Original Article

The prevalence of wasting in Czech infants: a comparison of the WHO child growth standards and the Czech growth references

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Abstract

The objective of this descriptive study was to evaluate the performance of the international World Health Organization (WHO) child growth standards in the Czech Republic and determine the prevalence of wasting among children using the 1991 Czech growth reference and the WHO growth standards. The study utilized the 2006 WHO Child Growth Standards and the 1991 Czech growth references. The WHO standards were based on a longitudinal study of 882 children aged 0–24 months and on cross-sectional studies of 6669 children aged 18–71 months. The 1991 Czech growth references were based on a cross-sectional survey including 90 910 children aged 0–18 years (34 164 were children aged < 5 years). The prevalence of wasting was significantly higher among Czech children when using the WHO growth standards compared with the Czech references. The prevalence of wasting among 0–5-month-old children was 15.5% among boys and 12.9% among girls compared with the expected 2.3% of the WHO standards. In the length category of 50 cm, 9.0% of boys and 9.9% of girls fell under the WHO wasting cut-off compared with the 3% from the Czech growth reference. The application of the WHO growth standards may results in a significant increase of Czech children classified in the category of wasting, especially among infants aged 0–5 months. The performance and potential impacts of the WHO growth standards should be evaluated further before their adoption in the Czech Republic and other countries with local growth references.

Keywords: child growth, WHO, growth monitoring, breastfeeding.

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Introduction

Growth charts represent an important assessment tool for the health and nutritional status of children from birth to 18 years of age (de Onis *et al*. 2004a). The growth references are used by paediatricians as well as parents to determine whether children's physical growth is adequate for their age and gender. In infants, the growth charts are also used to evaluate the adequacy of exclusive breastfeeding and to decide whether it may be necessary to introduce supplemental feeding in breastfed infants (de Onis *et al*. 2004a).

Since 2001, the World Health Organization (WHO) has recommended, as a public health measure, 6 months of exclusive breastfeeding followed by continued breastfeeding for 2 years or beyond with the introduction of safe and adequate complementary foods typically starting at the end of the completed sixth month of age (WHO 2002). Given these recommendations, it is important to utilize child growth

references that most accurately reflect the growth and development of the specific population before significant changes in feeding practices are suggested to parents, especially in the case of the early introduction of supplemental feeding to exclusively breastfed infant.

Because of the lack of nationally representative data on children's growth and development in individual countries, many nations have utilized the international growth references recommended by the WHO over the past several decades. The growth references were developed by the National Center for Health Statistics (NCHS) in 1977, and the data were obtained from a sample of predominantly artificially fed, middle-class children from a limited geographical region of the USA (WHO 1978). Serious concerns were raised regarding the use of the 1977 NCHS growth charts because previous research indicates that the growth of breastfed children differs from the growth of predominantly artificially fed children (WHO 1994; Cole *et al.* 2002). Specifically, it has been shown that breastfed children tend to grow and gain weight faster in the first 3 months than those receiving artificial feeding. After the first 3 months, there is a relative decrease in the velocity of growth of breastfed infants. After 6 months of age, weight-for-age as well as weight-for-length and length-for-age *z*-scores of breastfed children tend to be lower compared with the values of artificially fed infants (Garza & de Onis 2004).

Given the limitations of the NCHS growth references, the WHO released new international growth standards in 2006 (WHO 2006). The new WHO child growth standards were constructed based on the data from the Multicentre Growth Reference Study (MGRS) that was carried out in six different countries (Brazil, Ghana, India, Norway, Oman and the USA)

from 1997 to 2003 (WHO 2006). The MGRS included approximately 8500 children who were exclusively or predominantly breastfed for at least 4 months, thus using breastfed infants as the normative model for growth and development (WHO 2006). In addition, the children were growing in optimal socio-economic conditions at the time of the data collection (de Onis *et al.* 2004b). These inclusion criteria were utilized in order to reduce the impact of environmental variation on the study (Cole 1991). Thus, the growth standards are available for all children from birth to 5 years of age and outline the ideal physiological growth and development of children regardless of their nationality, ethnic origin and type of feeding (Cole 1991).

