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EARLY EATING HABITS IN INFANTS AND THEIR ASSOCIATION WITH IRON METABOLISM

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Infants experience rapid growth and development during their first year of life. The objective of the study was to investigate the early dietary habits of Latvian infants and their relation to iron metabolism. The study was composed of Study A "Research on eating habits of infants living in Latvia" (n = 344) and Study B "Research on the association between eating habits of infants living in Latvia and iron metabolism" (n = 73). 89% of infants (n = 18) were breastfed (BF) in the first month, and 21% (n =15) were exclusively BF for the first six months. The average age for introducing complementary food was five months. Iron intake was on average 7.4 mg. Iron deficiency (ID) was in 9.6% (n = 7) and iron deficiency anemia (IDA) in 4.1% (n = 3) of infants. The blood iron level was lower in 30% (n = 8) of infants fed with cow's milk. For infants who obtained iron predominantly from non-animal products, serum ferritin (SF) was within normal range. SF was within the normal range for 93% (n = 26) of infants who did not consume legumes. Dietary habits of infants in Latvia partly correspond to the guidelines. 63% of infants did not consume enough iron from food and ID was observed in 9.6% of infants and IDA in 4.1%. A lower iron level in blood occurred in breastfed infants and in infants for whom cow's milk was introduced at an early stage; a lower mean corpuscular volume level was observed in infants whose exclusive breastfeeding continued for at least the first four months; lower SF occurred in breastfed infants, in at least the first four months for exclusively breastfed infants, and in infants for whom whose legumes had been introduced in diet. A higher level of soluble transferrin receptors was observed in infants who were not first-born.

Keywords: *nutrition, breastfeeding, eating habits, iron deficiency.*

INTRODUCTION

There is very rapid growth and development in the first year of life of infants. In this period, the need of the infant's body for nutrients per 1 kg of body weight is much higher than that of an adult, and therefore the qualitative composition of food is particularly important. During this period of life, eating habits for the whole life are also developed. It is important to study whether the eating habits of infants living in Latvia comply with both the guidelines set out in Latvia and the guidelines of other leading organisations, such as the World Health Organisation (WHO), the European Food Safety Authority (EFSA) and the European Society for Paediatric Gastroenterology Hepatology and Nutrition (ESPGHAN). It is also interesting to observe how an infant's eating habits change over time.

Iron deficiency is identified as the most frequent deficiency in the first year of life (Domellöf *et al*., 2014). Lack of iron in the body or iron deficiency can cause irreversible impairment of cognitive development (Baker and Greer, 2010). Errors in an infant's diet are among the main reasons for iron deficiency. Therefore, compliance with the above-mentioned healthy eating habits is not only necessary for the prevention of diseases in later life, but, above all, for the prevention of iron deficiency. Timely detection of iron deficiency through biomarkers may reduce the risk of anaemia.

It is also important to investigate the association between eating habits and iron metabolism in infants who live in Latvia, taking into account their specific eating habits. If an association between eating habits and iron metabolism cannot be found, other factors that can affect iron metabolism and are characteristic to the population of Latvia should also be studied, such as the eating habits of pregnant women and the prevention of iron deficiency using medicines (Dewey, 2013; Vaivada *et al*., 2017).

The aim of the study was to investigate early eating habits in Latvian infants and their association with iron metabolism.

MATERIALS AND METHODS

The study consisted of two parts: Study A "Research on eating habits of infants living in Latvia" and Study B "Research on the association between eating habits of infants living in Latvia and iron metabolism". Part A of the cross-sectional study was conducted within the scope of a project supported by the European Food Safety Authority (EFSA) in 2012. Selection criteria of study participants for inclusion in the survey sample were: age, sex, and parental consent to participating in the study. Participants from all regions of Latvia in proportion to the birth indicators specified in the database of the Central Statistical Bureau (CSP) participated in the study.

The procedure for the selection of study participants consisted of two stages. General practitioners and pediatricians registered in the Latvian Medical Associations were invited to participate in the first stage. In the second stage, the medical practitioners were asked to randomly invite part of their patients to participate in the survey.

Data were analysed using the Statistical Package for Social Sciences (SPSS), STATA and Excel software. The National Food Composition Database was used for nutritional data analyses.

For analysis of the age of initiation of complementary feeding, 334 respondents were included in the study group, including those who were at the age of initiation of complementary feeding. For analysis of the duration of breastfeeding (BF), as well as the amount and frequency of intake of food groups, a sample of 266 infants was created, for which the inclusion criteria were age from birth to 12 months old, inclusive, as well as correctly indicated eating habit data in questionnaires.

