Early Human Development 85 (2009) 125–130

Contents lists available at ScienceDirect

Early Human Development

journal homepage: www.elsevier.com/locate/earlhumdev

Nutritive sucking pattern—From very low birth weight preterm to term newborn

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ARTICLE INFO

Article history:
Received 14 February 2008
Received in revised form 8 July 2008
Accepted 9 July 2008

Keywords:
Newborn
Very-low-birth-weight
Nutritive sucking
Pattern
Oral stimulation
Development

ABSTRACT

The contribution of maturation and stimulation to the development of oral feeding was investigated, with two main objectives: (1) to analyze the nutritive sucking pattern of very-low-birth-weight newborns from their first oral feeding to the acquisition of independent oral feeding, and (2) to compare the nutritive sucking patterns of these babies, after feeding autonomy, with healthy term newborns.

Methods: Two groups were considered for analysis. Group 1: $N=15$ Very-Low-Birth-Weight (VLBW), gestacional age (GA) = 28.15 ± 1.5, birth weight (BW) = 1178.3 ± 174.4. The intervention program began at 30.19 ± 1.52 weeks GA. Group 2: N = 25 term newborns, healthy, GA = 39.04 ± 1.2, BW = 3370.42 ± 310.76. Repeated measures of the following variables were taken (weekly for group 1): suction efficacy (SEF), rhythm of milk transfer (RMT), suctions, bursts and pauses. Group 2 was analysed only once between the 2nd and 5th day of life.

Results: Group 1 has revealed a minimal suction number at 32 GA weeks (82 ± 77.6) and maximal suction number at 36–37 GA weeks (162.7 ± 60.7). The number of sucks seemed to be dependent of weight ($p=0.005$), duration of intervention ($p=0.001$) and chronological age ($p=0.000$). Significant statistical effects of gestational age were not observed ($p=0.904$). Sucks in bursts represented 77% at the beginning of oral feeding (32 weeks GA), and 96% at 33 weeks GA, remaining constant thereafter. The number of sucks and bursts increased with GA and weeks of feeding. The mean duration of the pauses decreased from first to fourth week of feeding (week1 = 14.1 ± 9.1 and week4 = 6.4 ± 1.4 s). The sucking efficacy (SEF) was better explained by weight ($p=0.000$), number of sucks in 5 min ($p=0.025$) and chronological age ($p=0.044$). Gestational age ($p=0.051$) and nutritive intervention duration (NDI) ($p=0.110$) did not contribute to explain SEF. Despite the observation of significant statistical differences between groups regarding GA (35.9/39.08; $p=0.00$), chronological age (53.3/2.5; $p=0.00$) and weight (1875/3360; $p=0.00$), the nutritive suction pattern was not statistically different between groups after feeding autonomy.

Conclusion: in VLBW oral feeding before 32 weeks GA allows the attainment of a mature nutritive suction pattern before term (37–40 weeks). Experience seems to be one of the influencing factors in the change of the nutritive suction pattern.

1. Introduction

Hospital discharge of very-low-birth-weight (VLBW) babies depends frequently on their feeding autonomy [1,2]. The success in oral feeding depends on the adequate coordination of sucking, swallowing and breathing [3,4] and also on the behavioural states of the newborn [5,6]. Oral feeding is commonly initiated at 34 weeks of corrected age [7–9].

In the healthy term newborn, after birth, the coordination between rhythms of sucking, swallowing, and breathing, is optimized only following the first 48 h of life, and the qualitative alterations in the sucking pattern may be derived from sensorial feedback and from learning and feeding experience [4,10–12].

It has been debated whether maturation of the sucking–swallowing–breathing coordination is related with postconceptional age (maturation's perspective) or with experience (behaviourist perspective) [13]. Experience and practice enhance oral motor capacities and sucking–swallowing–breathing coordination [13,14]. Maturation of the suction and swallowing pattern seems to follow a caudocephalic process, since the stabilization of the swallowing rhythm precedes the stabilization of the sucking rhythm [15,16]. At 28 weeks of post-conceptional age sucking and swallowing are sufficiently coordinated to allow oral feeding. Swallowing movements can be first observed *in uterus* around 10–14 weeks of pregnancy [17]. However, at 28 weeks of gestation, coordination of swallowing and breathing is not well developed making oral feeding difficult and dangerous.

