



# Does the development and use of modern disposable diapers affect bladder control? A systematic review

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## Keywords

Enuresis  
Daytime urinary incontinence  
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Absorbent pads  
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## Abbreviations

TT, toilet training; DD, disposable diapers; NICE, National Institute for Health and Care Excellence

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## Summary

### Introduction and objective

During the last decades, the development of the modern disposable diaper (DD) has changed the way we diaper our children, as they are safe, easy to use, comfortable and easy to dispose, compared to cloth diapers used earlier. Concurrently, the age of initiating toilet training (TT) is rising. We aimed to investigate the connection between DD usage and the tendencies seen in TT and childhood urinary incontinence, with specific interest on studies evaluating the effect of diapering on enuresis.

### Study design

A literature search was conducted in PubMed and Embase. A systematic literature search was conducted, revealing 309 studies in Embase and 269 studies in Pubmed. After removing duplicates, 400 studies were eligible for screening. All abstracts were screened, and 12 relevant abstracts were

identified, but only eight studies were eligible. No prospective intervention studies specifically evaluating the effect of diaper on enuresis were identified. Literature on TT and diapers in general was identified using the respective search terms on both databases.

### Results

The eight studies identified showed a tendency towards diaper use being related to a delay on obtaining continence in children, but no secure conclusions can be made, as the literature is inadequate.

### Discussion and conclusion

Based on the available literature no secure conclusions can be drawn although an association is suggested. In order to evaluate the effect of diapers on incontinence, prospective randomized studies are needed.

The use of diapers in coping with incontinence in children has been used for more than hundreds of years. Over the years diapers have become more and more safe and comfortable. Along with the development of modern disposable diapers, the age of gaining continence through toilet training has been raised, and we wanted to investigate whether or not diaper use had an effect on obtaining bladder control. No general consensus exist on whether or not to diaper your children when toilet training, as no current evidence suggests, that the use of DD postpones the time of bladder control attainment, or that removal of the DD leads to resolution of incontinence. A systematic literature search were conducted revealing 8 relevant studies, evaluating diapers as a co-factor on incontinence, and data are presented and discussed. No subtle conclusions can be made, as literature is too sparse, but there is a tendency towards diapers having a negative effect on bladder control. We conclude that well-designed prospective randomized studies are needed in order to investigate the effect of diapers on incontinence further.

Summary figure Does diapers affect bladder control?.

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## Introduction

Enuresis, or bedwetting, is defined as non-voluntary void during sleep after the age of 5 years. It is highly prevalent, affecting around 9.0% of all 7-year old boys [1]. The treatment consists of behavioural interventions, alarm-treatment, desmopressin [2], anticholinergic medication or a combination. The age of initiating toilet training (TT) is increasing in western countries [3], and so is the reported prevalence of enuresis in areas that only recently adapted the use of modern disposable diapers (DD) such as China [4,5]. Although hypothesized currently no evidence suggests, that the use of DD postpones the time of bladder control attainment, or that removal of the DD leads to resolution of enuresis. However, centres recommend against using DD, as first measure towards night-time dryness training [6]. In the NICE guideline on enuresis [7], it is proposed to try non-diaper periods to assess any effect on enuresis frequency. These recommendations are based on expert opinion rather than robust scientific evidence.

The aim of this review is to evaluate the scientific knowledge on DD use in children with urinary incontinence, to assess, whether DD use is related to continence attainment. The article will provide a quick overview of the history of diapering and TT, and a systemic evaluation of the literature on diapering and incontinence.

## Diapers

Diapers, or other materials to absorb or withhold excreta from children, date back several hundreds of years. Diapering practices have always varied between cultures and regions, and these differences are still present today. Through the 19th century, the development of the modern DD, as we know it today, started. At first, cloth material was used. Later on, the cloth diapers were covered with plastic pants to avoid leakage, but the concealment of faeces and urine often lead to severe diaper dermatitis. In the 1940s the first prototype of the disposable diaper was developed, and through the 1980s the development of superabsorbent polymers has revolutionized the DD and other incontinence products. Today the construction of the modern DD, combined with the technology of adhesive tape and stretch, have increased comfort and helped lower the risks of getting dermatitis, compared to cloth diapers [8].

Comparing the modern DD to cloth diapers, there are major differences. Cloth diapers need more frequent changing than DD, which in terms can lead to more interrupted sleep at night for both children and caregivers [9], probably affecting mother–infant interaction. Kushnir J et al. [10] assessed the sleep quality in 72 enuretic children, comparing sleep with and without a night diaper. Sleeping without a night diaper impaired sleep quality, and children sleeping with a diaper had sleep quality similar to children without enuresis. The group recommend using night diapers in children with enuresis.