Surveys within the study were conducted using 24-hour dietary recall for two non-successive days and a food frequency questionnaire. Only data from food frequency questionnaires were used in this study, while 24-hour dietary recall diaries were used for validation of the data. In order to evaluate the obtained data on eating habits, several guidelines developed by leading specialists were used as references, for example, WHO, EFSA, Finnish national recommendations, and German national recommendations (WHO, 2009; EFSA, 2013; National Institute for Health and Welfare in Finland, 2016; Prell and Koletzko, 2016). For analysis of the association between mother's age and age of initiation of complementary feeding or duration of BF, the mother's age was characterised by an arithmetic average and standard deviation (SD). Analysis of variance (ANOVA) was used to compare subgroups.

Since the frequencies of consumption of different food groups and portion sizes were not normally distributed (Shapiro-Wilk test), they were indicated as median values with an interquartile range (IQR). The age was specified as an arithmetic average value with a standard deviation (SD). The Pearson's chi-squared test was used to compare proportions. A p value < 0.05 was accepted as statistically significant.

Study B was based on the methodology of Study A for collection of data on diet, and blood counts were used to determine iron metabolism, and indicators were also used.

The study intended to involve 100 infants, including equal numbers of girls and boys. The required sample size was calculated in OpenEpi, based on the expected prevalence of iron deficiency anaemia in Europe — 3% and 2.5% error (Hernell *et al*., 2015), or also based on the differences in prevalence of iron deficiency anaemia between infants who are and are not breastfed: 4% to 25% (Eussen *et al*., 2015). The study involved infants: aged 9–12 months old (inclusive); and birth starting from the 38th week of gestation and with birth weight no less than 2.5 kg. The study did not involve infants who had infectious diseases within the last two weeks; had required treatment of anaemia using medicines in the last three months; had a congenital pathology, chromosome disorders or other serious disease (for example, a transesophageal fistula, tracheomalacia, congenital heart diseases, Down syndrome, HIV, cancer); health disorders, diseases causing restrictions in the menu (for example, diagnosed food allergy, coeliac disease, etc.); known haemoglobinopathy or thalassemia; had a blood transfusion in the last six months; or parents had not signed the study consent form.

In order to determine eating habits, data from a survey of 87 respondents were obtained, and laboratory blood indicators were obtained from 65 respondents.

The data necessary for the study were collected using interviews. Two types of questionnaires were used for the interview: a food frequency questionnaire (FFQ) and 24-hour dietary recall diaries for three non-consecutive days, which were filled out within one week. Only data from 24-hour dietary recall diaries were used in this study, while FFQ were used for validation of the data.

Blood samples were taken from infants to collect data on CF, where parameters for determining iron metabolism, iron deficiency (ID) or iron deficiency anemia (IDA) were determined: full blood count (including mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MHCH)), iron, transferrin and iron-binding capacity, ferritin, and sTRs.

In order to determine the prevalence of IDA, the following indicators were determined: haemoglobin (Hb) < 110 g/l (WHO, 2001) and serum ferritin (SF) below < 12 μg/l or MCV < 74 fl (according to the recommendations of the European Paediatric Association and WHO).

The following criteria were used to determine ID: SF 12 μg/l and MCV 74 fl, and soluble transferrin receptors (sTfR) 2.4 mg/l.

The Kruskal–Wallis test and the Wilcoxon–Mann–Whitney test were used in the case of continuous variables to analyse the association between eating habits and other parameters and laboratory indicators of iron metabolism. The Pearson $\chi 2$ test was used for the analysis of the same associations, but in the case of discrete variables. The frequency of consumption of different food groups and portion sizes were not normally distributed (Shapiro–Wilk test), and were indicated as median values with an interquartile range (IQR). Age was specified as an arithmetic average value with a standard deviation (SD). A p value < 0.05 was accepted as statistically significant.

The study protocol was approved by the Latvian Central Medical Ethics Commission.

RESULTS

Overall, the prevalence of boys and girls, as well as the distribution of respondents by regions, was comparable to the demographic distribution of the Latvian population.

Prevalence of BF was determined within the interval of one month (Fig. 1). Almost all infants (89%) were breastfed in the first month of their life. When they reached the age of six months, the prevalence of BF reduced to 68%. The number of breastfed infants reduced along with the infant's age (p = 0.002). The lowest indicators of prevalence of BF were observed in months 11 and 12, 33%, and 45%, respectively.

