

# Exclusive Breastfeeding and Growth in Croatian Infants – Comparison to the WHO Child Growth Standards and to the NCHS Growth References

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## ABSTRACT

*The objective of this study was to compare the growth of exclusively breastfed infants and formula fed infants in eastern Croatia. Additionally, we compared growth patterns and estimated overweight based on the World Health Organization (WHO) child growth standards and the National Center for Health Statistics (NCHS) references. The growth of 88 Croatian infants in two feeding groups (44 breastfed and 44 formula fed) has been researched and presented. The feeding mode was obtained by the 24-hour dietary recall method. Anthropometric measurements were performed at birth and at 1, 2, 3, 4, 6, 9 and 12 months of age. There were significantly lower increases in weight and length in exclusively breastfed infants versus formula fed at 12<sup>th</sup> month ( $p < 0.05$ ). The weight gain of exclusively breastfed infants was  $6651 \pm 886$ g, and among formula fed infants  $7247 \pm 1254$ g, and also the exclusively breastfed infants showed significantly lower length gain ( $25.6 \pm 3.1$  cm) than formula fed infants ( $27.3 \pm 3.1$  cm) in the period from birth to the end of the first year. Differences shown in assessment of growth, depended of growth chart used: WHO child growth standards or NCHS references. A larger number of overweight children were found in the formula fed group in comparison to both references, suggesting that exclusive breastfeeding prevents this occurrence. We conclude that breastfeeding provided the nutrients necessary for infants to keep with the WHO standards of regular growth in children.*

**Key words:** infants, exclusive breastfeeding, formula fed, growth, WHO standards, Croatia

## Introduction

Breastfeeding provides healthy growth and development of infants. Mother's milk insures optimal nutrition, protects the newborn from infection and various allergies and helps in the maturation of gastrointestinal function<sup>1–5</sup>. Furthermore, several studies show that breastfeeding is associated with the reduced risk of overweight among children<sup>6–8</sup>. Pediatricians recommend exclusive breastfeeding until 6 months of age and they suggest that breastfeeding should be continued together with complementary food up to the second year<sup>9,10</sup>.

Growth is the most commonly used functional outcome measure of nutrient adequacy. Study results of the influence of feeding mode on the growth of infants varied due to the assorted methods of research<sup>11</sup>. There are investigations on the growth of infants in which the breastfed ones develop better than the artificially fed infants<sup>12</sup>. Some report that there is no significant difference in growth of breastfed infants and formula fed infants<sup>13–15</sup>.

Yet others show that formula feeding mode is associated with heavier infants<sup>16</sup>.

There exists a need for comparative studies on the growth of infants that will help public health care workers in their actions to further promote breastfeeding in Croatia. The evaluation of child growth curves are highly dependent on the growth charts used. Replacing the National Center for Health Statistics (NCHS) references<sup>17</sup>, international World Health Organization (WHO) child growth standards<sup>18</sup> are in use within Croatia while national data regarding infant body growth is established. The WHO standards depict normal human growth under optimal environmental conditions and can be used to assess children everywhere, regardless of ethnicity and socio-economic status. The new standards explicitly identify breastfeeding as the biological norm and establish the breastfed child as the normative model for growth and development<sup>19</sup>.

Our research can contribute to the national programs for infant nutrition and prevention of obesity in children. We used a prospective cohort design to examine the influence of nutrition on the growth of the infants in eastern Croatia. The objective of this study was to determine whether exclusively breastfed infants differ in average size from formula fed infants. Infants' growth were assessed using the WHO growth standards<sup>18</sup> and NCHS reference values<sup>17</sup>.

## Subjects and Methods

### Subjects

The subjects were all healthy full term infants from eastern Croatia, born in Osijek, and were included in the research by random sampling method after birth and followed until the completion of 12 months. To be included to the study participants had to fulfill the following criteria: single birth, healthy newborn without any congenital malformation or illness which would interfere with normal growth and development, born between 37 and 42 weeks of gestation, born with a weight of at least 2500 g and scored more than 7 on Apgar evaluation.

