GROWTH OF CZECH BREASTFED INFANTS IN COMPARISON WITH THE WORLD HEALTH ORGANIZATION STANDARDS

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SUMMARY

Growth references are important for paediatric health monitoring. It is critical to understand differences in growth interpretation and potential consequences when using available growth references. This study compares the growth of Czech breastfed children with the current WHO growth standards 2006 and the Czech references 1991, 2001.

A total of 960 infant/parent pairs in the Czech Republic were recruited through paediatric practices. Anthropometric data were collected during infants' first 12 months of life and parent questionnaires were gathered during a preventive visit at 18 months.

Czech breastfed infants were longer with a greater head circumference at all percentiles compared to the WHO standards and were similar to the national references. The percentile weight-for-age and weight-for-length values of infants (≤ 6 months) were lower, and higher (6–12 months) compared to the WHO standards. The infant growth in the sample differed from both the WHO standards as well as the national references.

Our findings indicate that the growth of Czech breastfed children differs from the current national references. These discrepancies were smaller compared to the WHO standards. The results of the study were used for new growth assessment guidelines to optimize feeding recommendations for Czech infants. The adoption of the WHO standards in the Czech Republic is not recommended.

Key words: breastfeeding, Czech, growth standards, infants, national references, WHO standards

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INTRODUCTION

The World Health Organization (WHO) released new growth standards for children aged 0–5 years in 2006 (1). The new standards are based on the Multicentre Growth Reference Study (MGRS) that included a sample of 8,500 children aged 0 to 5 years from 6 countries including Brazil, USA, Ghana, India, Norway, and Oman (2). The main goal of the study was to establish growth standards that could be utilized internationally and thus, serve as a universal assessment tool for growth and development comparisons of children globally (1, 2). Growth standards define how children should ideally grow, as opposed to the purpose of growth references that are meant to depict the actual growth of a given infant population. Since 2006, the new WHO standards have been successfully adopted by many countries and have been very useful for growth assessments, especially in nations that have not had appropriate local references available (3, 4). However, multiple countries are still in the process of considering the adoption of the new WHO standards and 30 countries have decided not to adopt these standards in their paediatric practice (3).

The Czech Republic is one of a few countries that have had the unique opportunity to utilize its own growth references over the last several decades. The Czech growth references have been constructed and periodically updated based on a long-term and systematic monitoring of the Czech paediatric population (5–7). While the first anthropometric characteristics were collected from 100,000 Czech children back in 1895 (9), the regular Nationwide Anthropological Survey (NAS), with anthropometric measurements from children and adolescents aged 0–18 years, has been conducted every 10 years since 1951 (5–8). Due to the lack of funding in 2011, the NAS was not completed for the first time since 1951. Thus, the 6th NAS completed in 2001 represents the most recent survey of Czech children and adolescents and growth curves from this survey are currently utilized in Czech paediatric practice (10), with the exception of weight-for-age, weight-for-height and BMI-for-age reference values that were derived from the 5th NAS (6).

Given the unique and long-term anthropometric data from the nationwide surveys, the Czech paediatric practice faced a challenging issue related to the adoption of the new WHO growth

standards during the past few years. An expert group on growth monitoring, assessment and growth standards was established by the National Institute of Public Health in the Czech Republic after the release of the new WHO standards in 2006. The group recommended to conduct a study that compared the existing Czech growth references, based on a sample of infants included in the NAS, regardless of their nutrition practices in the first months of life (i.e. breastfeeding, and formula feeding), to the WHO standards before the implementation of the new WHO standards would be recommended in Czech paediatric practice.

Czech children were found to be overall longer, starting at birth, than children included in the MGRS study. On the other hand, the values of weight-for-age and weight-for-length in the Czech growth references were similar to the WHO standards, and followed a similar trend to that observed in the sample of children from the MGRS study. The head circumference of Czech infants was found to be greater compared to the MGRS infants (11).