Since 2006, some countries have adopted the new WHO growth standards, largely because of the lack of representative data from their own paediatric populations (Wright *et al.* 2008). In contrast, the Czech Republic is among 17% of countries that conduct regular growth surveillance of representative samples of paediatric populations (de Onis *et al.* 2004a). The Nationwide Anthropological Surveys (NAS) in the Czech Republic have provided data for the construction and updates of growth charts for Czech children and adolescents since 1951. Similarly to other national and regional reference data (Roelants *et al.* 2010), the growth charts used for the Czech population are based on cross-sectional studies of healthy children, regardless of the mode of feeding (i.e. breastfed or formula fed). The current growth references used for Czech children are based on the results of the fifth NAS that was carried out in 1991 (Lhotská *et al.* 1993). The sixth NAS was conducted in 2001; however, only selected growth references were updated (e.g. length-for-age) because of a significant increase in the prevalence of overweight and obesity

Key messages

- The 2006 WHO growth standards represent a valuable tool for objective international comparisons of children's growth and development between individual countries.
- However, our study indicates that a significant proportion of otherwise healthy Czech infants could be suspected of wasting if the WHO standards were used to monitor children's individual growth and development in the Czech Republic.
- Further research on the suitability and implications of the 2006 WHO growth standards in paediatric practice is warranted in the Czech Republic.

among Czech children from 1991 to 2001 (Lhotská *et al*. 1993; Vignerová *et al*. 2006). Thus, the 1991 growth charts represent the primary growth reference that is currently used by Czech paediatricians and other health professionals.

Previous studies suggest that children's growth and development is influenced not only by environmental conditions (Garza & de Onis 2004), but also by other factors such as genetics, climate and feeding mode (Eveleth & Tanner 1990; Cole *et al*. 2002). Given the long tradition of the population-specific growth references in the Czech Republic, a comparison of the new WHO growth standards with the Czech growth references is warranted before the WHO growth standards can be adopted in the Czech Republic. Because specific nutrition interventions are often suggested when children's growth is inadequate, it is especially important to evaluate the performance of the WHO child growth standards in the Czech reference population in terms of wasting. Thus, the main purpose of this study was to compare the prevalence of wasting [defined by the WHO as weight-for-height below –2 standard deviation (SD), which includes both wasting and severe wasting] among Czech children using both the Czech growth reference and the new WHO growth standards.

Materials and methods

This descriptive secondary analysis utilized data from the international WHO child growth standards and the 1991 Czech growth references. The 2006 WHO growth standards cover children from 0 to 59 months of age (WHO 2006). The WHO growth standards are based on a single longitudinal study of 882 children aged birth to 24 months and on cross-sectional studies of 6669 children aged 18 to 71 months. Children included in the study were raised in optimal environments that did not constrain growth, including living with non-smoking mothers. All children were exclusively or predominantly breastfed for at least 4 months. Complementary foods were introduced by the age of 6 months, and children continued to be partially breastfed up to at least 12 months. Term low-birthweight (<2500 g) infants were not excluded from the study. The Box–Cox-power-exponential

method with curve smoothing by cubic splines was selected for constructing the growth curves (WHO 2006). In the WHO growth charts, wasting was detected using a cut-off of –2 SD of weight-for-length (height), which corresponded to the 2.3th percentile.

The growth references for the Czech population were constructed based on the results of the fifth NAS in 1991. This cross-sectional survey included 90 910 children from birth to 18 years of age, of which 34 164 were children younger than 5 years. Birth weight of all children was greater than 1500 g. The sample included children with all feeding patterns (exclusive breastfeeding, partial breastfeeding or artificial feeding). The length of breastfeeding was determined from a questionnaire that was given to the mothers (no breastfeeding; up to 1, 3 or 6 months; and more than 6 months). In this sample, 37.5% of infants under the age of 3 months were breastfed (Lhotská *et al*. 1993). No exclusion criteria were applied to the sample in terms of the family socio-economic status and the smoking status of the mother. The percentiles of weight-for-length (height) were obtained by the LMS method (Cole 1991), based on the Box–Cox power transformation. According to the Czech growth references, children with weight-for-length (height) values <10th percentile receive heightened attention in terms of inadequate growth. Children with weight-for-length (height) values below the 3rd percentile are evaluated as 'underweight' and are often referred for further examinations.