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doi:10.1016/j.earlhumdev.2008.07.003

Table 1
Descriptive characteristics of the sample

	Group 1	Group 2
N	15	25
Gestational age, weeks	28.15 (1.52)	39.08 (1.18)
Birth weight, grams	1178.30 (174.39)	3360.00 (308.70)
Gender, F/M	4/11	15/10
Apgar score 1st min	7.6 (3–9)	8.9 (8–10)
Apgar score 5th min	9 (7–10)	9.4 (9–10)
CRIB	1.3 (0–3)	–
NTISS	14.2 (7–18)	–
Ventilation time, days	1.46 (0–7)	–
Prenatal steroids, %	0.73	–
Beginning of stimulation (Gestational age, weeks)	30.19 (1.52)	–

Mean values and standard deviation; except for Apgar score, CRIB—Clinical Risk Index for Babies, NTISS—Neonatal Therapeutic Intervention Scoring System and ventilation time (minimal and maximal value); prenatal steroids percentage and gender distribution; F—female, M—male.

With age, preterm babies resort more frequently to the sucking component and they improve their capacity, efficiency and total amount of milk sucked. This seems to result from different factors: maturation, practice, coordination, increase in strength, decrease in fatigue, or from a combination of some of these factors [18–20].

The present study has the following objectives: 1) to evaluate the evolution of the sucking pattern in newborns with less than 32 weeks of gestational age (GA) and a birth weight (BW) less than 1500 g, submitted to a program of non nutritional and nutritional oral intervention, from the beginning of oral feeding up to autonomous oral feeding; 2) to compare the sucking pattern in this Group, after attaining oral feeding autonomy, with a Group of term newborns, relative to: sucking efficacy, rhythm of milk transfer and nutritive sucking pattern.

2. Methods

This study followed a repeated measurements design, in a Neonatal Intensive Care Unit (NICU) of a Level III Portuguese Hospital. For Group 1, a non-randomized convenience sample was selected, and submitted to an intervention program. This intervention includes non-nutritive (NNOI) and nutritive oral stimulation (NOI), kangaroo care, and massage therapy [21]. This Group included 15 newborns, 4 girls and 11 boys. Birth weight ranged between 500 g and 1499 g and gestational age was less than 32 weeks. These newborns were submitted, up to week 32, to the global intervention program [21]. Repeated observations took place every week throughout the treatment, with a maximum duration of six weeks.

Group 2 included 25 healthy term newborns, 15 girls and 10 boys (37 to 41 weeks GA). A non-randomized convenience sample was selected for this Group, in which no treatment was applied. These newborns were observed in a single moment, between the 2nd and 5th day of life (2.5+/−0.66 days) (Table 1), so that optimal sucking capacity was observed [10]. The descriptive characteristics of Groups 1 and 2 are presented in Table 1.

The following exclusion criteria were considered: a) newborns that initiated the intervention program after 32 weeks; b) IUGR (BW inferior to percentile 10 for GA; c) newborns that have interrupted the intervention program for more than a week (ex. Level II necrotizing enterocolitis or greater); d) neonatal asphyxia (Apgar score <5 at 5 min of life); e) intraventricular haemorrhage level 3 or 4 of the Papille classification [22]; f) central nervous system disorders; g) chromosomal disease; h) polymalformative syndromes; i) broncho-pulmonary dysplasia defined as oxygen dependence at 36 weeks.

The sucking rhythm pattern was analysed in its time frame by means of video. It may be evaluated by direct observation methods, which are also the least intrusive [10,23,24]. Observation of the mandible movements has a direct correspondence with the expression/compression component [10] and a good correlation with the electromyography method [23].

The other variables involved the measurement of quantities of milk, regarding sucking efficacy, rhythm of milk transfer and nutritive sucking pattern. For the present study the following variables were defined:

i. Quantity of milk ingested in the first 5 min of feeding. Defined as sucking efficacy (SEF), and expressed in mL;
ii. Quantity of milk ingested per minute, obtained by the proportion between the quantity of milk ingested and the elapsed time in minutes. Defined as milk ingestion velocity (MIV), calculated by SEF/time, and expressed in mL of milk/minute;
iii. Number of sucks in the first 5 min of feeding (Sc/5 min). Sucking was defined as simultaneous visible contraction movements of the lips and facial muscles;
iv. Average amount of milk ingested per suction, and designated by rhythm of milk transfer (RMT). Calculated by the ratio between the total amount of milk ingested and the total number of suctions and expressed in mL of milk per suction.
v. Total number of bursts per feeding episode (Bursts). A burst was defined as 2 or more sucks within a 2 second interval;
vi. Proportion of sucks in bursts (Sc/Bursts). Obtained through the division of the total number of sucks in bursts by the total number of sucks per feeding episode;
vii. Mean of sucks in burst (mBursts). Calculated by dividing the Sc/Bursts by the total number of bursts;
viii. Total number of pauses per feeding episode (Pauses). Pause was defined as the time interval equal or superior to 2 s, without any sucking activity movement;
ix. Proportion between the total time of pause and the duration of feeding (tPause). It was calculated by dividing the total time in pauses by the total feeding time;
x. Mean duration of Pauses, in seconds (mPauses);
xi. Age of beginning oral feeding (AO), in weeks of GA;
xii. Age of initiation of feeding autonomy (FA), in GA weeks, and defined as the capacity of sucking the total amount of milk prescribed, in all feeding episodes, for a period of 24 h;
xiii. The nutritive duration of intervention in weeks, since the beginning of NOI up to the acquisition of oral feeding autonomy (NDI).
xiv. Weight in grams (*W*).
xv. Chronological age in days (CA), day 1 being the day of birth.