Complementary feeding in the current sample had been initiated for 164 infants in total. The average age of initiation of complementary feeding was five months (SD = 1). Before the age of four months, 9% (n = 14) of infants received complementary food. Most parents (85%) introduced CF for infants at the age of 4–6 months. For six percent of infants (n = 10), CF was introduced starting from the age of seven months. The most common choice of first CF was porridge (64%) and the second most common choice of food was vegetables (21%). The most popular vegetables were pump-

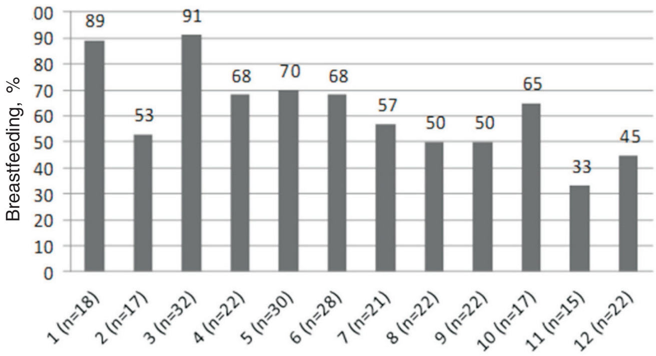

Fig. 1. Age, months (number of infants in the respective age group)

kin and potatoes. Fruit puree was chosen as the first CF in 10% of cases and other food in 5% of cases.

Some complementary foods were included in the menu of only a few infants before the age of four months. The biggest diversity of food was introduced at the age of 4 to 6.9 months old, and included vegetables, potatoes, fruit and berries, as well as cereals. From the age of seven months, each infant's diet included foods from nearly all food groups, such as cereals, vegetables and fruit, meat and fish, eggs, legumes, dairy products and others.

For further analysis, the infants were broken down into two groups: 0–5.9 months and 6–12.9 months. The menu of 86% (n = 126) of infants from the age of six months (n = 126) included vegetables. The average consumption was once a day and the average size of one portion was 80 g. Vegetables were included in the menu of only 10% (n = 12) of infants before the age of six months. In the vegetables group, the consumption of potatoes was analysed separately. The menu of 85% (n = 124) of infants older than six months included potatoes with the average frequency of consumption being once a day. The average amount consumed per meal was 17 g. Potatoes were included in the menu of only 8% (n = 9) of infants before the age of six months.

All CF groups were included in the menu, mainly from the age of six months. The menu of infants older than six months in 81% (n = 118) of cases included fruit and berries. The median frequency of consumption was once a day and the median consumed amount was 54 g per meal. The consumption of cereals was also popular (88%), but its median frequency of consumption was less than once a day (six times per week), and the median amount of consumed cereals per meal was 20 g. Meat was also introduced in the diet of most of the infants (73%, n = 107). The median frequency of consumption of meat was 1.7 times a day and the portion size was 46 g per meal. The menu of about one-third of infants (36%, n = 53) in this age group included fish. Fish consumption was relatively rare; the median frequency of consumption of fish was once a week and the amount of fish per meal was 30 g. Consumption of milk and dairy products was rather popular among infants older than six months. Milk and dairy products were introduced in the menu of 66% (n = 96) and 78% (n = 114), respectively. The median frequency of consumption of milk was less than once a day and that of dairy products — once a day; the amount of food per meal was 45 ml or 46 g of milk and 45 g of dairy products.

The diet of almost half of infants (45%, n = 65) from the age of six included eggs; the median frequency of consumption of eggs and the median consumed amount was 1 egg per week. Consumption of legumes was less common. They were introduced in the menu of 28% (n = 41) of infants in this age group. The average consumption of legumes was only once a month and the average amount per meal was 30 g. Fats were also included in the menu of most (73%, n = 107) infants from the age of six months. The median frequency of consumption of fats was five times a week and the amount per meal was 6 g.

The menu of infants younger than six months included fruit and berries in only 6% (n = 7) of cases, and cereal — in 5% (n = 6). Meat and fish were introduced in the menu of only some infants (3%, n = 3 and 1%, n = 1, respectively).

Milk and dairy products were introduced in the menu of 3% (n = 3) of infants younger than six months. The menu of only 1% (n = 1) of infants of this age included legumes and the menu of 3% (n = 4) included fats.

Overall, 73 respondents from different Latvian regions participated in Study B. There was a similar distribution among girls and boys, 56% and 44%, respectively. Unlike as in Study A, most of the respondents in the sample for this study were from cities other than Rīga, amounting to almost half or 44%. Most of the mothers were aged 26 to 35 years old (75% in the study B and 58% in study A). The level of education of mothers in both studies was almost identical, and higher education dominated in both.

The nutrition data analysis showed that iron was consumed in the amount of 7.4 mg per day on average (median = 6.5 mg/ day). Only 38% of infants (n = 27) consumed the recommended 8 mg of iron per day or more.

Iron with products of animal origin was consumed in the amount of 13% of the total intake of iron with food. A detailed analysis showed that less than 10% of the iron was taken up through products of animal origin for 35% (n = 25) of respondents, 10–20% was taken up by 39% (n = 28) of infants, and 20% or more by 26% (n = 19) of infants. It should be noted that of the total consumed meat, red meat constituted 56%, poultry — 35%, sausages — 9%, and offal — 1%.