The length measurements of Czech children aged <2 years were taken in the supine position, while the height measurements of children aged >2 years were taken in a standing position. Growth curves in the weight-for-length (height) charts were smoothed, and thus, the transition between length and height is smooth in the Czech reference data. In the WHO growth standards, the percentile values of weight-for-length are presented for lengths up to 110 cm, and they overlap with values of weight-for-height available for the range from 65 to 120 cm (WHO 2006). In this analysis, the weight-for-length values up to 90 cm (i.e. the values correspond to the age of 2 years at the 50th percentile) and the weight-for-height values from 90 cm onward were used in order to compare the WHO growth standards with the Czech growth reference.

The cut-off values for wasting of the WHO standards (WHZ = −2 SD) were entered into the software RustCZ [that contains the Czech growth references from the fifth NAS in 1991 (National Institute of Public Health, Prague, Czech Republic)], and a graphic display of the relationship between WHO standards and the Czech growth references was obtained. The values of weight-for-length/height at −2 SD of the WHO growth standards were expressed as *z*-scores and percentiles of the Czech growth reference. *Z*-scores of length/height-for-age, weight-for-age and weight-for-length/height were calculated for each child in the sample of the fifth NAS using the WHO Anthro software (version 2, World Health Organization, Geneva, Switzerland). The overall ratio of wasting in the sample of Czech children was calculated using the WHO criteria for wasting. *Z*-scores of weight-for-length/height were classified into age groups created by the WHO Global Database on Child Growth and Malnutrition (0–5, 6–11, 12–23, 24–35, 36–47 and 48–59 months) (WHO, http://www.who.int/nutgrowthdb/database/countries/cze/en).

Results

The values of the weight-for-length (height) used as a cut-off for wasting by the WHO for boys and girls expressed in both percentiles and *z*-scores of the Czech reference are presented in Table 1. The analysis determined the percentage of Czech children that would fall below the −2 SD for weight-for-length (height) if the WHO standards were used for the assessment of wasting in the Czech paediatric population. A significant increase in the percentage of children classified in the category of wasting was detected in all height categories in both boys and girls, including boys in the length category below 76 cm (which corresponds to 11-month-old children plotted in the length-for-age chart at the 50th percentile). Similarly, a significant increase in the percentage of children classified under −2 SD was noted among girls below 70 cm (corresponds to 8 months of age in the length-for-age chart at the 50th percentile).

An increased proportion of Czech children classified in the category of wasting was also evident at the length of 50 cm, where 9.0% of boys and 9.9% of girls

Table 1. World Health Organization cut-offs for wasting (−2 SD) expressed in percentiles and *z*-scores of the Czech growth reference for boys and girls

Length/height*	Boys		Girls	
	Percentile	Z-score	Percentiles	Z-score
50	9.0	−1.34	9.9	−1.29
52	9.9	−1.29	12.3	−1.16
54	10.0	−1.28	13.6	−1.10
56	14.0	−1.08	14.2	−1.07
58	16.9	−0.96	17.1	−0.95
60	18.7	−0.89	18.7	−0.89
62	19.5	−0.86	14.5	−1.06
64	15.9	−1.00	10.6	−1.25
66	12.3	−1.16	7.6	−1.43
68	9.5	−1.31	5.7	−1.58
70	7.4	−1.45	3.1	−1.87
72	5.8	−1.58	2.5	−1.96
74	3.5	−1.81	1.5	−2.17
76	2.9	−1.89	1.0	−2.34
78	1.9	−2.07	0.7	−2.48
80	1.3	−2.22	0.6	−2.51
82	0.9	−2.36	0.6	−2.53
84	0.9	−2.36	0.7	−2.48
86	0.9	−2.35	0.1	−2.21
88	1.3	−2.23	1.1	−2.29
90	1.7	−2.12	1.1	−2.29
92	1.7	−2.13	1.5	−2.18
94	1.6	−2.14	1.4	−2.20
96	1.5	−2.17	1.3	−2.23
98	1.7	−2.20	1.2	−2.27
100	1.6	−2.15	1.4	−2.21
102	1.7	−2.11	1.5	−2.17
104	1.5	−2.18	1.6	−2.14
106	1.5	−1.17	1.7	−2.12
108	1.9	−2.08	2.2	−2.02
110	1.8	−2.10	2.6	−1.94

SD, standard deviation. *Length < 90 cm; height ≥ 90 cm.

would fall under the −2 SD cut-off compared with the 3% from the Czech growth reference (e.g. 6.0% and 6.9% increase in the prevalence of wasting for boys and girls, respectively). The maximum differences in the prevalence of wasting using the two growth standards were found in the length category of 62 cm among boys, where the prevalence of wasting was 19.5% using the WHO standards compared with the 3% using the Czech reference data (i.e. increase of 16.5%). Among girls, the largest discrepancy was found in the length category of 60 cm where the prevalence of wasting was 18.7% compared with the 3% (i.e. increase of 15.7%) (Table 1).

