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Weighing the Facts: A Systematic Review of Expected Patterns of Weight Loss in Full-Term, Breastfed Infants

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1 Abstract

2

3 All breastfeeding infants lose some weight in the early days of life. Conventionally, 5-7%
4 loss of birth weight has been accepted as the normal and expected amount of weight loss
5 before infants begin to gain weight steadily. When infants lose more than 7% of their
6 birth weight, breastfeeding adequacy is sometimes questioned and formula
7 supplementation is often given. Despite the fact that 5-7% is well known and commonly
8 cited, little reliable evidence exists that supports use of this figure as a guide to practice.
9 A systematic review of studies that focused on infant weight loss was conducted. The
10 main objective was to determine the mean amount of weight loss for healthy, full-term
11 exclusively breastfed infants after birth. One previous review and nine primary studies,
12 published since 2008 were examined. The reported mean infant weight loss ranged
13 widely among studies from 3.79% to 8.6%. The point at which most infants have lost the
14 most amount of weight occurs 2-4 days after birth. Close examination of the studies,
15 however revealed significant methodological flaws in the research. Study limitations
16 commonly included gaps in data collection, lack of documented feeding type, sample
17 groups that lacked adequate numbers of exclusively breast fed infants, and the exclusion
18 of breast fed infants who lost the most weight. Well-designed clinical studies that address
19 these limitations are needed. In addition, the use of 5 well-defined, operationally useful
20 infant feeding groups is suggested in order to assist researchers with this work.

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25 Background

26 It is well established that some degree of early neonatal weight loss is normal.
27 For the first two days of life, breastfeeding infants receive only small amounts of
28 colostrum from the breast. After lactogenesis stage II (secretory activation) begins
29 usually on the 3rd day of life, most infants will begin to gain weight steadily. For a small
30 percentage of infants, too much weight loss may indicate a problem. Potential problems
31 may include poor breastfeeding management, undiagnosed metabolic disorders,
32 neurological disorders or other infant morbidities that cause poor feeding¹. A serious
33 outcome of unrecognized feeding problems and too much weight loss can be
34 hypernatremic dehydration. Complications of hypernatremic dehydration may include
35 renal and liver failure, disseminated intravascular coagulation, intracranial hemorrhage,
36 seizure and death.²

37 For many years 5-7% loss of birth weight, has been considered the normal and
38 expected amount of physiological weight loss for breastfed infants.^{3,4,5} This figure is now
39 being challenged. Researchers are suggesting that little is actually known about weight
40 changes in term babies during the first two weeks of life.^{6,7} Until recently, the growth of
41 breastfed babies was judged by a standard that was derived from data collected on
42 children who had largely been artificially fed.^{6,8} It was not until 2010 that updated
43 growth charts were disseminated by the World Health Organization (WHO)⁹ and reflect
44 growth patterns among children predominantly breastfed. Indeed, health differences
45 between breast and formula fed infants have become increasingly clear. Breastfeeding is
46 positively associated with fewer respiratory, gastrointestinal, and ear infections.^{10,11} Later
47 in life, breastfed infants experience less Type I and II diabetes, heart disease and

48 obesity.¹²

49 There are several well-documented factors associated with increased infant
50 weight loss after birth. These factors include higher weight at birth, female gender,
51 advanced maternal age and education, cesarean delivery, and jaundice.^{13,14} Delayed
52 lactogenesis has also been demonstrated to correlate strongly with increased weight loss³.
53 Recently, studies have also shown that intravenous fluid given during the antepartum
54 period can impact the amount of weight loss in the neonatal period.^{1,15}

55 Currently, different opinions exist about what constitutes normal infant weight
56 loss and when this weight loss is considered to be excessive. Controversy also exists
57 about when interventions, such as formula supplementation, should be initiated.^{1,7} The
58 International Lactation Consultant Association¹⁶ and the Academy of Breastfeeding
59 Medicine,¹⁷ both suggest that breastfeeding management should be evaluated in those
60 infants who exceed a 7% loss. The 2012 American Academy of Pediatrics⁸ policy
61 statement ‘Breastfeeding and the Use of Human Milk’ also notes that breastfeeding
62 infants should have a weight loss of no more than 7%.