21% (n = 15) of respondents followed the exclusive BF recommendations – to continue BF for the first six months of life; 29% (n = 21) of infants were breastfed from 4 to 5.9 months, and less than half (40% (n = 29)) of the respondents did not breastfeed or breastfed infants for less than four months.

In response to the questions about BF at the time of the survey, 44% (n = 32) of infants received breast milk, while 53% (n = 39) of infants received infant milk formula.

The average age of initiation of complementary feeding was five months (SD = 1), as in study A. Before the age of four months, only one infant (1%) received complementary food. Most of the parents (93%, n = 64) introduced CF for infants at the age of 4–6 months. For 6% of infants (n = 4), CF was introduced starting from the age of seven months.

At the time of the survey, cow's milk was introduced for 38% of infants, while meat for 34% of infants at the age of 4–6 months old, and for 53% at the age after seven months old.

An important fact was that 79% of mothers used iron medicines during pregnancy.

Iron deficiency was found in 9.6% (n = 7; 95% TI: 4.7–18.5%) of infants and iron deficiency anaemia in 4.1% of infants (n = 3; 95% TI: 1.4–11.4%).

Overall, more than a half of the infants showed iron metabolism indicators within normal limits: MCV, SF, iron and haemoglobin. However, only 36% (n = 26) had their sTfR within normal limits. An increased level of sTfr in blood might be evidence of reduced iron reserves in the body.

MCV, SF, iron, iron binding capacity, sTfR, and Hb were used as the main laboratory indicators of iron metabolism. Exclusive BF, the use of infant formulae, cow's milk, legumes and meat, and general intake of products of animal origin were considered as main nutritional factors when studying the association with iron metabolism.

Among continuous variables, BF had the biggest association with iron metabolism. The association of exclusive BF and BF with the following iron metabolism indicators was observed: iron, MCV and SF.

The level of iron in the blood of the infants who did not receive breast milk at the time of the survey was higher (10.7 μmol/l, n = 30, IQR = 5.7) than in those who were breastfed (8.5 μmol/l, n = 26, IQR = 3.1) ($p = 0.0125$). A similar association with exclusive BF was also observed for SF, where the level of SF was higher in infants who were not exclusively breastfed or were breastfed for a short period of time ($p = 0.0042$). A lower level of SF was observed in infants who were breastfed at the time of the survey ($p = 0.0010$). On the opposite side, the level of SF was higher in infants who received an infant milk formula ($p = 0.0157$) (Table 1).

An association of exclusive BF with MCV was observed, where the infants who were not exclusively breastfed for at least four months had lower MCV compared to not exclusively breastfed for at least four months: MCV 76 fl (n = 31, IQR 7.2) and 81 fl (n = 22, IQR 4) ($p = 0.0116$), respectively.

Table 1. Association of SF (ng/ml) with exclusive BF, BF, and use of infant formulae

Parameter		Median ng/ml	IQR ng/ml	n
Was the child exclusively breastfed at least until the age of 4 months?	Was not exclusively breastfed for at least 4 months	29.5	24.1	24
	Was exclusively breastfed for at least 4 months	17.8	14.3	31
Was the child breastfed during the survey?	Is not breastfed	30.5	22.9	30
	Is breastfed	16.1	10.7	27
Is the child fed with an infant milk formula during the survey?	Is not fed with a formula	17.8	17.3	27
	Is fed with a formula	26.2	25.9	33

The introduction of cow's milk in the diet was associated with the level of iron in the blood (p = 0.0171). Iron in blood was within normal limits in almost all (n = 30, 94%) infants whose diet did not include cow's milk and was lower in 30% (n = 8) of the infants in whose diet cow's milk had already been introduced. When analysing as a continuous variable, it was observed that the level of iron in the blood was lower in infants whose diet included cow's milk (8.3 μmol/l, n = 27, IQR 5.5), compared to infants without cow's milk in the diet (10.3 μmol/l, IQR 4.8, n = 32) (p = 0.0234).

An association was observed between the level of SF in blood and intake of legumes. The level of SF was within normal limits in most (93%, n = 26) infants whose diet did not include legumes, and to a lesser extent in those whose diet included legumes — 72% (n = 21) (p = 0.0425).

For infants who received iron predominantly from non-animal products, SF was within the normal range in 100% (n = 20) of infants receiving 10% iron from animal foods, 78% (n = 18) receiving 10–20% and 71% (n = 12) receiving 20% iron from animal foods (p = 0.0405).