Table 2. The prevalence of wasting among Czech children by the 2006 World Health Organization (WHO) standards (WHZ < −2 SD)

Age (months)	Boys (%)*	Girls (%)*	Both sexes (%)*
0–5	15.5	12.9	14.2
6–11	4.0	2.4	3.2
12–23	1.1	0.9	1.0
24–35	2.0	0.9	1.4
36–47	1.8	1.8	1.8
48–60	2.3	3.3	2.8

SD, standard deviation. *Expected values are 2.3% according to the 2006 WHO standards.

Table 3. Body length/height and weight of Czech children expressed in z-scores of the World Health Organization standards for boys and girls (mean values)

Age (months)	Length/height*		Weight	
	Boys	Girls	Boys	Girls
<1	0.07	0.15	−0.38	−0.43
1–1.99	0.00	0.17	−0.70	−0.67
2–2.99	0.13	0.17	−0.69	−0.67
3–3.99	0.24	0.23	−0.38	−0.46
4–4.99	0.39	0.41	−0.25	−0.21
5–5.99	0.58	0.50	0.00	−0.07
6–11.99	0.47	0.42	0.36	0.34
12–23.99	0.31	0.34	0.61	0.62

*Length < 90 cm; height ≥ 90 cm.

In terms of the individual age categories, the prevalence of wasting increased significantly among Czech infants aged 0–5 months when the WHO standards were applied. Specifically, the prevalence of wasting was 15.5% among boys and 12.9% among girls (Table 2). In contrast, this proportion was lower than the expected 2.3% (corresponds to −2 SD) in higher age categories, with the exception of 6–11-month-old boys and 48–60-month-old girls.

The results also indicated that some Czech children classified as being between the 10th and 25th percentile of the Czech references may fall below the −2 SD of the weight-for-length (height) of the WHO growth standards. Specifically, a significant number of children in the length category from 56 to 68 cm for boys (corresponds to the age 1–6 months in the Czech reference) and from 52 to 64 cm for girls (corresponds to the age 0.5–5 months) would fall under the WHO cut-off for wasting. The differences in height/length and weight between the samples of children from the fifth NAS and the MGRS study are presented in Table 3.

The values of the WHO standards are presented in relation to the Czech reference in both the percentile and the z-score classifications in Figs 1–4, respectively. The results showed that children participating in the MGRS study at the weight-for-length values of −2 SD gained weight faster in the first months following birth compared with the children in the fifth NAS in the Czech Republic. A peak difference between the two growth standards was reached in the length category around 62 cm for boys and 60 cm for girls. These lengths corresponded

to the age of 3 months for children at the 50th percentile in the length-for-age chart. Subsequently, the WHO weight-for-length values gradually dropped to attain the same values as those of the Czech reference data in the length category of 76 cm among boys (corresponds to 12 months for children at the 50th percentile of the Czech reference) and 70 cm among girls (corresponds to 8 months for children at the 50th percentile of the Czech reference). The WHO weight-for-length (height) values for the −2 SD continued falling until the length category of 82 cm in boys and 78 cm in girls (corresponds to 17 months among boys and 14.5 months among girls according to the Czech references). From these length categories up to the length of 110 cm (corresponds to the age of about 5 years for both sexes), the values of the z-scores of the WHO standards were lower than those of the Czech reference and the differences remained stable.

