

Longitudinal Study of Bowel and Bladder Control by Day and at Night in the First Six Years of Life. I:

Epidemiology and Interrelations between Bowel and Bladder Control

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Introduction

Knowledge about the development of bladder control and of bowel control determines the attitude towards toilet-training, and plays a part in aetiological and pathogenetic concepts about enuresis and encopresis. According to Mac Keith *et al.* (1973) and other authors, the development of nocturnal dryness is a process of maturation, complete by age five, which cannot be accelerated by training, but the behavior of dryness at night—which depends on the maturation having taken place—can be delayed by various factors, such as stress between the ages of two and three years (Douglas 1973). The development of day-time dryness is probably also a process of maturation and may be positively influenced by toilet-training. The development of bowel control has been less thoroughly studied. At present the rôles of maturation and toilet-training have been poorly defined (Bellman 1966, Silber 1969, Levine 1975).

Most of the literature describes only the development of bladder control, often only at night, or the development of bowel

control. However, a more comprehensive approach seems to be desirable for the following reasons. First, in toilet-training the developmental processes of bowel control and of bladder control by day and at night should not be dealt with separately. Second, it might be of interest to know how these processes are related to each other.

The purpose of this study is to describe in detail the development of bowel control and of bladder control during the day and at night, and to report what interrelations exist between these three processes. Further, the relevance of this data for toilet-training and for the management of enuretic and encopretic children will be discussed.

Subjects and Methods

From 1955 to 1976 a longitudinal study in growth and development of 413 healthy Swiss children was conducted at the Kinderspital Zurich, in co-operation with the Centre International de l'Enfance in Paris (Falkner 1960). These children form a representative selection of a Swiss urban population, according to the occupational status of the parents.

Before six months of age, data only on potty-training were obtained. After that age, data on the different stages of the development of bowel control and of bladder control are available for 72 children at nine months, for 96 children at 12 months, for 163 children at 18 months, and for 320 children at two years and thereafter (see Table II for the exact number of children examined).

The children were seen at the ages of one, three, six, nine, 12, 18 and 24 months, and thereafter at yearly intervals. The mothers reported the stage of bowel and bladder control by day and at night reached during the month before each examination. The following scoring system was used: 0 per cent = no control; 1 to 30 per cent = partial control during approximately one-third of the time; 30 to 70 per cent = control during one-third to two-thirds of the time; 70 to 95 per cent = total control except for a few relapses; and 100 per cent = total control. (For more detailed information see Falkner (1960) in which

TABLE I
Potty training

Age (mths)	Percentage of children put on pot
1	3
3	13
6	32
9	80
12	96
18	99
24	100

the complete questionnaires have been published.)

Results

INCIDENCE OF POTTY-TRAINING, BOWEL AND BLADDER CONTROL BY DAY AND AT NIGHT *Potty-training*

At three months 13 per cent and at six months 32 per cent of the children were held on the pot by their mothers, a few being held over the lavatory. The majority were put on the pot at between six and 12 months, that is when they had learned to sit alone. At 12 months 96 per cent were being placed on the pot (Table I).

TABLE II
Incidence of bowel control, bladder control by day and at night (%)*

Stage of control	Age (yrs)															
	9/12		1		1½		2		3		4		5		6	
	m	f	m	f	m	f	m	f	m	f	m	f	m	f	m	f
<i>Bowel control</i>																
0%	32	26	8	13	3	0	1	1	2	1	0	0	0	0	0	0
1-30%	18	16	14	11	5	5	7	1	0	0	0	0	0	0	0	0
30-70%	18	21	14	15	6	5	3	3	0	0	0	0	0	0	0	0
70-95%	24	24	32	22	29	25	16	12	2	1	2	3	2	1	1	1
100%	8	13	32	39	57	65	73	83	96	98	98	97	98	99	99	99
<i>Bladder control, day</i>																
0%	97	92	90	78	56	43	26	14	2	0	1	1	2	2	1	1
1-30%	3	4	8	11	15	29	10	10	1	1	1	0	0	1	2	0
30-70%	0	2	2	2	7	5	11	15	2	3	0	1	1	1	3	1
70-95%	0	0	0	9	12	7	36	39	78	78	9	9	5	4	3	1
100%	0	0	0	0	10	16	17	22	18	18	89	89	92	92	97	97
<i>Bladder control, night</i>																
0%	100	99	99	98	82	80	58	47	7	6	2	1	4	2	1	3
1-30%	0	1	1	2	10	6	13	11	11	6	4	2	1	2	3	0
30-70%	0	0	0	0	2	2	10	15	10	10	2	3	3	1	3	1
70-95%	0	0	0	0	4	6	12	18	56	56	15	8	6	6	3	2
100%	0	0	0	0	2	6	7	9	16	22	77	86	86	89	90	94
<i>n</i>	34	38	46	50	85	79	152	150	162	161	163	161	143	146	152	156

* Actual numbers of children are shown in bottom line of Table.