Contradictory results were observed in the association of the level of Hb in blood with the intake of iron with products of animal origin. A lower amount of iron consumed with products of animal origin was associated with a higher level of Hb observed in blood (p = 0.0188) (Table 2).

Contradictory data were also been obtained for the association with iron binding capacity. The highest level of iron binding capacity (80 μmol/l, n = 13, IQR = 10) was observed when infants received 150–250 g of products of animal origin per day, while it was lower (74 μmol/l, n = 14, IQR = 12) when less than 150 g of products of animal origin per day, or more than 250 g per day (70 μmol/l; n = 21; IQR = 7), were consumed (p = 0.0436).

The observations confirmed that the use of iron medicines during pregnancy has an association with MCV. The strongest association (p = 0.0061) was observed, if iron medicines

Table 2. Association of Hb in blood sample with intake of iron with products of animal origin

What share in the total amount of consumed iron was taken with products of animal origin?	Median g/l	IQR g/l	Nn
Less than 10%	124	10	21
10–19%	117	10	25
20% or more	118.5	12	18

were used during pregnancy or after giving birth. MCV was within normal limits in 84% (n = 43) of the infants whose mothers used iron medicines, while MCV was lower in 63% (n = 5) of infants whose mothers did not use iron medicines (p = 0.0061).

It was revealed that sTfR was within normal limits in 62% (n = 18) of infants who were first-born children, and only in 32% (n = 8) in infants who were not first-born children (p = 0.0275) (Table 2). An association was found between the order of birth of the child and sTfR and iron binding capacity. First-born children had a lower level of sTfR (1.7 mg/l, n = 29, IQR = 0.5 mg/l) and higher iron binding capacity in their blood sample compared to not first child (sTfR level 1.8 mg/l, n = 25, IQR = 0,5 mg/l) (p = 0.0179).

DISCUSSION

Healthy eating habits of infants should start with breast feeding. According to the recommendations of the WHO and the Latvian Ministry of Health, exclusive BF should continue for the first six months, and then CF should be introduced combining it with BF, and BF should continue up to the age of two years (WHO, 2009; Ministry of Health, 2003). The results of this study showed that 89% of mothers living in Latvia started BF infants in the first month of their life. Most mothers continue BF in the first half of a year of life in Nordic countries: Finland (58%), Sweden (63%), Latvia (68%), Iceland (74%) and Norway (80%) (Hornell *et al.* 2013). The BF indicator until the age of six months old is the highest in Latvia among the Baltic states: 31% in Lithuania and 40% in Estonia (Save the Children, 2012). The duration of BF has improved, if we compare these results with the latest published data. The initiation of breastfeeding of newborns has reduced from 94% to 89%, but breastfeeding until the age of six months, in accordance with the data provided by surveyed persons, has increased from 58% to 63%, and until the age of 12 months old from 39% to 45% (Oginska, 2008).

Regarding the recommended duration of exclusive breastfeeding, contradictions are observed in the results of several studies. Until 2001, WHO recommended to continue exclusive breastfeeding in the first four to six months (Fewtrell *et al.*, 2007). A systematic review of literature leads one to the conclusion that this opinion has changed, and since 2001 it has been recommended to continue exclusive breastfeeding in the first six months of life (Kramer and Kakuma, 2002; WHO and UNICEF, 2003). In 2004 and 2012, systematic reviews of literature on the optimal duration of exclusive breastfeeding showed that exclusive breastfeeding should continue in the first six months, but regarding iron intake the reviewed studies were contradictory, and one of the conclusions was that the level of iron in infants in emerging countries was lower (Kramer, 2002; Kramer and Kakuma, 2004). The Latvian Ministry of Health also recommends continuation of BF in the first six months of life (Ministry of Health, 2003). In the present study, 21% of the respondents followed the recommendation for exclusive breastfeeding, but a slightly less than half (40% (n = 29)) did not breastfeed at all or breastfeed for less than four months.

There are different opinions about the age of initiation of complementary feeding, and therefore, recommendations also vary. The Latvian national nutrition recommendations have been developed in accordance with WHO guidelines, where the initiation of complementary feeding is recommended from the age of six months, starting with a small amount of food and increasing it as the child becomes older (WHO, 2009; Dewey, 2013; Ministry of Health 2003). EFSA indicates that CF should be initiated in infants not earlier than at the age of four months and no later than at the age of six months (EFSA, 2013). EFSA recommendations match the latest recommendations of Finland. The German recommendations on infant nutrition specify that starting from the age of 4–5 months most infants are capable of taking CF (Prell and Koletzko, 2016). Similar results with regard to the age of introduction of CF can be found in an Italian study, where CF for infants was initiated at the age of four to six months, 34.2% and 85.5%, respectively (Giovannini *et al*., 2004). The results of both studies (A and B) showed that CF for infants was mainly initiated at the age of four to six months, in 85% and 93% of cases, respectively.