## Toilet training

Attainment of bladder and bowel control is an important developmental milestone and TT is the general description of a number of different practises that aim to help children to become continent. Failure to do so can result in physical and psychological consequences, like stool-withholding, subsequent constipation and faecal incontinence [11].

In a historical perspective, in western countries, recommendations on TT have evolved immensely through the 1900s. In the 1960s two prominent theories appeared: the parent-oriented approach, the proponents Azrin and Foxx [12], and the child-oriented approach, the proponent and developer T.B. Brazelton [13]. No international documents on consensus in TT has been produced but in the US the national guidelines for TT are traditionally based on the child-oriented approach [14]. This guideline recommends starting at 18 months of age. Another method of TT is the assisted infant TT [15] (elimination communication), a method especially popular in China and India, that can be started when the child is still an infant. The method involves timing, signals and intuition to address the child's need to eliminate. By recognizing and responding to the child's needs, this might enable the child to eliminate in appropriate places like the toilet. This method is gaining popularity in western countries. The child-oriented and the parent-oriented approach have never been compared in prospective randomized trials and which one are superior remains to be established.

The American association of Paediatrics recommend initiating training, when the child shows specific signs of readiness, including physical, emotional and behavioural milestones [14]. A review performed in 2012 by Kaerts N et al. [16] identified 21 readiness signs used in literature on TT through the last 60 years. They conclude, that there is neither consensus nor evidence-based research that states, which or how many readiness signs that should be present to suggest that TT ought to be started.

The perception of the right age for initiating TT varies widely between different generations, countries and cultures [17,18]. In western countries there is a tendency to gradually postpone TT over the last 50 years [3,19].

A study conducted in the 1980s found a mean age of completed TT to be between 24 and 27 months [20] whereas a later study performed suggested that only 50% had completed TT at 36 months of age [21]. Several plausible reasons for this development have been proposed, ranging from the easiness of use of modern disposable diapers [19] as well as the fact that an increasing number of households consist of 2 working parents [19]. Children are spending thus more time in day-care, and TT is becoming the responsibility of the day-care personnel too [22].

It has been proposed by several researchers, that the later initiation of TT can explain some of the increase that is seen in bowel and bladder dysfunction symptoms (LUTS) in children [19,23–25], including enuresis, urge incontinence and constipation, but a study performed by Largo et al. [26] goes in opposition to these theories, as they described two comparable cohorts, 20 years apart, where TT was initiated significantly later in the most recent

**Table 1** Summary of included studies.

Article	Study design	Key endpoints	limitations
Wang ZX et al. [5]	Cross-sectional questionnaire study (2017). N = 19.500 anonymous questionnaires sent out, response rate 97%. Children age 5–18 years. Compared to results from the 2006 survey with the same questionnaire.	Enuresis prevalence increased from 2006 to 2017: 4.1% vs. 7.3% Enuresis prevalence in children starting EC <sup>a</sup> before 6 months of age significantly lower than those who start after 12 months of age: 3.4% vs. 11.6% DD use right after birth, compared to group who never used DD, delayed EC significantly: 10.8 (±8.26) months vs. 8.4 (±7.65) months Enuresis prevalence according to: no use of DD, only nighttime use of DD, or use of DD both day and night: 3.54% vs. 7.37% vs. 8.61% Cessation of daytime DD use was significantly lower in the control group compared to the enuresis group: 26 (range 24–32) months vs. 20 (range 18–25) months In the control group, EC had been used significantly more than in the enuresis group: 297 (78.4%) vs. 157 (41.8%) Positive correlation between enuresis and increased DD use age: OR = 1.17 (ci 1.13–1.20)	Not clear how the authors divide the patients into DD usage group D1-D6. They only state that D1 used DD for the shortest time, and D6 used it for the longest time. Not clear what age is used as cut-off, or all patient data are pooled.
Xing Li et al. [28]	Retrospective case–control study, 376 children with mono-symptomatic enuresis and 379 matched controls. Data collected through questionnaires on different factors regarding enuresis, daytime DD use and elimination communication. Elimination communication was defined as training before 18 mth of age		The study is retrospective in nature, and hence subject to bias

*(continued on next page)*

Table 1 (continued)

