INTRODUCTION

Although physiological weight loss (PWL) in neonates during the first days of life is considered to be a physiological process, the range of normal PWL, the factors influencing PWL and the moment to intervene are still being discussed. Opinions of experts as well as neonatologists about the normal pattern of PWL differ, especially in respect to the possible upper limit of weight loss (Rautava, 2015). Further, controversial discussion continues on the question if hospitalised children with intravenous rehydration therapy should follow the same patterns of PWL as healthy neonates (Noel-Weiss et al., 2008).

Recently several studies related to weight loss of neonates have taken place in different countries (Preer et al., 2011, Martens and Romphf, 2007, Flaherman et al., 2014, Miller et al., 2015, Noel-Weiss et al., 2008). However, at the moment there is no study about PWL among Latvian neonates. Further, differences in the post-delivery phase among Latvian neonates and newborns in other countries in respect to feeding type or feeding content could influence PWL (Flaherman et al., 2014; Miller et al., 2015).

In addition, recently PWL charts have been developed based on measurements of American neonates (Flaherman et al., 2014; Miller et al., 2015). At present, the charts are recommended for use by the American Association of Pediatricians (AAP) and used by neonatologists in several countries. Therefore, it would be useful to analyse PWL differences in a Latvian patient sample and to create recommendations for medical professionals treating sick neonates about the usage of nomograms for PWL, as well as to evaluate the necessity to develop charts for the Baltics.

The aim of the present study was to analyse PWL and associated factors in Latvian neonates as well as to evaluate the possibility to use PWL charts of the American Academy of Pediatrics (AAP). The study included data (gestational week, delivery type, sex, feeding type, health status) of 220 Latvian newborns treated in the neonatology department of Children Clinical Hospital Gaigezers and in- and out-patient praxis in Riga. Their mean PWL was compared among neonates with different factors and plotted on PWL charts. The mean PWL was 6.4% (SD ± 2.31%) and in univariate analysis it was associated with feeding type (p = 0.06) and health status (p = 0.01). In multiple regression analysis PWL was significantly associated with health status (p = 0.01). The usage of AAP charts could be generally recommended to identify high risk neonates, but further development of charts for the Baltics should be discussed.

Key words: Birth weight, neonatal weight loss.
MATERIALS AND METHODS

Study design. The retrospective study was performed in the Children Clinical University Hospital Gaïezers and in the paediatric joint ambulatory care praxis in Rîga during 2014–2015, extracting data from patient data files about the dynamics of weight after birth, anthropometric data and other factors. The mean PWL was calculated and analysed in respect to different factors and further, plotted on PWL charts of AAP.

Patients. All neonates that were treated in the Children Clinical University Hospital Gaïezers from January until December 2015 and all infants from the praxis during the years 2014 and 2015 were included in the study. Patients were excluded from the final sample for analysis due to the following reasons: neonatal weighting happened too late, birth weight was not reported or the weight increase was unusual. Patients with PWL > 7% were considered as increased PWL, patients with PWL > 10% were considered as extreme PWL.

Patients with birth weight below 2.5 kg were considered as low birth weight, with weight above 4.5 kg as high birth weight neonates.

Methods. A questionnaire was developed that included the following criteria: sex, age, delivery type (C-section or vaginal delivery), week of delivery (term or preterm), birth weight, weight per day, feeding type (breast-feeding or formula-feeding), diseases or complications and place of data collection (hospital or praxis).

Statistical analysis. Descriptive statistics were used to characterise the patient sample and to calculate the mean PWL (+/-SD) values.

The mean PWL values were compared between the groups with different risk factors using the ANOVA test. Proportions were compared using the Chi-squared test. A paired t-test was used to compare weight between the 1st and the 10th day.

Multiple regression analysis was used to identify the factors that were independently associated with PWL: the variables with $p < 0.08$ in the univariate analysis were entered in the multiple regression analysis.

In general, a factor/calculation result was considered statistically significant if $p < 0.05$. Calculations were performed with the software Excel and Medcalc (version 16.4.1).

Ethical considerations. The study was approved by the Ethics Committee of the Institute for Experimental and Clinical Medicine, University of Latvia. All patient data were coded.

RESULTS

Patient characteristics. The total patient sample included data of 243 neonates, while the final sample for analysis included data of 220 neonates (Table 1). Of them, 118 neonates were from the hospital and 102 from the ambulatory praxis in Riga (four neonates in ambulatory praxis were sick, 98 — without health problems).

In total, sick neonates ($n = 122$) had the following diagnoses: infection and jaundice — 42, only infection — 20, only jaundice — 29, respiratory distress syndrome — 5, hypoxic ischemic encephalopathy — 2, and other diagnoses — 24.

Among the neonates, 70.5% (155/220) were breast-fed, 28.2% (62/220) were formula-fed; 74.1% (163/220) were delivered vaginally, 24.1% (53/220) via C-section; 25.5% (56/220) were preterm and 74.5% (164/220) term neonates (missing number up to 100% due to neonates with incomplete data).

