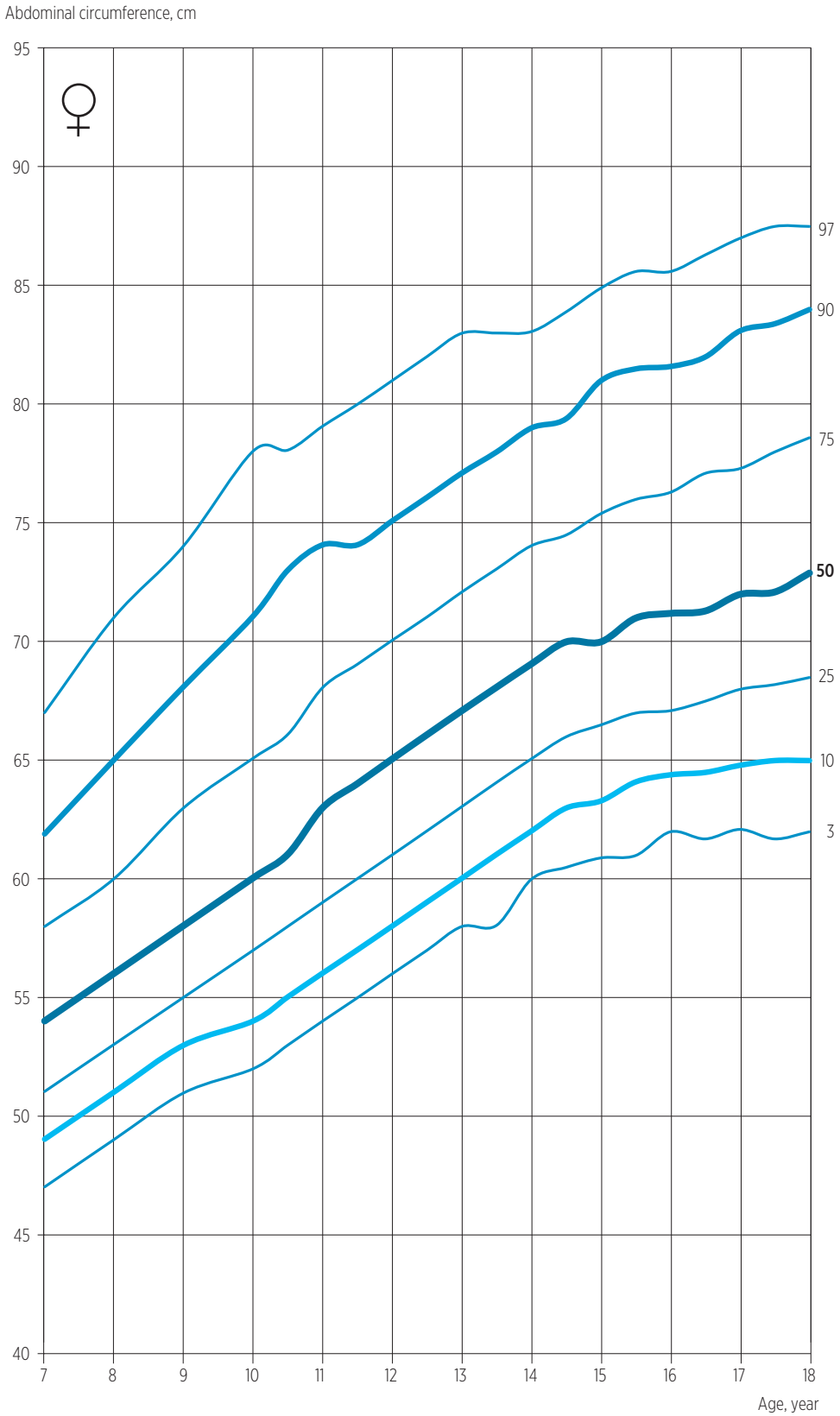
Age (year)	Case number (N)	Mean $\bar{x}$ (cm)	SD	Percentiles (cm)						
				3	10	25	50	75	90	97
7	2 090	54.82	5.06	47.04	49.05	51.06	54.03	58.01	61.91	67.02
8	2 063	57.15	5.62	49.04	51.04	53.05	56.04	60.03	65.04	71.04
9	2 048	59.42	6.21	51.00	53.01	55.03	58.05	63.01	68.12	74.05
10	1 980	61.61	6.71	52.02	54.03	57.01	60.06	65.10	71.09	78.04
10.5	1 531	62.70	6.64	53.02	55.05	58.02	61.06	66.11	73.03	78.08
11	1 600	64.05	6.77	54.03	56.05	59.03	63.02	68.08	74.09	79.09
11.5	1 473	64.84	6.62	55.01	57.03	60.03	64.03	69.06	74.09	80.01
12	1 558	65.95	6.66	56.02	58.03	61.03	65.07	70.07	75.10	81.01
12.5	1 437	66.94	6.53	57.01	59.04	62.04	66.09	71.05	76.09	82.02
13	1 525	68.11	6.52	58.01	60.04	63.06	67.10	72.10	77.11	83.00
13.5	1 377	68.82	6.28	58.06	61.05	64.08	68.09	73.07	78.00	83.01
14	1 457	69.71	6.33	60.00	62.03	65.07	69.07	74.05	79.01	83.07
14.5	1077	70.50	6.30	60.50	63.00	66.00	70.00	74.50	79.40	83.90
15	1108	71.20	6.50	60.90	63.30	66.50	70.00	75.40	81.00	84.90
15.5	808	71.80	6.50	61.00	64.10	67.00	71.00	76.00	81.50	85.60
16	854	72.10	6.50	62.00	64.40	67.10	71.20	76.30	81.60	85.60
16.5	613	72.50	6.70	61.70	64.50	67.50	71.30	77.10	82.00	86.30
17	671	72.80	6.70	62.10	64.80	68.00	72.00	77.30	83.10	87.00
17.5	453	73.20	7.00	61.70	65.00	68.20	72.10	78.00	83.40	87.50
18	511	73.80	7.20	62.00	65.00	68.50	72.90	78.60	84.00	87.50

Based on the reference data of the Hungarian Longitudinal Growth Study.



Based on the reference data of the Hungarian Longitudinal Growth Study.

Figure 3.25
Reference percentiles of abdominal circumference from the age of 7 to 18 years (boys)



Based on the reference data of the Hungarian Longitudinal Growth Study.

Figure 3.26
Reference percentiles of abdominal circumference from the age of 7 to 18 years (girls)

Table 3.15

Reference means and percentiles of abdominal circumference from the age of 7 to 18 years (boys) (Values corrected by fitting a second degree polynomial)

Age (year)	Case number (N)	Mean $\bar{x}$ (cm)	SD	Percentiles (cm)						
				3	10	25	50	75	90	97
7	2 321	55.51	5.09	48.13	49.77	51.68	54.48	57.14	62.28	68.71
8	2 279	57.73	5.37	49.75	51.67	53.84	56.79	59.99	65.46	71.55
9	2 229	59.92	5.91	51.42	53.57	55.98	59.05	62.72	68.44	74.21
10	2 140	62.02	6.34	53.13	55.50	58.09	61.28	65.33	71.22	76.71
10.5	1 608	63.10	6.40	54.00	56.46	59.13	62.38	66.60	72.54	77.89
11	1 683	64.26	6.57	54.88	57.43	60.17	63.47	67.83	73.80	79.02
11.5	1 538	65.19	6.66	55.77	58.40	61.20	64.55	69.04	75.02	80.12
12	1 605	66.31	6.63	56.67	59.38	62.22	65.62	70.21	76.18	81.17
12.5	1 458	67.36	6.66	57.59	60.36	63.23	66.68	71.36	77.29	82.17
13	1 526	68.46	6.57	58.51	61.34	64.24	67.73	72.47	78.35	83.14
13.5	1 391	69.54	6.27	59.45	62.32	65.25	68.77	73.56	79.36	84.06
14	1 452	70.78	6.17	60.40	63.31	66.24	69.80	74.62	80.32	84.93
14.5	1039	72.20	6.00	61.35	64.30	67.23	70.82	75.65	81.23	85.77
15	1074	73.30	6.20	62.32	65.30	68.21	71.83	76.65	82.09	86.56
15.5	764	74.30	5.90	63.30	66.30	69.19	72.83	77.62	82.90	87.30
16	824	75.10	6.20	64.29	67.30	70.15	73.82	78.56	83.66	88.01
16.5	608	75.90	6.10	65.29	68.30	71.11	74.80	79.47	84.37	88.67
17	641	76.40	6.10	66.31	69.31	72.07	75.77	80.36	85.02	89.28
17.5	459	77.20	6.10	67.33	70.32	73.02	76.74	81.21	85.63	89.85
18	484	77.40	6.10	68.36	71.33	73.96	77.69	82.03	86.19	90.38

Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.16

Reference means and percentiles of abdominal circumference from the age of 7 to 18 years (girls) (Values corrected by fitting a second degree polynomial)

Age (year)	Case number (N)	Mean $\bar{x}$ (cm)	SD	Percentiles (cm)						
				3	10	25	50	75	90	97
7	2 090	54.82	5.06	46.40	48.41	50.38	53.15	57.41	62.19	67.94
8	2 063	57.15	5.62	48.71	50.69	52.91	55.93	60.34	65.30	71.10
9	2 048	59.42	6.21	50.85	52.83	55.27	58.52	63.06	68.17	73.97
10	1 980	61.61	6.71	52.83	54.83	57.46	60.91	65.58	70.82	76.56
10.5	1 531	62.70	6.64	53.76	55.78	58.49	62.03	66.77	72.06	77.75
11	1 600	64.05	6.77	54.64	56.70	59.48	63.10	67.91	73.24	78.87
11.5	1 473	64.84	6.62	55.49	57.58	60.43	64.12	68.99	74.36	79.91
12	1 558	65.95	6.66	56.29	58.42	61.34	65.10	70.03	75.42	80.89
12.5	1 437	66.94	6.53	57.06	59.23	62.20	66.03	71.01	76.43	81.79
13	1 525	68.11	6.52	57.78	60.01	63.03	66.90	71.95	77.38	82.62
13.5	1 377	68.82	6.28	58.46	60.75	63.81	67.73	72.83	78.27	83.39
14	1 457	69.71	6.33	59.10	61.46	64.55	68.51	73.67	79.10	84.08
14.5	1077	70.50	6.30	59.69	62.13	65.25	69.24	74.45	79.88	84.70
15	1108	71.20	6.50	60.25	62.77	65.91	69.93	75.19	80.60	85.24
15.5	808	71.80	6.50	60.77	63.37	66.52	70.56	75.87	81.26	85.72
16	854	72.10	6.50	61.24	63.94	67.09	71.14	76.51	81.86	86.13
16.5	613	72.50	6.70	61.67	64.47	67.63	71.68	77.09	82.41	86.46
17	671	72.80	6.70	62.06	64.97	68.12	72.17	77.62	82.90	86.72
17.5	453	73.20	7.00	62.41	65.44	68.56	72.61	78.11	83.33	86.92
18	511	73.80	7.20	62.72	65.87	68.97	73.00	78.54	83.70	87.04

Based on the reference data of the Hungarian Longitudinal Growth Study.

