



Vacuum characteristics of the sucking cycle and relationships with milk removal from the breast in term infants☆☆☆



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ABSTRACT

Background: The importance of an infant's intra-oral vacuum in milk removal from the breast has been established. However, the relationship between the vacuum curve and milk transfer is not well understood.

Aims: To investigate the parameters of the infant suck cycle in relation to the volume of milk removed from the breast.

Study design: Cross-sectional study to elucidate the role of infant intra-oral vacuum in efficient milk removal from the breast.

Subjects: Nineteen fully breastfed term infants.

Methods: Intra-oral vacuum was recorded during monitored breastfeeds using a pressure transducer. Ultrasound imaging (milk flow) and respiratory inductive plethysmography (swallowing) were used to determine the nutritive sucking (NS) portion of the feed. Milk intake was determined by weighing infants before and after feeds. Vacuum traces of the first and next 2 min of NS from the first breast were analysed.

Results: The volumes of milk removed during both NS periods were negatively associated with peak vacuum ($p < 0.001$) and rate of vacuum application ($p < 0.001$), and positively related to area under first half of the suck cycle ($p < 0.001$). Most parameters changed significantly from the first 2 min of NS to the next 2 min including significant reduction in peak vacuum and area under first half of the suck cycle.

Conclusion: These results further support the role of intra-oral vacuum, specifically optimal peak vacuum, in effective and efficient milk removal during breastfeeding. It also appears that infants modify their sucking dynamics to adapt to changes in milk flow during milk ejection as the breast empties.

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1. Introduction

A distinguishing characteristic of human mammals is that they feed their young with breastmilk, removed by means of intra-oral vacuum [1]. It is one element that elicits milk ejection and ensures effective milk removal, which is essential to the maintenance of milk production that is locally controlled during established lactation [1]. When the infant attaches to the breast, a baseline vacuum (-56 ± 31 mmHg) is applied to create a seal to the breast [2–4]. During the first half of the suck

cycle, the infant moves the tongue downward creating a stronger vacuum (mean: -122 to -163 mmHg) [2–5] that coincides with milk removal from the breast [2]. During the second half of the suck cycle, the tongue moves up, milk is cleared from the oral cavity to the pharynx to be swallowed [2,6] and vacuum returns to its baseline thus completing one suck cycle (Fig. 1). While vacuum is associated with milk removal, levels of vacuum and characteristics of the suck cycle have not been investigated in relation to effectiveness of milk removal.

Sucking stimulates nervous impulses through the efferent arc of the milk ejection reflex to the hypothalamus that initiates the posterior pituitary gland to release oxytocin into the maternal circulation. Oxytocin binds to receptors on the myoepithelial cells surrounding the alveoli causing them to contract, ejecting milk towards the nipple (milk ejection) [7,8]. Thus, the negative pressure (intra-oral vacuum) combined with the positive pressure caused by milk ejection is the driving force of milk flow from breast to infant during breastfeeding [2,9]. As the breast empties, the rate of milk flow changes with subsequent milk ejections [10–12], suggesting that infants may modify their sucking patterns as the breastfeed progresses.

Abbreviations: DSC, duration of suck cycle; D½SC, duration of first half of suck cycle; A½SC, area under the first half of suck cycle; MSC, milk removed per suck cycle.