63 Some researchers use $\geq 7\%$ as a marker for excessive weight loss^{18,19} while other
64 use $\geq 10\%$.^{15,20,21} In a systematic review of infant physiological weight loss, Noel-Weiss
65 et al.⁷ noted that the choice of 7 or 10% appears to be an arbitrary demarcation of
66 substantial weight loss. Despite these differing professional opinions and lack of
67 evidence, the percentage of weight lost after birth remains one of the most frequently
68 used measures to assess infants’ well being. What is well known however is that
69 administering supplemental formula when not medically indicated interferes with the

70 establishment of effective breastfeeding.²² This is especially true in the early days of life
71 before lactogenesis is well established. Therefore, in order to prevent unnecessary
72 formula supplementation, clinicians need to know the difference between normal and
73 abnormal weight loss.²

74 Methodology

75 A systematic review of the literature was conducted to answer two research
76 questions. The first, what is the mean amount of weight loss for healthy, full-term
77 exclusively breastfed infants after birth? The second, when do most breastfed infants
78 reach their nadir or greatest point of weight loss after birth?

79 To answer these questions, a database search was conducted through the
80 University of Rhode Island Library. Four electronic databases were searched including
81 the Cochrane Database of Systematic Reviews, MEDLINE, CINAHL and PubMED.
82 Primary keywords included breastfeeding, infant, weight and weight loss. Inclusion
83 criteria were English only, reviews and primary studies whose main objective was to
84 determine normal patterns of weight loss for healthy, full-term infants. All research
85 designs and all countries of origin were considered for inclusion. The last systematic
86 review of the same topic was conducted in 2008⁷ and therefore the search was limited to
87 publications dated from 2008 – 2015. In addition to the review by Noel-Weiss, nine
88 primary studies were found that met these inclusion criteria.

89 Results

90 In 2008 Noel-Weiss and colleagues⁷ completed a systematic review on
91 physiological weight loss in the breastfed neonate. The objective of that review was to

92 establish the reference weight loss in the first two weeks of life for exclusively breastfed
93 neonates. Authors included in this review primary research studies with weight loss data
94 for healthy, full-term, exclusively breastfed neonates. They found eleven studies that met
95 the criteria; six of the studies researched non-weight topics but provided data about
96 weight change patterns. The studies consisted of works from several different cultures;
97 the sample sizes varied from 21 to 937 with a median of 120 participants. Results
98 indicated that mean weight loss for healthy term infants ranged from 5.7% to 6.6%, with
99 a standard deviation around 2%. Day 2 and 3 following birth appeared to be the days of
100 maximum weight loss and the majority of infants regained their birth weight within the
101 first two weeks after birth.⁷ Since 2008, nine primary studies with a focus on
102 determining normal patterns of infant weight loss in full-term infants have been published
103 (Table I).

104 In 2008, Crossland, Richmond, Hudson, Smith, and Abu-Harb⁶ completed a
105 prospective study to explore weight changes in 253 healthy full-term, singleton infants.
106 Infants were born in the Sunderland Royal Hospital in the United Kingdom and cared for
107 by midwifery teams that routinely practice skin-to-skin care after birth and encouraged on
108 demand breast feedings. Infants in the study were born via vaginal and cesarean section
109 (CS) delivery. Weights were collected in the hospital and the mothers weighed infants
110 daily at home for 2 weeks or longer, until the infant returned to birth weight. A total of
111 46 infants were dropped from the study due to consecutive missing weights. Among the
112 breastfed infants who were dropped, 13 had switched to formula feeding. This resulted in
113 a total of 111 exclusively breastfed infants and 142 formula fed infants in the study.⁶ Data
114 showed that the mean weight loss for exclusively breastfed infants was 6.4% (5.5 –

115 7.3%). The mean weight loss for formula fed infants was 3.7% (2.7- 4.7%). For both
116 groups, the nadir of weight loss was day 3 of life. A total of 85% of all infants regained
117 their birth weight by two weeks of age.