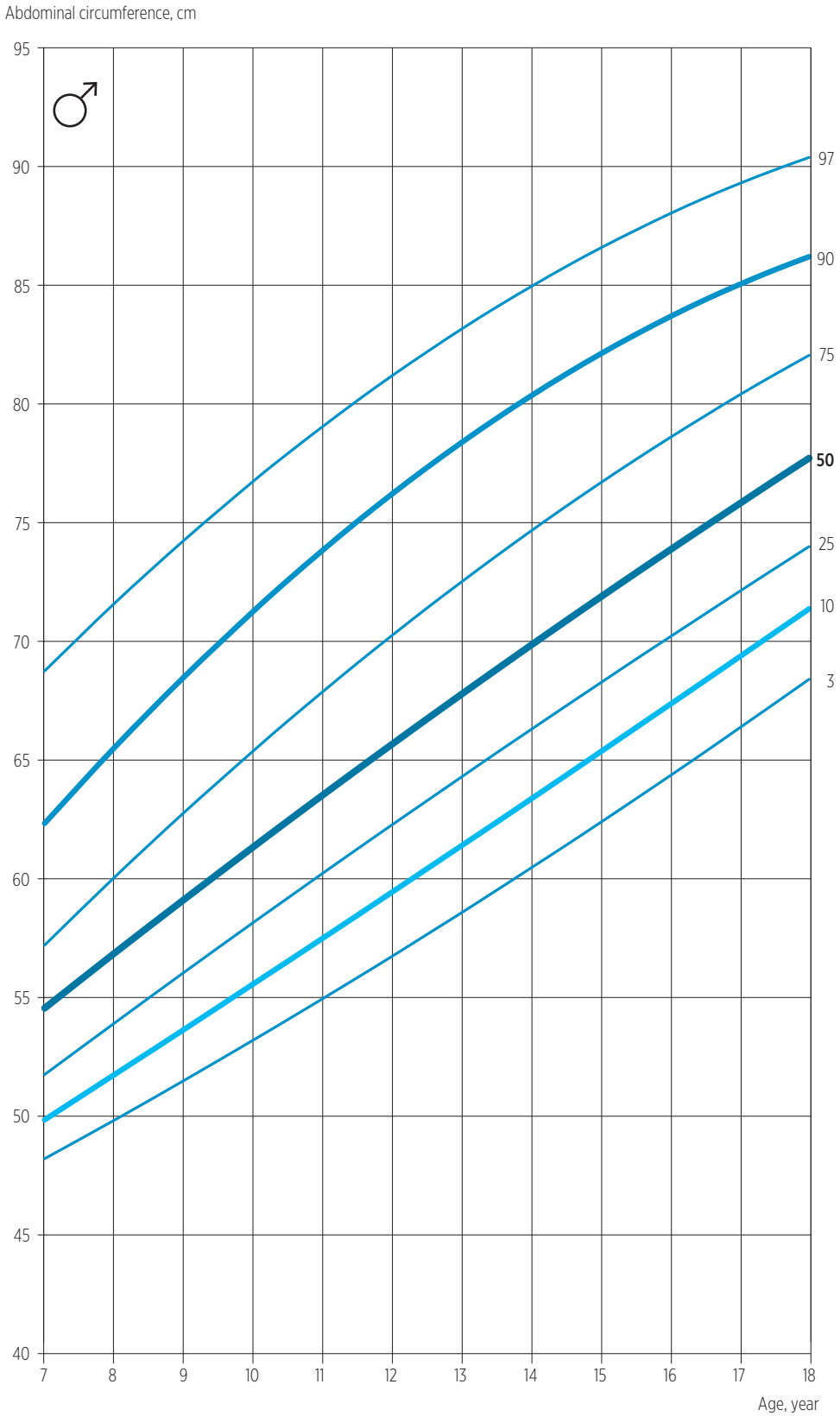


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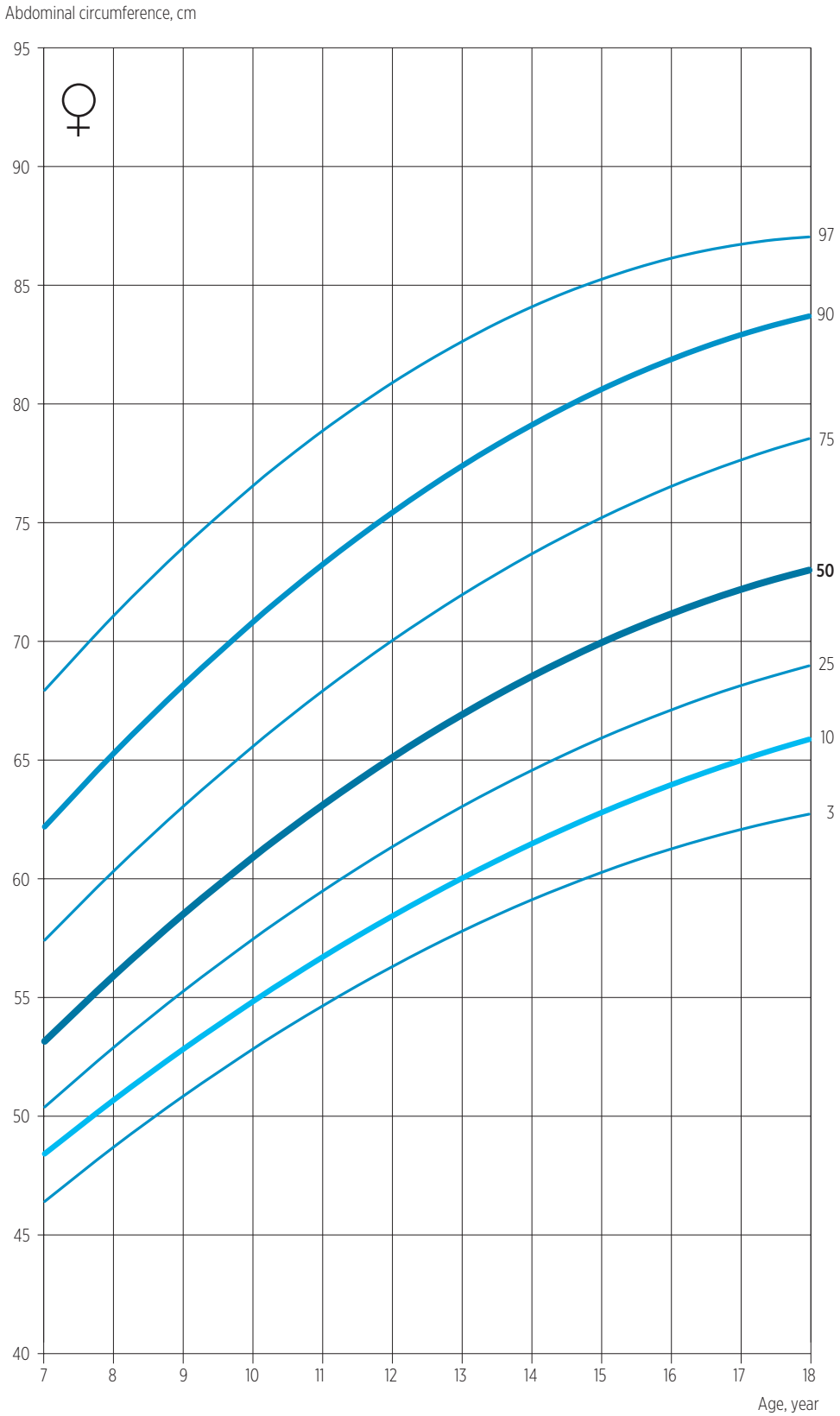
Figure 3.27

Reference percentiles of abdominal circumference from the age of 7 to 18 years (boys)
(Values corrected by fitting a second degree polynomial)



Based on the reference data of the Hungarian Longitudinal Growth Study.

Figure 3.28

Reference percentiles of abdominal circumference from the age of 7 to 18 years (girls) (Values corrected by fitting a second degree polynomial)

Table 3.17

Reference means and percentiles of triceps skinfold thickness from the age of 3 to 18 years (boys)

Age (year)	Case number (N)	Mean $\bar{x}$ (mm)	SD	Percentiles (mm)						
				3	10	25	50	75	90	97
3	2 094	10.1	3.3	5	6	8	10	12	14	17
4	2 127	10.3	3.4	5	6	8	10	12	15	18
5	2 207	10.4	3.7	5	6	8	10	12	15	19
6	2 208	10.5	4.1	5	6	8	10	13	16	20
7	2 106	10.0	4.0	4	6	7	10	12	15	20
8	2 081	10.6	4.3	4	6	8	10	12	16	21
9	2 074	11.1	4.7	4	6	8	10	14	18	22
10	2 023	11.7	5.0	4	6	8	11	15	19	23
10.5	1 564	12.2	5.3	4	6	8	11	15	20	24
11	1 645	12.3	5.4	4	6	8	11	15	20	25
11.5	1 533	12.5	5.4	4	7	9	12	15	20	25
12	1 619	12.6	5.4	4	7	9	12	16	20	25
12.5	1 501	12.9	5.4	5	7	9	12	16	20	25
13	1 593	13.0	5.4	5	7	9	12	16	20	25
13.5	1 452	13.6	5.4	5	8	10	13	17	21	25
14	1 528	13.8	5.5	5	8	10	13	17	21	26
14.5	1 137	14.3	5.5	6	8	10	14	18	21	26
15	1 160	14.8	5.8	5	8	11	14	18	22	27
15.5	839	15.3	5.7	6	9	11	14	19	22	29
16	882	15.2	5.9	5	9	11	15	19	23	28
16.5	632	15.1	5.7	6	8	11	14	18	23	28
17	690	15.0	5.8	6	9	11	14	19	22	30
17.5	466	14.4	5.9	5	7	10	14	18	22	28
18	522	14.3	6.0	5	7	10	14	18	22	28

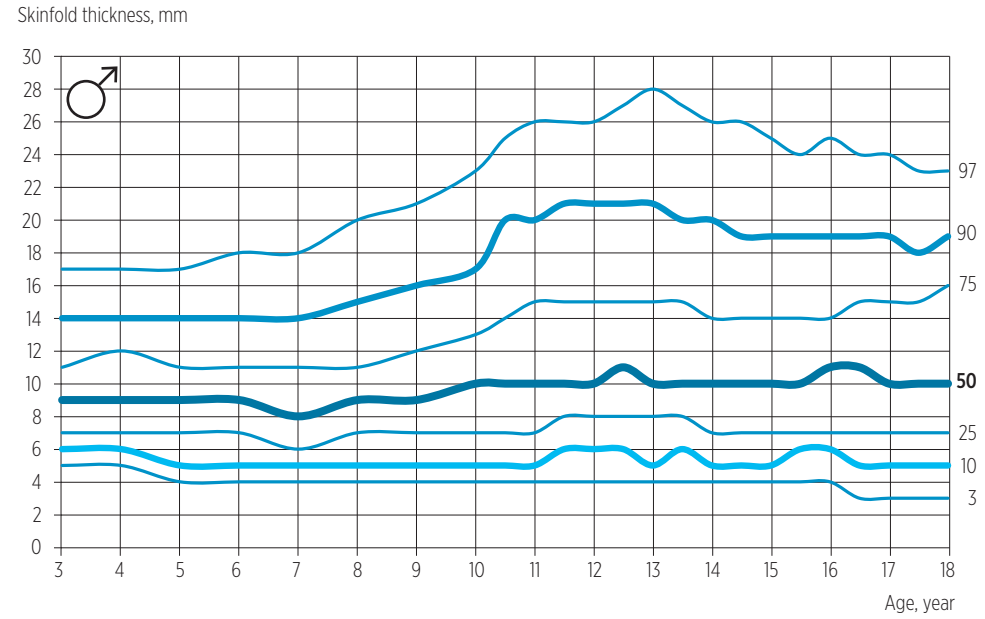
Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.18

Reference means and percentiles of triceps skinfold thickness from the age of 3 to 18 years (girls)

Age (year)	Case number (N)	Mean $\bar{x}$ (mm)	SD	Percentiles (mm)						
				3	10	25	50	75	90	97
3	2 094	10.1	3.3	5	6	8	10	12	14	17
4	2 127	10.3	3.4	5	6	8	10	12	15	18
5	2 207	10.4	3.7	5	6	8	10	12	15	19
6	2 208	10.5	4.1	5	6	8	10	13	16	20
7	2 106	10.0	4.0	4	6	7	10	12	15	20
8	2 081	10.6	4.3	4	6	8	10	12	16	21
9	2 074	11.1	4.7	4	6	8	10	14	18	22
10	2 023	11.7	5.0	4	6	8	11	15	19	23
10.5	1 564	12.2	5.3	4	6	8	11	15	20	24
11	1 645	12.3	5.4	4	6	8	11	15	20	25
11.5	1 533	12.5	5.4	4	7	9	12	15	20	25
12	1 619	12.6	5.4	4	7	9	12	16	20	25
12.5	1 501	12.9	5.4	5	7	9	12	16	20	25
13	1 593	13.0	5.4	5	7	9	12	16	20	25
13.5	1 452	13.6	5.4	5	8	10	13	17	21	25
14	1 528	13.8	5.5	5	8	10	13	17	21	26
14.5	1 137	14.3	5.5	6	8	10	14	18	21	26
15	1 160	14.8	5.8	5	8	11	14	18	22	27
15.5	839	15.3	5.7	6	9	11	14	19	22	29
16	882	15.2	5.9	5	9	11	15	19	23	28
16.5	632	15.1	5.7	6	8	11	14	18	23	28
17	690	15.0	5.8	6	9	11	14	19	22	30
17.5	466	14.4	5.9	5	7	10	14	18	22	28
18	522	14.3	6.0	5	7	10	14	18	22	28

Based on the reference data of the Hungarian Longitudinal Growth Study.



Based on the reference data of the Hungarian Longitudinal Growth Study.
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Figure 3.29

Reference percentiles of triceps skinfold thickness from the age of 3 to 18 years (boys)

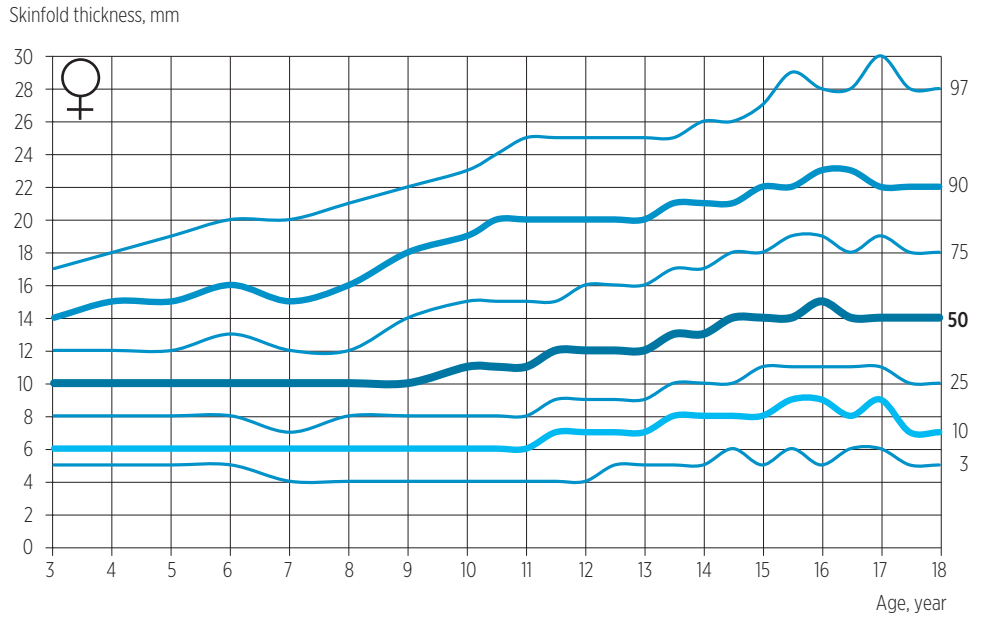

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Figure 3.30

Reference percentiles of triceps skinfold thickness from the age of 3 to 18 years (girls)

Table 3.19

Reference means and percentiles of subscapular skinfold thickness from the age of 3 to 18 years (boys)

Age (year)	Case number (N)	Mean $\bar{x}$ (mm)	SD	Percentiles (mm)						
				3	10	25	50	75	90	97
3	2 352	7.0	2.4	3	4	5	7	8	10	12
4	2 396	6.8	2.6	3	4	5	6	8	10	12
5	2 455	6.6	2.7	3	4	5	6	8	10	13
6	2 468	6.6	3.1	3	4	5	6	8	10	14
7	2 336	6.2	3.1	3	4	4	5	7	10	14
8	2 310	6.5	3.5	3	4	4	6	8	10	15
9	2 278	7.1	4.1	3	4	5	6	8	12	18
10	2 223	7.7	4.7	3	4	5	6	9	13	21
10.5	1 700	8.2	5.2	3	4	5	6	10	15	22
11	1 797	8.6	5.6	3	4	5	7	10	16	24
11.5	1 665	8.9	5.9	3	4	5	7	10	17	25
12	1 751	9.0	6.0	3	4	5	7	11	17	26
12.5	1 607	9.4	6.1	3	4	5	7	11	17	26
13	1 689	9.5	6.0	3	4	6	8	11	18	26
13.5	1 554	9.5	6.0	3	5	6	8	11	17	27
14	1 617	9.5	5.7	3	5	6	8	11	17	25
14.5	1 164	9.5	5.4	4	5	6	8	11	17	25
15	1 185	9.5	5.1	4	5	6	8	11	16	23
15.5	835	9.4	4.8	4	5	6	8	11	15	21
16	888	9.6	4.8	4	5	6	9	11	15	22
16.5	654	9.5	4.5	3	5	7	9	11	14	20
17	691	9.6	4.8	3	5	6	9	11	15	22
17.5	484	9.1	4.2	3	5	6	9	11	14	17
18	516	9.1	4.1	3	5	6	9	11	14	17

Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.20

Reference means and percentiles of subscapular skinfold thickness from the age of 3 to 18 years (girls)

Age (year)	Case number (N)	Mean $\bar{x}$ (mm)	SD	Percentiles (mm)						
				3	10	25	50	75	90	97
3	2 092	7.4	2.5	4	5	6	7	9	11	13
4	2 127	7.4	2.7	4	5	5	7	9	11	14
5	2 207	7.4	3.1	3	4	5	7	9	11	15
6	2 208	7.4	3.4	3	4	5	7	9	12	16
7	2 105	7.0	3.3	3	4	5	6	8	11	15
8	2 081	7.4	3.6	3	4	5	6	9	12	17
9	2 074	8.0	4.2	3	4	5	7	9	13	19
10	2 020	8.6	4.6	3	4	5	7	10	15	20
10.5	1 564	9.0	5.2	3	4	6	7	11	16	22
11	1 645	9.3	5.3	3	5	6	8	11	17	23
11.5	1 533	9.5	5.5	3	5	6	8	11	17	24
12	1 619	9.8	5.5	4	5	6	8	12	17	24
12.5	1 499	10.2	5.5	4	5	7	9	12	18	24
13	1 591	10.5	5.4	4	6	7	9	12	18	24
13.5	1 454	10.9	5.5	4	6	7	10	13	18	25
14	1 531	11.3	5.7	4	6	8	10	14	19	25
14.5	1 138	11.3	5.3	5	6	8	10	14	18	25
15	1 160	11.5	5.5	5	6	8	10	13	18	25
15.5	839	11.7	5.3	5	7	8	10	14	18	26
16	882	11.6	5.5	5	6	8	10	14	18	26
16.5	632	11.4	5.2	5	6	8	10	13	18	24
17	690	11.5	5.3	4	7	8	10	14	19	25
17.5	467	10.8	5.0	4	6	8	10	12	18	23
18	523	10.9	5.1	3	6	8	10	13	18	24

Based on the reference data of the Hungarian Longitudinal Growth Study.

