‘Elimination signals’ in healthy, NON toilet trained children aged 0–4 years : a systematic review

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‘ELIMINATION SIGNALS’ IN HEALTHY, NON TOILET TRAINED CHILDREN AGED 0- 4 YEARS: A SYSTEMATIC REVIEW

SUMMARY

Objective: An early start of toilet training, which is related to a younger age of acquiring full bladder control, can generate important health advantages. Infants display different 'elimination signals' related to voiding or defaecation. The aim of this systematic review is to map these ‘elimination signals’ in young, healthy children aged 0 - 4 years.

Method: The systematic literature search was performed in two databases and was conducted using the preferred reporting items for systematic reviews and meta- analyses (PRISMA statement).

Results: Two main distinctions in elimination signals were made. The first could be classified as visual, auditory and tactile, most frequently involving a change in facial expression, often combined with body movements and verbal expressions such as a short cry or grunting. Secondly. significant changes in heart rate, respiratory frequency or EEG frequency could be defined as 'clinically assessed elimination signals'.

Conclusion: Different 'elimination signals' could be detected in healthy children while voiding or defaecating and should be observed when initiating toilet training.

Detection of noticeable visual, auditory and tactile signals will facilitate and shorten this process.

Key words: Toilet training – elimination signals – infants - toddlers – potty training – functional constipation

INTRODUCTION

In a young child’s life the process of toilet training (TT) is a main and radical event. During this process an increase in bladder capacity is detected, while detrusor-sphincter coordination improves.[1] Three generations ago, initiation of toilet training occurred mainly before the age of 18 months, but the current tendency in Western society is to commence TT after 18 months, [1-3] leading to a delay in the age of acquiring bladder control.[3] By contrast, in African and Asian society toilet training is often initiated weeks after birth.[4]

An early start of TT, which results in a younger age of acquiring full bladder control, can generate important health advantages.[4] For instance, the spread of infectious diarrhoea and hepatitis will be

limited as a result of a decrease in the nappy change frequency, leading in turn to a reduction of the risk of contamination of the hands, communal toys and other objects. This contamination plays a major role in the transmission of enteropathogens, which cause outbreaks of diarrhoea in day care centers. [5, 6] Secondly, ~~initiation of TT at a young age will lead to a lower odd on constipation, stool toileting refusal, stool withholding or hiding from parents even though many parents are convinced that an early start has negative consequences.[7]~~ Blum et al. 2003, stated that younger age of intensive TT was not associated with constipation, stool withholding, or stool toileting refusal.[7] However, in Blum et al, 2004, the same author stated that later start of TT was associated with stool toileting refusal and constipation, probably in the form of functional constipation (although not specified in the paper). [3] Thirdly, Yang et al. 2011 reported that there is a strong decrease in parental stress.[4]

~~Delay of the acquisition of bladder control is partially to blame on the common accepted hypothesis that the emptying of the bladder occurs automatically.[8] As voiding is not initiated at a fixed bladder volume [9] - it can be induced at a bladder volume of 30 to 100 percent of the estimated bladder capacity [10] - one can assume that cortical processes also play a part in micturition [8, 9]. In neonatal infants micturition is generally preceded by a change in arousal.[1] This implies that even before the infant gains full bladder control, a maturational process in the connection between the spinal micturition reflex and the central nervous system occurs.[8] The amount of arousal, which can be seen as a signal indicating voiding, is related to the age of the infant.[8]~~

Although previously bladder function has been considered to occur automatically or autonomously, several observations strongly suggest that even the neonatal brain is already involved in the regulation of bladder function. Conscious voluntary control of the bladder is reflected by the ability to initiate voiding at different filling states of the bladder .[8,9] Furthermore newborn infants wake up from sleep just before they start to void (Yeung et al).