Analysis of physiological weight loss. The mean PWL of neonates was 6.4% (SD ± 2.4%). There was no significant difference in respect to PWL between boys and girls (Table 1). Increased PWL (> 7%) was observed among 89 neonates and extreme PWL (> 10%) was observed among 13 neonates. The maximum PWL for all neonates occurred on the third or fourth day (see Fig. 1). However, nearly all neonates (95%) regained their birth weight by the 10th day postpartum.

Weight loss in association with different risk factors. In the univariate analysis PWL was significantly associated with “feeding type” and “health status”, while gestational age, birth weight, delivery type and sex did not show significant association with PWL (Table 2). After entering the variables “health status” and “feeding type” into multiple

![Fig. 1. Cumulative frequency distribution of maximal weight loss in respect to days.](image-url)
regression analysis, the variable “health status” was significantly associated with PWL ($p = 0.01$), while the variable “feeding type” had lost significance.

**Characterisation of neonates with an increased PWL.** Increased PWL was observed significantly more often among healthy neonates compared to sick neonates: 49.5% (48/97) vs. 33.6% (41/122), $p = 0.01$. Other factors (delivery type, increased birth weight, feeding type) did not differ between neonates with normal and increased PWL.

**Mean PWL among Latvian neonates in accordance to AAP PWL charts.** After plotting the mean PWL among breast-fed neonates on AAP percentile charts, the mean PWL was below the 50th percentile in both cases: in neonates delivered via C-section and vaginally (Figs. 2 and 3). Even the standard deviation was mainly within the 75th percentile. Among vaginally delivered breast-fed neonates ($n = 117$) PWL was 6.8 ($\pm$SD 2.01) and 5.9 ($\pm$SD 1.97) among healthy and sick neonates, respectively.

Plotting the PWL data among formula-fed neonates on the chart showed that the mean PWL corresponded to the 75th percentile in both cases (Figs. 4 and 5). Since the numbers of neonates with formula feeding were small, mean PWL for healthy and sick neonates separately were not calculated.

![Fig. 2. Mean physiological weight loss (PWL) (with SD) of breast-fed vaginally delivered Latvian neonates ($n = 117$; healthy – 73; sick – 44) reflected on PWL charts of American Paediatric Association.](image)

![Fig. 3. Mean PWL (with SD) of breast-fed C-section delivered Latvian neonates ($n = 36$; healthy – 16, sick – 20) reflected on PWL charts of American Paediatric Association.](image)
DISCUSSION

In the studied neonatal patient sample the mean PWL among Latvian neonates was 6.4% (SD ± 2.3%). This corresponds to the results previously reported by Noel-Weiss et al. (2008) in a systemic review about neonatal PWL in different countries (data were taken from Bangladesh, France, India, Italy, Jamaica, Scotland, Serbia, Spain, Sweden, and the United States): their estimated mean PWL ranged from 5.7% to 6.6% (SD ± 2%). Furthermore, Latvian results correspond to the data from the studies used for the development of PWL charts in America and Italy: the mean PWL in the studies was 7.2% (SD ± 2.1%) and 6% (SD ± 1.7%), respectively (Bertini et al., 2014; Preer et al., 2011).

Further, a systemic review about neonatal PWL demonstrates that most neonates have their maximum weight loss between the second and fourth day, while the weight regain happens within 14 days postpartum (Thulier, 2015). Similarly, in the present patient sample the maximum weight loss for all neonates also occurred on the third or fourth day and overall the neonates regained their birth weight by the 10th day postpartum. However, some Latvian neonates (49.5% healthy, 33% sick) lost more than 7% of their birth weight, indicating increased PWL. Interestingly, increased weight loss was observed significantly more often among healthy neonates compared to sick neonates, which could be explained by the fact that healthy neonates were more often breast-fed.

In the univariate analysis, a difference in the mean PWL was observed in respect to feeding type and health status. An association between PWL and feeding type could be explained by the fact that all breast-fed neonates must learn the process of sucking. Additionally, the mother’s lactogenesis needs to develop during the first hours to days after birth, and therefore weight gain could be smaller among breast-fed neonates compared to formula-fed neonates, which could result in higher weight loss (6.5%) during the first days of life.

Similarly, a study from Scotland found out that breast-fed infants lost more weight than formula-fed neonates. Additionally, for breast-fed neonates it took longer to regain their birth weight (Macdonald et al., 2002). Further, the results from both previously described large patient sample American studies also shows that formula-fed neonates lose less weight compared to breast-fed neonates (Flaherman et al., 2014; Miller et al., 2015).

However, in our patient sample the association between PWL and feeding type was observed only in the univariate analysis, while in the multivariate analysis only the health status showed a significant independent association with PWL. In the studied patient sample sick neonates were born with a lower weight and possibly with some complications; therefore these neonates needed more medical support and possibly much attention was paid to weight gain (especially in preterm or small for gestational age neonates). This could result in introduction of additional nutrition methods (i.e. formula or mixed feeding) with exact dosages and regular weighing. In addition, sick neonates usually received intravenous fluids due to their health status, which would also lead to a lower weight loss.