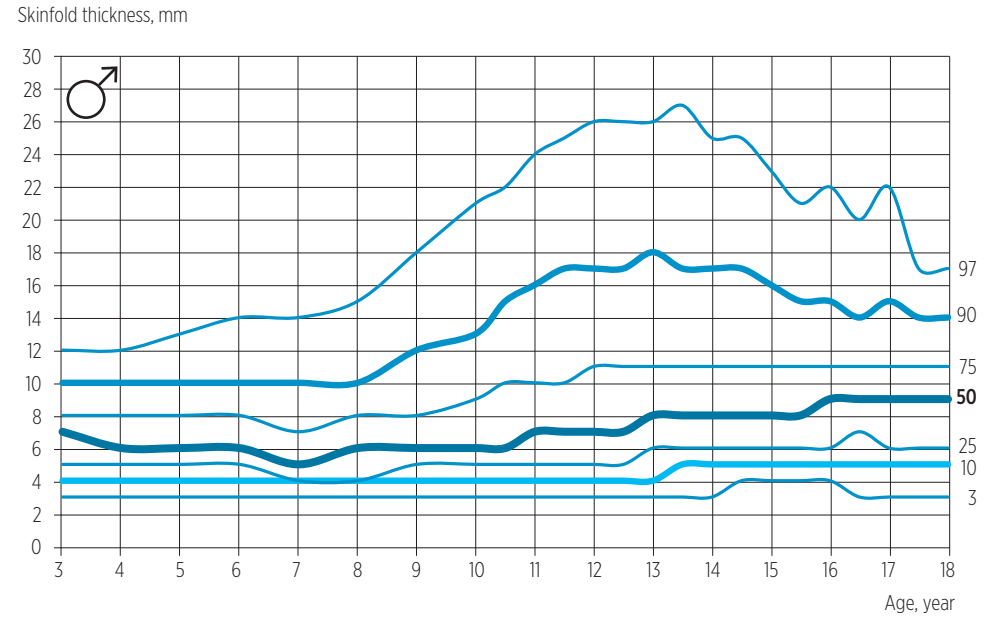

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Figure 3.31

Reference percentiles of subscapular skinfold thickness from the age of 3 to 18 years (boys)

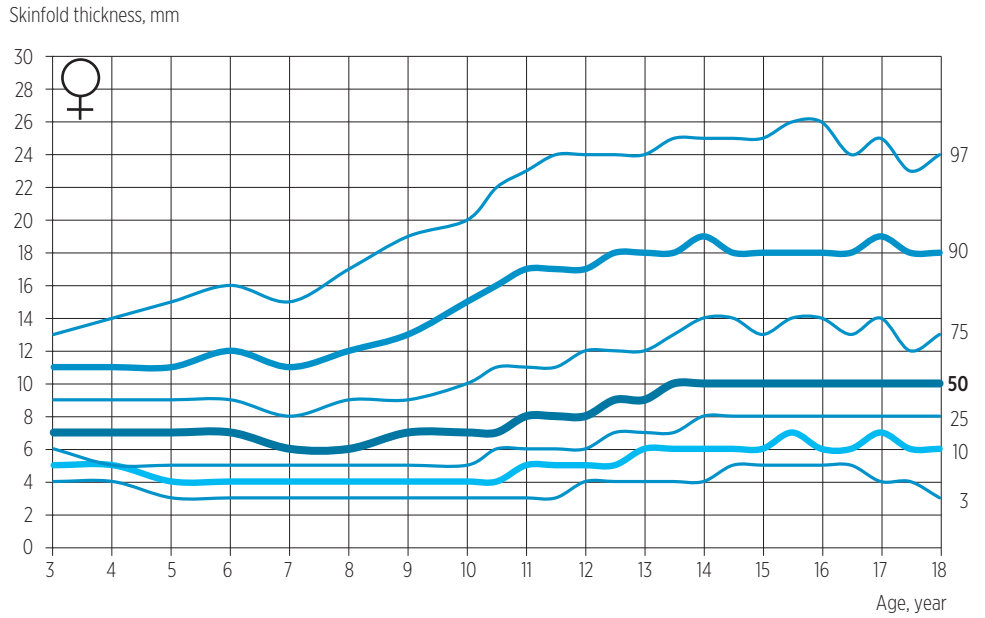

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Figure 3.32

Reference percentiles of subscapular skinfold thickness from the age of 3 to 18 years (girls)

Table 3.21

Reference means and percentiles of skinfold thickness at the abdomen from the age of 7 to 18 years (boys)

Age (year)	Case number (N)	Mean $\bar{x}$ (mm)	SD	Percentiles (mm)						
				3	10	25	50	75	90	97
7	2 335	7.3	4.2	3	4	5	6	9	12	18
8	2 305	8.0	4.7	3	4	5	7	9	14	20
9	2 275	8.8	5.4	3	4	5	7	10	15	23
10	2 220	10.0	6.3	3	4	6	8	12	19	26
10.5	1 692	10.6	7.4	3	4	6	8	13	22	30
11	1 788	11.1	7.8	3	4	6	9	14	22	30
11.5	1 656	11.5	8.2	3	4	6	9	14	24	32
12	1 739	11.9	8.3	3	4	6	9	15	24	32
12.5	1 597	12.0	8.0	3	4	7	10	15	24	31
13	1 680	12.3	8.2	3	5	7	10	15	24	34
13.5	1 541	12.2	7.9	3	5	7	10	15	23	32
14	1 606	12.1	7.6	3	5	7	10	15	23	31
14.5	1 163	11.9	7.3	4	5	7	10	15	21	31
15	1 172	12.1	7.4	4	5	7	10	15	22	30
15.5	836	11.7	6.9	4	5	7	10	14	20	28
16	888	11.8	7.0	4	5	7	10	15	20	29
16.5	654	11.6	6.6	4	5	7	10	14	19	27
17	691	11.6	6.8	4	5	7	10	14	20	27
17.5	476	11.1	6.0	4	5	7	10	13	19	24
18	508	11.1	6.0	3	5	7	10	14	20	24

Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.22

Reference means and percentiles of skinfold thickness at the abdomen from the age of 7 to 18 years (girls)

Age (year)	Case number (N)	Mean $\bar{x}$ (mm)	SD	Percentiles (mm)						
				3	10	25	50	75	90	97
7	2 104	8.2	4.2	3	4	5	7	10	14	18
8	2 078	9.1	4.9	3	4	6	8	11	15	22
9	2 071	10.0	5.5	3	5	6	9	12	17	24
10	2 019	11.1	6.2	3	5	7	10	14	20	26
10.5	1 559	11.9	7.1	3	5	7	10	15	22	30
11	1 639	12.4	7.3	3	5	7	10	16	23	30
11.5	1 526	12.8	7.5	4	5	7	11	16	23	31
12	1 613	13.3	7.4	4	6	8	12	17	23	32
12.5	1 494	13.8	7.6	4	6	8	12	17	24	31
13	1 585	14.2	7.4	4	6	9	13	18	24	32
13.5	1 443	14.6	7.5	4	7	9	13	18	25	33
14	1 520	15.1	7.5	4	7	10	14	20	25	33
14.5	1 134	15.1	7.8	4	7	10	14	19	25	34
15	1 156	15.2	7.7	4	7	10	14	19	25	34
15.5	839	15.1	7.5	5	8	10	14	19	25	32
16	882	14.9	7.6	4	7	10	13	19	25	33
16.5	631	14.6	7.1	5	7	10	13	18	23	32
17	689	14.5	7.1	5	7	10	13	18	23	31
17.5	451	13.7	7.5	4	6	9	12	17	23	35
18	507	13.8	7.8	4	6	9	12	17	23	33

Based on the reference data of the Hungarian Longitudinal Growth Study.

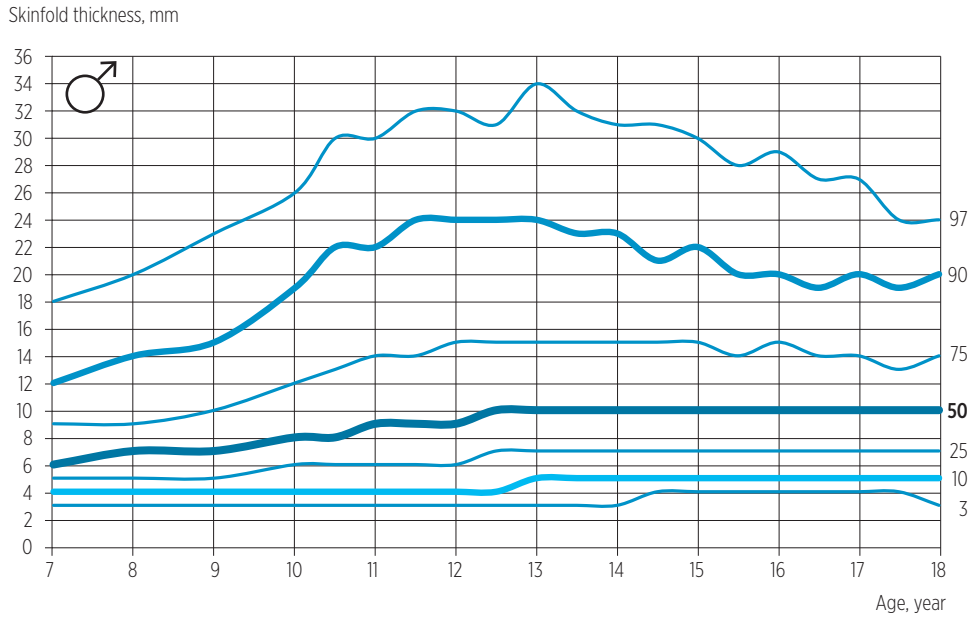

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Figure 3.33

Reference percentiles of skinfold thickness at the abdomen from the age of 7 to 18 years (boys)

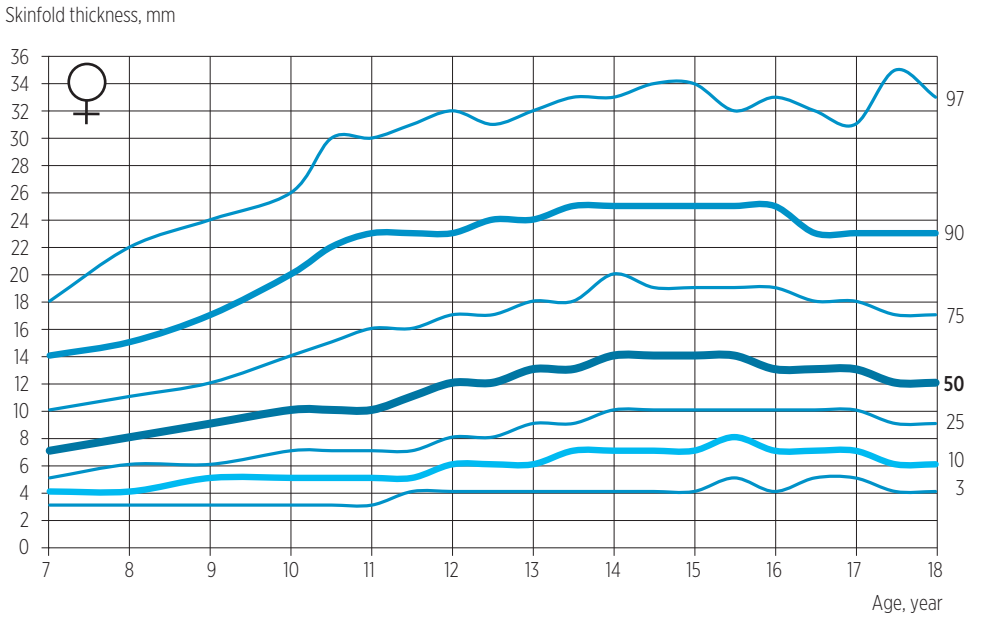

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Figure 3.34

Reference percentiles of skinfold thickness at the abdomen from the age of 7 to 18 years (girls)

Table 3.23

Reference means and percentiles of iliospinale skinfold thickness from the age of 7 to 18 years (boys)

Age (year)	Case number (N)	Mean $\bar{x}$ (mm)	SD	Percentiles (mm)						
				3	10	25	50	75	90	97
7	2 332	5.6	3.4	3	3	3	5	6	10	14
8	2 305	6.1	3.9	3	3	4	5	7	10	17
9	2 274	6.7	4.5	3	3	4	5	8	12	20
10	2 218	7.4	5.1	3	3	4	6	9	14	21
10.5	1 685	8.2	5.9	2	3	4	6	10	16	24
11	1 776	8.7	6.4	2	3	4	7	11	18	26
11.5	1 645	9.1	6.6	2	3	5	7	11	18	26
12	1 723	9.3	6.8	2	3	5	7	12	19	26
12.5	1 591	9.5	6.7	2	3	5	7	12	19	27
13	1 670	9.6	6.9	2	3	5	8	12	19	28
13.5	1 539	9.6	6.8	3	4	5	8	12	18	27
14	1 597	9.4	6.5	3	4	5	8	11	18	27
14.5	1 160	9.0	6.1	2	3	5	7	11	17	25
15	1 166	9.2	6.0	2	3	5	8	11	17	25
15.5	832	9.1	5.7	2	4	5	8	11	16	23
16	884	9.1	5.7	2	3	5	8	11	16	24
16.5	652	9.0	5.5	2	4	5	8	11	15	21
17	689	9.0	5.8	2	3	5	8	11	15	23
17.5	476	8.7	5.3	2	3	5	8	11	15	20
18	506	8.8	5.3	2	3	5	8	12	15	20

Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.24

Reference means and percentiles of iliospinale skinfold thickness from the age of 7 to 18 years (girls)

Age (year)	Case number (N)	Mean $\bar{x}$ (mm)	SD	Percentiles (mm)						
				3	10	25	50	75	90	97
7	2 100	6.6	3.6	3	3	4	6	8	11	15
8	2 078	7.1	4.1	3	3	4	6	9	12	18
9	2 069	7.9	4.7	3	4	5	7	10	14	20
10	2 013	8.6	5.1	3	4	5	7	10	15	21
10.5	1 558	9.3	5.8	2	4	5	8	12	17	23
11	1 639	9.6	5.9	2	4	5	8	12	18	24
11.5	1 523	9.9	6.0	3	4	6	8	12	18	24
12	1 609	10.3	6.1	3	4	6	9	13	19	25
12.5	1 488	10.8	6.4	3	4	6	9	13	20	27
13	1 580	11.1	6.3	3	4	7	10	14	20	27
13.5	1 442	11.5	6.4	3	5	7	10	14	20	27
14	1 517	11.7	6.3	3	5	7	10	15	20	27
14.5	1 133	11.3	6.0	2	4	7	10	14	20	25
15	1 152	11.5	6.1	2	5	7	10	14	20	25
15.5	833	11.6	6.0	2	4	8	10	14	20	25
16	878	11.4	6.1	2	4	8	10	14	20	26
16.5	630	11.4	6.0	2	4	8	10	14	19	26
17	686	11.6	5.9	2	4	8	11	14	19	25
17.5	447	11.0	5.8	2	3	7	10	14	19	25
18	504	11.0	5.8	2	3	7	10	14	18	23

Based on the reference data of the Hungarian Longitudinal Growth Study.