The following variables were also considered: the daily prescribed amount of milk (mL/Kg/day), the amount of milk prescribed in each feeding, the amount of milk administrated from a bottle, and the amount of milk prescribed through a probe. The weight of the child was used to calculate the amount of milk prescribed.

The initiation of NOI and NNOI were registered for Group 1 subjects, as well as the start of oral feeding, feeding autonomy and hospital discharge. The elapsed time from the beginning of NOI until the acquisition of oral feeding autonomy (NDI) was also calculated.

During a normal feeding period the newborns sucking behavior was videoed once a week. The same expert fed all the babies, using adequate nipple bottles, and she was instructed to avoid variations in the posture and feeding technique.

Babies were in a behavioural state of awareness (stage 4 of Brazelton) [25] when they begun the feeding. A wide angle profile of the face was used to film the baby's face, so as to capture the mouth, lips, and facial muscle movements. The initial 5 min of the feeding episode was filmed [19], during which the baby maintained sucking (corresponding to 25% of the total time of feeding calculated in 20 min). For the babies that sucked the total amount of milk in less than 5 min, the duration of the complete feeding episode was used for the calculation of some variables, and SEF value equals the amount of prescribed milk.

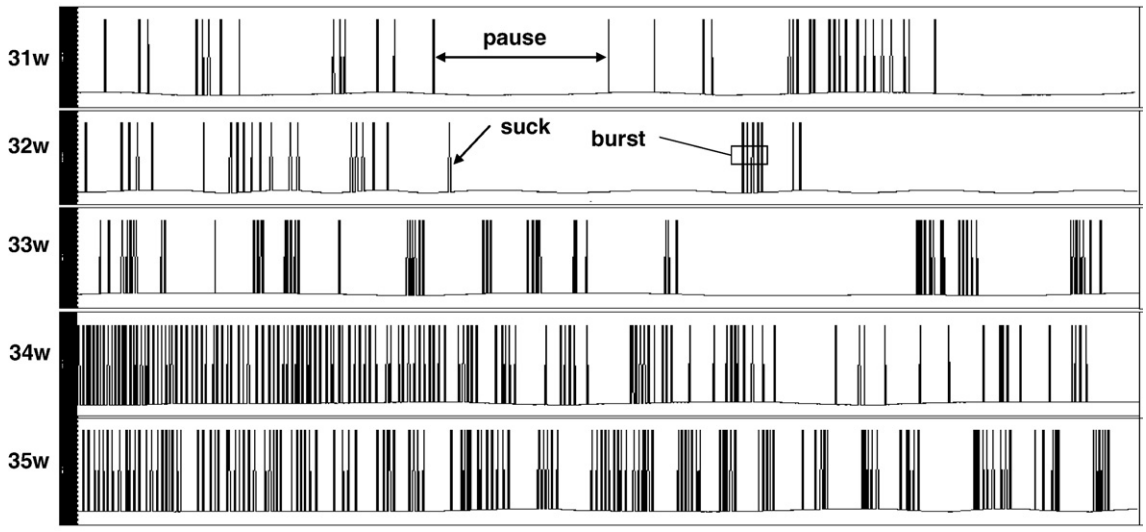

Fig. 1. Count of sucks between the 1st and last week in case 2 of Group 1. The *x* axis gives time from zero to 300 s. The *y* axis represents the development of sucking episodes from week 31 to week 35. The spikes are the sucks, the interval between sucks, equal or superior to 2 s corresponds to pauses; 2 or more spikes with interval less than 2 s between them correspond to bursts.

The term newborns (Group 2) were filmed during a baby bottle feeding episode between 48 h and 120 h of life. The newborns were filmed in the nursery, near the mothers, but the administration of milk was performed by the same expert that fed the babies in Group 1. All filming procedures were identical to those considered for Group 1. The amount of milk ingested in the first 5 min of the feeding was registered according to the definition used by Lau et al. [19].

The videos were analysed, and the counting of sucks was done by pressing a sensor connected to an A/D Biopac converter, with posterior processing in AcqKnowledge Software, version 3.8.1, with a sampling frequency of 100 Hz. Sucks were defined by simultaneous movement of the lips and contraction of facial muscles. The registration of sucks over time is represented in Fig. 1. The calculations of all variables involving time were based upon this registration.