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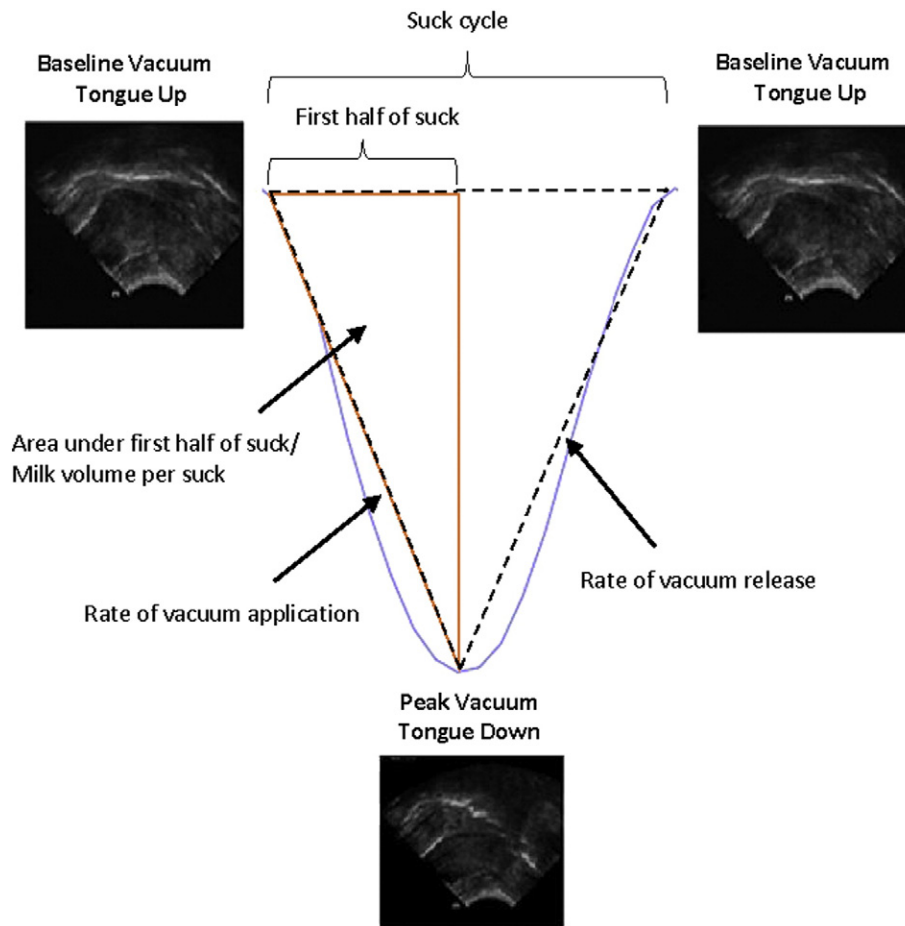


Fig. 1. Adapted from Sakalidis and Geddes [4]. Infant's tongue movement during the suck cycle. During the first half of the cycle, the mid-tongue is in contact with the palate and baseline vacuum is applied. As the tongue lowers, vacuum increases and milk flow into the oral cavity is observed. During the second half of the cycle, vacuum decreases as the tongue moves up and milk is cleared from the oral cavity. As milk is only removed during the first half of the suck, the area under the first part of the suck cycle is based on the area of triangle with coordinates of three vertices: time at baseline vacuum, peak vacuum and time at the peak vacuum. Rate of vacuum application and release were slopes of a linear regression cycle fitted onto the section between baseline and peak vacuums.

It has been established that infants remove 50% of the milk in the first 2 min and 80% of the milk in the first 4–5 min of a breastfeed [13]. It is estimated that the first milk ejection occurs within 2 min of starting the breastfeed, and the second in the following 2 min (based on milk ejection duration ranges of 45 s to 3.5 min) [10,11,14]. While the role of the tongue during milk removal is clear, the relationship between intra-oral vacuum and effectiveness of milk transfer is still not well understood. Based on previous studies, it has been assumed that milk is removed from the breast over the full suck cycle and is proportional to the magnitude and duration of the pressure applied [15]. However, ultrasound studies have shown that milk removal only occurs in the first half of the cycle when vacuum is applied, and that the second half is related to clearance of the milk from the oral cavity [2,5]. Therefore, it is important to acquire an in-depth understanding of the breastfeeding infant's suck cycle and intra-oral vacuum applied during breastfeeding in relation to the volume of milk removed. This is essential to enable comparisons of infants with oral anomalies such as ankyloglossia, lip tie, and palatal anomalies as they often display breastfeeding difficulties such as reduced milk transfer, strong intra-oral vacuum and maternal nipple pain [16–20] compared to effective milk removal in term infants without oral anomalies or breastfeeding difficulties.

This study aimed to characterize parameters of the infant intra-oral vacuum sucking cycle applied during breastfeeding such as peak vacuum, rate of vacuum application, duration of the suck cycle (DSC),

duration of first half of suck cycle ($D\frac{1}{2}SC$) and area under the first half of the suck cycle ($A\frac{1}{2}SC$). We also investigated associations between those parameters and the volume of milk removed by the infant during the first 4 min of nutritive sucking (NS) to determine whether vacuum is related to effective breastfeeding.

2. Material and methods

2.1. Participants

Fully breastfeeding mother–infant dyads were recruited through the Australian Breastfeeding Association and Community Health Centers between 2009 and 2010 for a previously reported study [21]. Term singletons (birth gestation ≥ 37 weeks, birth weight ≥ 2500 g) less than 24 weeks of age with no previously reported oral anomalies and/or feeding difficulties were included in the study. Mothers provided informed written consent to participate in the study, which was approved by the Human Research Ethics Committee of The University of Western Australia (RA 4/1/1305).

2.2. Intra-oral vacuum

The intra-oral vacuum applied by the infant during breastfeeding was recorded and saved as previously described [2,21] using a pressure

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