At the beginning of this research 120 infants and their mothers were recruited without regard to whether they were breastfed or formula fed. Feeding mode of infants, for each subject, was observed during 12 months and subjects were segregated into exclusively breastfed or formula fed group. For this research we did not influence the feeding mode so that the decisions about feeding was left to the mothers who were then aligned to the breastfed or formula fed group and determined the course of the study. Upon its completion, the study investigated the growth of 88 infants (43 male and 45 female) divided into two groups: 44 breastfed and 44 formula fed.

The main criterion for recruiting the subjects was »exclusive breastfeeding«. Our use of this term is as WHO defines it: exclusive breastfeeding is nutrition provided exclusively by the mother's milk without other liquids and foods<sup>9</sup>. The group of exclusively breastfed (44 infants) were infants exclusively breastfed from birth to 4 months of age. The group of formula fed subjects consisted of infants who were fed standard infant formulas from birth (44 infants).

### Methods

The data was collected at preventive pediatric offices in the eastern Croatian towns of Osijek and B. Manastir during the period of September 2003 through December 2004. The research was approved by the Osijek Community Health Center's Ethics Committee. The written consent of the parents was obtained in all phases of the study and confidentiality was ensured. The feeding mode was according to the decision of the parents. Infants were enrolled in the first week after birth and followed up at 1, 2, 3, 4, 6, 9, and 12 months of age for anthropometric measurements and feeding mode interview. At each interview, information on the feeding mode of the

infant was obtained by the 24-hour dietary recall method<sup>20</sup>, in brief we asked the mother what and how much the infant consumed in the last 24 hours. Further questions of the survey dealt with breastfeeding as well as feeding with formula, cow's milk and the introduction of weaning food. Anthropometric measurements carried out as a direct method of measuring the influence of nutrition on growth status included weight, length, head circumference, chest circumference and mid-upper arm circumference. Anthropometric measurements were performed in all subjects according to standard procedures<sup>21</sup>. Infants were weighed naked using the pediatric Sartorius scale for infants (variation  $\pm 5$  g). Crown-to-heel length was measured using infantometer to the nearest 1 mm. Circumferences of the head, chest, and mid-upper arm were measured to the nearest 1mm using an inextensible measuring tape. Anthropometric measurements were recorded by the same trained individual to maintain consistency. The examination was performed on the day when the infant completed each month of life, with a  $\pm 7$  day variation allowed.

### Statistics

Statistical analysis was conducted with Statistica 7.1 (StatSoft Inc., Tulsa, USA). The acceptable level of statistical significance for all tests was  $p < 0.05$ . For all numeric variables the mean values, standard deviation and coefficient of variation were calculated. The differences between the numeric variables were tested with the Student *t*-test and differences between z-scores with the repeated measures ANOVA. For the evaluation of the infant growth, weight and length were converted to weight-for-age and weight-for-length z-scores using WHO Anthro Software<sup>22</sup> for assessing growth and development of the world's children whose basis are reference values from the WHO child growth standards.

## Results

### Characteristics of mothers

All together 88 mothers with their newborns were included in the study from birth until the completion of 12 months. General information of the tested mothers is shown in Table 1. The average age of breastfeeding mothers was  $27.8 \pm 5.8$  years, and the average age of not breastfeeding mothers was  $25.4 \pm 3.4$  years, this is statistically significant difference ( $t = 2.344$ ;  $p = 0.022$ ). Most of the mothers had a secondary school education. A larger percentage of smokers did not breastfeed their infants (39%). Only 18% of breastfeeding mothers smoked which also showed statistical significance ( $t = 2.158$ ;  $p = 0.034$ ). In the group of breastfeeding mothers the introduction of weaning food began at the average age of 4.3 months, in the group of not breastfeeding mothers the introduction of weaning food began at the average of 3.5 months. The difference shown was statistically significant ( $t = 7.171$ ;  $p = 0.00$ ). Undiluted cow's milk was given to breastfed children at the average age of 10.5 months, and milk for-

**TABLE 1**  
CHARACTERISTICS OF MOTHERS IN EXCLUSIVELY BREASTFED AND FORMULA FED INFANTS

Characteristics		Breastfed (n=44)	Formula fed (n=44)
Maternal age (year)	X±SD	27.8±5.8*	25.4±3.4
Parity (number)	X±SD	1.9±1.3*	1.5±0.6
Education			
No education	%	5	2
Primary school	%	14	18
Secondary school	%	59	62
University degree	%	22	18
Smoking	%	18*	39
Weaning food**(month)	X±SD	4.3±0.9*	3.5±0.5
Cow's milk***(month)	X±SD	10.5±2.3	9.2±2.6

\*Significantly different from mothers with formula fed infants, Student *t* test,  $p < 0.05$ .