Signals which an infant presents before, during or after micturition will be defined as ‘elimination signals’ (ES). Only a few ES have so far been identified. Caregivers can learn to interpret these signals indicating the infant’s elimination need and can prepare TT in an adequate way. In a parent-oriented approach, this concept of interpreting ES, by which TT can often be initiated at a younger age, is based on a

combination of parental and infantile readiness. When time is available, TT is started. The caregiver's perspective on this early onset of TT is that even though their infant is not mature enough to understand the expectation about when to use a potty, they can assist their child by learning how to recognize the need to void. In this way, bladder control is acquired at a younger age. Sometimes even at the age of 6 months.[11] Taking this into account, it can be stated that implementation of these signals in TT will advance the process. A first step in developing guidelines for TT, which will be of significant importance to paediatricians and parents, is to assess the currently reported ES. The aim of this systematic review is thus to enumerate 'elimination signals' in young healthy children aged 0 - 4 years.

MATERIALS AND METHODS

This systematic literature search was performed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[12]

Sources and search strategy

A search strategy was defined: (Arousal OR body signals OR signs of urgency OR voiding postponement OR toilet training OR potty training OR assisted infant toilet training OR baby-led potty training OR infant potty training OR natural infant hygiene OR pot training OR elimination OR elimination signals OR elimination communication OR elimination signs OR infant behaviour OR polysomnography) AND (urination OR defaecation OR voiding OR micturition). The search query was run in Pubmed and Web of Science in 2019. No limits were used.

Study Selection

In order to be included in this systematic review, clinical studies (S) had to report signals given before or during voiding or defaecation (O) in infants or preschool children (P). Eligibility of the search results was determined by applying the following inclusion criteria: 1) healthy human subjects between 0- 4 years, 2) published in English, French, German or Dutch, 3) full text report. Abstracts, letters, editorials, case reports, meta-analyses or systematic reviews were excluded. Screening for relevant studies was performed in two phases: application of the predefined inclusion criteria on title and abstract (phase 1) and on full text (phase 2). After the second selection phase, the references of all included studies were screened and, if eligible for this study, included, to ensure that no relevant literature was missed. Screening was performed independently by two authors. In case of disagreement a third author was consulted.

Risk of individual bias

Methodological quality was assessed with the Newcastle - Ottawa Quality Assessment Scale. It was performed by two independent researchers (KVDC, AV) who were blinded to each other. In case of uncertainty a third researcher (TVA) was consulted. The most important methodological limitations were comparability and selection of the population.

RESULTS

Data items

Data-extraction consisted of patient type (age and the corresponding number of participants), 2) method of assessment and 3) main results (Table 1). No statistical analysis could be performed on the extracted data.

Insert Table 1 here

Information sources and search strategy

The search strategy resulted in 951 hits in all databases. After de-duplication, 770 studies remained, which were screened on title and abstract. After the first screening phase, 39 studies met the inclusion criteria and were taken to phase 2, for a more in-depth screening on full text. A total of 11 studies were found to be eligible. Studies not meeting inclusion criteria were excluded, mainly because the study was performed on children who were already toilet trained or because they did not report data about variables related to 'elimination signals'. A summary of the applied search strategy can be found in Figure 1.

Insert Figure 1 here

Study characteristics

The 11 studies included cross sectional and qualitative research designs. The age of the participants from the included literature ranged between newborn [8, 13-19] and 4 years [20]. The number of subjects varied between 4 [15] and 286 [21]. Six studies were performed in Europe, four in Asia and one in Africa. (Table 1)

Conditions in which elimination signals were assessed.

The studies investigated elimination signals in five different ways: 1) polysomnography [22-25], 2) observation [11, 15, 20, 26], 3) ultrasonography [26], 4) questionnaire/ interview [11, 27, 28] and 5) eyelid motion + leading to detection of wet diaper [29].

Syntheses of the results

Two main distinctions between ES can be made: ES measurable without the use of clinical equipment and those only detectable in a clinical setting. The former will be classified as visual, tactile and auditory ES, the latter as clinically assessed ES.