118 In 2010 Mulder, Johnson and Baker¹⁸ studied excessive weight loss in 53
119 breastfed infants born at a mid-western community hospital in the United States (U.S.).
120 A secondary analysis of data from a psychometric study examining the Mother Infant
121 Breastfeeding Progress Tool was completed. This convenience sample included women
122 who were, “attempting” to breastfed and who delivered stable infants between 35-42
123 weeks gestation. A total of 31 (59.6%) infants in the study were born via vaginal delivery
124 and 20 (38.5%) were born via CS. Infant weights were collected for two days. The
125 reported mean weight loss that occurred on day 1-2 was $3.79 \pm 1.25\%$. The researchers
126 also reported that 20.8% of infants lost $\geq 7\%$ of their birth weight by day 2 of life.¹⁸

127 Also in 2010, Flaherman, Bokser and Newman²³ evaluated the relationship
128 between weight loss at < 24 hours and subsequent in-hospital weight loss $> 10\%$. The
129 authors described how targeting infants at risk for greater weight loss could allow for the
130 provision of more supportive care. A retrospective analysis was completed that included
131 1049 term infants born at the University of California, San Francisco. Exclusively
132 breastfed infants were categorized with mixed feeding infants and the reported mean
133 weight loss was $6.1 \pm 2.1\%$ and the mean time to weight nadir was 38.7 ± 18.5 hours. The
134 researchers were able to demonstrate that infants who lost $\geq 4.5\%$ birth weight at < 24
135 hours were at greater risk for weight loss of $\geq 10\%$.²³

136 A prospective study by Grossman et al.²⁴ sought to determine the weight-loss
137 nadir among infants born at a Baby-Friendly hospital in Boston, Massachusetts. The

138 objective was to identify predictors of weight loss in the first week of life. A total of 121
139 healthy, term infants born via vaginal and CS were included in the study. Hospital
140 weights were recorded; in addition research assistants collected daily weights for one
141 week following birth. Results indicated that exclusive breast milk fed infants ($n = 32$)
142 lost $5.5 \pm 2.0\%$, mainly breastfed infants ($n = 66$) lost $5.5 \pm 2.1\%$, mainly formula-fed
143 infants ($n = 16$) lost $2.7 \pm 1.7\%$ and exclusively formula-fed infants ($n=7$) lost $1.2 \pm 1.0\%$
144 ($P < 0.001$). The mean time to nadir was 2.5 days after birth and ranged from 0 to 7 days.
145 Feeding category, gestational age, and insurance were the greatest predictors of percent
146 weight-loss.²⁴

147 In 2012, Preer, Newby, and Philipp²⁵ published a study of 200 infants delivered at
148 a Boston Medical Center also designated as a Baby-Friendly facility. The objective of
149 that study was to determine average weight loss among exclusively breastfed infants
150 delivered by CS and to identify correlates of greater than expected weight loss. Hospital
151 staff collected daily weights during the post partum stay, for 3-4 days. Researchers found
152 the mean weight loss for full-term, exclusively breastfed infants was $7.2\% \pm 2.1\%$. A
153 total of 75% of the infants reached their nadir of weight loss prior to discharge (day 3 or
154 4). In addition absence of labor prior to CS ($p = .0004$), lower gestational age ($p=.0004$)
155 and higher birth weight ($p < .0001$) were all associated with greater than expected weight
156 loss.²⁵

157 A retrospective, chart review was completed by Davanzo, Cannioto, Ronfani,
158 Monasta, and Demarini.¹⁴ Researchers studied 1003 full-term infants who had been
159 admitted to the regular newborn nursery of the Institute of Maternal and Child Health in
160 Trieste, Italy. This is a level 3 maternity hospital where rooming in is practiced. The

161 objective was to assess the extent of neonatal weight loss and its association with selected
162 clinical variables. Infants were weighed daily until discharge on day 2-4; infants born via
163 vaginal and CS were included. A mean percent weight loss of $6.3\% \pm 2.0\%$ for the
164 breastfed group and $7.5 \pm 2.4\%$ for the formula fed group was reported. For all infants,
165 the weight loss during hospitalization ranged from 0 – 13.2%. Any formula feeding, CS,
166 hot season and jaundice were independently associated with neonatal weight loss $\geq 8\%$.¹⁴