\*\*Introduction of weaning food.

\*\*\*Introduction of cow's milk.

mula fed children received undiluted cow's milk a bit earlier with the average of 9.2 months ( $t = 0.239$ ;  $p = 0.811$ ).

### Weight gain of infants

We measured weight gain of exclusively breastfed and formula fed infants at 6, 9, and 12 months of age (0–6, 0–9, 0–12) and the difference of weight gain between breastfed and formula fed groups. At birth the mean weight for breastfed infants was  $3443 \pm 404$  g and for formula fed  $3398 \pm 403$  g and that difference was not statistically significant ( $p < 0.05$ ). Breastfed infants had significantly lower rates of weight gain than formula fed infants at 6 and 12 months of age (Figure 1). From birth to the

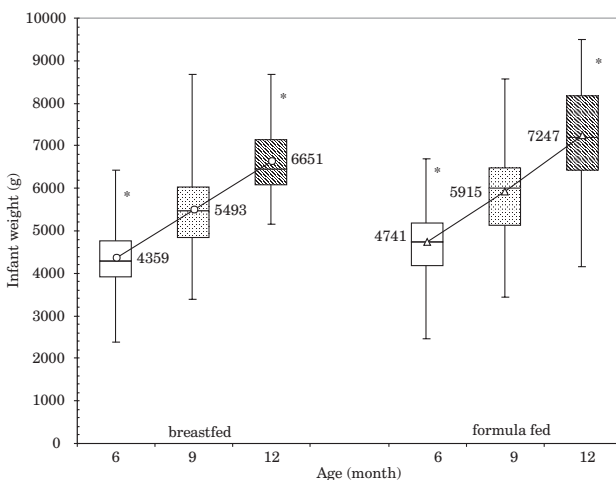


Fig. 1. Mean weight gain of exclusively breastfed and formula fed infants from birth to 6, 9, 12 months of age. Values are  $X \pm SD$ , compared with using Student *t*-test. Differences were considered statistically significant for  $p < 0.05$ . \* significant difference between breastfed ( $n = 44$ ) and formula fed infants ( $n = 44$ ).

completion of 6 months, the average weight gain with breastfed children was 8.8% lower than that of formula fed infants. Breastfed infants had an average weight gain of  $4359 \pm 832$  g, formula fed infants average weight gain was  $4741 \pm 929$  g ( $4359$  g:  $4741$  g;  $t = -2.031$ ,  $p = 0.045$ ,  $df = 85$ ), the difference here was also statistically significant,  $p < 0.05$ . From birth to the end of 9 months, breastfed infants had 7.7% lower weight gain than formula fed infants. In this time frame the breastfed infants' average weight gain was  $5493 \pm 1031$  g, while the formula fed infants had an average weight gain of  $5915 \pm 1120$  g, but the difference was not statistically significant. From birth until the end of 12 months the average weight gain of breastfed infants was  $6651 \pm 886$  g, and the average formula fed infants weight gain was  $7247 \pm 1254$  g ( $6651$  g:  $7247$  g;  $t = -2.577$ ,  $p = 0.012$ ,  $df = 77$ ), the difference was significant.