Statistical analysis was performed using the SPSS 13.0 (Statistical Package for the Social Sciences, Inc., USA), and a significance level of $\propto$=5% was adopted.

Statistical analysis was oriented towards three main aspects: (1) the variation of variables that reflect the nutritive sucking pattern, such as Rhythm of Milk Transfer (RMT), Sucking Efficacy (SEF) and milk ingestion velocity (MIV), in different gestational ages, (2) the

Table 2
Descriptive characteristics of the studied variables according to gestational age in group 1—mean values and standard deviation

	32 wGA	33 wGA	34 wGA	35 wGA	36 wGA
N	7	12	12	13	9
Weight	1386.20 (202.20)	1512.20 (253.80)	1543.90 (236.50)	1713.70 (285.70)	1753.20 (208.10)
CA	28.70 (7.90)	36.60 (6.50)	41.10 (9.60)	48.60 (9.40)	56.00 (10.90)
Sucks/5 min	82.40 (77.60)	110.83 (37.10)	112.80 (67.50)	153.60 (55.70)	162.70 (60.70)
Bursts	10.50 (8.90)	18.10 (6.20)	15.20 (6.50)	14.90 (5.40)	13.00 (6.80)
Suc/Burst %	77 (20)	96 (0.01)	89 (11)	92 (15)	97 (04)
mBurst	6.20 (4.40)	6.70 (5.10)	7.90 (8.10)	11.30 (6.90)	15.40 (8.60)
Pauses	18.10 (8.70)	21.60 (6.80)	21.80 (5.50)	19.20 (8.00)	13.80 (7.90)
tPause %	74 (24)	64 (12)	66 (22)	48 (20)	37 (19)
mPause	16.03 (12.90)	9.70 (3.80)	8.90 (2.50)	7.30 (2.70)	7.10 (2.20)
SEF	5.20 (2.90)	11.30 (11.20)	8.80 (8.80)	16.90 (11.90)	24.70 (9.20)
MIV	1.10 (0.61)	2.42 (2.45)	1.77 (1.75)	3.90 (3.50)	6.40 (3.40)
RMT	0.10 (0.07)	0.11 (0.11)	0.09 (0.08)	0.13 (0.11)	0.17 (0.10)

wGA: gestational age in weeks; CA: chronological age in days; Sucks/5 min: number of sucks in the first 5 min of feeding; Suc/Burst%: proportion of sucks in burst; mBurst: mean of sucks per burst; tPause%: percentage of the feeding in pause; mPause: mean duration of pause; SEF: sucking efficacy; MIV: milk ingestion velocity; RMT: rhythm of milk transfer.

Table 3
Descriptive characteristics of the studied variables according to feeding week (1st to 5th week) in group 1—mean values and standard deviation

	1st w	2th w	3th w	4th w	5th w
N	15	15	14	9	5
Weight	1339.00 (149.00)	1517.00 (176.00)	1677.00 (224.00)	1833.00 282.00)	1853.00 (220.00)
GA	32.90 (1.18)	34.00 (1.20)	34.50 (1.20)	35.60 (0.90)	36.30 (0.77)
CA	32.30 (10.80)	39.90 (11.50)	45.60 (11.30)	52.10 (10.60)	57.80 (6.50)
Sucks/5 min	68.10 (46.30)	130.60 (54.70)	137.70 (63.70)	153.60 (53.10)	172.60 (63.60)
Bursts	11.60 (6.10)	16.80 (7.10)	14.00 (7.30)	15.00 (4.20)	17.40 (6.50)
Suc/Burst %	80 (17)	90 (15)	97 (02)	96 (09)	96 (06)
mBurst	4.90 (3.30)	8.20 (6.90)	12.90 (9.30)	10.50 (4.30)	12.80 (11.00)
Pauses	19.60 (7.40)	22.00 (6.50)	15.70 (7.70)	19.00 (6.50)	19.20 (8.30)
tPause %	79 (18)	59 (19)	50 (21)	45 (20)	45 (22)
mPause	14.10 (9.10)	8.20 (2.90)	8.90 (3.10)	6.40 (1.40)	7.00 (1.60)
SEF	4.40 (2.60)	7.80 (6.40)	18.60 (12.20)	23.50 (12.30)	26.20 (5.90)
MIV	0.90 (0.51)	1.69 (1.60)	4.70 (3.70)	5.60 (3.80)	5.20 (1.10)
RMT	0.07 (0.05)	0.07 (0.05)	0.17 (0.12)	0.18 (0.11)	0.16 (0.05)