Discussion

The main purpose of this study was to compare the 1991 Czech growth reference with the 2006 WHO child growth standards and determine the prevalence of wasting among Czech children using both growth standards. The results of our analysis indicate that significant differences exist between the Czech growth reference and the WHO growth standards. As suggested in previous studies (Paulova *et al.* 2008;
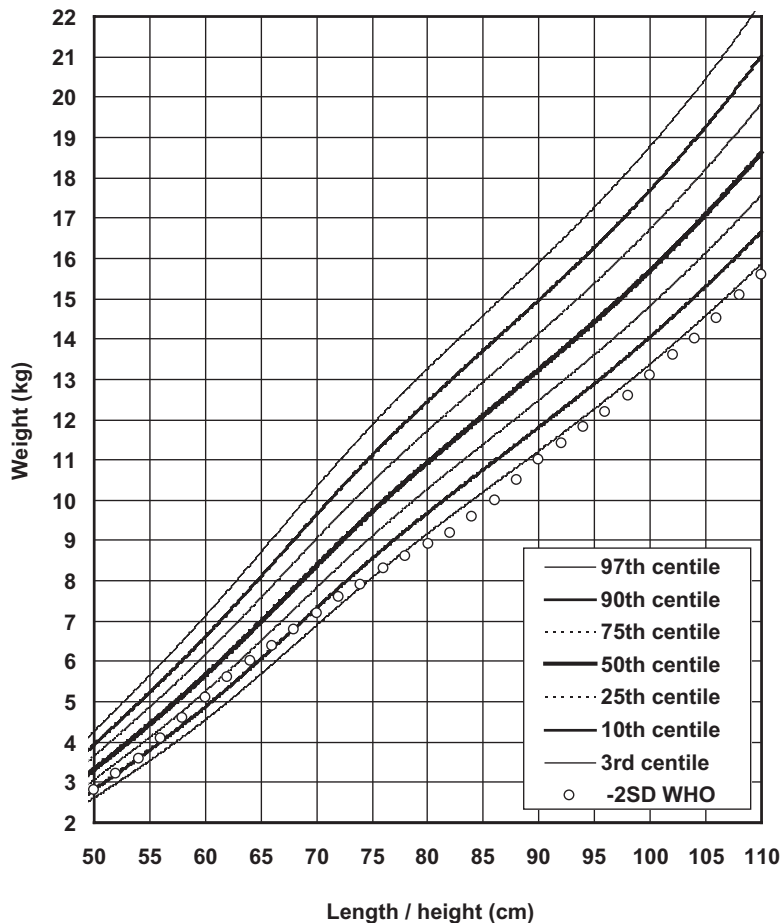
Fig. 1. Growth charts of weight-for-length for Czech boys (lines) and −2 SD of World Health Organization standards (points).

Roelants *et al.* 2010), such discrepancies may present practical challenges in growth monitoring for paediatricians and other healthcare professionals if the WHO standards were to be adopted in the Czech Republic and other countries where local growth references are available.

Based on the results of our study, the number of children suspected of wasting would increase considerably if the WHO growth standards were used for growth monitoring in the Czech Republic. In the age category of 0–5 months, 14.2% of Czech children would fall into the category of wasting, which would represent an increase of 11.9% from the expected prevalence of 2.3% based on the WHO growth standard. A large proportion of Czech infants would also fall from the category of slender children without any suspected nutritional problems (i.e. 10–25th percen-