The growth discrepancies described above led the expert group to a decision to conduct further research with the goal of providing additional data and help public health officials decide whether replacement of the existing Czech growth references with the WHO growth standards would be advantageous for Czech paediatric practice. According to the Institute of Health Information and Statistics of the Czech Republic, 40% of Czech infants were breastfed for ≥ 6 months and 66% of birth clinics/hospitals met the WHO criteria for Baby Friendly Hospital in 2011 (12). Given the societal emphasis on breastfeeding and the relatively high rate of breastfed children, accurate growth assessment of Czech infants represents an important and timely issue in this country. Thus the study of the growth of Czech breastfed children was organized. The main purpose of the current study was to compare a sample of Czech exclusively or predominantly breastfed infants to the WHO growth standards 2006. The same criteria as in MGRS were used in selecting the sample of Czech breastfed children.

MATERIALS AND METHODS

Design, Subjects and Procedures

This longitudinal study was conducted according to the guidelines outlined by the Declaration of Helsinki. All study procedures involving human subjects were approved by the Ethics Committee of the Third Faculty of Medicine, Charles University prior to any data collection. The study utilized longitudinal data collected between April 2009 and May 2010.

A total of 43 paediatricians around the Czech Republic volunteered to participate in the study and to serve as primary points of data collection during a mandatory health examination of infants at 18 months of age. During the visit, paediatricians explained the purpose and details of the study to parents and asked volunteers to sign a written informed consent form for their and their child's participation in the study. After having signed the consent form, a scripted interview was conducted with each parent with the goal of obtaining detailed data related to socio-economic status, breastfeeding duration and infant age of complementary food introduction. The information was collected by the paediatricians using a standard questionnaire. Additional information was also obtained from infants' vaccination and health records containing their anthropometric measurements from all previous visits, including measurements at birth. All children in the Czech Republic are expected to pass a total of 11 examinations from the birth to the age of 18 months (at birth, 2–3 days after a hospital discharge, at 2 weeks, 6 weeks, 3 months, 4 months, 6 months, 8 months, 10 months, 12 months, and 18 months). In our sample 87% of infants' data were completed from ≥ 10 measurements and 13% from < 10 measurements.

Low number of the growth data was collected from the children at the age between 12 and 18 months. This trend could be explained by the fact that in the Czech Republic a health examination is not currently mandatory during the infant's 12–18 months of life. Because of these missing data, growth curves for the age 12–18 months could not be reliably constructed. Therefore, only growth curves for infants aged 0–12 months were constructed for the purpose of the current study to compare the Czech breastfed infants' growth patterns to the WHO standards.

Data from a total sample of 1,775 children were collected by paediatricians. In order to compare the samples, the same criteria as in MGRS were used in selecting the sample of Czech breastfed children (Table 1). A total of 960 infants (471 boys and 489 girls) with complete data met the inclusion criteria and thus were selected for the current study.

Three percentile curves were used to compare the growth characteristics of Czech breastfed infants to the WHO growth standards (3rd, 50th, 97th percentile). In Czech paediatric practice, these percentile curves have been utilized for assessment of inadequate (< 3rd percentile) and/or excessive (≥ 97th percentile) growth (6, 10). Because the percentile curves in relation to the WHO standards were nearly identical for both genders, only values for boys were discussed and presented in this study.

Statistical Analysis

Data collected during the health examinations were carefully checked for anthropometric quality (e.g. an individual growth curves were constructed and examined for every child and each measurement) and individual cases were excluded from the final analysis if unusual values were detected. Final data were processed using a nonparametric model called the Generalized Additive Models for Location, Scale and Shape (GAMLSS) (13). The GAMLSS model represents a widely used group of generalized linear models (GLM), generalized additive models (GAM), and LMS method. GAMLLS was utilized in the development of the new WHO growth standards (15). Furthermore, the Box-Cox-power-exponential method with cubic splines was selected for constructing the WHO growth curves (13–15).