GA: gestational age in weeks; CA: chronological age in days; Sucks/5 min: number of sucks in the first 5 min of feeding; Suc/Burst %: proportion of sucks in burst; mBurst: mean of sucks per burst; tPause %: percentage of the feeding in pause; mPause: mean duration of pause; SEF: sucking efficacy; MIV: milk ingestion velocity; RMT: rhythm of milk transfer.

comparison between Groups in respect to oral feeding autonomy and nutritive sucking pattern, and (3) the correlations between variables. *T*-tests (Paired Samples *t* test—P-S *t* test and Independent Samples *t* test—I-S *t* test), Wilcoxon Signed Ranks (W-S-R test) and Mann–Whitney–*U* test (M–W–*U* test) were used for comparisons, and linear regression and Pearson bi varied correlation test were adopted to analyze correlations between variables.

Informed consent from the parents was obtained and the study was approved by the Hospitals Ethics Committee.

3. Results

A minimum amount of suctions in 5 min was observed at 32 weeks (82.40±77.60) and a maximum value at 36 weeks (162.7±60.7). The number of suctions increased with gestational age. Statistically significant differences were detected between 32/34 weeks ($p=0.002$; P-S *t* test), 32/35 weeks ($p=0.010$; P-S *t* test), 33/36 weeks ($p=0.025$; P-S *t* test), and 34/35 weeks ($p=0.037$; P-S *t* test) (see Table 2).

As expected, a gradual increase in the number of sucks (Sc/5 min) per week of feeding was also observed, the first week being clearly different from other subsequent moments (see Table 3). Comparisons between the Sc/5 min in the first and subsequent weeks were all statistically significant ($p<0.01$; P-S *t* test). The values of Sc/5 min observed in the second week were also significantly different from those observed at the fifth week ($p=0.045$; P-S *t* test).

A multiple linear regression model, with the variables Weight (*W*), nutritive duration of intervention (NDI), chronological age (CA), and gestational age (GA) as predictors, could account for 41.1% of the total number of suctions in 5 min. In this model the explanatory variables were *W* ($p=0.005$), NDI ($p=0.001$), and CA ($p=0.000$). The contribution of gestational age was not statistically significant in this model ($p=0.904$).

The number of bursts increased with gestational age from 32 to 33 weeks of gestational age, keeping a constant from there on (see Table 2). This difference was statistically significant between 32/35w ($p=0.028$; P-S *t* test).

The number of sucks in bursts increased dramatically with gestational age, varying from a minimum of 2 to a maximum of 103 at 36 week. At 32nd week of gestational age the mean percentage of sucks was 75%, and after the 35th week of gestational age nearly all sucks (97%) were clustered in bursts (see Table 2). The percentage of sucks in bursts observed at 32 weeks of gestational age was significantly different from the one observed after that moment ($p<0.05$; P-S *t* test).

The proportion of sucks in bursts was positively correlated with the gestational age ($r=0.363$; $p=0.004$), the chronological age ($r=0.338$; $p=0.008$) and the weight ($r=0.355$; $p=0.005$). It also correlated negatively with the number of pauses ($r=-0.335$; $p=0.009$) and with the duration of pauses in relation to feeding duration (tPause) ($r=-0.629$; $p=0.000$).

The number of bursts and the proportion of sucks in bursts also increased from week to week of oral feeding (see Table 3). In both variables there were statistically significant differences between first and third week of oral feeding ($p=0.001$; W-S-R test).

The total number of pauses doesn't change significantly along the different gestational ages. However, its duration lessens with an increase in gestational age (see Table 2), being this difference statistically significant between the 32nd week and the 35th week of GA ($p<0.05$; P-S *t* test).

The number of pauses was positively correlated with the number of bursts ($r=0.692$; $p<0.001$) and negatively correlated with chronological age ($r=-0.279$; $p=0.031$). The percentage of time on pause during feeding decreased with gestational age, reducing from 74% at 32 weeks to 37% at 36 weeks of gestational age (see Table 2). Statistically significant differences were observed between 32/34 week ($p=0.028$; W-S-R test), 33/35 week ($p=0.046$; P-S *t* test), 34/35 week ($p=0.016$; P-S *t* test) and 34/36 week ($p=0.045$; P-S *t* test).