tile of weight-for-length in the Czech reference) to the WHO category of 'wasting'. For example, among children between the 3rd and 25th percentile of the Czech reference, nearly all girls and 85% of boys from the length category of 50–59.9 cm would fall below the −2 SD for weight-for-length (height). Similarly, 89% of boys and 43% of girls from the length category of 60–69.9 cm would fall below the −2 SD of the WHO standard (Wright *et al.* 2008). Czech children are longer/taller and lighter than the children participating in the MGRS, which is shown in Table 3 where the length/height and weight of Czech children are expressed in *z*-scores of the WHO growth standards for both boys and girls. That fact that Czech children are longer/taller and lighter may explain such a large difference in the reference data (Wright *et al.* 2008). Similar findings related to length/height were
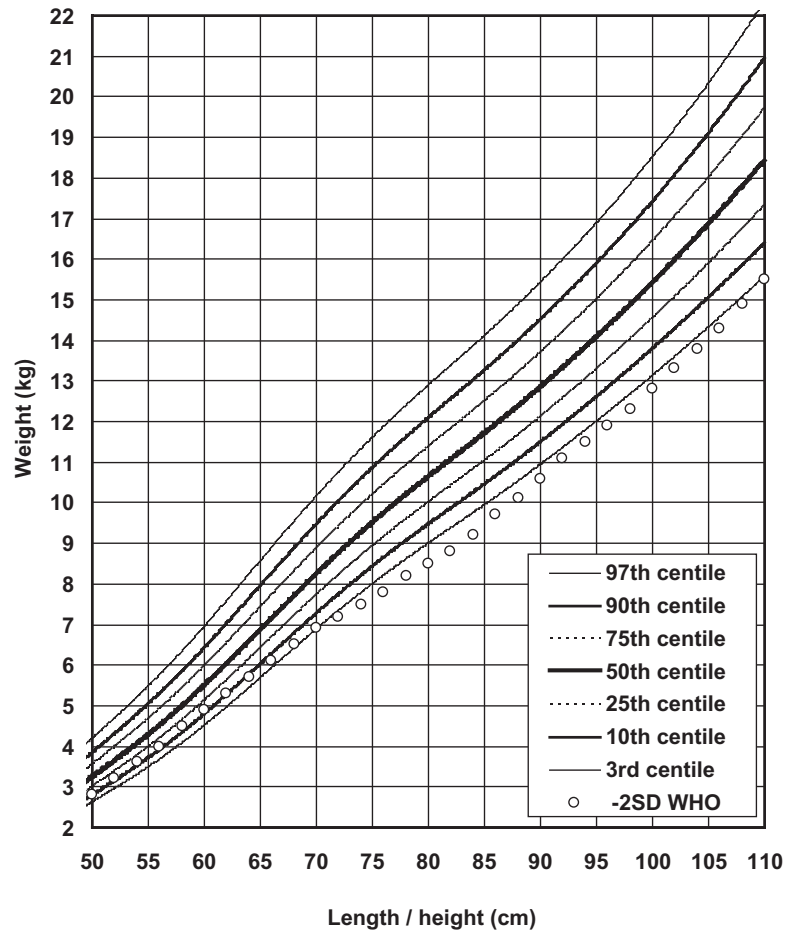
Fig. 2. Growth chart of weight-for-length for Czech girls (lines) and − 2 SD of World Health Organization standards (points).
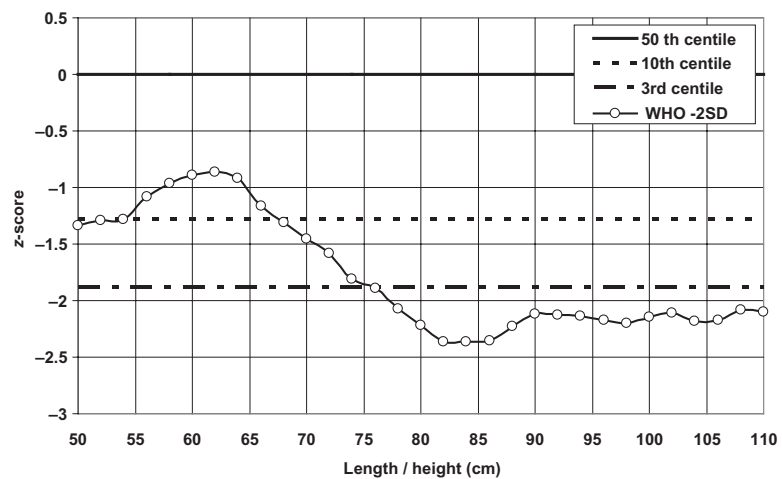

Fig. 3. The 50th, 10th and 3rd centile of Czech references of weight-for-length for boys (lines) and − 2 SD of World Health Organization standards expressed in *z*-score of Czech references (points).
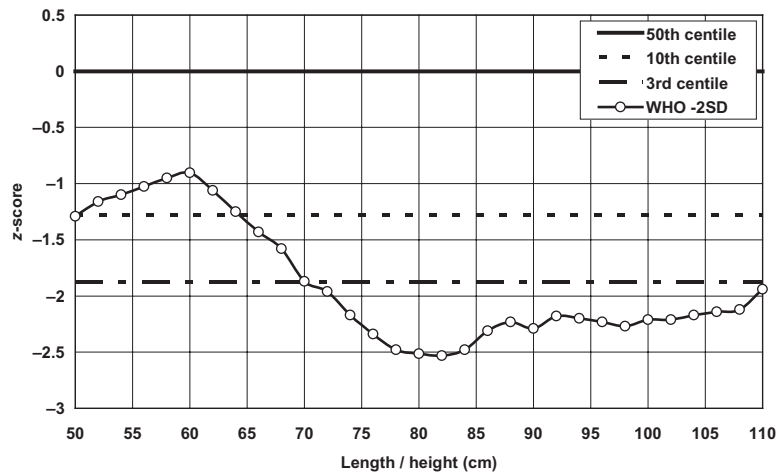
Fig. 4. The 50th, 10th and 3rd centile of Czech references of weight-for-length for girls (lines) and − 2 SD of World Health Organization standards expressed in z-score of Czech references (points).

reported from other countries, including Great Britain and Belgium (Wright *et al.* 2008; Roelants *et al.* 2010).