### Length gain of infants

Length gain was measured for exclusively breastfed and formula fed infants at the completion of 6, 9, and 12 months (0–6, 0–9, 0–12) and the differences of the length gain between the groups of breastfed and formula fed children evaluated (Figure 2). At birth the mean length for both groups breastfed infants and formula fed were  $50.3 \pm 1.7$  cm. From birth until the completion of 6 months length gain within the breastfeeding group was 5.6% lower than the formula fed group. Breastfed infants had an average length gain from birth to the end of 6 months of  $16.7 \pm 2.6$  cm and the formula fed group  $17.6 \pm 2.3$  cm. This difference is not significant. From birth until the end of 9 months the length gain of the breastfed group was 4.7% lower than those formula fed. In that period breastfed infants had the average length gain of  $21.0 \pm 3.6$  cm, those fed milk formula length gain was  $22.0 \pm 3.1$  cm but the difference was not significant. From birth to 12 months of age the average length gain of the breastfeeding infants was 6.7% lower than those

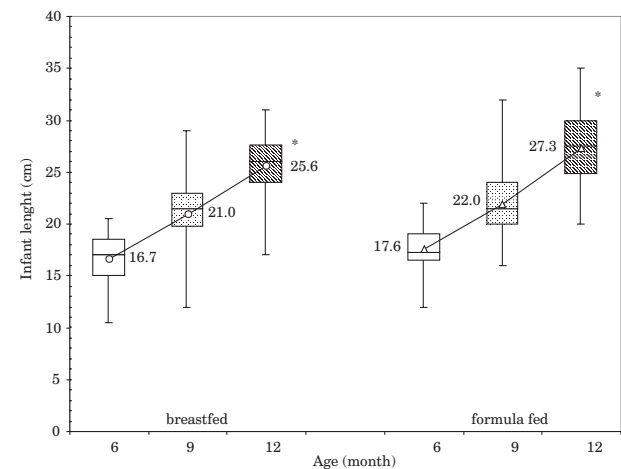


Fig. 2. Mean length gain of exclusively breastfed and formula fed infants from birth to 6, 9, 12 months of age. Values are  $X \pm SD$ , compared with using Student *t*-test. Differences were considered statistically significant for  $P < 0.05$ . \* significant difference between breastfed ( $n = 44$ ) and formula fed infants ( $n = 44$ ).

formula fed. Breastfeeding infants had the average length gain at the completion of 12 months of 25.6±3.1 cm, formula fed infants had an average length gain at the completion of 12 months of 27.3±3.1 cm (25.6:27.3 cm; t-test=-2.588, p=0.011, df=86) and the difference was statistically significant (p<0.05).

*Head circumference, chest circumference and mid-upper arm circumference*

No significant differences in growth of head circumference were observed at 6, 9, and 12 months in the two feeding groups. From birth to the completion of 6 months the head circumference gain of the breastfed group was 9.1±1.2 cm, and of formula fed group was 9.0±1.4 cm. From birth until completion of 9 months the growth of head circumference in the breastfeeding group was 10.9±1.6 cm, and within the formula fed group was 10.6±1.6 cm. From birth to the completion of 12 months the growth of head circumference of the breastfeeding group was 12.3±1.1 cm, and the formula fed group was 12.1±1.4 cm. Likewise, there were not any significant differences (0–6, 0–9, 0–12) either in the average growth of chest circumference or in the mid-upper arm circumference between the exclusively breastfed and formula fed infants (data not shown).

*Weight-for-age, length-for-age, weight-for-length z-scores*

We tracked growth in terms of weight and length of infants over the 12 month period. The changes in z-scores of the exclusively breastfed and formula fed infants for weight-for-age and length-for-age during the first year of life compared to WHO growth standards and to NCHS references (Figure 3 and 4). As shown in Figure 3

infants in both groups exclusively breastfed and formula fed achieved lower z-scores weight-for-age in the first six months when assessed using WHO standards compared to NCHS references, but higher weight-for-age z-scores in second half of first year and these differences were statistically significant at 1<sup>th</sup>, 2<sup>th</sup>, 3<sup>th</sup>, 4<sup>th</sup>, 6<sup>th</sup>, 9<sup>th</sup> and 12<sup>th</sup> month (p<0.05). Also exclusively breastfed infants accomplished higher z-scores weight-for-age vs. formula fed till sixth month of age and significant differences were at 1<sup>th</sup>, 2<sup>th</sup>, 3<sup>th</sup>, and 6<sup>th</sup> month based on WHO standards and also at 1<sup>th</sup>, 2<sup>th</sup>, 3<sup>th</sup>, 4<sup>th</sup> and 6<sup>th</sup> month based on NCHS references. After sixth month, results become opposite and significant differences exclusively breastfed vs. formula fed were established at 9<sup>th</sup> and 12<sup>th</sup> month based on WHO standards and at 12<sup>th</sup> month based on NCHS references (p<0.05). Weight-for-age z-scores in both breastfed and formula fed infants were above median based on both standards.