In addition to the inspection of concrete absolute values and z-scores, an (approximate) statistical test based on the z-scores (taking WHO or Czech reference as fixed) can be done. Monthly z-scores can be examined separately considering smallest sample size. This conservative approach gives z-scores larger than about 0.33 as significant. For additional z-score analysis, only values corresponding to the 50th percentile for length, weight and head circumference of Czech infants were compared to the WHO standards and to the current Czech growth references. Z-scores for height-for-age, weight-for-age, head circumference, and weight-for-height were computed using the WHO Anthro Programme (version 3.1.0) (16). Similar procedures were followed when the

Table 1. *A Comparison of inclusion criteria for infants in the MGRS study and Czech infants in the sample of Czech breastfed children*

Inclusion criteria	MGRS infants	Czech infants
Socioeconomic status not constraining growth (low infant mortality rate, < 5 % prevalence of stunting, wasting, and underweight at 12–23 months of age)	yes	yes
Low altitude (< 1,500 m)	yes	yes
Low mobility of the target population	yes	yes
Minimum of 20% of mothers willing to follow feeding recommendations	yes	yes
Existence of breastfeeding support system	yes	yes
Minimum of a maternal high-school degree	no	yes
Non-smoking mother before and after delivery	yes	yes
Single full-term birth	yes	yes
Low-birth-weight (< 2,500 g)	born at term not excluded	born at term excluded (0.17% excluded)
Exclusively/predominantly breastfed for ≥ 4 months	yes	yes

50th percentile values of all measurements were compared to the Czech growth references using the RustCZ software (17).

RESULTS

The type of feeding received by the Czech infants by month is presented in Figure 1. At 4 months of age, 92.2% of the sample were exclusively breastfed (only breast milk and vitamin drops). The rest of the infants were predominantly breastfed (only water or other non-dairy liquids in addition to otherwise exclusive breastfeeding). Approximately 73.3% of the infants were exclusively breastfed at 6 months of age, with 9.9% predominantly breastfed and 13.0% partially breastfed (i.e. mixed feeding with breast milk and other sources of energy and nutrients). At 6 months, 3.8% of the sample was not breastfed at all. At 12 months, 64.8% of the infants continued to be partially breastfed.

The length of the infants (Fig. 2) in the study was greater compared to the WHO growth standards starting at birth. The length difference at birth was approximately 1 cm, with greater differences at 12 months at the 50th and 97th percentiles (1.4 cm and 1.8 cm, respectively). At the 3rd percentile, the length values were lower compared to the WHO standards between 2 weeks and 3 months.