In recent years, the international WHO standards were compared with the previously developed growth references (e.g. 2000 Center for Disease Control and 1977 NHCS growth charts) (de Onis *et al.* 2007; Mei *et al.* 2008; Nash *et al.* 2008), and the impact of the WHO growth standards implementation was explored in a variety of paediatric populations (de Onis *et al.* 2006; Seal & Kerac 2007; Fenn & Penny 2008; Isanaka *et al.* 2009). Although many researchers agree that the new WHO standards may represent a useful tool for the early detection of acute malnutrition, they also caution that their application may considerably increase the prevalence of wasting and severe wasting in infants under the age of 6 months in various paediatric populations around the world (Seal & Kerac 2007; Mei *et al.* 2008; Isanaka *et al.* 2009). For instance, the adoption of the 2006 WHO growth standards in a representative sample of American children aged 0 to 23 months resulted in a significant increase in the prevalence of wasting among infants under the age of 5 months compared with the 2000 CDC growth references (Mei *et al.* 2008).

Our study confirms these concerns because a significant proportion of otherwise healthy Czech infants under the age of 5 months would be suspected of wasting if the WHO standards were used to monitor their individual growth and development.

While such misclassifications may occur regardless of the type of growth standards used in a paediatric practice, our results suggest that the risk of false growth/nutrition assessments in Czech infants could be significantly higher if the WHO growth standards were to be used for growth monitoring of Czech infants. Infants suspected of wasting often receive heightened attention and, in many cases, are referred for further medical tests to rule out serious illness. Such tests may be stressful and may impair the psychological health of the child as well as the mother, which in turn may lead to worsened nutritional status. Additionally, a mother's or a paediatrician's suspicion that an insufficient quantity of breast milk is the reason for the infant's inadequate growth may result in a premature introduction of artificial feeding. Thus, the adoption of the WHO growth standards for growth monitoring in the Czech Republic may not only lead to medical practices that are stressful to children and parents, but such practices may also undermine the promotion of exclusive breastfeeding within the first 6 months of life in a significant proportion of Czech infants (WHO 2002). Additionally, the adoption of the WHO growth standards within the Czech paediatric practice would also lead to changes in the growth assessment methods that have been used in the Czech Republic.

Given the results of our study, further research on the suitability and implications of the 2006 WHO growth standards in the Czech Republic is warranted.

As suggested in previous research (Garza & de Onis 2007; Mei *et al.* 2008; Nash *et al.* 2008), additional testing and validation derived from evidence-based practice are needed to gain a better understanding of their performance for growth monitoring in a clinical setting and in relation to the local reference, especially in terms of children with potential wasting and severe wasting. In the process of considering the WHO growth standards adoption, it is critical to verify and understand the practical impact of these standards on exclusively and/or predominantly breastfed children in the Czech Republic. Unique research efforts in this area are currently under way through a study supported by the Ministry of Health of the Czech Republic. Because breastfed children tend to grow and develop differently compared with artificially fed children (Cole *et al.* 2002), this study will allow for an in-depth evaluation of the WHO growth standards in a sample of exclusively or predominantly breastfed Czech children. If the WHO growth standards were to be adopted in the Czech Republic in the future, an intense in-depth training program for paediatricians and other healthcare professionals along with a nationwide parent education would be necessary in order to minimize potential errors in individual child growth assessment while increasing parental knowledge related to breastfeeding, overall growth and appropriate introduction of complementary feeding to infants.

Despite some challenges associated with the adoption of the WHO growth standards in the Czech Republic, it is important to note that the new WHO growth standards represent an important tool for the assessment of children's growth and development globally. In contrast to the Czech Republic, many countries lack population-specific growth references, and thus, the international growth standards serve as a valuable tool for monitoring and assessing growth in various paediatric populations around the world (Roelants *et al.* 2010). More importantly, the 2006 WHO growth standards represent a valuable international tool for objective comparisons of children's growth and development between individual countries that would not be possible using national/regional growth references. The WHO growth standards are also of great importance for the promotion of breastfeeding worldwide as they use breastfed children as the normative standard for growth and development.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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