Visual, tactile and auditory ES

Children communicate their need to void or defaecate with the help of visual, auditory and tactile ES. [8, 13-17, 19, 21, 30-34] (Figure 2)

Insert Figure 2 here

The most frequently reported ES just before voiding is a change in facial expression [14-16, 20, 21, 30], often combined with body movements [8, 15-17, 19, 20, 30, 35]. Thirty-six to fifty-two percent of the children woke up just before voiding.[16, 18, 20] However, in those children who did not wake up, associated limb and facial movements were detected.[20] Signs of kicking/ pushing [14, 21, 30], pointing or waving [15, 21], and stepping motions [14] are some examples of these body movements. In children who were already awake and active, Duong et al. 2013 reported that infants at the age of 1 year might stop playing.[14]

Other reported visually detectable ES are: a change in facial color [14], passing gas [21], a stony face [14], and a genital change (erection) [14]. However, it should be said that these latter ES are not clearly defined and often only reported once.

Although most ES before voiding are visually detectable, auditory ES were also reported. Infants can express their urge to void by verbal expressions e.g., a short cry [8, 13, 14, 16, 30], grunting [30] or vocalizations [14, 21]. A simple vocalization is defined as an ES used to communicate an overall urge to void or defaecate.[21] Combined with eye opening [13] and body movements, crying can be classified as a sign of arousal.[8, 13] These signs might be present even if the infant does not wake up.[8]

Additionally, it was shown that the need to void or defaecate might also be revealed by a change in skin- or muscle tension [30] or temperature of the genital area.[14]

After voiding, children seem to be relieved and satisfied.[14]

Clinically assessed ES

Different ES have been described as only detectable in clinical settings with the use of specialized equipment. [16-20] (Figure 3)

Insert Figure 3 here

Insert Table 2 here

Voiding in term infants was accompanied by a significant rise in heart rate (HR) ($p<0.001$ [16]; $p< 0.05$ [19]), but with a decrease in respiratory frequency (RF) ($p<0.001$).[16, 20] In fourteen percent of term neonates visual, auditory or tactile ES were not detectable. Nonetheless, a rise in HR ($p< 0.03$) [16], RF ($p<0.02$) [16] and electroencephalogram (EEG) frequency ($p< 0.01$) [19] occurred just before voiding. It is worth noting that this rise in HR ($p < 0.05$) and EEG frequency ($p <0.01$) remained in the 5-second interval after voiding. [19]

In contrast, no significant change in HR, RF and EEG frequency was detectable in preterm infants either just before or after voiding. [17]

DISCUSSION

The purpose of this review is to summarize available data on ES before and during the voiding process in pre-toilet trained children. Two different classifications of ES were described. The first one concerning ES of a visual [8, 13-17, 19, 21, 30-34] auditory [14, 21, 30, 34] and tactile nature [21, 30]. The second allocation relating to ES only detectable by clinical investigations.

Although ES are detectable in most children, it is quite remarkable that this is not present in every child. [8, 13, 17, 21, 32-34] According to Rugolotto et al, almost 90% of the parents reported that their children showed ES. Children in whom parents were able to detect ES, seemed to have acquired full bladder control at a remarkably younger age. [21] Moreover, the absence of ES in early childhood increases the chance of nocturnal enuresis at the age of 5 to 7 years.[13]

The amount of ES detectable in infants increases as they grow older [14, 33]. At the age of 3 months 76% of the infants wake up just before micturition.[33] This percentage rises to 90% at the age of 6 months and at the age of 1 year at least 97% of the infants show signs of awakening before voiding. [33] Duong et al.2013 stated that ES expressed at the age of 6 months are similar to those seen in the neonatal period, but are more noticeable.[14]