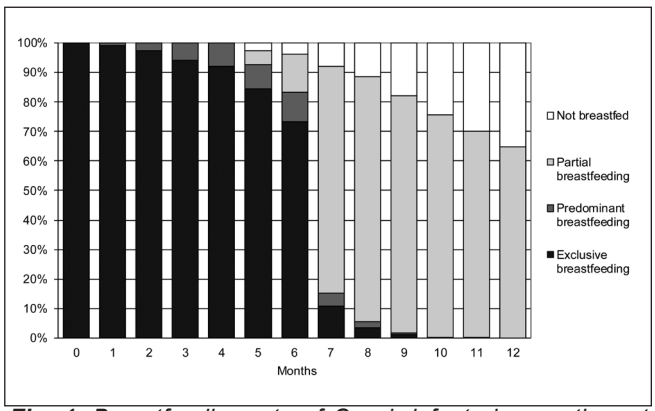

Fig. 1. *Breastfeeding rate of Czech infants by months categories.*

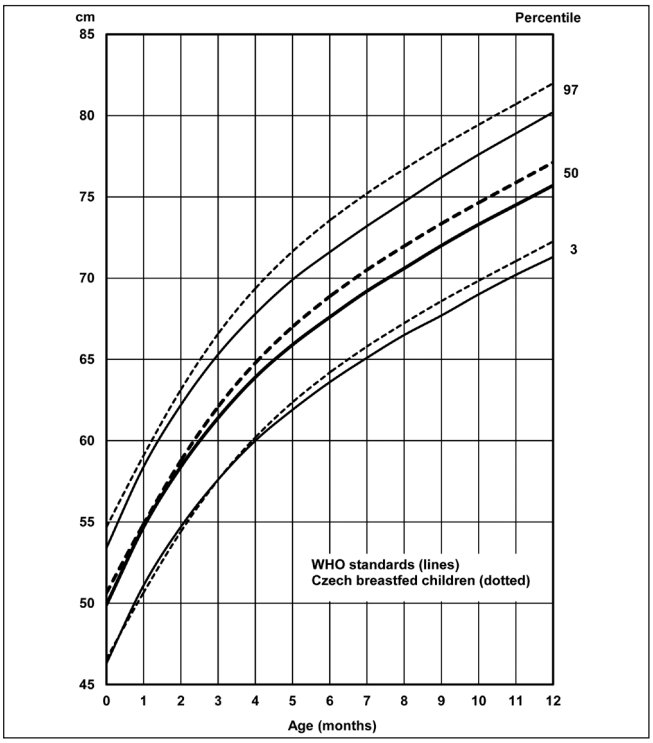

Fig. 2. *A comparison of length-for-age values between the WHO standards and Czech breastfed children.*

Figure 3 presents the percentile values for weight-for-age of the Czech breastfed infants compared to the WHO standards. The values at the 50th percentile of the Czech infants were consistently but slightly below the WHO growth curve only up to 7 months of age. Between 7 and 12 months of age, the percentile weight-for-age values were higher compared to the WHO values. Even greater differences in weight-for-age were detected at the 3rd and 97th percentiles, with 300–430 g differences at the 3rd percentile between 4 and 6 months of age. The findings indicated that the Czech and WHO growth curves did not match until 11 months of age at the 3rd percentile and 7–8 months at the 97th percentile.

Weight-for-length values of Czech infants (up to 70 cm) were lower compared to the WHO growth standards (Fig. 4). The largest

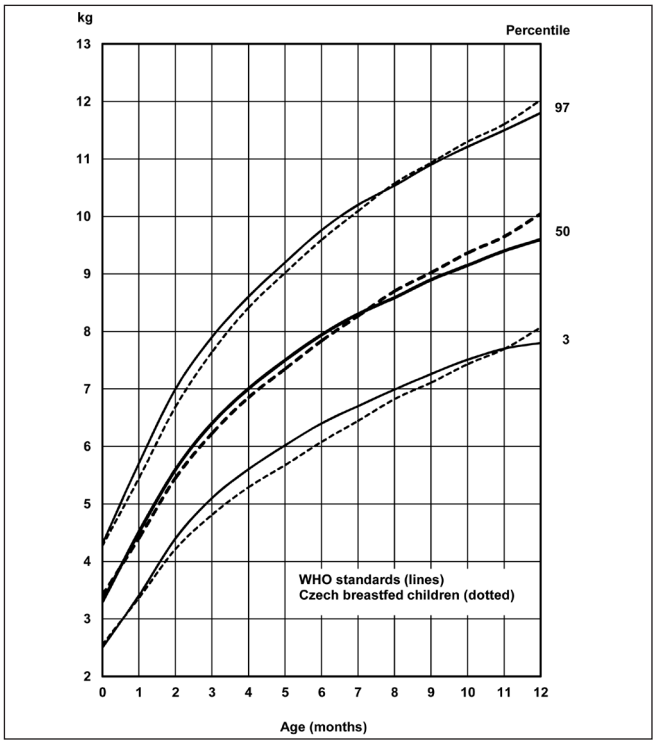

Fig. 3. *A comparison of weight-for-age values between the WHO standards and Czech breastfed children.*

differences were observed in infants with length of 60–70 cm (400 g difference in weight). At the 3rd percentile, the differences were as high as 760 g. Approximately between 55–70 cm, the WHO growth curve at the 3rd percentile exceeds the values of the 10th percentile in the Czech breastfed infants and even approaches the values of the 25th percentile in Czech breastfed boys. At 70–75 cm of length, the percentile growth curves crossed, thus indicating that the weight-for-length of the Czech breastfed infants was relatively high compared to the WHO standards.

Additionally, the head circumference of the Czech infants was larger by 5 mm at birth compared to the infants involved in MGRS. This trend was consistent over time and led to a head circumference difference of 1 cm at 12 months at the 3rd, 50th as well as the 97th percentiles.