Article	Study design	Key endpoints	limitations
Hansakunachai T et al. [29]	Cross-sectional population based study; 3453 children aged 5–15 (mean 9.6) years, response rate 70%.	Enuresis prevalence: 3.9% No difference between children with and without enuresis in terms of toilet training before 24 months of age: OR 0.96 (0.65–1.41) Diaper use in the non-enuretic group showed a tendency to be higher compared to the enuresis group, but not significantly: OR 0.66 (0.46–0.96)	No clarification is presented on diaper use.
Hofmeester I et al. [30]	Retrospective cohort study; 907 consecutive patients, aged 11–42 years, subjected to in-hospital adapted Dry Bed Training (ADBT). The study aimed to identify predictors for positive outcome of ADBT.	Current diaper use before treatment were, in logistic regression analysis, a positive predictive factor on success of ADBT after 6 months. OR on original data and pooled imputed data are presented: OR 0.54 (0.35–0.83) and 0.64 (0.42–0.98)	No data on diaper use 30% of data missing, and this and imputed.
Tarbox RS et al. [31]	Prospective case study in young man (29 years old) with mental retardation. Withdrawal design over 1 month, to evaluate effect of wearing diapers on urinary accidents and successful voids on the toilet.	Wearing diapers, he had substantially more accidents. Wearing diapers, he had substantially less successful voids.	Fluid intake was not standardized. The fact that it is only a case study makes it hard to extrapolate anything, but the discussion is interesting.
Simon JL et al. [32]	Prospective case study in five typically developing children, 4 girls and 1 boy, aged 21–30 months of age. They wore no diapers, and where prone to sit on the toilet every	Underwear alone increased continence and decreased accidents in two of the 5 children. Two of the five showed no improvement on wearing underwear alone, and one even	Four of the children had already undergone a toilet-training procedure, and their diapering habits were not comparable.

Table 1 (continued)

Article	Study design	Key endpoints	limitations
Van Dommelen P et al. [33]	30 min. Number of accidents and successful voids where recorded. The children had to undergo training in both diapers, pull-on training pants, and normal underwear. A randomized controlled trial on 570 children (4 or 5 years of age), evaluating simple behavioural interventions on enuresis. The children were grouped into 4 groups; group 1: lifting to urinate and ask for a password, group 2: the same as group 1, without a password, group 3: using a reward system, group 4: a control group. Should be used for 6 months, or until 14 wet nights in a row had been present.	experienced worsening of symptoms, as she developed withholding of her urine.  After 6 months of training, the lifting group without password was the only intervention that resulted in significantly more dry children compared to the control group: 37% vs. 21% Wearing a diaper at night had a significant negative effect on becoming dry, compared to the children that did not use diapers at night after 6 months of training: 24% vs. 39%	Only 33 patients did not use diapers, compared to the rest, 512. Data on comparability of the two groups missing Subgroup analysis on diaper use and randomization group missing
Grzeda M et al. [34]	Cross-sectional questionnaires performed at 7.5 years of age (n = 1258), and repeated at 9.5 years of age on parental strategies to overcome enuresis	Wearing diapers/ protective pants as a treatment of enuresis at the age of 7.5 years could not be used as a predictor for dryness/ continuing enuresis at the age of 9.5 years	No data on diapering are presented.

<sup>a</sup> Elimination communication.

cohort, but the age of gaining continence, both by day and by night, did not differ.

## Materials and methods

A systematic literature search was conducted in PubMed and Embase. In Embase we used the following terms

(incontinence:ab, ti OR continence:ab, ti OR enuresis:ab, ti OR 'nocturnal enuresis':ab, ti OR bedwetting:ab, ti OR 'urine incontinence': ab,ti) AND (diaper: ab, ti OR nappy: ab, ti OR underwear: ab, ti OR pullups:ab, ti OR 'protection pants':ab, ti OR 'disposable diaper':ab,ti) revealing 309 articles/abstracts. In Pubmed we used ("incontinence" OR "continence" OR "enuresis" OR "nocturnal enuresis" OR

“bedwetting” OR “urine incontinence”) AND (“diaper” OR “nappy” OR “underwear” OR “pullups” OR “protection pants” OR “disposable diapers”) revealing 264 articles/abstracts. 173 duplicates were removed (see Fig. 1). One additional relevant article was found going through reference lists. The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) were used [27].

Eligibility criteria for full text screening were prospective and retrospective studies evaluating diaper use as variable on incontinence. Inclusion criteria also demanded that the articles should be written in English, and the full text should be available online. Studies performed in elderly people were excluded. Two independent reviewers, AB and KK, screened all abstracts.