Recognition of ES may play an important part in assisted TT [14, 15, 30]. In this method, the voiding urge is detected with the aid of ES, after which caregivers place the infant in a facilitated voiding position.[15] When micturition occurs, the infant is rewarded, which reinforces the behaviour.[30] When TT occurs using this method, acquisition of bladder control is reached at a younger age. Infants are reported as being toilet trained between 8.5 – 10.7 months.[15] Despite the general common

maturational theory, Devries et al.1977 showed that infants can acquire bladder control at 5 months.[30]. However, due to socio-cultural influences, this approach is not suitable for all cultures. In Western culture, the importance of waiting to toilet train until there is a certain readiness, is commonly accepted. [36, 37] However, there is a great variation in the age suggested for initiation of TT. Brazelton et al.1962 state that although children might present readiness signs at 18 months, TT is ideally initiated at 24 months. Schum et al, 2002 support this, but report a range of 22-30 months in the normally developing child. Even though Foxx and Azrin's method is more parent oriented, they also state that a certain toilet readiness is necessary. This can usually be assessed at 20 months. These differences in suggested age might lead to confusion among parents about when to start TT. Assessments about starting TT too early or too late are not always easy. By listing ES, a first step towards guiding caregivers in facilitation of TT can be madeis given.

However, when no ES are displayed, it is impossible to detect any need for voiding. Because of their immaturity, preterm neonates do not present any ES. As a consequence, this toilet training method is not relevant for these infants. It can be assumed that preterm infants present a higher risk for communicative and linguistic retardation compared to term infants.[38, 39] The cause of this deficit can be related to the immaturity of the cerebral hemispheres. Indeed, prematurity is associated with smaller size of the cerebral hemispheres. This might cause certain long term neurological developmental disorders.[40] Due to the higher risk of communicational disorders, it is not surprising that these infants present more difficulties in communicating their elimination urge to parents and caregivers.

It should be mentioned that not all ES can be used. Those detectable with clinical investigations are less advantageous in the identification of the urge. Additionally, ES detected after voiding are less beneficial as voiding has already occurred. In this situation it is not appropriate to hold the infant in a voiding facilitating position [32], but experiencing the wet sensation will increase the child's awareness of the voiding process. This will presumably lead to an increased awareness of the visceral sensation of the need to void.

Another limitation in the use of ES in toilet training is the subjectivity in the analysis of ES. An infant's cry can indicate an urge to void, but might also express other needs such as fatigue or hunger.[41] In assisted TT, recognizing ES is considered to be a learning process.[14, 30] Caregivers learn to match certain facial expressions to the need to void. Besides specific pushing actions, the infant can present a voiding- or defaecation urge with a rise in skin colour and muscle tension.[30] However, a specific

description of how to measure these differences in tension is not further described in the article. Nevertheless, if a caregiver already starts to give consideration to these ES in the neonatal period, they will become more experienced in correctly interpreting the infant's need to void or defaecate.[14, 30] Overall, this indicates that recognition of ES by the caregivers will become easier with experience as the child grows older, and because older children present these ES more frequently and more obviously.

Limitations of the study

Relevant studies might be missed by focusing only on two databases. When constructing an adequate search strategy, it was clear that there was a great variability in the terminology used for 'elimination signals'. The latter was initiated by Rugolotto et al., but it was notable that terms such as signs of arousal [8, 16], body signals [15], arousal response [13], signs of urgency and voiding postponement [34] or simple signs [14], all referred to approximately the same definition: 'signs given by the infant to communicate directly and indirectly the need to void or defaecate'. This illustrates a lack of research on elimination communication. Given the low levels of evidence due to the observational designs, further research is warranted. Ideally, effort should be spent on the construction of a randomized control design with a larger sample size and outcome measurements performed only by trained researchers. In the study by Duong et al., for example, observations were performed by parents or caregivers. Since no standardization of measurements was achieved, this might have an influence on the validity and reliability of the analyzed results.[8, 14, 32-34]

By including only original studies, written in English, Dutch, French or German, other resourceful studies might be missed. Some studies have relatively small sample sizes [13, 15, 31], and this might play a part in the difficulty in generating an overall conclusion. A fourth limitation of this review is the lack of randomized control trials. It should be reported that there is no internationally acceptable definition of 'achieving full bladder control'.[21, 34] Rugolotto et al., defined daytime dryness as 'children who have general acquired bladder control but who have sometimes a little accident, with a maximum of two per week'. In contrast, Jansson et al., consider a child 'dry' when accidents no longer occur.