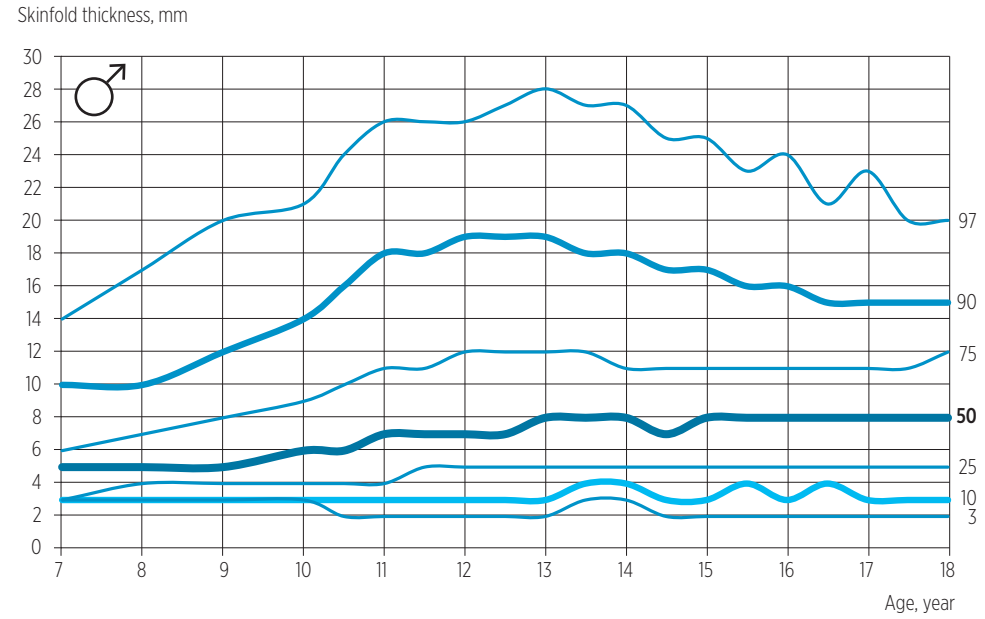

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Figure 3.35

Reference percentiles of iliospinale skinfold thickness from the age of 7 to 18 years (boys)

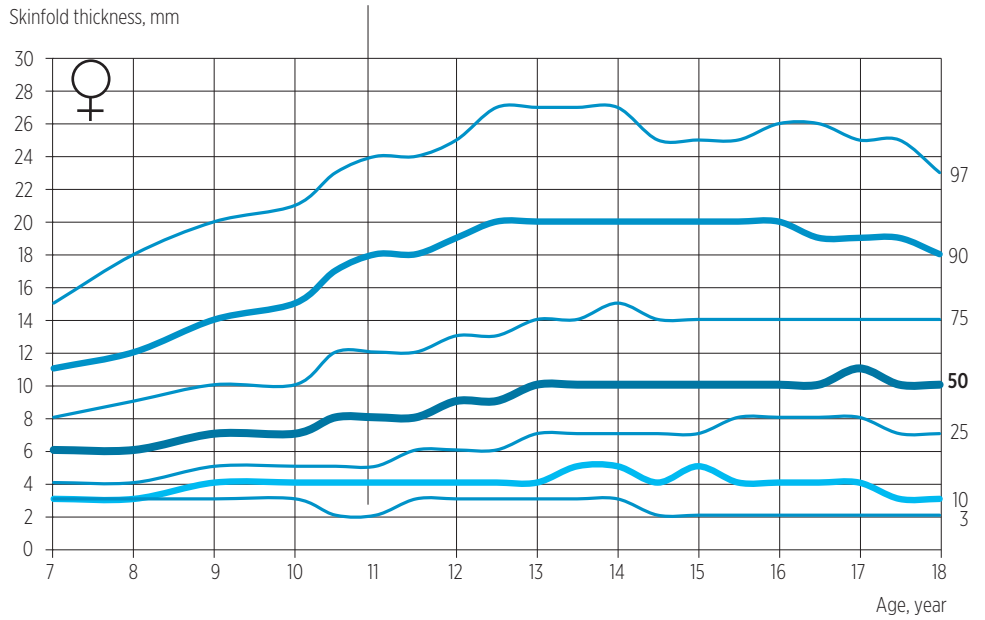

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Figure 3.36

Reference percentiles of iliospinale skinfold thickness from the age of 7 to 18 years (girls)

Table 3.25

Reference means and percentiles of triceps, subscapular, suprailiacal, and abdominal cumulated skinfold thicknesses from the age of 7 to 18 years (boys)

Age (year)	Case number (N)	Mean $\bar{x}$ (mm)	SD	Percentiles (mm)						
				3	10	25	50	75	90	97
7	2 330	28.1	12.7	15	17	20	25	32	43	59
8	2 301	30.1	14.5	15	17	20	26	34	47	68
9	2 272	32.6	16.9	15	18	22	28	38	53	79
10	2 216	35.7	19.6	15	18	23	30	42	61	89
10.5	1 677	38.4	22.3	14	18	24	31	46	72	98
11	1 766	40.0	23.6	14	18	24	32	49	75	103
11.5	1 635	41.5	24.5	14	19	25	34	50	77	101
12	1 715	42.5	25.1	15	19	25	35	52	79	106
12.5	1 584	43.0	24.8	15	20	26	35	52	79	105
13	1 664	43.4	25.3	15	20	26	36	52	80	108
13.5	1 530	43.1	24.5	15	20	27	36	51	77	105
14	1 590	42.3	23.5	16	21	27	36	51	74	103
14.5	1165	41.7	22.7	17	20	26	36	50	71	103
15	1187	41.7	22.5	16	20	26	36	50	72	102
15.5	836	41.5	21.0	17	20	27	37	49	68	92
16	889	42.0	21.1	17	20	28	38	50	67	90
16.5	655	41.4	20.3	16	20	27	40	50	64	90
17	692	41.6	21.1	15	19	26	40	49	67	94
17.5	484	39.9	18.9	14	19	26	39	48	64	80
18	516	40.1	19.3	14	18	25	39	50	66	78

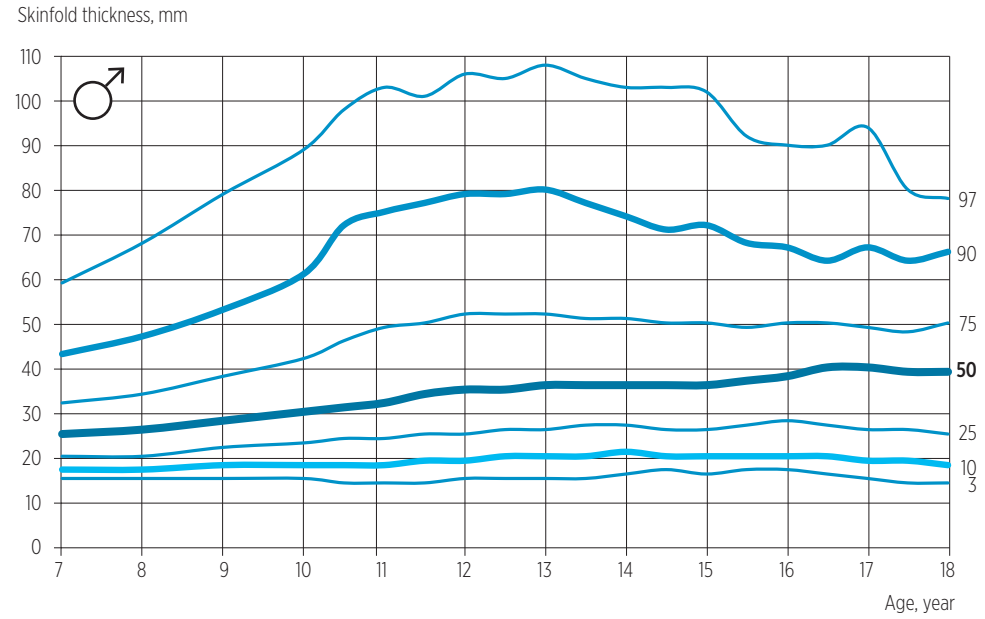
Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 3.26

Reference means and percentiles of triceps, subscapular, suprailiacal, and abdominal cumulated skinfold thicknesses from the age of 7 to 18 years (girls)

Age (year)	Case number (N)	Mean $\bar{x}$ (mm)	SD	Percentiles (mm)						
				3	10	25	50	75	90	97
7	2 099	31.9	13.3	16	19	23	29	37	48	64
8	2 073	34.2	15.2	16	20	24	30	39	54	75
9	2 067	36.9	17.4	16	20	25	32	44	60	82
10	2 011	39.9	19.0	17	21	26	35	49	66	88
10.5	1 554	42.4	21.4	16	21	27	37	53	71	96
11	1 636	43.5	21.8	16	22	28	38	54	74	100
11.5	1 520	44.8	22.2	17	23	29	39	55	77	98
12	1 606	46.1	22.2	18	24	31	40	56	78	99
12.5	1 485	47.8	22.6	18	25	32	43	59	79	100
13	1 575	48.7	21.9	19	26	34	44	60	79	100
13.5	1 437	50.6	22.4	21	27	35	46	63	81	104
14	1 510	51.9	22.1	20	29	36	48	63	82	103
14.5	1138	51.9	22.1	21	28	37	48	63	80	103
15	1161	52.8	22.5	20	29	37	49	64	82	106
15.5	839	53.6	22.0	21	29	38	49	65	82	108
16	882	52.9	22.5	20	29	38	49	64	81	110
16.5	632	52.4	21.4	20	28	39	50	62	79	108
17	690	52.5	21.5	21	28	39	49	63	78	108
17.5	467	49.2	22.3	15	24	35	46	60	76	103
18	523	49.4	22.5	15	23	36	46	62	75	103

Based on the reference data of the Hungarian Longitudinal Growth Study.



Based on the reference data of the Hungarian Longitudinal Growth Study.
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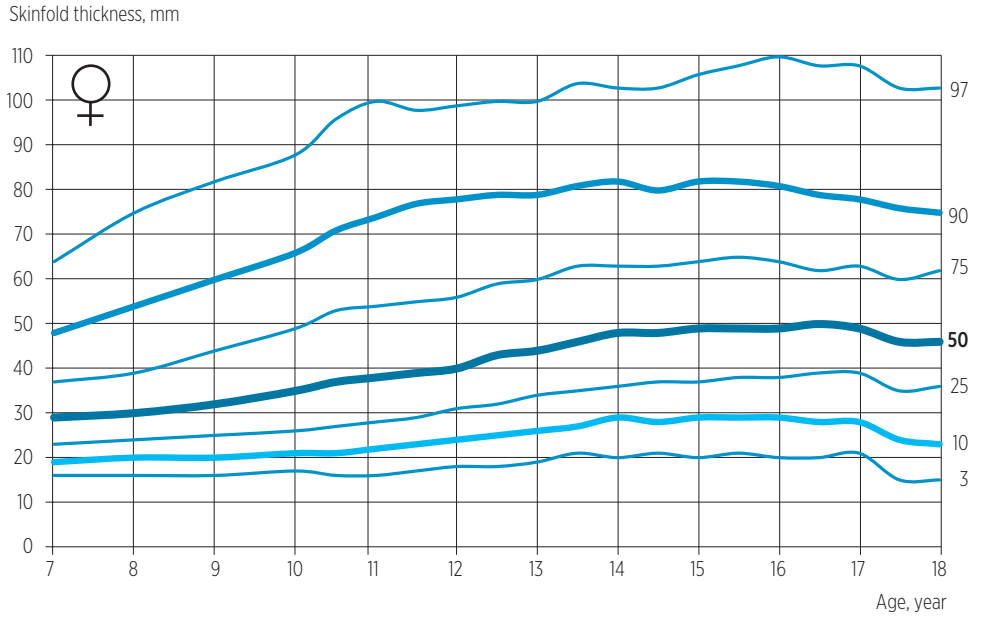
Figure 3.37

Reference percentiles of triceps, subscapular, suprailiacal, and abdominal cumulated skinfold thicknesses from the age of 7 to 18 years (boys)



Based on the reference data of the Hungarian Longitudinal Growth Study.
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Figure 3.38

Reference percentiles of triceps, subscapular, suprailiacal, and abdominal cumulated skinfold thicknesses from the age of 7 to 18 years (girls)

4. BODY HEIGHT VELOCITY BETWEEN THREE AND 18 YEARS IN HUNGARY AT THE THE TURN OF THE SECOND MILLENIUM (KÁLMÁN JOUBERT, KORNÉLIA MAG, MARTIN VAN'T HOF, SAROLTA DARVAY, RÓZSA ÁGFALVI)

Introduction

Growth rate can only be calculated based on longitudinal child growth surveys. Growt,h rate means and percentiles, which are based on the data of the follow up survey and performed on a representative sample of a sufficiently large number of children, can be used as reference values in paediatric practice.

Previously, only foreign – mainly English – percentile curves and table values were available in Hungary on body height growth rate for paediatricians. Growth rate reference percentiles can be used to inspect the observed growth rate in the specific age stage of the surveyed child. They can also be used to detect and screen pathologically accelerated or slowed growth of a child.

The most widely known European standards for body height growth rate were published by *Tanner J.M. et al. (1966; 1976; 1985).* Following its publication, growth rate standards for different countries were published based on longitudinal survey results from those countries. These include, for example, studies in Switzerland by *R.H. Largo et al. (1978),* in the Netherlands by *Kemper, H. C. G., Storm-van Essen, L., & vant Hof, M. A*[4]*. (1984),* in Belgium by *R.C. Hauspie and A. Wachholder (1986),* in Poland by *Chrzastek-Spruch H, Susanne C, Hauspie R (1990),* and in Spain by *Longas (2005)*. In Hungary, the first rate curves were drawn based on data of the "Longitudinal growth survey in Budapest between 1970 and 1988" (*Eiben et al., 1992*).

As mentioned, only follow-up surveys implemented on a representative sample with high case numbers are suitable for developing practicable reference standards of body height growth rate. Based on the short description of the "Materials and methods" chapter we will see that the Hungarian Longitudinal Growth Study (hereinafter referred to as: HLGS) is the first research programme in Hungary that complies with these conditions. One highlighted objective of the HLGS is to develop age-related reference percentiles for important body measurements (see for example: *Joubert–Darvay–Ágfalvi 1989; 1996a; 1996b; 2000; 2004; 2005).*

A particularly important result of the study are the reference percentiles of body height velocity. Here, we present curves of body height growth rates for boys and girls, which were made by applying the *Preece-Baines I. (1978)* model.

Materials and methods

To analyse body height growth rate, data for ages three to 18 were used from the reference data population of the Hungarian Longitudinal Growth Study.

One of the first tasks during the data processing of the research programme was to select those included in the so-called reference or standard data population (*Joubert–Ágfalvi 1989).* According to the specific request of the Paediatric Professional Board, only children who were born with a birth weight between 2500 and 4500 g, and who were not suffering from any diseases that would have influenced growth and development or from any other long-lasting diseases, were included in the HLGS "reference data population". At birth, 2984 boys and 2701 girls were included in the so-called reference data population, and among them we could perform the survey on 516 boys and 523 girls at 18 years of age. For this piece of work we only used data for boys and girls in the reference population who had no missing measurements between the age of three and 18 years. Finally we used the datasets of 325 boys and 309 girls to construct the rate curves.

4 At this point, we pay tribute to Professor Martin van't Hof, whose professional advice helped a lot on the one hand in the elaboration of the methodology for calculating growth velocity in the OLGYV study, on the other hand in the realization of the KidLongi program (van't Hof M. A. et al (2000a;. 2000b; 2000c; 2000d).

By applying suitable mathematical models, rate percentiles were developed from body size data measured repeatedly at specific ages during children's follow-up surveys. Changes of the rate percentiles provide a picture of the growth rate that is characteristic for the examined age – prepuberty and puberty.

Parametric models

First we need to construct the growth curves characteristic for the surveyed boys and girls by parametric model fitting. The main point of parametric model fitting is to determine height with a parametric equation for a given age, and we estimate the parameters based on the available measurements.

There are several parametric models at our disposal: logarithmic curve, exponential curve, Gompertz exponential function and the Preece-Baines model. We chose to use the Preece-Baines type I model because percentile curves generated with this method are the most widespread in clinical use.

The function is as follows: $$h = h_1 - \frac{2(h_1 - h_T)}{e^{s_0(t-T)} + e^{s_1(t-T)}}$$

h: height for a "t" time; *T:* time parameter; h_1: final (adult) height; h_T: body height at time "T"; s_0, s_1: speed constants; *t:* variable of the model, which relates to the time, at the age for which we want to determine body height; *e:~2,*71828...