The values of the Czech breastfed infants for all measures (length-for-age, weight-for-age, weight-for-length, head circumference-for-age) at the 50th percentile, expressed in z-scores, differed from the WHO standards (Fig. 5). The birth data, with the exception of weight-for-length z-scores, were greater among Czech infants. Length-for-age and head circumference-for-age z-scores were similar after the first month of life, however, these values have gradually increased thereafter. After the first 6 months of age, length-for-age values reached a value of 0.6 and remained relatively constant until the age of 12 months. The head circumference z-scores increased at a regular rate up to the value of 0.8 at 12 months. Weight-for-age values of the Czech infants differed to the smallest degree from the WHO standards, with the values being slightly below the WHO standards up to 7 months of age with a gradual rise after that. The weight-for-length values of the Czech infants were consistently below the WHO standards between 0 to 11 months.

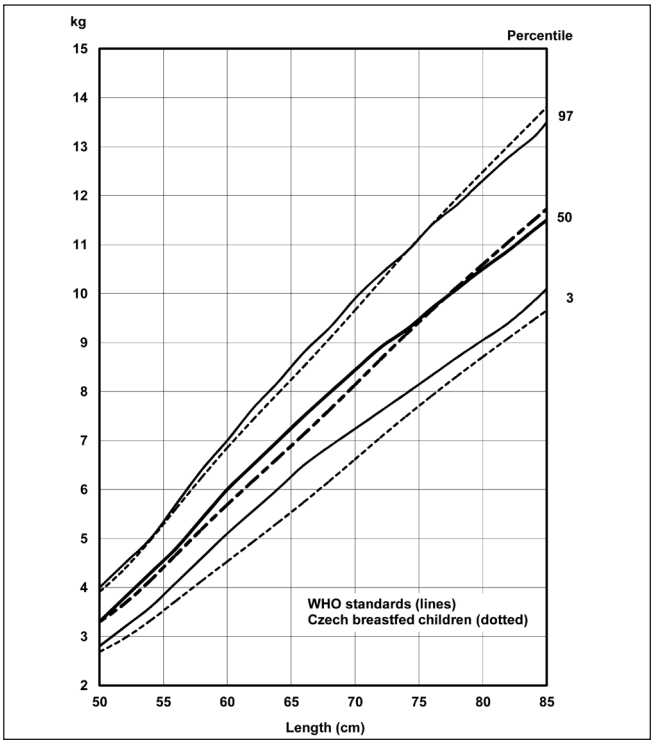

Fig. 4. *A comparison of weight-for-length values between the WHO standards and Czech breastfed children.*

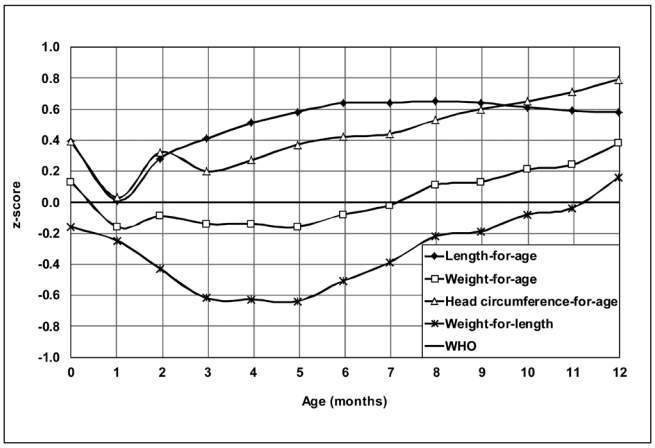

Fig. 5. *Growth parameters of Czech breastfed infants expressed in z-scores of the WHO standards.*

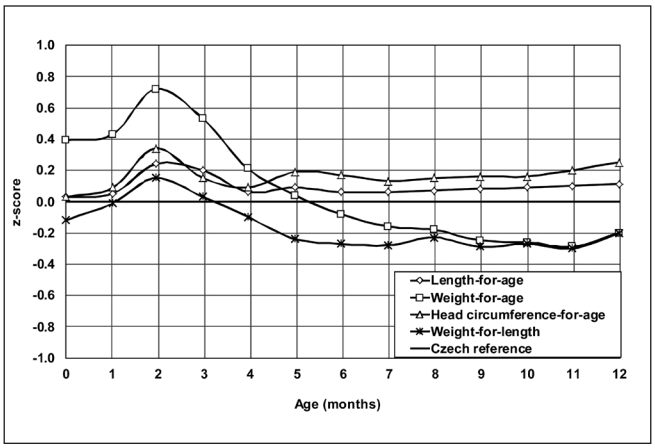

Fig. 6. *Growth parameters of Czech breastfed infants expressed in z-scores of the Czech references.*