Implications for research

'Elimination signals' should be observed when initiating TT. The results of this systematic review suggest that further research into the detection of signs related to the elimination process is warranted. Since detection of visual, auditory and tactile signals could facilitate and shorten the TT process, we would

welcome more studies performed in Western society as socio-cultural factors seem to play a prominent role in TT and the tendency towards delay in acquiring bladder control.

Conflict of interest statement

Declarations of interest: none

REFERENCES

1. Duong TH, Jansson UB, Holmdahl G, et al. Urinary bladder control during the first 3 years of life in healthy children in Vietnam-a comparison study with Swedish children. J Pediatr Urol. 2013;9:700-706.

2. Bakker E, Wyndaele JJ. Changes in the toilet training of children during the last 60 years: the cause of an increase in lower urinary tract dysfunction? BJU International. 2000;86:248-252.

3. Blum NJ, Taubman B, Nemeth N. Why is toilet training occurring at older ages? A study of factors associated with later training. J Pediatr. 2004;145:107-111.

4. Yang SS, Zhao LL, Chang SJ. Early initiation of toilet training for urine was associated with early urinary continence and does not appear to be associated with bladder dysfunction. . Neurourol Urodyn, . 2011.; 30(7)::1253-1257.

5. Pickering LK, Bartlett AV, Woodward WE. Acute infectious diarrhea among children in day care: epidemiology and control. Rev Infect Dis. . 1986 Jul-Aug;8(4)::539-547.

6. Hadler SC, McFarland L. Hepatitis in day care centers: epidemiology and prevention. Rev Infect Dis. . 1986 Jul-Aug;8(4)::548-557.

7. Blum NJ, Taubman B, Nemeth N. Relationship between age at initiation of toilet training and duration of toilet training: a prospective study. Pediatrics. 2003;111:810-814.

8. Sillen U, Hjalmas K. Bladder function in preterm and full-term infants-free voidings during four-hour voiding observation. Scand J Urol Nephrol Suppl. 2004:63-68.

9. Neveus T, Sillen U. Lower urinary tract function in childhood; normal development and common functional disturbances. . Acta Physiol (Oxf), . 2013;207(1): :85-92.

10. Yeung CK, Godley ML, Ho CKW et al . Some new insights into bladder function in infancy. British Journal of urology 51995) 76. 235-40

11. deVries MW, deVries MR. Cultural relativity of toilet training readiness: a perspective from East Africa. Pediatrics. . 1977 Aug;:60(62):170-177.

12. Moher D, Liberati A, Tetzlaff JF, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Ann Intern Med. 2009;151(4):264-269.

13. Morokuma S, Fukushima K, Kato K. Relationship between arousal response in newborn infants before micturition and bed-wetting from 5 to 7 years of age. Early Hum Dev. . 2013 Dec;89(12)::989-991. .

14. Duong TH, Jansson UB, Hellstrom AL. Vietnamese mothers' experiences with potty training procedure for children from birth to 2 years of age. J. Pediatr. Urol. 2013;Dec;9 (6):808-814.

15. Smeets PL, Lancioni GE, Ball TS, et al. Shaping Self-initated toileting in infants. Journal of applied behavior analysis. 1985;18:303_308.

16. Yeung C, Godley M, Ho C, et al. Some new insights into bladder function in infancy. British Journal of Urology. . 1995;76(2):235-240.

17. Zotter H, Grossauer K, Reiterer F, et al. Is bladder voiding in sleeping preterm infants accompanied by arousals? Sleep Med. . 2008;Jan;9(2):137-141.

18. Zotter H, Sausen G, Urlesberger B, et al. Does bladder voiding during sleep and wakefulness change the behavioural state of infants? Acta Pædiatrica 2006; 95: 1644-1647.

19. Zotter H, Sauseng W, Kutschera J, et al. Bladder voiding in sleeping infants is consistently accompanied by a cortical arousal. J Sleep Res. . 2006 15(1):75-79.