Bowel Control

By the end of the first year about 60 per cent of the children showed partial and about 35 per cent complete bowel control (Table II). At two years about 75 per cent and at three years practically all the children were completely bowel-trained.

Bladder Control by Day

At age one 10 per cent of the boys and 20 per cent of the girls were partially dry by day, but none was completely dry (Table II). At two years most of the children had at least partial bladder control, and about 20 per cent had complete bladder control. The third year shows no increase in completely dry children, but 78 per cent of them had a score of 70 to 95 per cent (dry except for a few relapses). At four years 89 per cent and at six years 97 per cent of the children were completely dry.

Bladder Control at Night

At the end of the first year very few children were partially, and none completely, dry at night (Table II). At two years of age about 50 per cent of the children still had no bladder control, and only 8 per cent were completely dry. By three years most of the children were partially dry; about 20 per cent were completely dry, which was about the same

percentage as those who have complete diurnal bladder control. During the fourth year the majority of the children became completely dry at night, and by six years more than 90 per cent had complete bladder control.

Complete Bowel and Bladder Control

Most children gained first bowel control, then bladder control by day and finally at night. So by the end of the third year about 75 per cent of the children had complete bowel control, but not complete bladder control by day and at night (Table III). In addition to complete bowel control, diurnal bladder control (but not nocturnal) is reported in 5 to 14 per cent of the children. The majority gained complete bladder control by day, and subsequently also at night, during the fourth year of life. Therefore the proportion with complete bowel and bladder control during the day and at night was only 5 per cent at age two and 11 per cent at age three, but more than 75 per cent of the children at age four and more than 90 per cent at age six were completely clean and dry by day and at night.

About 8 per cent of the children had a different pattern in their development of bowel control and bladder control. Between two and five years of age, 3 to 6 per cent achieved bowel control and bladder con-

TABLE III
Complete bowel control and/or bladder control by day and/or at night (%)

	--	+	+	+	--	+	--	--
Bowel control	--	+	+	+	--	+	--	--
Bladder control by day	--	--	+	+	+	--	+	--
Bladder control at night	--	--	--	+	+	+	--	+
Age (yrs)								
9/12	89.5	10.5	0	0	0	0	0	0
1	64.5	35.5	0	0	0	0	0	0
1½	36.8	49.7	8.8	2.8	0.9	0	1.0	1.0
2	21.7	54.8	13.8	5.4	1.0	2.6	0.7	0.7
3	2.8	73.7	5.4	10.9	0.3	5.9	1.0	1.0
4	2.0	6.0	11.3	76.6	0.3	3.5	0.3	0.3
5	0.3	3.1	7.2	85.5	0.3	3.0	0.6	0.6
6	0.6	1.2	5.1	91.3	0.6	0.9	0.3	0.3

trol at night, but not by day, and about 1 per cent were not clean and dry at night, but dry by day. Complete bladder control by day and at night without bowel control was seen only in exceptional cases.

Sex

Development of bowel control and of bladder control by day and at night commences and is completed earlier in girls than in boys (Table II). For the following results, data of boys and girls are not separated, because there is no significant sex difference.

INTERRELATIONS BETWEEN BOWEL CONTROL, BLADDER CONTROL BY DAY AND BLADDER CONTROL AT NIGHT

Bowel Control and Bladder Control by Day and at Night

χ^2 tests calculated from cross-tabulations of the intermediate stages of bowel and bladder control by day and at night show highly significant relationships (Table IV). The relevance of these data is shown in

Table V. Between 1½ and three years, only 2 to 6 per cent of the children with incomplete bowel control were dry by day and none was dry at night. However, 18 to 25 per cent of the children with complete bowel control were completely dry during the day and 5 to 19 per cent were dry at night. Therefore if bowel control was not complete, bladder control usually was missing or only partial, especially at night. If bowel control was complete, bladder control still could be missing or partial, but children with complete bowel control had a good chance of being dry by day, and also may be at night.

Bladder Control by Day and at Night

The development of bladder control by day and of bladder control at night are closely related to each other (Table VI). Table VII shows that between 1½ and three years only a few children were completely dry at night if they lacked day-time bladder control. If day-time bladder control was complete, however,

TABLE IV
Relationships* between bowel control and bladder control by day and at night, 1 to 3 years of age

Age (yrs)	Correlations between bowel control and	
	Bladder control by day	Bladder control at night
1	$p < 0.05, \chi^2 = 30.8$	$p < 0.05, \chi^2 = 26.4$
1½	$p < 0.001, \chi^2 = 91.5$	$p < 0.001, \chi^2 = 76.4$
2	$p < 0.001, \chi^2 = 107.9$	$p < 0.001, \chi^2 = 53.6$
3	$p < 0.001, \chi^2 = 101.5$	$p < 0.001, \chi^2 = 86.2$

* χ^2 and p-values of cross-tabulations of the intermediate stages of bowel and bladder control. (df = 16.)