Growth rate of body height

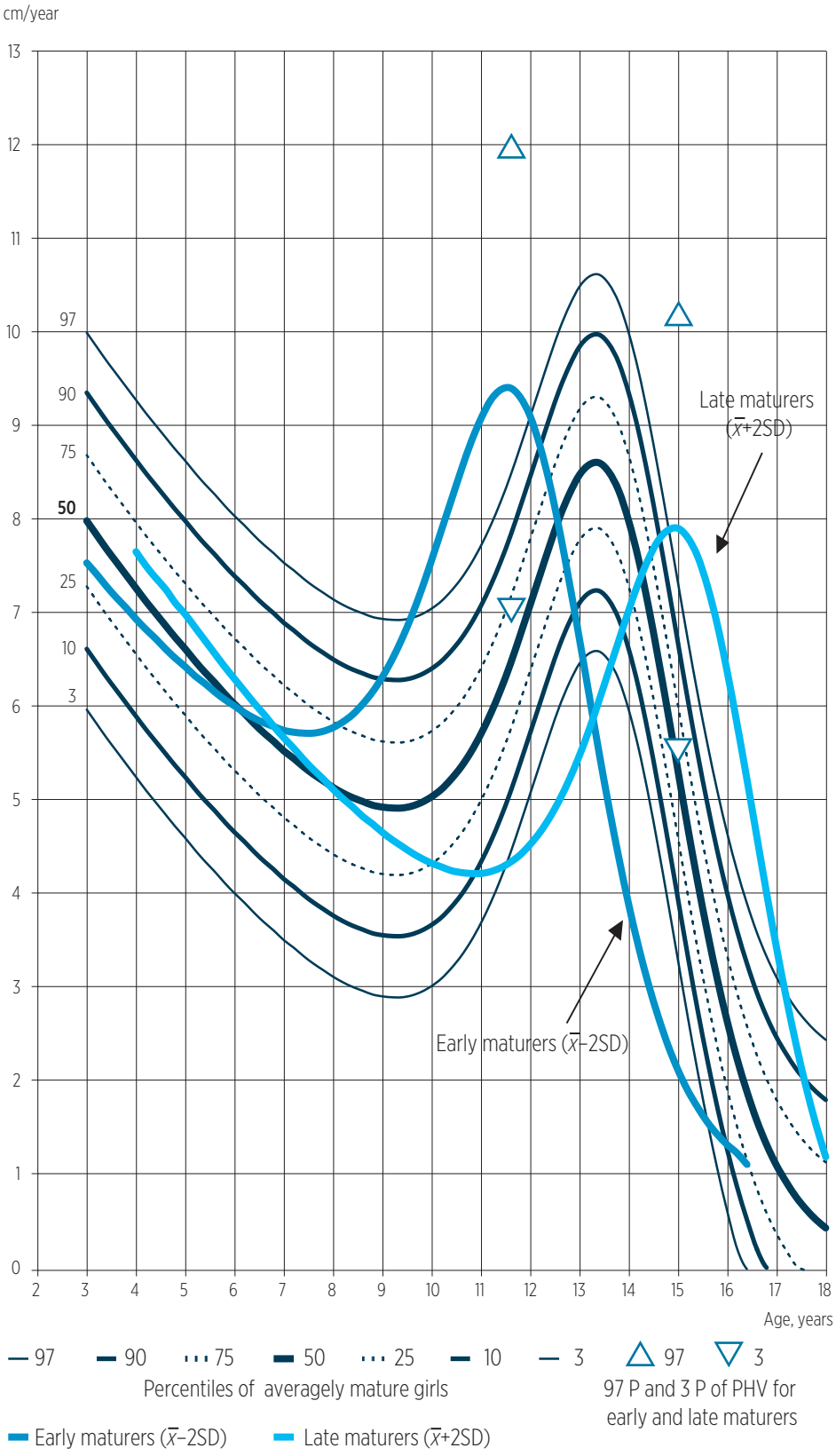
We applied nonlinear regression to determine the five parameters by using the Splus 2000 computer program. We obtained individual body height growth curves. After this, parameters of the curves of each individual were calculated. To define the general curves, the mean and standard deviation of the parameters had to be defined by sex. From values obtained this way, the desired percentile curves could be edited using the corresponding z-values of standard normal distribution.

We obtained growth rate curves as derivatives of the growth curves. Thus, through parameters calculated as described, it is not the Preece-Baines model but its derivative that defines growth rate (growth rate = body height change in one unit of time).

$$h' = \frac{2(h_1 - h_T)\left(s_0 e^{s_0(t-T)} + s_1 e^{s_1(t-T)}\right)}{\left(e^{s_0(t-T)} + e^{s_1(t-T)}\right)^2}$$

The Peak Height Velocity (PHV) of rate curves calculated individually and obtained during the calculations occurred at different ages. As a result, the median curve calculated from them is significantly flatter than what is characteristic of individual growth rate curves. In order to make the calculated velocity curves suitable for clinical use we proceeded as follows. For each parameter we calculated the median values. The medians define the so-called "constant median curve",. The body height growth rate general percentile curves seen in *Figures 4.1* and *4.2* were obtained by proceeding in the same manner for each percentile curve (*Tanner-Whitehouse-Takaishi 1966).*

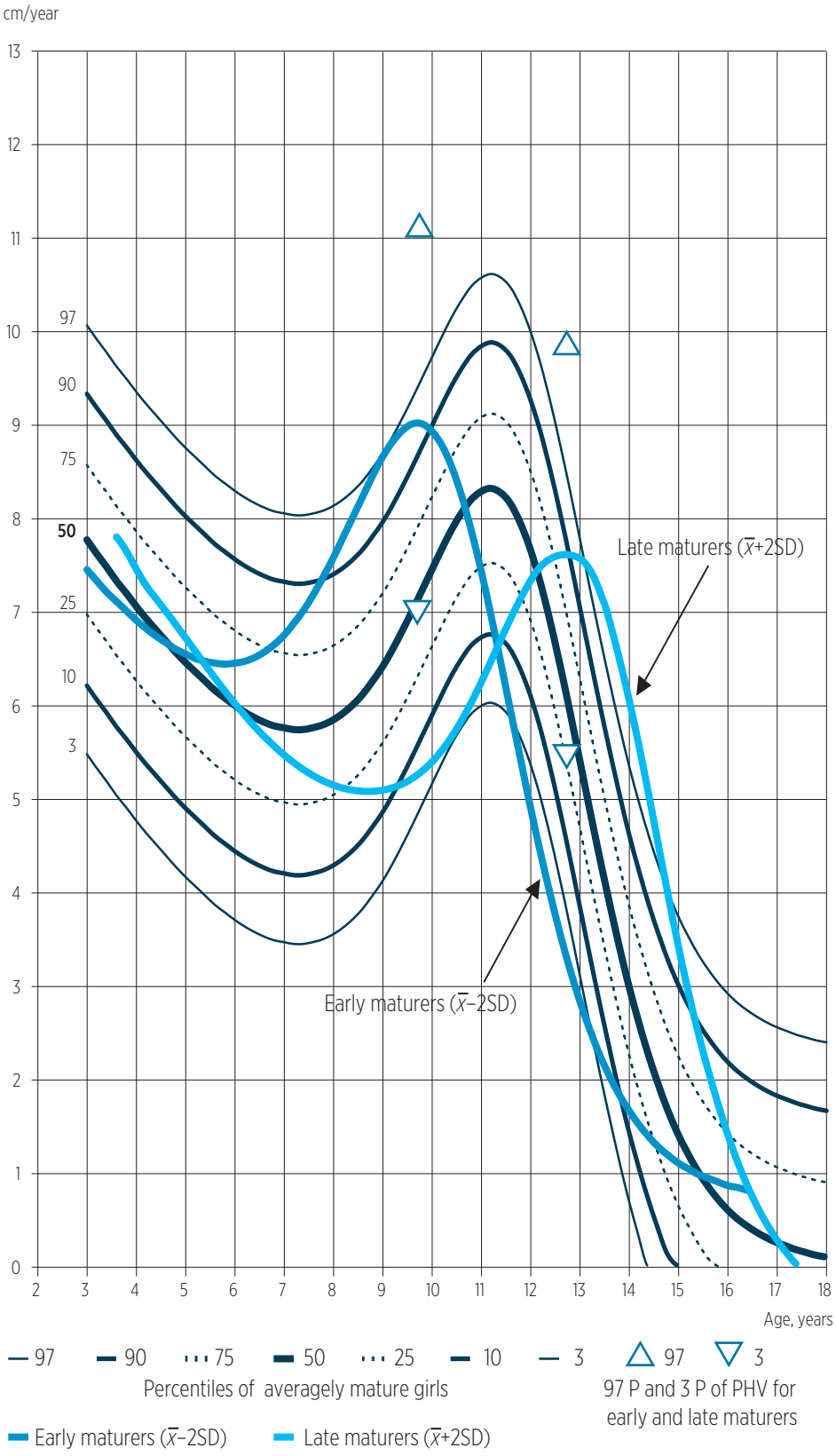
As seen in *Figure 4.1*, and as can be verified by numerical data in *Table 4.1*, the growth rate continuously decreases after the age of three years, and reaches its minimum prior to puberty – on average at the age of 9.3 years in boys, with a 4.9cm/year rate. Subsequently, the intensely accelerating body height growth rate reaches the peak velocity value (PHV) of growth rate in puberty for 4.1 years, which is 6.6cm/year. On average, this is reached at the age of 13.4 years. At this age, 3% of the boys show a body height growth rate lower than 6.59cm/year (3rd percentile), while 3% have a higher body height growth rate than 10.61cm/year (97th percentile) or girls (see data of *Figure 4.2* and *Table 4.2*) the minimum prepubertal growth rate is on average observed at the age of 7.3 years, with a rate of 5.73cm/year velocity. The body height peak velocity (PHV) in puberty for girls is 8.32cm/year, which is usually reached at the age of 11.2 years. At this age, 3% of girls show less than 6.03cm/year body height growth rate (3rd percentile), while 3% has higher than 10.61cm/year body height growth rate (97th percentile).



Based on the reference data of the Hungarian Longitudinal Growth Study.

Figure 4.1

Body height growth rate percentiles of Hungarian boys (continuous and dashed black lines). The 50 percentile of boys maturing -2SD earlier than the mean are indicated with dark blue; while the 50 percentile of boys maturing +2SD later than the mean are marked with light blue.



Based on the reference data of the Hungarian Longitudinal Growth Study.
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Hungarian Demographic Research Institute

Figure 4.2

Body height growth rate percentiles of Hungarian girls (continuous and dashed black lines). The 50 percentile of boys maturing -2SD earlier than the mean are indicated with dark blue; while the 50 percentile of boys maturing +2SD later than the mean are marked with light blue.

Table 4.1

Body height growth rate percentiles of Hungarian boys.At the end of the table, the 50 percentile of boys maturing -2SD earlier than the mean; and the 50 percentile of boys maturing +2SD later than the mean

Age (year)	Percentiles							Early maturing ($\bar{x}$-2 SD)	Late maturing ($\bar{x}$+2 SD)	△	▽
	3	10	25	50	75	90	97				
3	5.97	6.61	7.28	7.98	8.68	9.35	9.99	7.53			
3.2	5.82	6.46	7.13	7.83	8.53	9.20	9.84	7.41			
3.4	5.67	6.31	6.98	7.68	8.38	9.05	9.69	7.28			
3.6	5.53	6.17	6.84	7.54	8.24	8.91	9.55	7.16			
3.8	5.39	6.03	6.70	7.40	8.10	8.77	9.41	7.05			
4	5.25	5.89	6.56	7.26	7.96	8.63	9.27	6.93	7.65		
4.2	5.11	5.75	6.42	7.12	7.82	8.49	9.13	6.82	7.50		
4.4	4.98	5.62	6.29	6.99	7.69	8.36	9.00	6.72	7.37		
4.6	4.85	5.49	6.16	6.86	7.56	8.23	8.87	6.61	7.25		
4.8	4.72	5.36	6.03	6.73	7.43	8.10	8.74	6.51	7.10		
5	4.60	5.24	5.91	6.61	7.31	7.98	8.62	6.42	6.98		
5.2	4.47	5.11	5.78	6.48	7.18	7.85	8.49	6.32	6.84		
5.4	4.35	4.99	5.66	6.36	7.06	7.73	8.37	6.24	6.70		
5.6	4.24	4.88	5.55	6.25	6.95	7.62	8.26	6.15	6.56		
5.8	4.12	4.76	5.43	6.13	6.83	7.50	8.14	6.07	6.42		
6	4.01	4.65	5.32	6.02	6.72	7.39	8.03	6.00	6.29		
6.2	3.91	4.55	5.22	5.92	6.62	7.29	7.93	5.93	6.16		
6.4	3.80	4.44	5.11	5.81	6.51	7.18	7.82	5.87	6.03		
6.6	3.70	4.34	5.01	5.71	6.41	7.08	7.72	5.82	5.91		
6.8	3.61	4.25	4.92	5.62	6.32	6.99	7.63	5.78	5.78		
7	3.51	4.15	4.82	5.52	6.22	6.89	7.53	5.74	5.66		
7.2	3.43	4.07	4.74	5.44	6.14	6.81	7.45	5.72	5.55		
7.4	3.34	3.98	4.65	5.35	6.05	6.72	7.36	5.71	5.43		
7.6	3.26	3.90	4.57	5.27	5.97	6.64	7.28	5.71	5.32		
7.8	3.19	3.83	4.50	5.20	5.90	6.57	7.21	5.73	5.22		
8	3.12	3.76	4.43	5.13	5.83	6.50	7.14	5.77	5.11		
8.2	3.06	3.70	4.37	5.07	5.77	6.44	7.08	5.83	5.01		
8.4	3.01	3.65	4.32	5.02	5.72	6.39	7.03	5.91	4.92		
8.6	2.97	3.61	4.28	4.98	5.68	6.35	6.99	6.02	4.82		
8.8	2.93	3.57	4.24	4.94	5.64	6.31	6.95	6.15	4.74		
9	2.91	3.55	4.22	4.92	5.62	6.29	6.93	6.31	4.65		
9.2	2.90	3.54	4.21	4.91	5.61	6.28	6.92	6.50	4.57		
9.4	2.90	3.54	4.21	4.91	5.61	6.28	6.92	6.72	4.50		
9.6	2.92	3.56	4.23	4.93	5.63	6.30	6.94	6.97	4.43		
9.8	2.96	3.60	4.27	4.97	5.67	6.34	6.98	7.25	4.37		
10	3.02	3.66	4.33	5.03	5.73	6.40	7.04	7.56	4.32		
10.2	3.10	3.74	4.41	5.11	5.81	6.48	7.12	7.88	4.28		
10.4	3.21	3.85	4.52	5.22	5.92	6.59	7.23	8.20	4.24		
10.6	3.34	3.98	4.65	5.35	6.05	6.72	7.36	8.52	4.22		

Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 4.1

Body height growth rate percentiles of Hungarian boys.At the end of the table, the 50 percentile of boys maturing -2SD earlier than the mean; and the 50 percentile of boys maturing +2SD later than the mean (Continuation)