20. Yeung CK. The normal infant bladder. Scand J Urol Nephrol Suppl. 1995;173:19-23.

21. Rugolotto S, Sun M, Boucke L, et al. Toilet training started during the first year of life: a report on elimination signals, stool toileting refusal and completion age. Minerva Pediatr. . 2008 Feb;60(1)::27-35.

22. Zotter H, Sauseng W, Kutschera J, et al. Bladder voiding in sleeping infants is consistently accompanied by a cortical arousal. Journal of Sleep Research. 2006;15:75-79.

23. Zotter H, Sauseng W, Urlesberger B, et al. Does bladder voiding during sleep and wakefulness change the behavioural state of infants? Acta Paediatrica. 2006;95:1644-1647.

24. Zotter H, Grossauer K, Reiterer F, et al. Is bladder voiding in sleeping preterm infants accompanied by arousals? Sleep Medicine. 2008;9:137-141.

25. Yeung CK, Godley ML, Ho CK, et al. Some new insights into bladder function in infancy. Br J Urol. 1995;76:235-240.

26. Sillen U, Solsnes E, Hellstrom AL, et al. The voiding pattern of healthy preterm neonates. Journal of Urology. 2000;163:278-281.

27. Rugolotto S, Sun M, Boucke L, et al. Toilet training started during the first year of life: a report on elimination signals, stool toileting refusal and completion age. Minerva Pediatr. 2008;60:27-35.

28. Duong TH, Jansson UB, Holmdahl G, et al. Urinary bladder control during the first 3 years of life in healthy children in Vietnam - A comparison study with Swedish children. Journal of Pediatric Urology. 2013;9:700-706.

29. Morokuma S, Fukushima K, Kato K. Relationship between arousal response in newborn infants before micturition and bed-wetting from 5 to 7 years of age. Early Human Development. 2013;89:989-991.

30. de Vries MW, de Vries MR. Cultural relativity of toilet training readiness: a perspective from East Africa. Pediatrics. 1977;60:170-177.

31. Fukushima K, Morokuma S, Nakano H. Relationship between eye movement period and micturition in newborn infants differs from that of human fetuses at term. Croat Med J. . 2005 Oct;46(5)::781-785.

32. Holmdahl G, Hanson E, Hanson M, et al. Four-hour voiding observation in healthy infants. J Urol. . 1996;156(5):1809-1812.

33. Jansson UB, Hanson M, Hanson E, et al. Voiding pattern in healthy children 0 to 3 years old: a longitudinal study. J Urol. 2000;164:2050-2054.

34. Jansson U, Hanson M, Sillén U, et al. Voiding pattern and acquisition of bladder control from birth to age 6 years-a longitudinal study. J Urol. 2005 174(1):289-293.

35. Zotter H, Urlesberger B, Pichler G, et al. Do wet diapers induce arousals in sleeping infants? Acta Paediatr. 2007 Mar;96:452-453.

36. Schum TR, Kolb TM, McAuliffe TL, et al. Sequential acquisition of toilet-training skills: a descriptive study of gender and age differences in normal children. Pediatrics. . 2002 Mar;109(3)::E48.

37. Brazelton TB. A child-oriented approach to toilet training. Pediatrics. . 1962 Jan;29:121-128.

38. Wong HS, Huertas-Ceballos A, Cowan FM, et al. Evaluation of early childhood social-communication difficulties in children born preterm using the Quantitative Checklist for Autism in Toddlers. . J Pediatr, . 2014. ;164(1): :26-33.

39. Cattani A, Bonifacio S, Fertz M, et al. Communicative and linguistic development in preterm children: a longitudinal study from 12 to 24 months. . Int J Lang Commun Disord, . 2010. ;45(2)::162-173.

40. Walsh JM, Doyle LW, Anderson PJ, et al. Moderate and late preterm birth: effect on brain size and maturation at term-equivalent age. . Radiology,. 2014. ;273(1): 232-240.

41. Leavitt LA. Mothers' sensitivity to infant signals. . Pediatrics, . 1998. ;102(5):1247-1249.