When compared to the current Czech growth references, the growth of exclusively breastfed infants was significantly greater in the first 2 months of life (Fig. 6), with a relative decrease in growth rate in the following months. Length-for-age z-scores were slightly higher between 4 and 12 months and remained around the value of 0.06. Similarly, the head circumference z-scores were stable starting at 3 months, reaching values around 0.15.

Data from all anthropometric measures that were collected, including head circumference, indicated that breastfed infants in our sample grew faster up to the age of 2 months with a subsequent relative decline in growth thereafter compared to the existing Czech growth references. Weight-for-age z-scores at 6 months were negative and continued to decline until 11 months of age. Lastly, weight-for-length z-scores were also negative (–0.25) starting at 4 months of age.

Taking into account the approximate (conservative) approach, we took z-scores larger than 0.33, in absolute value, as indicating significant differences from a standard under consideration. The results showed that values of the 50th percentile of the length-for-age values of the Czech breastfed infants were significantly different from the WHO standards between 3 and 12 months of age, weight-for-length values were significantly different between 2 and 7 months and head circumference values differed significantly between 5 and 12 months (Fig. 5). When these values were compared with the existing Czech national growth references, the only statistically significant difference was found in weight-for-age from 0 to 3 months of age. Difference of the 50th percentile values of all other body characteristics in all age categories were statistically non-significant (Fig. 6).

DISCUSSION

The main purpose of the current study was to examine differences and similarities in growth of the Czech breastfed infants in comparison with the 2006 WHO growth standards and the Czech national growth references. The need for the current study arose after the previous research had found important differences in the course of the percentile growth curves between the WHO standards and the currently utilized national growth references in the Czech Republic (11).

The findings of our study indicate that Czech breastfed infants follow a different pattern of growth than infants included in the MGRS study (15). While the growth of Czech breastfed infants differs somewhat even from the current Czech references (6, 10), these differences were, in absolute values and in the form of z-scores, smaller than the differences in relation to the WHO standards. Given the strong public health emphasis and the increasing rates of breastfeeding, the current study adds important knowledge on growth patterns of breastfed infants in the Czech Republic.

To date, a number of studies have examined the impact of the implications of the WHO growth standards on growth assessment or specific nutrition-related outcomes, such as obesity, in other countries (18–24). For instance, examinations of growth patterns among British children were conducted by the Expert Group on Growth Standards of the Scientific Advisory Group on Nutrition and Royal College of Paediatrics and Child Health (25, 26). First, the WHO standards were adopted from 2 weeks to 24 months with the use of the United Kingdom 1990 growth references after the age of 2 years (25). More recently, the Royal College of Paediatrics and Child Health developed new growth charts using the WHO standards for use in children from 2 weeks to 4 years of age. Because British infants have higher birth weight than infants in the MGRS dataset, British 1990 birth data were preferred and recalculated for use in the new UK-WHO growth standards (25, 26).

The WHO standards were adopted for children aged 0 to 24 months by some countries, including USA and Australia (19, 27). Concerns about utilizing the WHO growth standards for children aged 2 and older in Australia, a country without available local growth references, have been also recently expressed (28).

Our results are consistent with studies from several countries where the adoption of the WHO standards has been considered in recent years but not recommended to fully replace the existing national growth references. For instance, a study of a large sample of children in Belgium and Norway found substantial difference between the local references and the new WHO standards (4, 29). The adoption of the 2006 WHO growth standards was thus not supported and local growth references have continued to be utilized in the respective countries (29).