Further, the observed association between PWL and health status could be explained by the fact that most of the sick neonates included in the study were hospitalised patients. As mentioned, most likely during the time in hospital they received regular and systematic residential treatment and support. In comparison, most healthy neonates were from the ambulatory praxis and exclusively received breast milk; therefore variations in their weight could occur. One can also speculate that healthy neonates possibly received less regular controls compared to neonates in hospitals.

However, factors as gestational age, birth weight (low birth weight, high birth weight), delivery type, jaundice and infections showed no significant influence on PWL. In contrast, a study from Brazil found out that in exclusively breast-fed neonates Caesarean delivery might be a risk fac-

![Fig. 4. Mean PWL (with SD) of formula-fed C-section delivered neonates (n = 16; healthy – 1, sick – 15) reflected on PWL charts of American Paediatric Association.](image)

![Fig. 5. Mean PWL (with SD) of formula-fed vaginally delivered Latvian neonates (n = 45; healthy – 5, sick – 40) reflected on PWL charts of American Paediatric Association.](image)
Another interesting factor that should be analysed further is the consequence of mother’s intravenous infusion for the child. One study from Australia showed that PWL among neonates was bigger, when the mother had received intravenous infusion during pregnancy (Tawia and McGuire, 2014). The same results were reported from a Canadian study (Noel-Weiss et al., 2008). Although data about maternal history were not analysed in our study, it could influence PWL. Therefore, it would be interesting to add information about detailed maternal anamnesis to evaluate a correlation between maternal intravenous fluid, delivery type, and PWL.

After plotting Latvian neonates’ data on the American Pediatric Association charts, the PWL of breast-fed infants was below the 50th percentile, thus suggesting that breast-fed Latvian neonates lost less weight compared to American neonates. One of the possible explanations could be differences in milk content between populations. This is supported by Broka et al. (2015) showing that Latvian mothers’ milk contained a significantly lower amount of fat, but a higher amount of protein, compared to milk from American mothers.

Further, PWL of formula-fed neonates corresponded to the 75th percentile, however, the number of neonates was rather low (indirectly indicating good breast feeding practices among Latvian neonates), which could influence the results.

Nevertheless, the AAP charts could be recommended for use in practice to identify high-risk neonates, because based on the charts the neonates with increased PWL will not be lost. Although the mean PWL of Latvian neonates generally corresponded to American charts, PWL differences reflect the necessity to develop charts for Latvian neonates. Therefore, a bigger prospective study, with at least twice as many neonates and regular weighing times (every two hours) is recommended to increase the significance of data in each patient group and to develop nomograms for Latvian or Baltic region.

**CONCLUSION**

In the studied patient sample the mean PWL (6.4%) of neonates was comparable to data from other populations. However, PWL among newborns with health problems was lower, possibly due to formula feeding and/or receiving intravenous therapy. Although the implementation of nomograms for evaluation of PWL should be encouraged among neonatologists, the differences between PWL in Latvian and American neonates indicate the need to develop charts for neonates in Latvian/Baltic population.

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FIZIOLOGĪSKS SVARA ZUDUMS JAUNDZIMUŠAJIEM: SSAISTĪTIE FAKTORI UN ATBILSTĪBA NORMATĪVIE

Veseliem jaundzimušajiem pirmajā dzives nedēļa novēro fizioloģisku svaru zudumu (FSZ), pastāv dažādi viedokļi par to ietekmējošiem faktoriem. Uz vairākās valstīs veikto pētījumu pamata ir izveidotas svara zuduma diagrammas. Tomēr pētījumi par FSZ iepriekšējam Latvijas jaundzimušajiem lidz šim nav tikuši veiktī. Šī pētījuma mērķis bija analizēt FSZ un to ietekmējošus faktorus jaundzimušajiem Latvijā, kā arī izvērtēt iespēju izmantot Amerikas Pediatriu asociācijas (APA) svara zuduma liknes Latvijas jaundzimušajiem. Retrospektīva pētījuma ietvaros tika analizēti dati jaundzimušajiem Bērnu kliniskās universitātes slimnicas “Gaiķezers” jaundzimušo nodaļā un ambulatorā praksē. Vidējais FSZ pētījuma kopas (n = 220) bija 6,4% (SD ± 2,31), vienpakaļ pieveidojoties 6,9% (SD ± 2,71) veselīgiem jaundzimušajiem (p = 0,01), kā arī mākslīgi barotiem 6,8% (SD ± 2,83) barotiem (p = 0,06). Daudzfaktoru analīzes rezultātā iespēja izmantot APA svara zuduma diagramma. Lai gan APA svara zuduma diagrammas varētu ieteikt izmantošanu jaundzimušo nodaļām Latvijā, kā arī pievērsties veseliem un/vai intravenozās terapijas dēļ.