A different pattern was for length-for-age z-scores (Figure 4) where in first six months infants had similar length gain, using both WHO standards and NCHS references. Infants in both groups, exclusively breastfed and formula fed achieved significant higher length-for-age z-scores at 9<sup>th</sup> and 12<sup>th</sup> month when assessed using WHO standards compared to NCHS references.

At the 12<sup>th</sup> month formula fed achieved higher length-for-age z-scores opposite to breastfed infants (1.02 vs. 0.55 assessed using the WHO standards; 0.79 vs. 0.38 assessed using the NCHS) and the differences were significant (p<0.05).

Figure 5 shows the prevalence of infants who were above ±2 SD from the median for weight-for-length z-scores during of first year period based on WHO standards and the NCHS reference in breastfed and formula

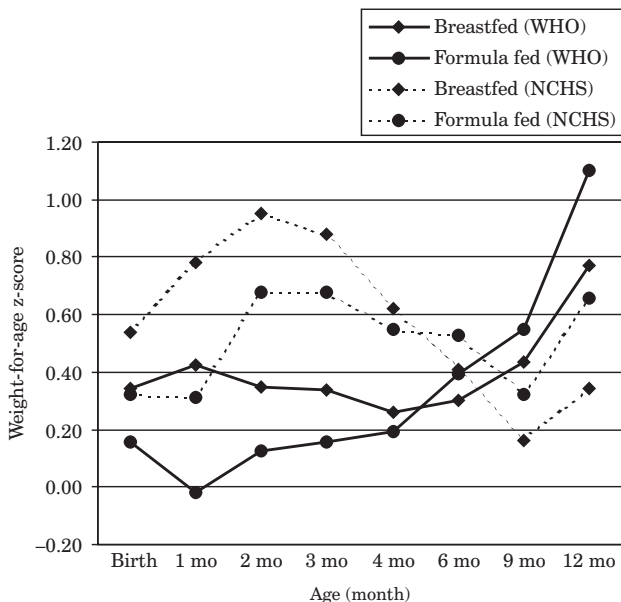


Fig. 3. Weight-for-age z-scores of the breastfed and formula fed infants during the first year of life compared to WHO growth standards and NCHS references.

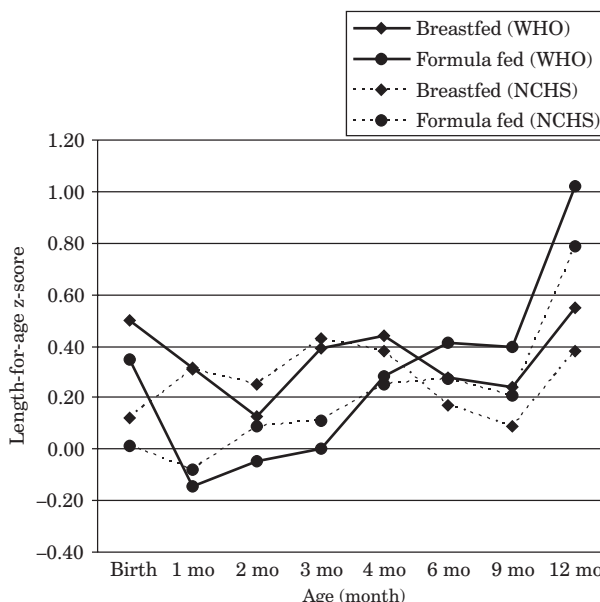


Fig. 4. Length-for-age z-scores of the breastfed and formula fed infants during the first year of life compared to WHO growth standards and NCHS references.