We identified eight articles [5,28–34] evaluating the effect of diapers on incontinence. No prospective intervention studies specifically evaluating the effect of diaper on enuresis were identified. No meta-analysis was performed, as it was not feasible, with the studies included. A qualitative analysis of the included studies was performed.

## Incontinence and diapering

Patients suffering from enuresis experience reduced quality of life compared with healthy children [35,36]. In

literature, several independent researchers have reported a rise in prevalence of enuresis [4,5,28,37,38] over the last 30 years. The eight included articles are presented in Table 1. Key outcomes and relevant data on diapering are presented.

Wang ZX et al. [5] proposes, that longer usage of disposable diapers in a Chinese cohort, and a delay in beginning toilet training (elimination communication), might explain the increase in prevalence in China (Table 1). The article presents a rise in prevalence of enuresis between 2006 and 2017. The use of DD all day compared to using DD only at night seems to increase the risk of enuresis further. One might speculate that children with daytime urinary incontinence would have enuresis for a longer time compared to monosymptomatic children. Whether or not DD use has pushed the age of initiating EC, or it is the other way around are uncertain. The group concludes that the rise in prevalence might be multifactorial.

In the same research group, Li X et al. [28] demonstrate in a retrospective case–control study involving 376 children with NE, and 379 age and sex-matched controls, that children with enuresis, stopped using day-time DD later than those who did not have enuresis. The authors discuss, that sleeping with a diaper takes away the wetness feeling, and thus impact the bladder-brain link, and interrupts the normal maturation of the urination control centres, in

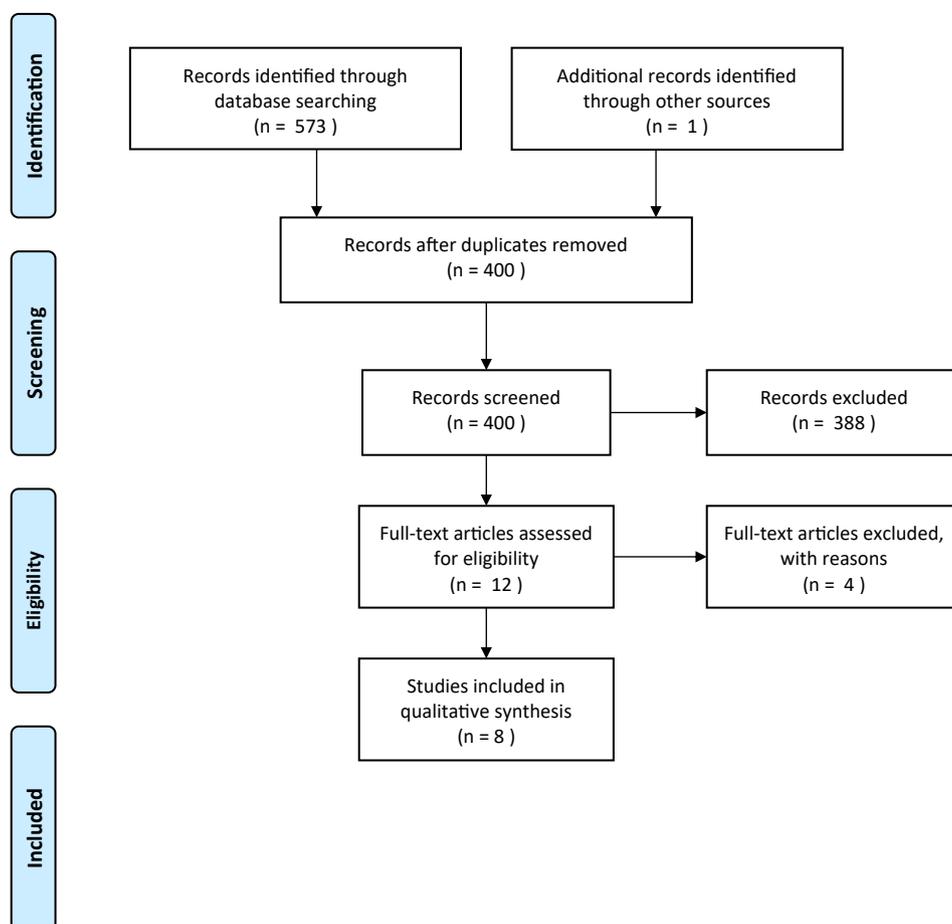


Fig. 1 PRISMA flow diagram.

terms leading to later age of night-time continence. It seems in this study, that EC and cessation of diaper use in the day-time can shorten the time to nocturnal continence, which is interesting, as it seems that day-time diapering is affecting nocturnal bladder control. The study is retrospective, and thus prospective studies on these interesting findings are needed.