TABLE V
Incidence of complete bladder control by day and at night at a given stage of bowel control, 1½ to 4 years of age

Stage of bowel control	Percentage with complete bladder control at age of			
	1½ yrs	2 yrs	3 yrs	4 yrs
0-70%	5/0*	4/0	0/0	0/0
70-95%	6/2	2/0	(2/6)/(1/6)†	(1/3)/(2/3)†
100%	18/5	25/11	17/19	90/84

* Percentages by day/at night.

† These numbers were too small to give percentages, so proportions of children are shown, e.g. 2 out of 6, 1 out of 6.

about 25 per cent of the children at ages 1½ and two years were dry at night, and 65 per cent of those aged three and 86 per cent of those aged four were dry at night. Therefore children who are not dry by day usually are not dry at night. With complete diurnal bladder control there is a good chance of also being dry at night.

Discussion

In 1955, most of the Swiss children in this study were put on the pot when they were able to sit alone, and in 96 per cent toilet-training was started by the end of the first year*. Similar data in other European countries at the same period are reported by Douglas (1958) and Hindley (1968). With this early onset of toilet-training, bowel control and bladder control developed very differently. Whereas 30 per cent of the children were completely

bowel trained at age one, and 97 per cent at age three, none of them was dry by day or at night at age one, and only 20 per cent at age three. About 80 per cent of the children had been sitting on the pot for more than two years before they accomplished bladder control by day and at night during the fourth year of life. In agreement with Klackenberg (1971) and Lovibond (1964), and in contrast to Young (1964), this leads us to suppose that at least the development of bladder control can hardly be accelerated by training. Further evidence for this assumption is given elsewhere (Largo and Stutzle 1977).

Our data on bladder control between one and three years of age are not consistent with those of other authors who report a higher percentage of dry children by day and at night in this age group (see review by de Jonge 1973). The reason for this difference is, we assume, that in our study mothers were asked not only whether the child was dry or not, but also at what intermediate stage he was. So at age three, 20 per cent of the children were completely dry by day and at night, but 75 per cent had a score of 70 to 95 per cent for bladder control by day and at night; that is, they were dry except for a few relapses during a one-month period. We believe that in most studies these children with nearly complete bladder control have been classified as completely dry. At ages four and five, in agreement with most authors (de Jonge 1973), 80 per cent and 90 per cent respectively are dry by day and at night.

* Preliminary data of the second Zurich longitudinal study shows that in 1974 less than 5 per cent of the Swiss children were put on the pot during the first year of life.

TABLE VI

Relationship* between bladder control by day and bladder control at night, 1 to 5 years of age

Age (yrs)	
1	$p < 0.01, \chi^2 = 33.2$
1½	$p < 0.001, \chi^2 = 111.2$
2	$p < 0.001, \chi^2 = 132.6$
3	$p < 0.001, \chi^2 = 126.4$
4	$p < 0.001, \chi^2 = 143.5$
5	$p < 0.001, \chi^2 = 123.4$

* χ^2 and p-values of cross-tabulations at intermediate stages of bladder control by day and at night. (df = 16.)

TABLE VII

Incidence of complete bladder control at night at given stage of bladder control by day, 1½ to 5 years of age

Stage of bladder control by day	Complete bladder control at night at age of				
	1½ yrs	2 yrs	3 yrs	4 yrs	5 yrs
0-70%	—	0.5	7	—	—
70-95%	—	7	8	48	65
100%	28	25	65	86	93

Consistently, the development of bowel and bladder control was found to be slightly more advanced in girls than in boys.

Our data tend to show that a similar developmental process is responsible for diurnal and nocturnal bladder control, and also for bowel control. In more than 90 per cent of our children there was a high correlation between, first, the development of bowel control, then diurnal bladder control and finally nocturnal bladder control. These findings give further evidence that it is mainly the process of maturation which determines the development of bowel and bladder control. The practical relevance of these interrelations can be summarized as follows. (1) Without complete bowel control it is unlikely that a child is dry during the day and it is very unlikely that he is dry at night. With complete bowel control, bladder control can still be missing or partial: however, children with complete bowel control have a good chance of being dry by day and may be also at night. (2) Children with incomplete bladder control by day are usually not dry at night. Not all children with complete diurnal bladder control are dry at night, but there is a good chance that they will be.

In some children the development of bowel and bladder control may be different. 3 to 6 per cent of our children between two and five years of age were clean and dry at night, but not dry by day. An even higher incidence of children dry at night but not by day at age $2\frac{1}{2}$ years is reported by Roberts and Schoellkopf (1951). About 1 per cent of our children were dry by day, without being clean and dry at night.