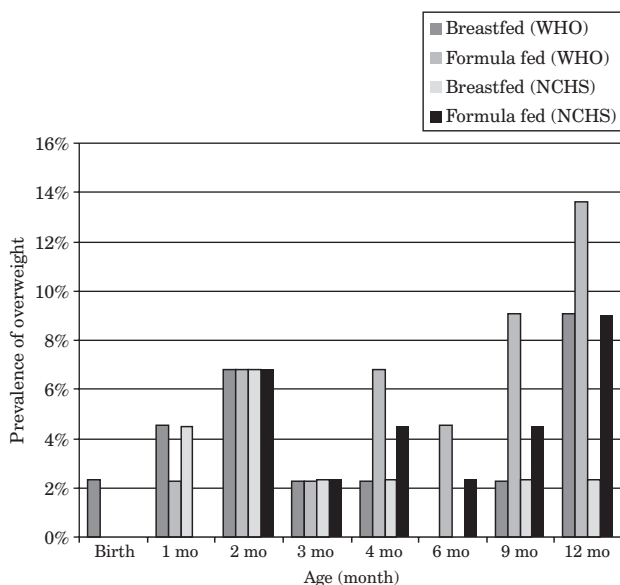


Fig. 5. Prevalence of overweight (above  $+2$  SD from the median for weight-for-length) by age based on the World Health Organization (WHO) standards and the National Center for Health Statistics (NCHS) reference in breastfed and formula fed Croatian infants.

fed infants. In the formula fed group there were a larger number of overweight infants at 12 months compared to WHO standards (9.1% vs. 13.6%) as well as NCHS references (2.3% vs. 9%).

## Discussion

Our results show the significant differences in weight and length gain between exclusively breastfed and formula fed infants at the age of 12 months. Some authors claim that breastfed infants develop better than formula fed infants<sup>9,23,24</sup>, while several show opposite results<sup>16,25,26</sup>. Additionally, others show that there are no differences in growth between breastfed and formula fed infants<sup>15,27</sup>. Some authors consider the amount of protein in a mother's milk the limiting factor of growth in a breastfed child<sup>28</sup>, others provide evidence that there exists a difference in physical development due to the type of nourishment the infant receives<sup>29,30</sup>.

In our study, the association between achieved size of infants and feeding mode can be compared with several similar studies<sup>15,25,26,29,30</sup>. Our findings correlate with results found with American infants<sup>25,26</sup>. Croatian examined exclusively breastfed infants had from birth until the completion of 12 months 596 g (9%) lower weight gain than formula fed infants. Similarly, at age of 8–11 months American infants who were exclusively breastfed for 4 months indicated a disparity in weight compared with other feeding groups<sup>26</sup>. Also, the difference in weight gain changes between breastfed and formula fed infants was shown by Butte et al.<sup>25</sup>, where female formula fed children of 6 to 9 months had a higher weight gain than

breastfed females with values of 12.8 g/day for formula fed and 9.6 g/day for breastfed. With our female breastfed and formula fed subjects, there existed a difference in weight gain. At the end of 6 months, our breastfed females had a 322 g (7.9%) lower weight gain than female infants who were formula fed, and at the completion of 9 months the breastfed female infants had 483 g (8.4%) lower weight gain than the female formula fed subjects. Opposite to our results, several researchers in developing countries have documented association between formula feeding mode and undernourishment<sup>12,23–24</sup>. The explanation for the deficit in growth among formula fed infants in developing countries is poverty, poor sanitation, shortage of safe water, improper preparation of milk formula, and subsequent contamination of food that may lead to gastrointestinal infections<sup>2,23,24,31</sup>.

The findings were similar for length gain. In our study from birth to the age of 12 months the length gain among exclusively breastfed infants was 1.7 cm lower than that of the length gain of formula fed infants, which is significant difference. Our study confirmed a larger increase in length among formula fed infants than breastfed infants, similar to other studies<sup>25,26,30</sup>.

The circumference of the head is a stable index for growth, unaffected by short-term nutrition, attending as a long-termed control of brain growth in infants. In our study changes in head circumference were followed up to the end of the first year. We did not find any significant differences between exclusively breastfed and formula fed infants in the growth of head circumference. Similar results were found by Kramer et al. who postulated that the type of nutrition does not affect growth of head circumference<sup>30</sup>. Also Butte et al.<sup>25</sup> confirm the lack of difference in head circumference growth between breastfed and formula fed infants.