A randomly selected cross-sectional population-based study conducted in Thailand [29] evaluated 3453 school children aged 5–15 years, and compared the group with enuresis ( $n = 146$ ), with the rest. Diaper use was not associated with enuresis in this study, but a description of diaper use, day or night, was not provided.

A retrospective cohort study performed from 2003 to 2013 by Hoffmeester et al., involving 907 patients between the age of 11–42, showed that current diaper use, before treatment, was a predictive factor of positive outcome of Adapted Clinical Dry Bed Training [30]. The authors did not discuss this finding in terms of plausible mechanisms involved. These findings are contradictory to earlier presented studies that suggest that wearing diapers are postponing nocturnal continence, but the study populations are hard to compare, as they are very different.

Tarbox RS et al.'s [31] results showed significantly more successful voids on the toilet during the no-diaper periods. The authors discuss, whether or not factors of negative reinforcement like decrease in the sensation of wetness, social detection of accidents, or the effort necessary to urinate, could be involved. They also propose, that diapers may have had a decremental effect on his toilet use, as it might have been more convenient for him and the staff for him to just urinate in the diaper. Even though the study suffers several weaknesses, the discussion remains very interesting.

Simon JL et al. [32] performed a similar study. The children would have to wear normal underwear instead of diapers for a period through the day, with easy access to a toilet. They were requested to sit for 3 min on the toilet for every hour. 2 of the children experienced improvement in terms of incontinence episodes and increased their spontaneous voids. The authors conclude, that some children might benefit from avoiding the use of diapers during the TT process. No positive predictors could be presented due to low amount of data.

A study performed in Holland aimed to evaluate the value of simple behavioural interventions for enuresis [33] in a prospective randomized manner. The group concludes, that diaper use are a negative factor in succeeding with the training after 6 months.

A study by Grzeda et al. [34] concluded, that wearing diapers/protective pants as a treatment of enuresis at the age of 7.5 years couldn't be used as a predictor for dryness/continuing enuresis at the age of 9.5 years. The study was performed as a cross-sectional questionnaire study at the two time points.

## Discussion and conclusion

Modern DD become more and more safe, reliable, and accessible, and the use of DD is increasing. DD have several advantages in terms of comfort; newer materials decrease

the risk of diaper dermatitis, and scientist argue that they increase sleep quality in children with enuresis [10].

Along with the development of better DD, an increase in age of initiating TT is suspected [3] as well as an increase in the prevalence of LUTS in children [19], including enuresis [5]. Although tempting to do so, a robust correlation between diaper use and continence attainment cannot be established, as no large randomized prospective studies have been performed evaluating only diapering as intervention. The evidence on the effect of DD on enuresis and TT is sparse, and it is premature to draw any conclusions, though it seems that DD use might have a negative effect on continence attainment, although one study reports a better chance of success when wearing diapers [30], but these findings were in children >11 years of age, and hence not comparable to the other cohorts described.

Whether or not modern DD affects TT practice, or it is the other way around is debatable. We might speculate, that the more comfortable and convenient a diaper gets, the more it takes to motivate the child and the parents, to stop using them. Cloth diapers had to be changed very often, bear a higher risk of dermatitis, and demanded excessive laundering [39]. In the lack of alternatives TT was initiated earlier in the past. The fact that more and more parents both have full time jobs, and that children spend the largest part of the day in day-care is an extra challenge as less time for TT is available, making the DD even more convenient, and necessary, to cope with incontinence in small children. We tend to lean against DD affecting TT practice the most, but they are intervened, and no definite conclusions can be made.

The studies presented in this review give conflicting results. Some studies believe firmly in the association between diapering and prolonged enuresis, as other studies do not find this link. Whether or not DD use have different effects on enuresis compared to daytime urinary incontinence are hard to assess from the included studies, as all daytime cessation of DD would be combined with some kind of TT as well.

For the children with enuresis avoidance of the night diapers, may lead to discomfort awakenings of both child and parents, interrupted and poor sleep quality [10], further motivating the on-going use of DD until spontaneous resolution of symptoms. The current recommendation, at least at our clinics, is that parents can try a period without DD to see if this is changing the frequency of enuresis. If this is not the case the families are suggested to use DD if they find it easier.

Whether children, or a subgroup of children, could actually gain continence just by stopping using DD, remains to be answered through prospective randomized studies.

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## Declarations of interest statement

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