In a study by Rollan-Cachera and Peneau (30), the WHO standards were compared to growth references in France, USA, Netherlands, Belgium, and the United Kingdom. For the first 3 months of life, all country-specific references showed lower values for weight and length compared to the WHO standards. After 6 months of age, country-specific reference values were generally higher than the WHO standards. This study provides more evidence that in addition to the infants in the Czech Republic, children in other countries do not follow the growth pattern outlined by the 2006 WHO standards as well. As Rolland-Cachera and Peneau (30) point out, the type of growth reference utilized has a direct effect on the interpretation of the child's growth in paediatric practice. Therefore, it is critical for paediatricians to be aware of differences between the available growth references and growth standards and realize potential consequences of the growth assessment on specific feeding recommendations (30).

The growth curves in the current study showed that Czech breastfed infants are uniformly longer at all ages and at all percentiles compared to the WHO growth standards; yet the values are consistent with the currently used Czech growth reference values. Similarly, the infant's head circumference values are greater at all percentiles than the WHO standards, but identical to the Czech growth references (6, 10). Thus, the implementation of the WHO growth standards among Czech breastfed infants could lead to a variety of consequences, similar to those reported in previous studies (19, 30). For instance, a greater number of Czech infants aged 0–5 months would be classified in the category of "wasting" (i.e. under the 3rd percentile for weight-for-length) (31). On the other hand, our finding that breastfed infants have a greater weight gains in their first 3 months of life compared to the national growth references is consistent with the results of the MGRS study. After that period the relative decrease in weight gain among breastfed infants occurs when compared to the national growth reference values (Figure 6). This result is essential for the support of long-term breastfeeding. So it is our task to convey this information to Czech paediatricians as well as to parents.

The transition from the Czech references to the WHO standards would be difficult because none of the Czech references

follows the patterns of the WHO growth standards. As a result, relatively sudden and substantial differences in children's growth assessments would occur during the transition. Lastly, the implementation of the new WHO standards would be challenging due to practical reasons that were highlighted in the previous work, such as time and cost demands of in-depth training necessary for health professionals and new approaches to convey the results to parents (32). Thus, the decision to revise the existing growth assessment guidelines in the light of the findings presented here was a compromise between the utilization of the prospective (WHO growth standards) and descriptive (Czech national references) growth charts.

The current study confirmed that the growth of Czech breastfed infants is specific and differs from the growth of other infants and the type of feeding needs to be considered in growth assessments. While the local growth references are preferred over the new WHO standards in the Czech Republic, it should be acknowledged that the 2006 WHO growth standards still represent an important tool for growth comparisons in paediatric samples across nations, for comparisons of country-specific references to the global growth norm for breastfed children, and are especially useful in countries without local growth reference data (29).

CONCLUSION

One of the WHO major focus areas is a promotion of long-term breastfeeding, in part because breastfeeding represents an important protective measure against obesity. The WHO growth standards 2006 clearly point out the fact that breastfed infants have a very unique and specific pattern of growth and development compared to other infants. Our findings from the representative sample of Czech breastfed infants indicate that it is not possible to automatically adopt the WHO standards into paediatric practice in the Czech Republic. While the growth of Czech exclusively breastfed infants differs somewhat from the current national references, it differs more significantly from the WHO growth standards.

The implementation of the WHO standards would be extremely challenging in the Czech Republic not only due to large financial and organizational costs, but especially due to different growth patterns of the Czech breastfed infants. Our study has significant practical implications in the area of public health especially for paediatricians who routinely recommend feeding to parents based on growth assessments. Thus, new growth assessment guidelines have already been provided to paediatricians in the Czech Republic (32). The new guidelines contain, among others, the following important information and specific recommendations based on the findings of the current study: Exclusively breastfed infants gain weight faster in the first few months of life compared to the Czech national reference of weigh-for-age values. It is important to be aware of the relative decrease in weight gain among breastfed infants around the age of 3 months, when compared to the national growth reference values, in order to avoid premature introduction of supplemental feeding at this critical time. The existing Czech references for length-for-age and head circumference-for age can be utilized for assessment of growth in Czech breastfed children immediately without any adjustments.

Acknowledgements

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Conflict of Interests

None declared

All study procedures involving human subjects were approved by the Ethics Committee of the Third Faculty of Medicine, Charles University prior to any data collection.

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