Our study has shown that most of the infants in both observed groups achieved growth prescribed by the WHO growth standards and also by NCHS references. Nevertheless, there were differences in our study between weight-for-age z-scores depending of used growth charts that are consequence of different basic data construction. The WHO standards identify breastfeeding as the biological norm and establish the healthy breastfed child as the normative model for growth<sup>19</sup>. Because of specific growth pattern of breastfed infants in first six months new WHO standard curves for weight are higher than NCHS references and as we expected WHO weight-for-age z-scores are lower than NCHS weight-for-age z-scores. During next six months, situation changes to opposite, because of weaning food impacting on the infant's growth.

Weight for length z-scores above  $+2$ SD are accepted as standard statistical cutoff points to determine the overweight<sup>32</sup>. An important result of our study, compared with both WHO standards and NCHS references, was higher number of overweight in formula fed group at the end of first year. This result of our study has suggested that breastfeeding prevents obesity in early childhood. The prevalence of overweight at 12 month was higher in all infants when we used WHO standards, than when us-

ing NCHS references, because the basic WHO data depends on breastfed infants. There are a few theories why formula fed infants may gain more weight. Some studies have shown differences related to intake and nutritional composition of breast milk compared with milk formula<sup>33–36</sup>. Another proposed mechanism by which breastfeeding may protect against being overweight is behavioral. Some authors claim that breastfeeding promotes maternal feeding styles that are less controlling and thereby, allow infants greater self-regulation of energy intake<sup>37</sup>. The protective effect of breastfeeding on being overweight has already been observed in pre-school age children in Germany<sup>7</sup> and US<sup>6</sup>. We may hypothesize whether milk formula nutrition creates a predisposition to be overweight, but to confirm this it is necessary to further follow the growth of our subjects.

Our study confirmed differences between WHO child growth standards and NCHS international growth references and accentuated importance of growth charts for assessment of individual and population infant growth. It is recommended that the new WHO standards for in-

fants and children to 5 years of age should replace the older NCHS reference values<sup>38</sup>.

Furthermore, comparing the growth of the exclusively breastfed infants with the standards provided by WHO, we have noticed that the anthropometric data of our breastfed subjects were within the normal values of the growth of infants. Our results confirmed breastfeeding as the preferred feeding mode for infants that adequately influence the physical growth of children.

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## ISKLUČIVO DOJENJE I RAST DOJENČADI U HRVATSKOJ – USPOREDBA S WHO STANDARDIMA I NCHS REFERENTNIM VRIJEDNOSTIMA

### SAŽETAK

Cilj istraživanja bio je utvrditi utjecaj isključivog dojenja na rast dojenčadi te usporediti rast isključivo dojene dojenčadi i dojenčadi hranjene mliječnom formulom na području istočne Hrvatske. Usporedili smo rast dojenčadi i procijenili postotak pretilih na temelju WHO standarda i NCHS referentnih vrijednosti. Istraživanje je provedeno na 88 djece, podijeljenih u dvije prehrambene skupine: u skupinu 44 isključivo dojenih i u skupinu 44 nedojenih. Način prehrane utvrđen je pomoću metode 24-satnog prisjećanja. Antropometrijska ispitivanja djece provedena su pri rođenju, s navršenih 1, 2, 3, 4, 6, 9 i 12 mjeseci života. Isključivo dojena djeca imala su statistički značajno manji porast tjelesne mase i duljine nego hranjeni mliječnom formulom na kraju prve godine ( $p < 0,05$ ). Porast tjelesne mase od rođenja od kraja prve godine bio je kod dojenih  $6651 \pm 886$  g, a kod hranjenih formulom  $7247 \pm 1254$  g. Također, dojeni su u istom razdoblju pokazali značajno manji porast tjelesne duljine u usporedbi s nedojenim ( $25,6 \pm 3,1$  cm vs.  $27,3 \pm 3,1$  cm). Pokazali smo postojanje razlika između krivulja rasta WHO i NCHS. Većina djece iz obje prehrambene skupine postigli su rast sukladno standardima Svjetske zdravstvene organizacije. Međutim, u skupini nedojenih kod obje komparacije utvrđen je veći broj pretilih dojenčadi što ukazuje na preventivni utjecaj isključivog dojenja na pretilost.