Age (year)	Percentiles							Early maturing ($\bar{x}$-2 SD)	Late maturing ($\bar{x}$+2 SD)	△	▽
	3	10	25	50	75	90	97				
10.8	3.50	4.14	4.81	5.51	6.21	6.88	7.52	8.82	4.21		
11	3.69	4.33	5.00	5.70	6.40	7.07	7.71	9.07	4.21		
11.2	3.91	4.55	5.22	5.92	6.62	7.29	7.93	9.27	4.23		
11.4	4.16	4.80	5.47	6.17	6.87	7.54	8.18	9.38	4.27		
11.6	4.44	5.08	5.75	6.45	7.15	7.82	8.46	9.40	4.33	11.90	6.90
11.8	4.75	5.39	6.06	6.76	7.46	8.13	8.77	9.30	4.41		
12	5.07	5.71	6.38	7.08	7.78	8.45	9.09	9.10	4.52		
12.2	5.39	6.03	6.70	7.40	8.10	8.77	9.41	8.78	4.65		
12.4	5.71	6.35	7.02	7.72	8.42	9.09	9.73	8.37	4.81		
12.6	6.01	6.65	7.32	8.02	8.72	9.39	10.03	7.87	5.00		
12.8	6.26	6.90	7.57	8.27	8.97	9.64	10.28	7.31	5.22		
13.2	6.57	7.21	7.88	8.58	9.28	9.95	10.59	6.11	7.25		
13	6.46	7.10	7.77	8.47	9.17	9.84	10.48	6.72	5.47		
13.2	6.57	7.21	7.88	8.58	9.28	9.95	10.59	6.11	6.06		
13.4	6.59	7.23	7.90	8.60	9.30	9.97	10.61	5.50	6.06		
13.6	6.49	7.13	7.80	8.50	9.20	9.87	10.51	4.92	6.38		
13.8	6.29	6.93	7.60	8.30	9.00	9.67	10.31	4.38	6.70		
14	5.97	6.61	7.28	7.98	8.68	9.35	9.99	3.88	7.02		
14.4	5.06	5.70	6.37	7.07	7.77	8.44	9.08	3.03	7.57		
14.6	4.50	5.14	5.81	6.51	7.21	7.88	8.52	2.68	7.77		
14.8	3.91	4.55	5.22	5.92	6.62	7.29	7.93	2.37	7.88		
15	3.30	3.94	4.61	5.31	6.01	6.68	7.32	2.11	7.90	10.3	5.5
15.2	2.69	3.33	4.00	4.70	5.40	6.07	6.71	1.89	7.80		
15.4	2.11	2.75	3.42	4.12	4.82	5.49	6.13	1.71	7.60		
15.6	1.57	2.21	2.88	3.58	4.28	4.95	5.59	1.55	7.28		
15.8	1.07	1.71	2.38	3.08	3.78	4.45	5.09	1.42	6.87		
16	0.62	1.26	1.93	2.63	3.33	4.00	4.64	1.31	6.37		
16.2	0.22	0.86	1.53	2.23	2.93	3.60	4.24	1.22	5.81		
16.4	0.00	0.51	1.18	1.88	2.58	3.25	3.89	1.10	5.22		
16.6	0.00	0.20	0.87	1.57	2.27	2.94	3.58		4.61		
16.8	0.00	0.00	0.61	1.31	2.01	2.68	3.32		4.00		
17	0.00	0.00	0.39	1.09	1.79	2.46	3.10		3.42		
17.2	0.00	0.00	0.21	0.91	1.61	2.28	2.92		2.88		
17.4	0.00	0.00	0.05	0.75	1.45	2.12	2.76		2.38		
17.6	0.00	0.00	0.00	0.62	1.32	1.99	2.63		1.93		
17.8	0.00	0.00	0.00	0.51	1.21	1.88	2.52		1.53		
18	0.00	0.00	0.00	0.42	1.12	1.79	2.43		1.18		

Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 4.2

Body height growth rate percentiles of Hungarian girls. At the end of the table, the 50 percentile of girls maturing -2SD earlier than the mean; and the 50 percentile of girls maturing +2SD later than the mean

Age (year)	Percentiles							Early maturing ($\bar{x}$-2 SD)	Late maturing ($\bar{x}$+2 SD)	△	▽
	3	10	25	50	75	90	97				
3	5.48	6.21	6.97	7.77	8.57	9.33	10.06	7.45			
3.2	5.33	6.06	6.82	7.62	8.42	9.18	9.91	7.33			
3.4	5.19	5.92	6.68	7.48	8.28	9.04	9.77	7.21			
3.6	5.04	5.77	6.53	7.33	8.13	8.89	9.62	7.11	7.80		
3.8	4.91	5.64	6.40	7.20	8.00	8.76	9.49	7.01	7.63		
4	4.77	5.50	6.26	7.06	7.86	8.62	9.35	6.91	7.47		
4.2	4.64	5.37	6.13	6.93	7.73	8.49	9.22	6.82	7.31		
4.4	4.52	5.25	6.01	6.81	7.61	8.37	9.10	6.74	7.15		
4.6	4.40	5.13	5.89	6.69	7.49	8.25	8.98	6.67	7.00		
4.8	4.28	5.01	5.77	6.57	7.37	8.13	8.86	6.60	6.85		
5	4.17	4.90	5.66	6.46	7.26	8.02	8.75	6.55	6.70		
5.2	4.07	4.80	5.56	6.36	7.16	7.92	8.65	6.50	6.56		
5.4	3.97	4.70	5.46	6.26	7.06	7.82	8.55	6.47	6.43		
5.6	3.87	4.60	5.36	6.16	6.96	7.72	8.45	6.45	6.30		
5.8	3.79	4.52	5.28	6.08	6.88	7.64	8.37	6.44	6.17		
6	3.71	4.44	5.20	6.00	6.80	7.56	8.29	6.45	6.05		
6.2	3.64	4.37	5.13	5.93	6.73	7.49	8.22	6.47	5.93		
6.4	3.58	4.31	5.07	5.87	6.67	7.43	8.16	6.51	5.81		
6.6	3.53	4.26	5.02	5.82	6.62	7.38	8.11	6.57	5.71		
6.8	3.49	4.22	4.98	5.78	6.58	7.34	8.07	6.65	5.61		
7	3.47	4.20	4.96	5.76	6.56	7.32	8.05	6.75	5.51		
7.2	3.45	4.18	4.94	5.74	6.54	7.30	8.03	6.88	5.42		
7.4	3.45	4.18	4.94	5.74	6.54	7.30	8.03	7.02	5.34		
7.6	3.47	4.20	4.96	5.76	6.56	7.32	8.05	7.19	5.27		
7.8	3.50	4.23	4.99	5.79	6.59	7.35	8.08	7.38	5.20		
8	3.55	4.28	5.04	5.84	6.64	7.40	8.13	7.58	5.15		
8.2	3.62	4.35	5.11	5.91	6.71	7.47	8.20	7.80	5.10		
8.4	3.71	4.44	5.20	6.00	6.80	7.56	8.29	8.02	5.07		
8.6	3.82	4.55	5.31	6.11	6.91	7.67	8.40	8.24	5.05		
8.8	3.96	4.69	5.45	6.25	7.05	7.81	8.54	8.46	5.04		
9	4.11	4.84	5.60	6.40	7.20	7.96	8.69	8.66	5.05		
9.2	4.29	5.02	5.78	6.58	7.38	8.14	8.87	8.82	5.07		
9.4	4.49	5.22	5.98	6.78	7.58	8.34	9.07	8.94	5.11		
9.6	4.70	5.43	6.19	6.99	7.79	8.55	9.28	9.01	5.17		
9.8	4.92	5.65	6.41	7.21	8.01	8.77	9.50	9.01	5.25	11.20	6.96
10	5.14	5.87	6.63	7.43	8.23	8.99	9.72	8.93	5.35		
10.2	5.36	6.09	6.85	7.65	8.45	9.21	9.94	8.78	5.48		
10.4	5.57	6.30	7.06	7.86	8.66	9.42	10.15	8.55	5.62		
10.6	5.75	6.48	7.24	8.04	8.84	9.60	10.33	8.24	5.79		

Based on the reference data of the Hungarian Longitudinal Growth Study.

Table 4.2

Body height growth rate percentiles of Hungarian girls. At the end of the table, the 50 percentile of girls maturing -2SD earlier than the mean; and the 50 percentile of girls maturing +2SD later than the mean Continuation)

Age (year)	Percentiles							Early maturing ($\bar{x}$-2 SD)	Late maturing ($\bar{x}$+2 SD)	△	▽
	3	10	25	50	75	90	97				
10.8	5.90	6.63	7.39	8.19	8.99	9.75	10.48	7.86	5.98		
11	5.99	6.72	7.48	8.28	9.08	9.84	10.57	7.43	6.18		
11.2	6.03	6.76	7.52	8.32	9.12	9.88	10.61	6.95	6.40		
11.4	5.99	6.72	7.48	8.28	9.08	9.84	10.57	6.44	6.62		
11.6	5.88	6.61	7.37	8.17	8.97	9.73	10.46	5.92	6.84		
11.8	5.68	6.41	7.17	7.97	8.77	9.53	10.26	5.41	7.06		
12	5.41	6.14	6.90	7.70	8.50	9.26	9.99	4.90	7.26		
12.2	5.07	5.80	6.56	7.36	8.16	8.92	9.65	4.42	7.42		
12.4	4.66	5.39	6.15	6.95	7.75	8.51	9.24	3.97	7.54		
12.6	4.20	4.93	5.69	6.49	7.29	8.05	8.78	3.55	7.61		
12.8	3.71	4.44	5.20	6.00	6.80	7.56	8.29	3.17	7.61	9.72	5.50
13	3.19	3.92	4.68	5.48	6.28	7.04	7.77	2.83	7.53		
13.2	2.67	3.40	4.16	4.96	5.76	6.52	7.25	2.53	7.38		
13.4	2.16	2.89	3.65	4.45	5.25	6.01	6.74	2.26	7.15		
13.6	1.67	2.40	3.16	3.96	4.76	5.52	6.25	2.03	6.84		
13.8	1.20	1.93	2.69	3.49	4.29	5.05	5.78	1.83	6.46		
14	0.76	1.49	2.25	3.05	3.85	4.61	5.34	1.66	6.05		
14.2	0.37	1.10	1.86	2.66	3.46	4.22	4.95	1.51	5.55		
14.4	0.01	0.74	1.50	2.30	3.10	3.86	4.59	1.38	5.04		
14.6	0.00	0.42	1.18	1.98	2.78	3.54	4.27	1.27	4.52		
14.8	0.00	0.13	0.89	1.69	2.49	3.25	3.98	1.18	4.01		
15	0.00	0.00	0.64	1.44	2.24	3.00	3.73	1.10	3.50		
15.2	0.00	0.00	0.43	1.23	2.03	2.79	3.52	1.04	3.02		
15.4	0.00	0.00	0.24	1.04	1.84	2.60	3.33	0.98	2.57		
15.6	0.00	0.00	0.08	0.88	1.68	2.44	3.17	0.94	2.15		
15.8	0.00	0.00	0.00	0.74	1.54	2.30	3.03	0.90	1.77		
16	0.00	0.00	0.00	0.62	1.42	2.18	2.91	0.86	1.43		
16.2	0.00	0.00	0.00	0.52	1.32	2.08	2.81	0.84	1.13		
16.4	0.00	0.00	0.00	0.44	1.24	2.00	2.73	0.81	0.86		
16.6	0.00	0.00	0.00	0.37	1.17	1.93	2.66		0.63		
16.8	0.00	0.00	0.00	0.31	1.11	1.87	2.60		0.43		
17	0.00	0.00	0.00	0.26	1.06	1.82	2.55		0.26		
17.2	0.00	0.00	0.00	0.22	1.02	1.78	2.51		0.11		
17.4	0.00	0.00	0.00	0.18	0.98	1.74	2.47		−0.02		
17.6	0.00	0.00	0.00	0.15	0.95	1.71	2.44		−0.13		
17.8	0.00	0.00	0.00	0.12	0.92	1.68	2.41		−0.22		
18	0.00	0.00	0.00	0.10	0.90	1.66	2.39		−0.30		

Based on the reference data of the Hungarian Longitudinal Growth Study.

Growth rate of early and late maturing children

Reference data related to body height growth rate and the velocity of early and late maturing children present important information for professionals studying children's growth.

Body height growth rate curves of early and late maturing children were calculated as follows. We determined the peak growth points based on the fitted growth rate curves. In order to determine whose growth is characterised by early and whose growth is characterised by late growth among the children in the sample (separately for boys and girls), we had to calculate peak growth means ($\overline{X}$), and standard deviation (SD) *(Hauspie et al. 1992).* We obtained the following categories.

Early growth: children whose *peak growth* (PHV) occurs two standard deviations earlier than the average growth peak: PHV < ($\overline{X}$ – 2SD)

Average growth: children whose *peak growth* occurs within the range of the mean peak growth ± 2 standard deviation ($\overline{X}$ —2SD) ≤ PHV ≤ ($\overline{X}$ + 2SD)

Late growth: children whose *peak growth* occurs two standard deviations later than the mean growth peak: PHV > ($\overline{X}$ + 2SD)

For calculating the growth rates of different groups we applied the method used for determining the growth curves of average children.

Results

The minimum body height growth rate of early maturing boys is observed at the age of 7.5 years, with a value of 5.70cm/year. They reach peak growth velocity at the age of 11.6 years on average, which is 9.40 cm/year (50th percentile). Three per cent of early maturing boys (3rd percentile) have a growth rate of 6.9cm/year or lower. Three per cent (97th percentile) have a body height growth rate of 11.9cm/year or higher (data in *Figure 4.1* and *Table 4.1*).

As observed in *Figure 4.2* and based on data in *Table 4.2*, the minimum body height growth rate of early maturing girls is 6.44 cm/year, which is reached on average at the age of 5.8 years. The peak growth velocity of girls in this group is 9.01 cm/year (50th percentile), when their mean age is 9.8 years. The growing rate is 6.96cm/year or less in case of 3% of the early maturing girls, while for 3% of them growth velocity is 11.2cm/year or higher (97th percentile).

The minimum body height growth rate of late maturing boys is 4.2cm/year, which is observed on average at the age of 10.9 years. The peak value of body height growth rate is 7.90cm/year (50th percentile), the mean age that can be established for this data is 15.0 years. The 3rd percentile of late maturing boys' growth rate at this age is 5.5cm/year, while the 97th percentile is 10.3cm/year.

The minimum body height growth rate of late maturing girls is 5.04cm/year, which is observed at the age of 8.8 years. Peak growth velocity of late maturing girls is 7.61 cm/year, which on average can be observed at the age of 12.8 years (50th percentile). The growth rate of 3% of late maturing girls is 5.5cm/year or less (3rd percentile), while the growth rate of the fastest growing 3% (97th percentile) is 9.72cm/year or higher.

Summary

The first Hungarian body height growth rate reference percentile curves were presented in this chapter. Calculations were based on data for those aged three to 18 years in the Hungarian Longitudinal Growth Study reference population. The data sets of 325 boys and 309 girls were used to develop the velocity curves. Velocity percentile curves were constructed by using the Preece-Baines models. The usual percentile curves were calculated for boys and girls (3rd, 10th, 25th, 50th, 75th, 90th and 97th percentiles). The 50th percentiles of the growth rate of early maturing and late maturing children were also determined, as well as the related 3rd and 97th percentiles. The peak height velocity (PHV) in puberty of Hungarian children's body height was 8.6cm/year for boys, and 8.3cm/year for girls. The mean age related to the peak height velocity was 13.4 years for boys and

11.2 years for girls. The peak height velocity of early maturing children was 9.40cm/year for boys, and 9.01cm/year for girls, which was achieved at the age of 11.6 of boys and 9.8 years of girls on average. Peak height velocity of late maturing boys was 7.90cm/year, when they were on average 15 years old. Peak height velocity of late maturing girls was 7.61cm/year, which was observed at the age of 12.8 years on average.

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5. MENARCHEAL AGE OF HUNGARIAN GIRLS AT THE TURN OF THE MILLENNIUM (KÁLMÁN JOUBERT, SAROLTA DARVAY, RÓZSA ÁGFALVI, GYULA GYENIS)

Introduction

Puberty is the process of reproductive maturation and the milestone of it for females is the time of menarche, i.e. the first menstrual period. Puberty is a complex phenomenon involving the hypothalamus, pituitary gland and gonads (HPT axis). Puberty is also associated with skeletal growth and maturation in general. This is the main cause of the strong correlation between the secular trends in height and age at menarche (*Ellison 2002*). Historical trends show a connection between the increase in stature and decrease of the age of menarche during the nineteenth and twentieth centuries in northern and western Europe (*Danker-Hopfe 1986; Ellison 2002; Hauspie et al. 1997; Herzog-Gutsch 2002; Olesen et al. 2000; Tanner 1973; Eveleth–Tanner 1976*).