The guidelines express a single opinion in relation to the introduction of vegetables in the diet and state that vegetables should be one of the first foods to be introduced as complementary food. The study showed that vegetables and potatoes are a very popular choice of food, and they are introduced into food after reaching the age of six months. Also, fruits and berries are eaten by 81% of infants older than six months on a regular basis. The recommendations in Latvia provide that fruit and berries may be introduced at the same time as vegetables (Ministry of Health, 2003). Such recommendations are supported by the Finnish nutrition guidelines (National Institute for Health and Welfare in Finland, 2016).

WHO, Finnish, and Latvian nutrition guidelines provide that porridge may be chosen as one of the first components of CF (WHO, 2009; National Institute for Health and Welfare in Finland, 2016; Ministry of Health, 2003). The EFSA and German nutrition guidelines recommend starting porridge after the first CF has been introduced in the diet (EFSA, 2013; Prell and Koletzko, 2016). This study showed that cereals are consumed mainly after six months of age, and used less than once a day in the amount of 20 g per meal. This might be too little.

Cow's milk is not recommended for use by children before they reach the age of one year (Department of Education and Early Childhood Development, 2014; Ministry of Health, New Zealand, 2008; Crawley and Westland, 2015). However, the ESPGHAN indicates that small amounts of cow's milk and milk alternatives may be introduced after iron-fortified products have been included in the menu. Early introduction of cow's milk and its use in amounts exceeding 500 ml is related to the development of iron deficiency in the body (Agostoni *et al*., 2008). 66% of infants consume cow's milk in Latvia before they reach the age of one year; however, it is used less than once a day, including 45 ml of milk in one meal. Fermented dairy products are mainly introduced after six months of age (78% of infants). In accordance with Latvian nutrition recommendations, dairy products should only be introduced into the infants' diet after they reach the age of one year (Ministry of Health, 2003). Finnish recommendations state that dairy products may be introduced starting from the age of ten months old (National Institute for Health and Welfare in Finland, 2016). Other recommendations do not include clear instructions regarding the use of dairy products.

Meat is an important source of haem iron, where iron is inherently of high bioavailability compared to sources of non-haem iron, which can be found in meat alternatives (for example, legumes), as well as iron-fortified cereals (Critch, 2014). The present study on the introduction and use of meat in infants provides good results. Meat is introduced into the diet of children in 73% of cases, when they reach the age of six months, and later its consumption per meal increases considerably when calculated per meal, reaching intake of almost twice a day. According to the WHO and the Pan American Health Organization, "meat, poultry, fish or eggs should be eaten daily or as often as possible" to satisfy the child's need for nutrients (WHO and Pan American Health Organization, 2003). The Latvian recommendations provide that meat should be introduced at the age of eight months (Ministry of Health, 2003). Intake of fish is recommended by replacing fish with meat once or twice a week, but fish is only consumed by 36% of children after they reach the age of six months, and this is done once a week.

In accordance with Latvian recommendations, eggs should only be introduced after children reach the age of one year. These study results show that eggs are consumed after infants reach the age of six months, and 45% of children eat one egg per week. Contrary to the Latvian recommendations, WHO and Finnish nutrition guidelines permit the intake of eggs before infants reach the age of one year (WHO, 2009; Ministry of Health, 2003; National Institute for Health and Welfare in Finland, 2016).

The reviewed guidelines do not describe the intake of legumes, unlike Latvian nutrition guidelines that indicate that legumes may be introduced at the age of eight months (Ministry of Health, 2003). This study showed that only 28% of infants who are six months old or older consume legumes, and they do this rarely and in small amounts.

Prevalence of iron deficiency and iron deficiency anaemia in infants in emerging countries and in developed countries is still recognised as an important issue. The systematic review of literature confirmed that iron deficiency is a common problem in European countries and is found in 2% to 25% of infants aged 6–12 months (Eussen *et al*., 2015). The authors mention the association of iron deficiency with several eating habits such as: intake of cow's milk, iron-fortified foods as complementary food, red meat, fruit and vegetables. Iron deficiency anaemia is mainly below 5% in Nordic countries and Western Europe, while it reaches up to 50% in some countries and populations in Eastern Europe. Similarly as in Latvia, up to 50% of infants also do not receive the recommended dose of iron in most countries — France, Germany, Iceland, Netherlands, Poland, Spain, Sweden, United Kingdom (Eussen *et al*., 2015).

Statistically significant results confirmed that infants who were exclusively breastfed had a lower level of SF and MCV in blood, which might suggest early iron metabolism disorders. A cohort study on related risk factors for exclusively breastfed infants, using Hb and SF as iron metabolism indicators, showed that the number of infants at age 6 months with ID has grown by more than four times, reaching 26.1%, where IDA was found in 23.9% of infants (Rosa *et al*., 2014).