167 Fonseca, Severo, Barros and Santos¹³ also examined the determinants of weight
168 changes for infants during the first 96 hours of life. They prospectively sampled 1,288
169 full-term infants born in 5 different metropolitan hospitals in Porto, Portugal. Infants
170 were weighed twice, once at birth and then again before discharge in order to determine
171 total weight loss. For 61% of the total sample (n= 1,288), this second weight was
172 collected at or prior to 48 hours of life. Exclusively breastfed infants made up the
173 breastfed category (n = 291, 52.2%); all other infants were part of the formula/mixed-
174 feeding group. The mean weight loss for all infants was $6.7\% \text{ SD} \pm 2.32$; weight loss
175 ranged between 0 and 18.2%. Excessive weight loss was positively associated with
176 maternal age > 40 years, maternal education, cesarean delivery and phototherapy-treated
177 jaundice.¹³

178 In 2014, Bertini, Breschi and Dani²⁰ published a retrospective chart review of data
179 from 1760 infants. All healthy, full-term, singleton infants born via vaginal delivery at
180 the Margherita Birth Center at the University Hospital in Florence, Italy were enrolled.
181 The infant feeding policies and procedures at this hospital complied with the WHO's Ten
182 Steps to Successful Breastfeeding. The objective of the study was to construct a
183 percentile chart of neonatal weight loss. Weight was recorded at birth and every 12 hours

184 until discharge, which usually occurred between 48-72 hours of life. Results showed a
185 mean weight loss of $5.95\% \pm 1.73$ (range 0.0% - 9.9%). No infants in this study lost
186 $> 10\%$ of their birth weight. The mean time to nadir was 43.72 ± 11.6 hours after birth
187 and ranged from 12-72 hours.²⁰

188 Most recently, Flaherman et al.²⁶ introduced early weight loss nomograms for
189 exclusively breastfed newborns based on delivery mode. The researchers retrospectively
190 extracted recorded weights from the charts of 108,907 singleton infants born ≥ 36 weeks
191 gestation at Northern Kaiser Permanente hospitals. The authors found that differences in
192 weight loss by delivery method became evident 6 hours after delivery and persisted over
193 time. For infants delivered vaginally, the median weight loss was 4.2%, 7.1%, and 6.4%
194 at 24, 48, and 72 hours of age. For infants born via CS, the median percent weight loss
195 was 4.9%, 8.0% 8.6%, and 5.8% at 24, 48, 72, and 96 hours after delivery. Hour-by-hour
196 nomograms were created to assist in early identification of infants who might be on a
197 trajectory for excessive weight loss and associated adverse outcomes.²⁶

198 Five of the primary studies presented in this review were conducted in the U.S
199 and four were completed in Europe. Two of the U.S. studies took place in facilities that
200 had earned the Baby Friendly award.^{24,25} The Baby-Friendly Hospital Initiative is a
201 global program supported by the World Health Organization and the United Nations
202 Children's Fund that recognizes hospitals and birth centers that give optimal
203 breastfeeding support. Many Baby-Friendly policies and practices impact the likelihood
204 that a breastfed infant will not receive formula in the first two days of life.²⁷ Among the
205 European studies, three of the authors described routine practices such as rooming-in and
206 skin to skin care which are also known to improve breastfeeding outcomes.^{6,14,20}

207 The sample sizes in the nine studies in this review ranged from 53 to 108,907
208 participants. The mean infant weight loss ranged from a low¹⁸ of 3.79 ± 1.25 to a high²⁵
209 of $7.2\% \pm 2.1\%$. When reported in hours, time to nadir ranged from a low²³ of 38.7
210 ± 18.5 to a high²⁰ of 43.72 ± 11.6 hours. Other researchers reported that the time to reach
211 nadir was longer, taking on average 3-4 days^{6,25}. Overall, as compared to the findings in
212 the review by Noel-Weiss, there is a slightly greater amount of reported weight loss and a
213 slightly longer time to nadir. Close examination of these nine studies, however, reveals
214 several reasons why there is still insufficient evidence to determine normal physiological
215 weight loss and time to nadir for breastfed infants.