The Hungarian secular trend in menarcheal age can be described through surveys in the population of some small cities and by two large country-wide surveys. The first study was carried out in Kaposvár, a small city in the south-western part of Hungary in 1947–48 (*Véli 1968*), where the menarche median was 13.90. Thirty years later the menarcheal age had fallen to 12.61 years (*Suskovics–Eiben 2002*). In Körmend, a city in the western part of Hungary, cross-sectional growth studies organised by Otto Eiben were carried out every ten years from 1958 to 1998 (*Eiben–Tóth 2005*). The age of menarche declined from 13.53 to 12.75 in the first decade of the study between 1958 and 1968. After that a negative secular trend occured: in 1978 the age at menarche was 12.80, in 1988 it was 12.93 and in 1998 it was 12.95 (*Eiben–Mascie-Taylor 2003*).

It may be interesting to note that beyond the western border of Hungary, in eastern Austria, the menarcheal age is significantly lower (12.04) than in western Hungary (Kirchengast–Göstl, 2006).

In Érd, a small city in the neighbourhood of Budapest, where cross-sectional growth studies were also conducted every ten years from 1979 to 1999, the age at menarche decreased during the study period from 12.85 to 12.56 (*Gyenis et al. 2004*).

In the city of Eger (situated in northern Hungary) there was no significant change in the menarcheal age from 1980 to 2004, and the values remained close to each other: 12.76 and 12.72 (*Pantó 1980; Zsákai et al. 2004*).

The first country-wide survey in Hungary (n=7008) was published in 1963 (*Bottyán et al. 1963*) and the value of the menarche median was 13.23. However, the sampling was not representative of the country, neither in geographical nor in demographic respects. Nevertheless, the subsamples of the study were taken from agricultural, industrial, urban and rural communities, from villages and towns, and also from mountainous, hilly and flat parts of the country.

The first Hungarian National Growth Study, also organised by Otto Eiben, was carried out in 1981–85 (*Eiben–Mascie-Taylor 2003*). It was a nationally representative study of children and youth (n=39035), and the age at menarche was 12.78 years.

Age at menarche from cross-sectional studies in Hungary are summarised in the *Table 5.1*.

Differences in the age at menarche in Hungarian studies from the 1960s are very small, ranging from between 12.40 and 12.89.

The majority of the data about menarcheal age in different populations of Hungary were collected from cross-sectional samples, and there are therefore limited data available from longitudinal studies (e. g. *Eiben et al. 1992; Ferrández 2005; Prader et al. 1989; Sempé et al. 1971*).

Table 5.1

Data on age at menarche in Hungary (data from Bodzsár 1998, with minor modifications)

Place of study	Authors	Year of data collection	Menarcheal age (years)
Budapest	Doktor	1891	15.33[a)]
Kaposvár	Véli–Thoma	1948–49	13.90
Kaposvár	Véli	1960–61	12.89
Körmend	Eiben	1968	12.75
Székesfehérvár	Bodzsár	1972	12.61
Fejér county (villages)	Bodzsár	1972	12.80
Jászság (villages)	Pápai	1983	12.75
Debrecen	Csoknyay–Borsos	1979–84	12.65
Jászberény	Pápai	1981–84	12.40
Magyarország	Eiben–Pantó	1981–84	12.78
Magyarország	Farkas	1981–84	12.79
Eger	Pantó	1980	12.76
Érd	Gyenis et al.	1979	12.85
Érd	Gyenis et al.	1989	12.60
Érd	Gyenis et al.	1999	12.56
Hungary	Németh et al.	1987–89	12.92
Hungary	Joubert et al.[b)]	1989–1999	12.55
Somogy county	Suskovics.	1995–97	12.70
Eger	Zsákai et al.	2004	12.72
Hungary	Bodzsár–Zsákai	2003–2006	12.75

[a)] Estimated value
[b)] Joubert et al. 2006

The aim of our study was to present the mean age of menarche from a nationally representative longitudinal sample, and to analyse the connection between body development and the age of menarche.

Materials and methods

The Hungarian Longitudinal Growth Study started in 1979 under the title "Medical and Demographic Study of Pregnant Women and Newborn Babies". The initial phase of the programme was conducted on a two per cent nationally representative sample of pregnant women between November 1979 and December 1982. The Longitudinal Growth Study started with at-birth measurements of neonate babies of the women in the sample *(Joubert–Ágfalvi 1988, 1988a).* Repeated measurements of children were performed every 30 days until the age of six months, then every 60 days in the second half year of their lives, and every quarter of a year until the age of 24 months. After this, district and school nurses measured and examined children until the age of 10 years on their birthdays each year, and every half year between the age of 10 and 18 years.

The Hungarian Longitudinal Growth Study aimed to record not only anthropometric data but also biological parameters, such as the age of menarche. Menarche age was recorded for 1709 girls in the survey. In accordance with the request of the Paediatric Professional Board of Hungary, only babies whose weight was between 2500g and

4500g at birth and who did not suffer from long-lasting and/or chronic illness, which would have influenced their development and growth, were included in the reference database. Among them were 1481 girls whose menarche data were studied due to the selective effect of other variables in the analysis.

Results and discussion

First, we present the distribution of the age of menarche, according to age of the surveyed girls in *Figure 5.1*. The curve fitted to the distribution according to age approximately resembles the bell-shaped form. In the studied sample, the earliest appearance of menarche is at the age of 9 years, and the latest appearance can be observed at the age of 16 years.

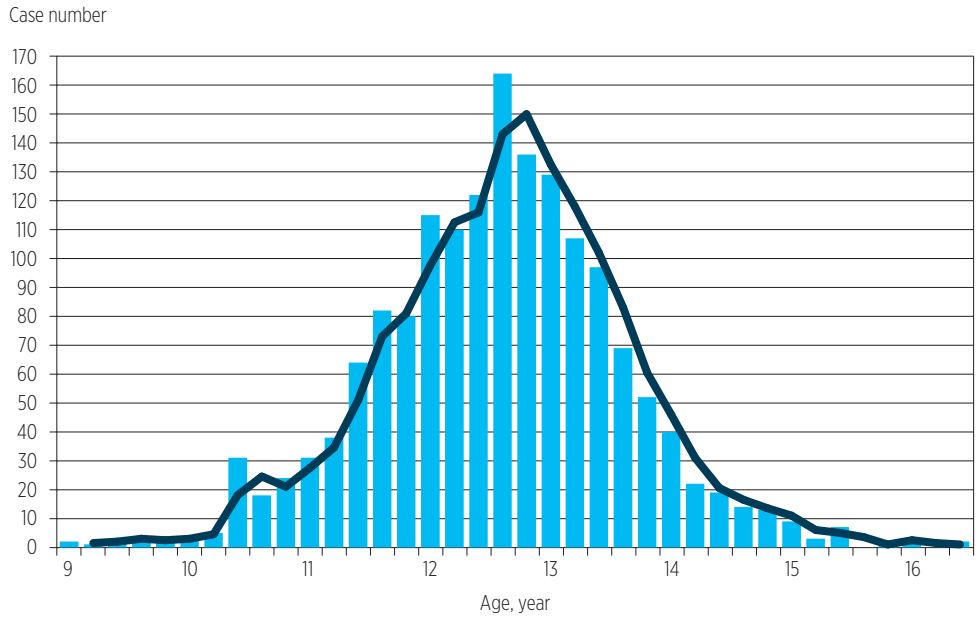

Figure 5.1
Distribution age of menarche, according to age of the surveyed girls

In *Figure 5.2* the cumulative percentile distribution of menarcheal age is presented according to age. On the cumulative curve of the figure the points are indicated under the age at which menarche did occur in 10%, 50%, and 90% of girls.

Age of menarche is significant because it indicates one of the most important stages of the process of an individual becoming a woman from a child, but the age of menarche is also decisive with regards to other processes related to the growth and development of girls.

In some cases menarche occurs 14 to 18 months after observing peak height velocity (PHV) of girls in puberty. Thus, the age variation of menarche is often used to measure the fluctuations in the period of puberty within the population, or between different populations *(WHO 1995)*.

Regarding the phenomenon described above, *Figure 5.3* presents the growth rate percentiles of girls' body height. We mark the mean and the standard deviation of the surveyed girls' menarcheal age on the age axis. The observed peak height velocity (PHV) at the 50th percentile of the girls body height growth rate is 8.32cm/year, which is achieved on average at the age of 11.2 years *(Joubert et al. 2007)*.

The mean menarcheal age of the surveyed girls is 12.55 (±SD = 0.98) years. Thus the age at menarche follows the mean age of peak height velocity by 16.44 months. This fits well with the 14 to 18 months delay from the time of the PHV described by the WHO

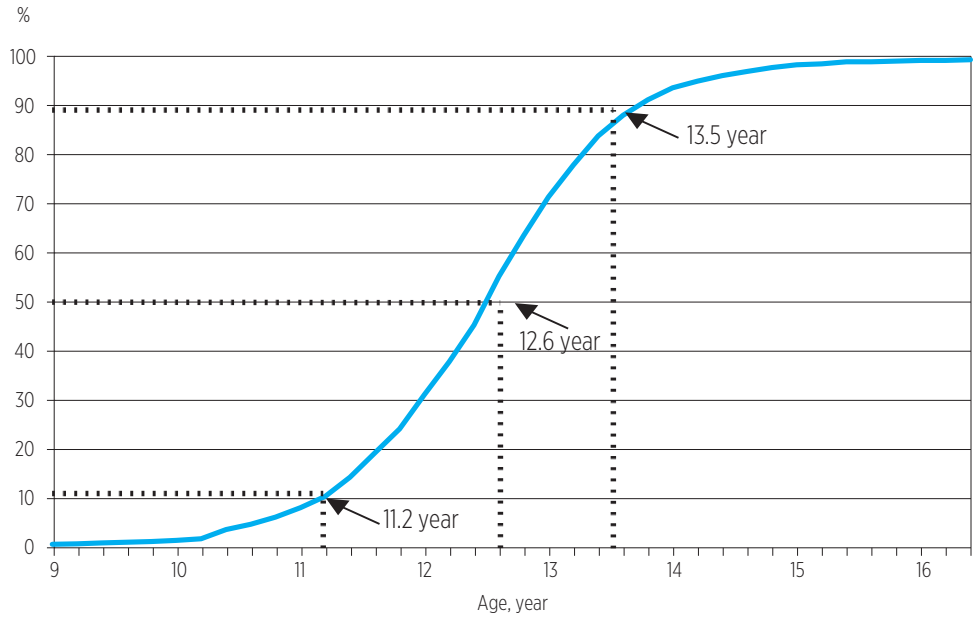

Figure 5.2
Cumulative distribution of menarche according to age

(1995). In the Budapest longitudinal study (Eiben *et al*. 1992), the mean age of menarche was 12.79 years, in spite of the fact that the data were collected only from Budapest, the capital of Hungary.

We analysed the change of height, weight, chest circumference and BMI between the ages of 9 and 16 years, depending on whether menarche had or had not occurred for girls at that age. Age-related changes of the mean values of individual variables are presented by separate curves for girls whose menarche has not yet occurred at the specific age, and separately for those whose menarche was observed in the specific year (*Figures 5.4*, *5.5* and *5.6*).

In *Figure 5.*4 the age-related reference percentiles of body height are presented. The figure includes body height means established by age for the menstruating and non-menstruating groups, and the two sets of values are connected by a line each.

Concerning the differences between the body height means of the two groups, we can conclude that except for the lower and upper age groups with very few individuals the subjects for whom menarche occurred at a specific age are significantly taller in each age groups – by 2 to 4cms – than those for whom it had not yet occurred. This phenomenon is clearly related to the comment earlier according to which menarche occurs – in our sample on average – 16.44 months after the peak height velocity.

In *Figure 5.5* we present body mass mean values for the two observed groups of girls represented by a line graph each, in addition to body mass reference percentiles. Similar to the phenomenon experienced for body height, the mean body mass is significantly higher in all age groups for whom menarche had occurred than for whom menarche had not yet occurred. The difference is greatest at the age of 11 years: 7.45kg. The difference between the two mean curves support the hypothesis of *Frisch and Revelle* (1970), that a critical body weight is necessary for the occurrence of menarche, in which body fat increase plays a significant role. For menarche to occur, the level of body fat has to reach 17%, while regular menstrual cycles will develop only if body fat content reaches 20-22% and BMI is between 16.1 to 18.0 (*Csoknyai 1998).*

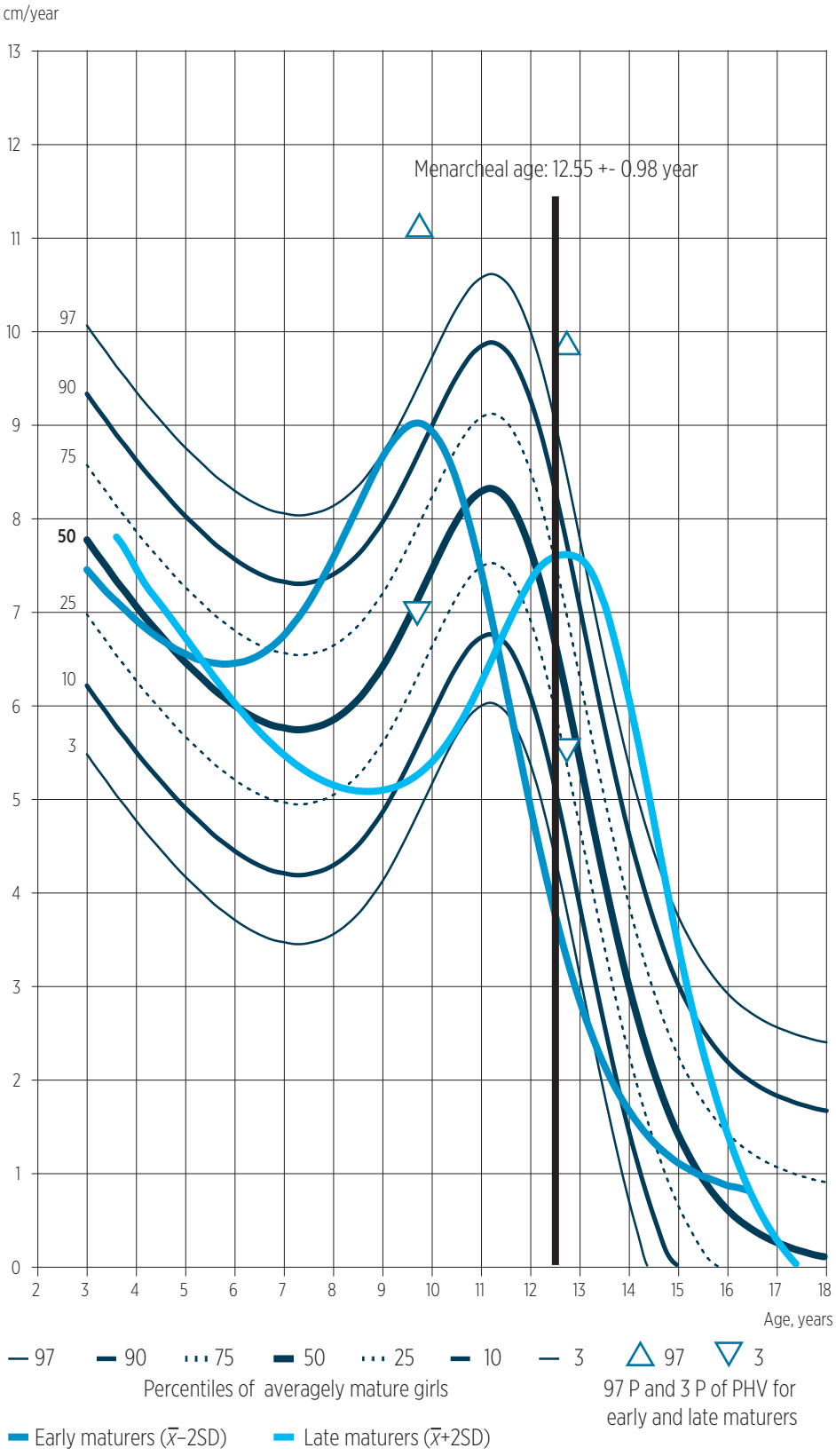

Figure 5.3
Body height growth rate percentiles and menarcheal age of Hungarian girls (Based on data of the Hungarian Longitudinal Growth Study)