The association between the duration of exclusive breastfeeding and iron deficiency was also described in a study conducted in Bolivia. The results showed that infants who were breastfed for four months or longer had a strong association with iron deficiency, but not anaemia. The level of iron and Hb was considerably lower with increased duration of exclusive breastfeeding (Burke *et al*., 2018). A statistically significant association with iron and SF was found –— the level of iron and SF was higher in infants who did not receive breast milk. A study in China showed that breastfeeding had a significant association with iron metabolism ($p < 0.001$). The authors have concluded that the risk of ID and IDA is higher in infants who receive breast milk or mixed feeding. Although favourable effects of breastfeeding cannot be doubted, the authors emphasise that it may cause risk of ID and therefore, guidelines for the determination and prevention of iron deficiency and anaemia are necessary (Clark *et al*., 2017). Similar results are described by Korean authors where the infants who were exclusively breastfed, iron deficiency was observed in 52.9% and anaemia in 28.3% of cases; in those infants who received both breast milk and infant milk formula, ID was observed in 10.1% and IDA — in 4.2%, while who received infant milk formulae, ID and IDA were observed in 3% and 0%, respectively ($p < 0.001$) (Hong *et al*., 2017).

The present revealed association between the consumption of cow's milk and reduced level of iron in the blood, as well as an association with sTfR, which was increased in infants for whom the intake of cow's milk had already been initiated. The systematic review of literature and meta-analysis confirm the negative impact of cow's milk on iron metabolism in infants and young children, as the intake of cow's milk by infants is related to increased risk of iron deficiency (Griebler *et al*., 2016).

The study results showed that the introduction of meat was associated with the level of Hb in blood. Interestingly, in infants for whom intake of meat was introduced at an early stage, at the age of 4–6 months, the level of Hb was reduced in 20% of cases and within normal limits in 80% of infants, respectively. Another intervention study revealed an association between the use of meat and Hb level. The results of that study suggested that depending on the amount of meat in the diet, the HB level in blood changed considerably ($p = 0.008$). However, no significant difference was observed in SF and Tfr indicators, as in our this study (Engelmann *et al*., 1998). These research results did not show an association between the frequency or amount of intake of meat and iron metabolism indicators in the blood. Furthermore, another prospective cohort study studied whether more meat in the diet of children aged 4 to 24 months old would improve the metabolism of iron and other microelements in the body. A considerable association was observed in infants at the age of 12 months old between SF and meat intake ($p < 0.023$). A trend for an inverse association between Hb concentration and the intake of meat was observed in the same age group ($p < 0.068$) (Taylor *et al*., 2004).

A similar cross-sectional study was conducted in Jerusalem. The results of this survey showed that ID was observed four times more often in the group where children consumed very little meat than in children who consumed it two or more times per week ($p = 0.023$). However, such an association with iron deficiency was not observed in the case of use of poultry. It was also concluded that iron deficiency is related to the insufficient intake of red meat. Developed countries consume poultry much more often than red meat, which may become a risk factor for iron deficiency and increase its prevalence (Moshe *et al*., 2013). A randomised double-blind controlled study in Germany was conducted to determine whether the low content of meat in complementary food, which is accepted by European Union law, may increase the risk of iron deficiency in the period of complementary feeding in infants receiving adequate nutrition. In the group of healthy infants, who were breastfed or fed with infant milk formula and received complementary food in accordance with nutritional recommendations, average iron metabolism biomarker indicators were within normal limits before (four months), during (seven months) and after (ten months) the involvement with different amounts of consumed meat. No significant differences in biomarkers were found between the groups where meat was consumed in increased and low amounts as might be expected. This study did not reveal any difference in the intake of iron with food between high and low meat consumption groups. The researchers emphasised that the most important discovery was that after the primary data analysis, no justified evidence of disturbed iron metabolism was found for infants receiving meat as complementary food in lower amounts than recommended by the European Union. However, secondary analysis of data showed that such a small amount of meat in the diet of many infants consuming breast milk in the first four to six months of their life in accordance with recommendations may increase the risk of iron metabolism disorders in the second half of the first year of their life (Dube *et al*., 2010).

Although infants living in Latvia do not consume legumes in large amounts, their use has shown statistically significant associations with iron metabolism. The intake of legumes was associated with a lower the level of SF in blood. This might be explained by the high content of phytates in legumes, which bind to iron and thus delay its absorption by the child's body (Gibson *et al*., 2010; Dewey, 2013; Lim *et al*., 2015).