216 Discussion

217 In 2008, Noel-Weiss and colleagues⁷ reported consistent problems with
218 methodology in the breastfeeding studies included in their review; specifically there were
219 major gaps in data collection. In most of the studies infant weights were not measured
220 daily after discharge. Lack of measurements made determining the lowest weight and
221 normal patterns of weight loss impossible. Another limitation was a lack of clarity
222 among feeding groups. Most of the studies in the 2008 review did not identify when
223 infants received supplemental formula feedings. This is an important consideration as
224 newborn infants who consume formula lose less weight compared to infants who are
225 breastfed.

226 Unfortunately these same problems continue to be present in the current literature.
227 Specifically, the gap in daily weight collections is a major limitation. In several of the
228 studies, researchers reported that weights were measured for 2 to 4 days after birth. Yet,

229 the majority of infants in all of these studies had hospital weights collected for only two
230 days or less often.^{13,14,20,25,26} Most of the infants were vaginally delivered and so were
231 discharged from the hospital by the first or second day of life. In the largest study,
232 published by Flaherman et al.²⁶, a total of 83,433 (76.6%) infants were born vaginally and
233 25,474 (23.4%) were delivered by CS. In this study 72% of the vaginally delivered
234 infants had only 1 weight recorded in addition to their birth weight. Additionally, 75% of
235 the infants delivered by CS had ≥ 2 weights recorded prior to discharge.²⁶ Interestingly,
236 in the work by Mulder et al.,¹⁸ weights on all infants were only collected for two days no
237 matter the type of delivery. Not surprisingly, this study generated the lowest mean
238 percentage of weight loss (3.79% + 1.25%).¹⁸ The majority of infants in that study had
239 probably not reached their nadir of weight loss before data collection ceased.

240 Lack of measurements also impacts the reported time to nadir. The only way to
241 accurately determine time to nadir is to weigh infants daily until they begin to gain
242 weight. Crossland⁶ demonstrated this very strategy and weighed infants daily for a
243 minimum of 14 days after birth. These authors found that most infants reached the nadir
244 of weight on day 3, later than was reported by Bertini et al.²⁰ and Flaherman et al.²⁶. If
245 weights are not recorded daily until the time when infants begin to gain, researchers are
246 left making best guesses as to when the maximum amount of weight loss has occurred.

247 Problems with the clear identification of infant feeding groups also continue to be
248 prevalent in the literature. Mulder et al.¹⁸ included women who were “attempting” to
249 breastfed their infants. They did not indicate if breastfeeding was successful or if
250 formula was given. Similarly, in the large study (n= 1760) done by Bertini et al.,²⁰
251 researchers described how the infant feeding policies and procedures at the hospital

252 complied with the WHO's Ten Steps to Successful Breastfeeding. They suggested that
253 all infants in this study were exclusively breastfed but they did not collect data regarding
254 feeding type. Unfortunately, birth in an environment supportive of breastfeeding is not an
255 assurance that the infants born there are actually breastfed. It is very likely that many
256 infants in both of these studies consumed formula in varying amounts.

257 Other researchers recorded infant feeding type but combined feeding groups for
258 data analysis. Flaherman et al.²³ sampled 1049 infants, 853 (86%) were exclusively
259 breastfeeding, 144 (14%) were given mixed feedings and 53 (5%) were given formula
260 feeding. For data analysis, they collapsed the exclusive and mixed feeding infants, which
261 resulted in a mean weight loss of $6.1 \pm 2.1\%$. It is possible that the inclusion of infants
262 who consumed supplemental formula decreased the total amount of weight loss. The
263 study by Davanzo et al.¹⁴ used a similar approach. The authors used the WHO
264 breastfeeding definitions but combined exclusive and predominant breastfeeding infants
265 together into one category. They also combined complementary breastfed infants
266 together with formula fed infants. Interestingly, this was the only study that has ever
267 reported a greater percent of mean weight loss among formula fed versus breastfed
268 infants ($7.5 \pm 2.4\%$ vs. $6.3 \pm 2.0\%$, $p = <.001$)¹⁴. The combination of complementary
269 (mixed) breastfed infants together with infants who were formula fed may have impacted
270 the results. Some of the complementary breastfed infants were likely given formula due
271 to excessive weight loss, which may have increased the total weight loss for that group.