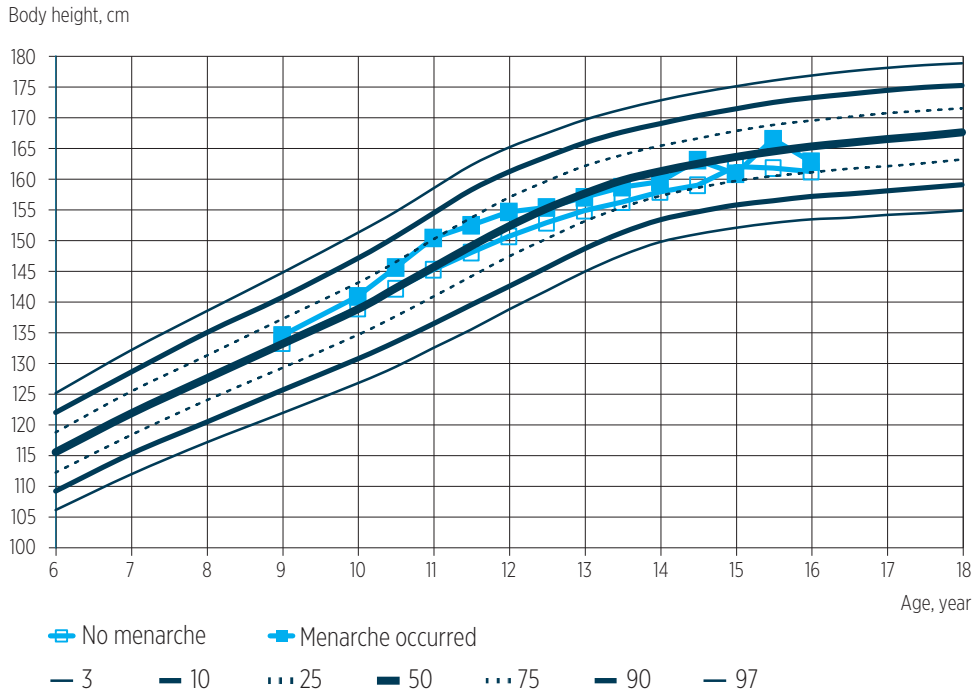

Figure 5.4

Reference percentiles of body height, mean value changes of menstruating and non-menstruating girls according to age

Concerning the differences between the body height means of the two groups, we can conclude that except for the lower and upper age groups with very few individuals the subjects for whom menarche occurred at a specific age are significantly taller in each age groups – by 2 to 4cms – than those for whom it had not yet occurred. This phenomenon is clearly related to the comment earlier according to which menarche occurs – in our sample on average – 16.44 months after the peak height velocity.

In *Figure 5.5* we present body mass mean values for the two observed groups of girls represented by a line graph each, in addition to body mass reference percentiles. Similar to the phenomenon experienced for body height, the mean body mass is significantly higher in all age groups for whom menarche had occurred than for whom menarche had not yet occurred. The difference is greatest at the age of 11 years: 7.45kg. The difference between the two mean curves support the hypothesis of *Frisch and Revelle* (1970), that a critical body weight is necessary for the occurrence of menarche, in which body fat increase plays a significant role. For menarche to occur, the level of body fat has to reach 17%, while regular menstrual cycles will develop only if body fat content reaches 20-22% and BMI is between 16.1 to 18.0 (*Csoknyai 1998).*

Through this reference on the role of nutritional condition (BMI) in the occurrence of menarche, we can now demonstrate how the age-related BMI means of the two groups of girls change besides the BMI reference percentiles (*Figure 5.6*).

Based on *Figure 5.6* it is clear that among surveyed girls a BMI mean higher than 18 (higher than 19 for the majority of the studied age years) is associated with menarche occurrence in each age year. The difference of BMI means of the two groups is the highest for early age years: BMI is more than 2kg/m^2 higher at the age of 9, 10, and 11 years in whom menarche occurred in the specific age year.

Figure 5.7 shows the mean chest circumferences of the two groups of girls against chest circumference reference percentiles. Girls, for whom menarche occurred at a specific age, have a chest circumference at least 1cm wider in each age year up to the

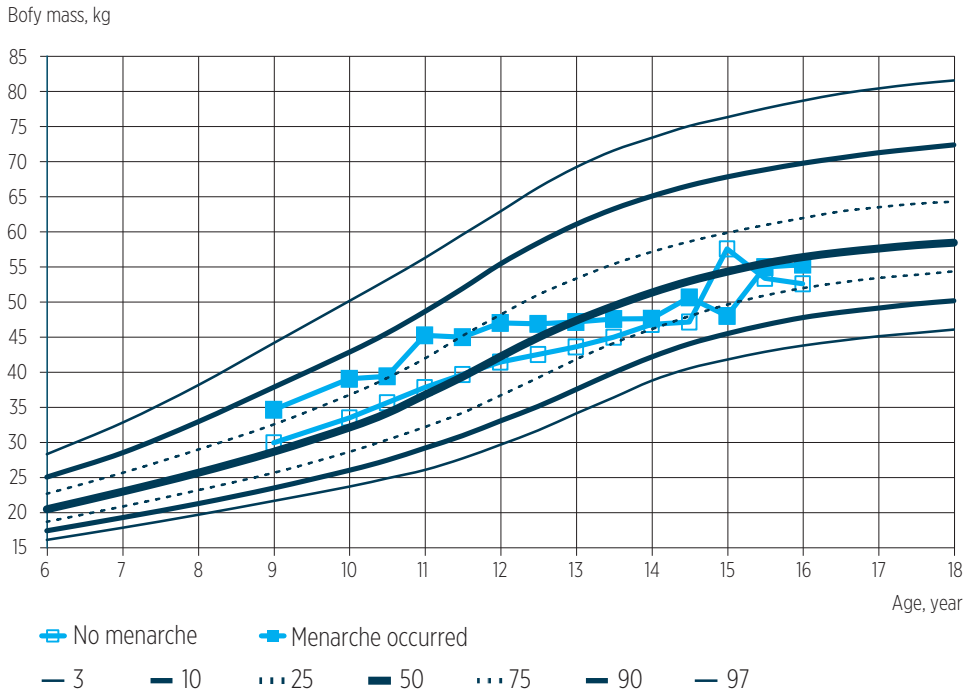

Figure 5.5

Reference percentiles of body mass, and age-related mean value changes of menstruating and non-menstruating girls

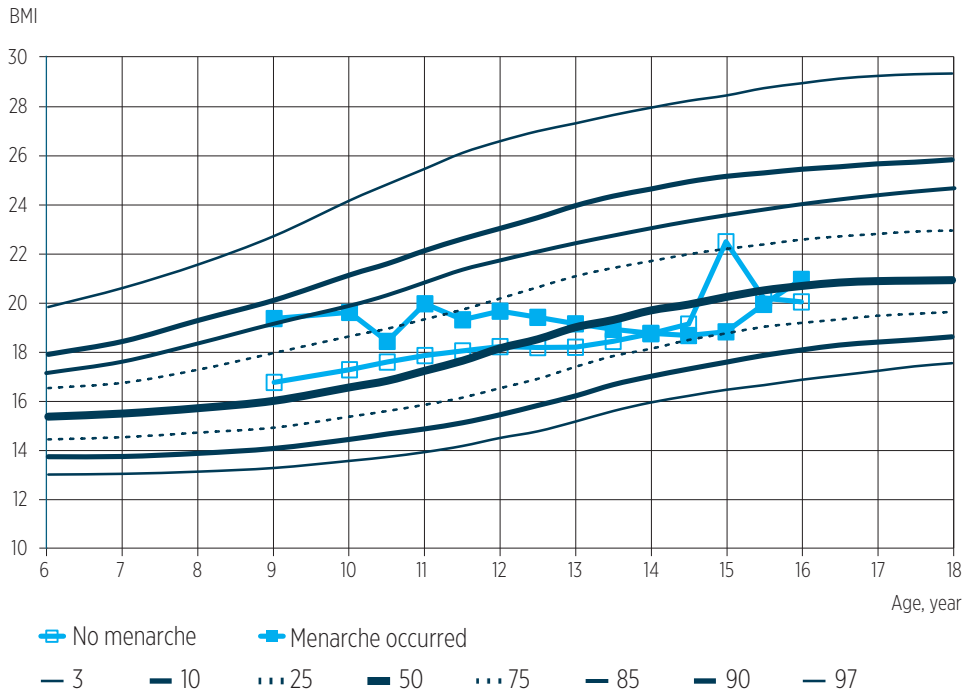

Figure 5.6

Reference BMI percentiles and age-related mean value changes of menstruating and non-menstruating girls

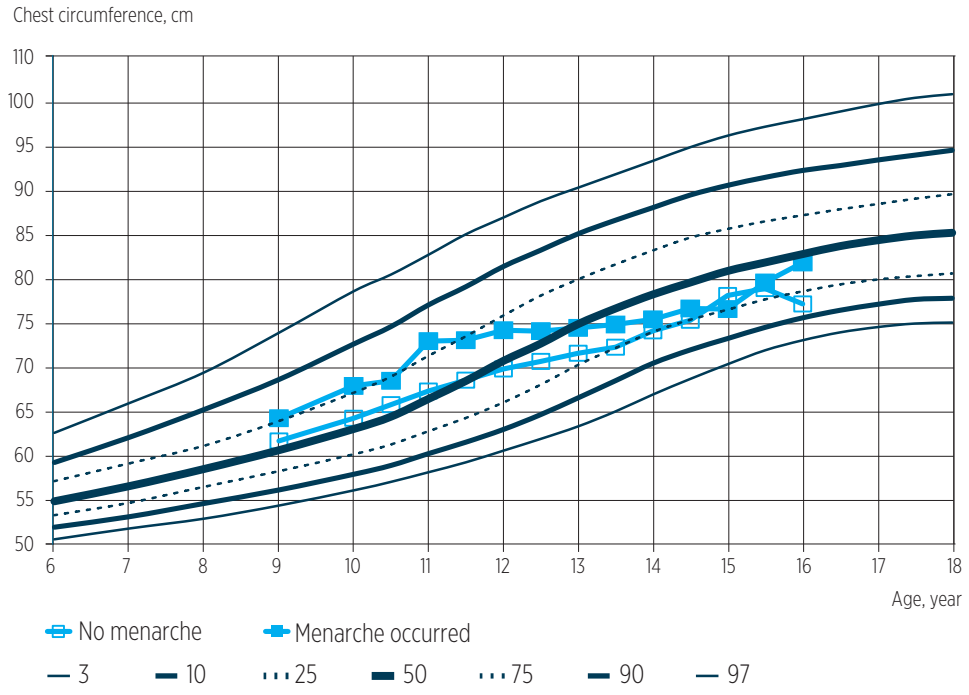

Figure 5.7

Reference percentiles of chest circumference, and age-related mean value changes of menstruating and non-menstruating girls

age of 15 years than the mean of the other group of the same age year. This difference is highest at the age of 11 years – more than 6 cm.

The wider chest circumference mean observed at age of menarche is – on the one hand – related to the body mass increase observed earlier. On the other hand, it can be explained by secondary sex characteristics, specifically, development of the breasts.

In our study, the mean age at menarche was 12.6 years, which is lower than the value in the sample of the first representative cross-sectional study in Hungary (12.78 years) carried out in 1981-1984 by O. G. Eiben and E. Pantó (Eiben & Mascie-Taylor 2003). Therefore, this study demonstrates well the decline of age at menarche in Hungary.

Summary

We reported the age of menarche of girls from the Hungarian Longitudinal Growth Study (HLGS) carried out between 1980 and 2001. The mean age at menarche in the sample was 12.55 year (SD=0.98). The earliest appearance of menarche was at the age of nine years, and the last appearance was observed at the age of 16 years. We analysed the change of height, weight, chest circumference and BMI between the ages of nine and 16 years, depending on whether menarche had or had not occurred for girls at that specific age. The subjects for whom menarche had occurred at that specific age were significantly taller, heavier and had wider chest circumferences in each age groups than those for whom it had not yet occurred.

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SUMMARY

The Hungarian Longitudinal Growth Study is the first growth study performed on a nationally representative sample from birth to the age of 18 years in Hungary. The importance of the study is enhanced because the follow up of studied children's growth and development was implemented in such a way that until the age of 14 the recorded sizes are national reference values without any corrections. Recorded values had to be weighted only between the ages of 14.5 and 18 years due to regionally different drop out rates. Means and percentiles of studied parameters are national reference values from birth to the age of 18 years after the application of weights generated by an expert. Sampling, sample attrition, the weighting procedure and reliability issues of the data are described above in Chapter 2.

During the implementation of the Hungarian Longitudinal Growth Study, and according to the original objectives, authors from time to time published reference means and reference percentiles of body measurements which are frequently used in paediatric practice.

The present volume has been prepared with the same aim. Age-related reference means, standard deviations and reference percentiles of body height (body length), body weight (body mass), BMI, body weight for body height, head circumference, chest circumference, abdominal circumference, and skinfold measurements – measured values in the triceps, subscapular, iliospinal, and abdominal region – are presented together with derived percentile figures.

In Chapter 4, authors presented a slightly shorter version of their study submitted for publication to the Hungarian journal of paediatrics (*Gyermekgyógyászat)* entitled: "Body height growth rate between the age of 3 and 18 years in Hungary in the period at the turn of the millennium", in which the first Hungarian reference values and reference percentile figures of body height growth rate were provided for users. Full datasets of 325 boys and 309 girls of the reference population were used to develop the body height growth rate (pace). The *Preece–Baines I* model was used to construct the reference percentile curves of the Hungarian body height velocity. Other important results of the study were as follows: the peak height velocity (PHV) in puberty of Hungarian children's body height is: 8.6cm/year for boys, and 8.3cm/year for girls. The average age associated with peak height velocity is 13.4 years for boys and 11.2 years for girls. The peak height velocity of early maturing boys is 9.40cm/year, and of early maturing girls is 9.01cm/year, which is achieved at the age of 11.6 and at 9.8 years on average. The peak height velocity of late maturing boys is 7.90cm/year, when they are age 15.0 on average. Peak height velocity of late maturing girls is 7.61cm/year, which is observed at the age of 12.8 years on average.

This volume also presented the first results related to the menarche age of girls (Chapter 5). These results are based on the sample of the Hungarian Longitudinal Growth Study. First, international and Hungarian changes and the secular tendency of menarche age were reviewed. Then, age-related frequency and the cumulative distribution of the menarcheal age of the 1709 girls enroled in the study were presented. The mean menarcheal age of studied girls is 12.59 ± 0.96 years. By comparing this mean age with the observed peak height velocity (PHV) of the girls' body height (8.32cm/year, achieved on average at the age of 11.2 years) we established that menarcheal age follows the mean age of peak height velocity of body height by 16.44 months. This fits perfectly the 14 to 18 months period provided by WHO for this time interval.

In Chapter 3, we examined the difference between the mean values of age-related body height, body mass, BMI, and chest circumference for girls not yet menstruating at a specific age and for those who had been through their first menarche by that age. We found that girls of the latter group are characterised by significantly higher measured

means than girls of the same age who had never menstruated before. The greatest difference in mean values between the two groups can be observed at the age of 11 for body height (5.04cm), body mass (7.45kg) and chest circumference (6.13cm). These results support the known fact that prior to menarche there is a significant body weight increase (and, as we have already mentioned, peak height velocity *(PHV)* of body height also occurs 16.44 months earlier). The excess of mean BMI verifies this relationship, especially for early menarcheal ages. For these girls, nutritional excess at the age of 9 to 11 is 2kg/m^2.

Finally, below we provide a list of papers that have been published based on the Hungarian Longitudinal Growth Study.

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