Although eating habits are very important in the prevention of iron deficiency, it is important to study not only the impact of nutrition, but also the potential association of other factors with iron metabolism in infants. This study examined the association of iron deficiency with the use of iron medication during pregnancy or after giving birth, the mother's age, mother's education and the order of birth of the child. Statistically significant results were only found for the association of the order of birth of the child and sTfR, where sTfR in first-born infants was within normal limits in more infants (62%) compared to those who were not first-born (32%).

Based on the data of this study as well as when examining the results of other studies, it is important to consider and study the association with the mother's age, the order of birth of the child, mother's nutrition and mother's health condition (Marques *et al*., 2016), mother's education, socioeconomic condition of the family (Thane *et al*., 2000), infant's sex (Soh *et al*., 2004), infant's weight, including excessive weight, obesity and other factors (Cox *et al*., 2016; Soh *et al*., 2004).

CONCLUSIONS

1. Eating habits of infants living in Latvia partially correspond to the guidelines of the Latvian Ministry of Health: diversity of food is observed, complementary feeding is initiated at the recommended age, cow's milk is not used in amounts exceeding 600 ml per day, and meat is introduced in the diet in a timely manner and in sufficient amounts. However, only 21% follow the exclusive BF recommendation.

2. 63% of infants at the age of 9–12 months do not consume a sufficient amount of iron with food and ID was observed in this group in 9.6% of infants, while IDA in 4.1% of infants.

3. Associations with the following eating habits at an early age and other factors that affected iron metabolism in a favourable were found: a higher level of SF in the blood was observed in infants who received an infant milk formula; a normal level of SF in the blood was observed in infants who consumed iron with food at least in the recommended dose (8 mg); a normal MCV level in the blood in the second half of the first year of life was observed in mothers who used iron medicines during pregnancy and after giving birth.

4. Associations with the following eating habits at an early age and other factors that affected iron metabolism in an unfavorable way were as follows. A lower level of iron in the blood was observed in infants for whom cow's milk was introduced at an early stage; a lower MCV level was also observed in those infants whose exclusive breastfeeding continued for at least the first four months of life compared to infants who were not exclusively breastfed for at least four months; a lower SF was observed in those infants who were breastfed and whose exclusive breastfeeding continued for at least the first four months of life, as well as in those infants in whose diet legumes have been introduced; a lower level of iron in the blood was observed in infants who were breastfed; a higher level of sTfR in the blood was observed in infants who were not first-born compared to those who were first-born.

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AGRĪNIE UZTURA PARADUMI ZĪDAIŅIEM UN TO SAISTĪBA AR DZELZS VIELMAIŅU

Pirmajā dzīves gadā notiek ļoti strauja augšana un attīstība. Pētījuma mērķis bija izpētīt Latvijas zīdaiņu agrīnos uztura paradumus un to saistību ar dzelzs metabolismu. Pētījums sastāv no A (n = 344) un B (n = 73) daļām. Gandrīz visi zīdaiņi (89%) bija zīdīti pirmajā dzīves mēnesī, un pirmos sešus mēnešus 21% (n = 15). Vidējais papilduztura ieviešanas vecums bija pieci mēneši. Dzelzi ar uzturu uzņēma vidēji 7,4 mg dienā. Dzelzs deficīts (DD) bija 9,6% (n = 7) un dzelzs deficīta anēmija (DDA) — 4,1% (n = 3). Dzelzs līmenis asinīs bija samazināts 30% (n = 8) zīdaiņu, kuri saņēma govs pienu. Zīdaiņiem, kuri dzelzi uzņēma galvenokārt no dzīvnieku valsts produktiem, seruma feritīna (SF) līmenis bija normas robežās. SF bija normas robežās 93% (n = 26), kuri nelietoja pākšaugus. Zīdaiņu ēšanas paradumi Latvijā daļēji atbilst vadlīnijām. 63% zīdaiņu neuzņem pietiekami daudz dzelzs ar uzturu, un DD tika novērots 9,6% zīdaiņu, DDA — 4,1%. Zemāks dzelzs līmenis asinīs bija zīdītiem zīdaiņiem un zīdaiņiem, kuriem govs pienu sāka dot agrīnā vecumā; zemāks vidējā korpuskulārā hemoglobīna līmenis bija tiem zīdaiņiem, kuri saņēma ekskluzīvo zīdīšanu vismaz pirmos četrus mēnešus; zemāks SF bija zīdītiem zīdaiņiem un zīdaiņiem, kas saņēma zīdīšanu vismaz pirmos četrus mēnešus, zīdaiņiem, kuru uzturā bija iekļauti pākšaugi; augstāks serumā šķīstošo transferāna receptoru līmenis tika novērots zīdaiņiem, kuri nebija pirmdzimušie.