272 Lack of clarity among infant feeding groups is a challenging problem, particularly
273 for studies focused on infant weight. At first glance, the solution may appear simple;
274 researchers must carefully control their sample and include adequate numbers of

275 exclusively breastfed infants. This seemingly simple solution, however, presents a
276 complex set of challenges. If breastfed infants lose too much weight, they are often given
277 formula supplementation. Yet, in order to determine patterns of weight loss among the
278 exclusively breastfed, infants fed formula must be excluded from the sample group.
279 After excluding supplemented infants, the end result may be a sample that is biased as it
280 contains only those infants who did not lose much weight. This exact scenario was
281 demonstrated in several of the studies^{14,25,26}.

282 Preer et al.²⁵ described how breastfeeding infants with excessive weight loss were
283 given formula supplementation and excluded from their study. As described by the
284 authors, this resulted in a sample that was not representative of the true population of
285 breastfed infants²⁵. Similarly, Davanzo et al.¹⁴ noted that when neonatal weight loss was
286 $\geq 8\%$, supplemental feedings were often given. In the largest study, Flaherman²⁶ also
287 described how 16,871 breastfed infants (15.4%) received formula supplementation and
288 were removed from the study. In this study, formula was frequently given to treat
289 excessive weight loss. As a result, the amount of weight loss in the exclusively breastfed
290 population may have been underestimated. Flaherman et al. coped with this limitation by
291 implementing a sensitivity analysis that matched censored to uncensored infants²⁶. The
292 nomograms were recreated based on this matching strategy and the results indicated that
293 removing these infants from the sample group did not create a substantial source of bias.
294 No other published studies have used this matching strategy.

295 In the end, it may not be possible to create large sample groups in which all
296 infants are exclusively breastfed. Therefore, researchers must do the next best thing.
297 Sample groups must be created that more accurately report what infants are consuming.

298 Table II outlines five definitions for infant feeding groups as proposed by this author in
299 2010. These definitions are operationally useful and allow for the inclusion of almost
300 every infant into an appropriate sample group.²⁸ Mean weight loss can be established for
301 each category. While the inclusion of five categories may seem cumbersome, the
302 problem of infants losing too much weight is generally limited to breastfed infants.
303 Therefore the main categories of interest are the exclusive and predominantly breastfed
304 feeding groups. Care providers would benefit from knowing more information about
305 expected weight loss patterns for infants in these feeding categories.

306 Conclusion:

307 In 2008 Noel-Weiss et al.⁷ determined that the normal and expected amounts of
308 infant weight loss after birth could not be accurately determined. In most of the eleven
309 studies in their review, infant weights were not measured daily after discharge and infants
310 were not clearly categorized into feeding groups. At the time, these two methodological
311 flaws in the research made it impossible to determine a mean for normal physiological
312 weight loss in term breastfed infants.

313 The systematic review presented by this author was completed to determine if,
314 since 2008, more scientific evidence has become available. Specifically, this author
315 sought to determine the mean amount of weight loss for healthy, full-term exclusively
316 breastfed infants after birth. In addition a second objective of this review was to
317 determine when infants reach their nadir of lost birth weight. Unfortunately, the current
318 literature still does not provide enough evidence to accurately answer these questions.

319 The same methodological flaws reported in 2008 continue to be found in the
320 current literature. A limited number of infant weights have been collected, feeding

321 methods have not always been well documented and infants feeding groups have been
322 combined for data analysis. In addition, breastfed infants who lost the most amount of
323 weight have been excluded from sample groups. As a result of these methodological
324 flaws, an accurate mean percentage of infant weight loss and the time to nadir remain
325 elusive. In fact, given that infants who received formula have been included while
326 infants who lost the most have at times been excluded from sample groups, it is likely
327 that the mean amount of infant weight loss for breastfeeding infants is higher than has
328 ever been reported.

329 Professional guidance and care in the early weeks of life can enhance
330 breastfeeding duration.²⁹ Alternatively, inaccurate information and ill-founded advice
331 can easily derail breastfeeding efforts. Clinicians require accurate data in order to make
332 sound decisions. Well-designed clinical studies are needed to determine the normal and
333 expected patterns of weight loss for the breastfed infant. It is only when clinicians have
334 this information that they can provide the best guidance and care in order to promote,
335 protect and support breastfeeding infants.

336

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