A multiple linear regression model explained 49% of the proportional time spent in pause. The best predictors were chronological age

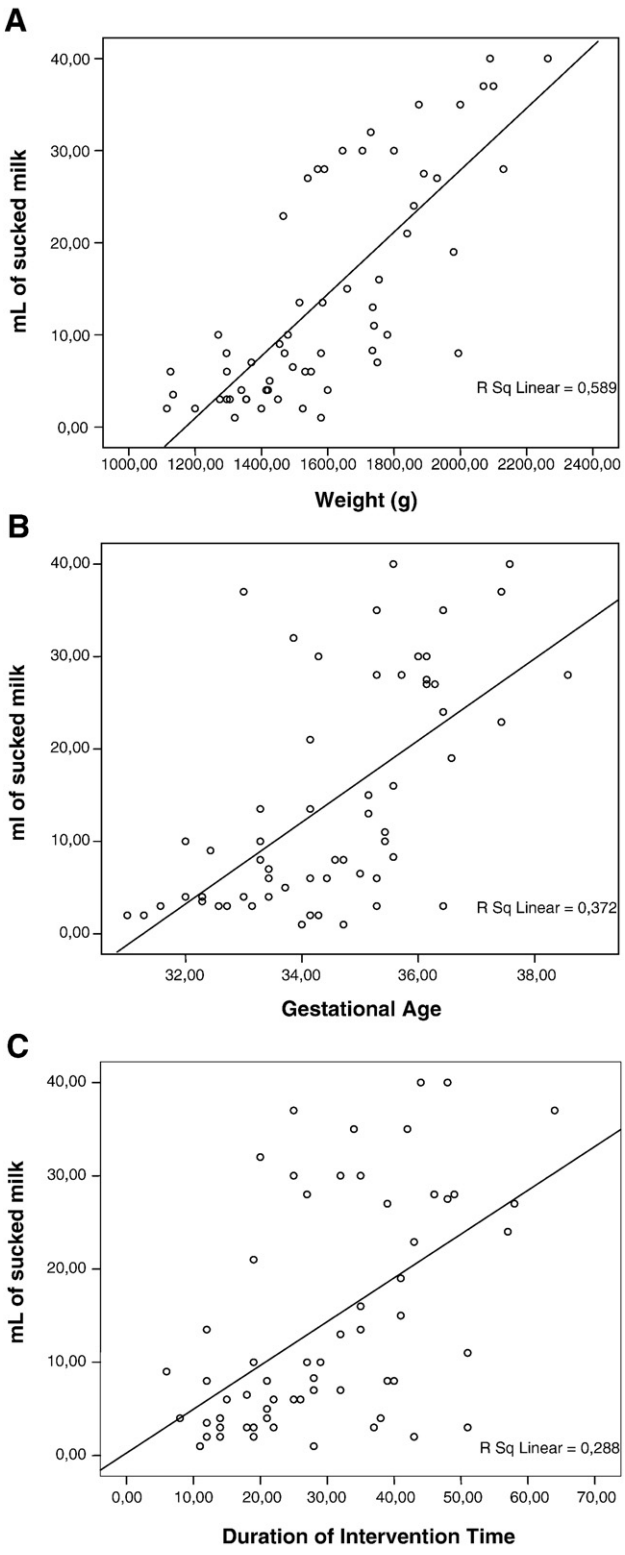

Fig. 2. A) Positive correlation between the amount of sucked milk (SEF) and Weight (g) (*R* Sq Linear=0,589); B) Positive correlation between the SEF and gestational age (*R* Sq Linear=0.372); C) Positive correlation between the SEF and Duration of Intervention Time (days) in Group 1 (*R* Sq Linear=0.288).

Table 4
Descriptive characteristics of the studied variables according to feeding autonomy in group 1 and group 2—mean values and standard deviation

	Group 1	Group 2	*p* value*
N	15	25	
Weight	1875.00 (232.90)	3360.00 (308.80)	0.000†
GA (weeks)	35.90 (1.33)	39.08 (1.18)	0.000‡
CA (days)	53.30 (12.30)	2.50 (0.65)	0.000‡
Sucks/5 min	147.40 (47.60)	156.50 (57.00)	0.606†
Suck/min	36.50 (8.70)	34.60 (11.80)	0.590†
Bursts	13.00 (6.70)	13.10 (6.00)	0.938†
Suc/Burst	0.98 (0.01)	0.93 (0.07)	0.065‡
mBurst	14.70 (9.00)	15.10 (13.10)	0.619‡
Pauses	14.60 (7.30)	18.20 (9.60)	0.221†
tPause	0.39 (0.16)	0.47 (0.19)	0.165†
mPause	6.90 (2.40)	8.10 (4.10)	0.581‡
SEF	32.10 (4.79)	37.90 (14.50)	0.361‡
MIV	8.30 (2.30)	8.50 (3.40)	0.839†
RMT	0.24 (0.08)	0.24 (0.06)	0.784†

*p value statistically significant if <0,05; †T Test comparing mean for two independent samples; ‡Mann Whitney U Test. GA: gestational age; CA: chronological age; Sucks/5 min: number of sucks in the first 5 min of feeding; Suc/Burst: proportion of sucks in burst; mBurst: mean of sucks per burst; tPause: percentage of the feeding in pause; mPause: mean duration of pause; SEF: sucking efficacy; MIV: milk ingestion velocity; RMT: rhythm of milk transfer.

($p<0.001$), Weight ($p=0.015$) and nutritive duration of intervention (NDI) ($p=0.03$).

The duration of pauses decreased with the feeding experience. It was maximum at the first week and minimum at week 4 (see Table 3). Differences were statistically significant between the first and subsequent weeks ($p<0.020$; W-S-R test).

Sucking efficacy, measured by the amount of milk per feeding, increased from 32nd week gestational age to 36 week GA (Table 2). Differences were statistically significant ($p<0.05$; P-S t test) between weeks 32 and 36.

In a simple linear regression model adjusted for the combination of variables sucking efficacy/gestational age (SEF/GA), sucking efficacy/nutritive duration of intervention (SEF/NDI) and sucking efficacy/weight (SEF/W), a low positive correlation coefficient was found. In this model the sucking efficacy (SEF) was best explained by weight in 58.9% (Fig. 2A), by gestational age (GA) in 37% (Fig. 2B) and by nutritive duration of intervention (NDI) in 28% (Fig. 2C).

A multiple linear regression model was applied, considering sucking efficacy (SEF) as a dependent variable and gestational age (GA), chronological age (CA), nutritive duration intervention (NDI), weight (W), and number of sucks (Suc5 min) as predictors. The linear correlation coefficient was positive ($r=0.836$), and the SEF was explained by the independent variables in 67% (r^2 adjusted = 0.672). The best predictors were the Weight ($p=0.000$), the Suc5 min ($p=0.025$) and the CA ($p=0.044$). In this model, the GA ($p=0.051$) and NDI ($p=0.110$) did not reach statistical significance.

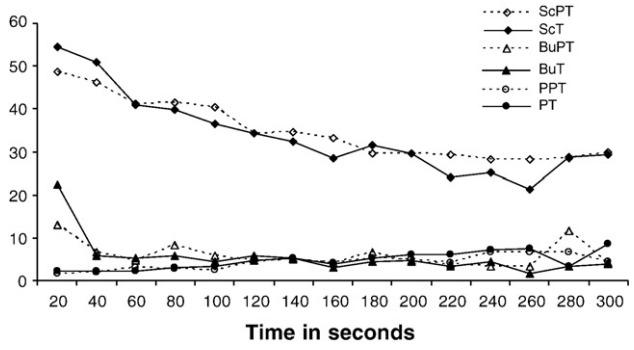

Fig. 3. Variation in the number of sucks; sucks per burst and pauses duration during feeding at autonomy in Group 1 and Group 2. ScPT (sucks in Group 1), ScT (sucks in Group 2), BuPT (bursts in Group 1), BuT (bursts in Group 2), PPT (pauses in Group 1) and PT (pauses in Group 2).

The milk ingestion velocity (MIV) and the rhythm of milk transfer (RMT) increased with gestational age (Table 2).

The comparisons between Group 1, at GA of feeding autonomy, and Group 2, between the 2nd and the 5th days of life, are presented in Table 4.

As the feeding episode progressed the number of sucks reduced, as well as the duration of bursts; the duration of pauses increased. This trend was similar in both Groups at different week of feeding and similar to the one observed at the moment of feeding autonomy (Fig. 3).

Groups 1 and 2 were significantly different at the moment of feeding autonomy, in what concerns gestational age (Mean Rank 8,93/27,44; $p=0.000$; M–W–U test), chronological age (Mean Rank 33.00/13.00; $p=0.000$; M–W–U test) and weight ($p=0.000$; I-S t test) (see Table 4).

The variables that characterized the sucking pattern, such as the total number of sucks, number of sucks per minute, number of bursts, duration of bursts, percentage of sucks in burst, number of pauses, duration of pauses and percentage of duration of pause, were not significantly different between Groups. Sucking efficacy (SEF), milk ingestion velocity (MIV), and rhythm of milk transfer (RMT) were also similar in the two Groups (see Table 4).

4. Discussion

The number of sucks per feeding episode consistently increased with gestational age in VLBW preterm babies, being less than 100 until 32 weeks GA, between 100 and 150 until 34 weeks GA and more than 150 from 35 weeks of GA onwards. The variation of the number of sucks with gestational age was also observed by other authors [15,18,26–28]. The number of sucks was significantly different from the first and the second feeding week to the following weeks, suggesting that, besides the maturation effect, experience also seems to influence the number of sucks. The effect of experience was described by other's [9,11,18,29] and is in accordance with the values found in the multiple linear regression analysis, where the duration of intervention, chronological age and weight influenced significantly the number of sucks.

The proportion of sucks in bursts seems to follow two or three stages. It was less than 80% at 32 weeks GA, it was around 90–95% until 35 weeks GA, and higher than 95% after 35 weeks GA. These results are in accordance to those referred by Gewolb et al. [16], indicating that the development of sucking activity follows a predictable maturation pattern. At 32–33 weeks GA a fast pattern of low amplitude sucking was observed, with a frequency of 2–3 Hz, not necessarily rhythmic or coordinated with swallowing. After 33 weeks GA sucking decreases to approximately 1 Hz, stabilizing and matching the swallowing activity, and establishing a sucking–swallowing dyad [3,15]. Organization of the sucks in bursts would be the next step [15], and a little different than those found by Medoff–Cooper et al. [26], in which the only difference found was between 36/37 weeks GA and the term age 38/42 weeks GA. Maturation and experience seem to interact in the development of the sucking pattern [15,26].

The duration of pauses was correlated with chronological age, duration of intervention, and weight (multiple linear regression: r^2 adjusted = 0.494, $p<0.05$). The correlation between the number of bursts and the number of sucks per burst, gestational age, and weeks of feeding was negative, as reported in other studies [18,26,30].

There was a progressive increase in the amount of milk sucked. This increase occurred with gestational age (from 5.20 mL at 32 weeks GA to 24.70 mL at 36 weeks GA for Group 1 and 37.9 mL for Group 2), as well as feeding week (4.4 mL in week1, 26.20 mL in week5 for Group 1). In breast fed term newborns, Riordan et al. [10] have calculated the amount of ingested milk to be 12.7 to 55.4 mL. We have observed identical values.

The existence of a positive correlation between the SEF and the weight, CA, NDI and the number of sucks in 5 min, in Group 1, seems to indicate the influence of experience (CA and NDI) and muscular strength (weight) in the quantity of sucked milk. These influences were also demonstrated by other authors [8,11,18].

The comparison between Groups regarding feeding autonomy, and despite the significant differences in gestational age (35.90/39.08) and weight (1875/3360 gr), showed no differences in the variables used to describe the sucking competence. This may be the result of the experience attained by Group 1, since we found a significant difference in the chronological age when comparing both Groups (53.5/2.5 days). These results are in accordance with the observations by different authors [11,18,24,26].

Another important factor in the change of pattern seems to be muscular strength, which increases with weight gain, as was demonstrated for the number of sucks, the frequency of sucks and burst duration in the non-nutritive sucking (NNS) [31–33]. We have observed a positive and statistically significant correlation between the sucking efficacy, weight gain and chronological age, but no statistical effect of gestational age, when evaluated by multiple linear regressions.

The stimulation of NNS seems to favour the self-organization of the preterm newborn [34] allowing a better weight gain and nutritive sucking capacity improvement [6,35]. However, Pickler and Reyna [36] reported recently a case of no effect of NNS in NS, which was associated with newborn's short time stimulation. Mizuno and Ueda [29] also concluded that there was no interference of non-nutritive sucking (NNS) in the nutritive sucking (NS) pattern acquisition in term newborns. The relationship between these sucking patterns is, at least, controversial [37,38].

The research about the effects of stimulation upon nutritive sucking is promising. Some authors have demonstrated that early and repeated teaching can facilitate the development of nutritive sucking [11,14,18,39]. Among other possible explanations, it is plausible that stimulation accelerates the maturation and coordination of the muscles (tongue and mandible) used in expression [18]. The improvement of sucking pattern coordination can be obtained through the maintenance of a stimulus of the oral and peri-oral peripheral mechanoreceptors that mimics the natural movement [40].

Our results indicated that there are other factors, besides maturation, that influence the sucking pattern. The increase in sucking efficacy seems to depend mainly upon muscular strength, highly correlated with bodyweight. Sucking efficacy was directly influenced by burst duration and percentage of sucks in burst, as well as by the decrease in the mean duration of pauses and the percentage of feeding episode at pause. Experience, expressed by chronological age and duration of intervention, also plays a role in the process of development of nutritive sucking. Finally, gestational age, that is a direct indicator of maturation, is a relevant variable in the whole process.

These results also suggest that VLBW born before 32 weeks GA, without neurological or breathing problems, when submitted to a non nutritive and nutritive stimulation program, can begin oral feeding before 32 weeks GA, provided they have sucking capacity and efficacy during feeding. The beginning of oral feeding in VLBW at 32 weeks GA, makes possible a mature sucking pattern before 37–40 weeks GA. This fact allows earlier hospital discharge.

The duration of oral intervention programs, as well as the technical characteristics of stimulation requires further investigation.

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