The development of bowel control essentially is completed by the end of the third year and that of bladder control by the fifth to sixth year. The latter finding is in agreement with Mac Keith (1973), who

states that maturation in nocturnal bladder control is complete in 98.5 per cent of the population by age five. Based on our results, what conclusions can be made about disorders in bowel and bladder control after the third or fifth year respectively? Concerning encopresis, bowel control is completed in practically all children before bladder control is complete. Therefore, if children with complete bladder control lack bowel control, this cannot be attributed to a maturational delay. Concerning enuresis diurna, daytime dryness is usually achieved prior to or concurrent with nocturnal dryness. Thus enuresis diurna in a child completely dry at night is scarcely ever due to a delay in maturation. However, if a child has primary enuresis nocturna (in the sense that he is wet every night) and had developed bladder control by day and bowel control unusually late, a delay in maturation may be a sensible explanation. With the understanding that becoming clean and becoming dry by day and at night may be one unique maturation process, a detailed history of the development of bowel and bladder control in enuretic children should be obtained. It might help to clarify further the presence or absence of delayed maturation in such cases.

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AUTHORS' APPOINTMENTS

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SUMMARY

The development of bowel and bladder control by day and at night during the first six years of life in 320 Swiss children in the Zurich longitudinal study (1955-1976) is described in detail. A scoring system was used which included intermediate stages of control. With toilet-training started in 96 per cent of the children during the first year of life, bowel control was completed in 32 per cent at age one, in 75 per cent at age two and in 97 per cent at age three. Complete bladder control by day and at night were established in none of the children at age one, in 20 per cent at ages two and three and in 90 per cent at age four. Complete bowel control and complete bladder control by day and at night were found in 5 per cent at age two, in 11 per cent at age three, in 77 per cent at age four and in 91 per cent at age six.

The significant relationships between bowel control, bladder control during the day and bladder control at night ($p < 0.001$) demonstrate that the same developmental process acts in bowel and bladder control. Highly correlated to each other, first bowel control develops, then bladder control by day and finally bladder control at night. The relevance of these interrelations for toilet-training and for the management of enuretic and encopretic children is discussed.

RÉSUMÉ

Etude longitudinale du contrôle rectal et vésical de jour et de nuit dans les six premières années de la vie: II. Epidémiologie et interrelations entre le contrôle rectal et vésical

Le développement du contrôle rectal et vésical de jour et de nuit au cours des six premières années de la vie chez 320 jeunes enfants est décrit en détail, à partir d'un système de notation qui comprend les stades intermédiaires du contrôle. L'apprentissage de la propreté a débuté chez 96 pour cent des enfants dans la première année de la vie, le contrôle rectal est acquis chez 32 pour cent à l'âge de un an, 75 pour cent à l'âge de deux ans et 97 pour cent à l'âge de trois ans. Le contrôle vésical complet de jour et de nuit n'est jamais observé avant l'âge d'un an, dans 20 pour cent des cas aux âges de deux et trois ans et 90 pour cent à l'âge de quatre ans. Le contrôle rectal complet et le contrôle vésical complet de jour et de nuit ont été notés chez cinq pour cent des enfants à l'âge de deux ans, 11 pour cent à l'âge de trois ans, 77 pour cent à l'âge de quatre ans et 91 pour cent à l'âge de six ans.

Il a été trouvé une relation significative ($p < 0,001$) entre le contrôle rectal, le contrôle vésical de jour et le contrôle vésical de nuit, ce qui suggère qu'un même processus de développement agit à la fois sur le contrôle rectal et le contrôle vésical. Le contrôle rectal se développe en premier, puis le contrôle vésical de jour et enfin le contrôle vésical de nuit. Les conséquences de ces relations pour l'éducation de la propreté et le traitement des enfants énurétiques et encoprétiqes sont discutés.

ZUSAMMENFASSUNG

Eine Langzeitstudie über Darm- und Blasenkontrolle am Tage und in der Nacht in den ersten 6 Lebensjahren: II. Epidemiologie und Wechselbeziehungen zwischen Darm- und Blasenkontrollen

Die Entwicklung der Darm- und Blasenkontrolle am Tag und in der Nacht in den ersten 6 Lebensjahren wurde an 320 Kindern ausführlich untersucht, indem ein Beurteilungsschema verwandt wurde, das Zwischenstadien zur Kontrolle enthielt.

Bei 96 Prozent der Kinder wurde mit dem Sauberkeitstraining im 1. Lebensjahr begonnen; Eine Kontrolle des Stuhlgangs wurde in 32 Prozent im Alter von 1 Jahr, in 75 Prozent mit

2 Jahren und in 97 Prozent mit 3 Jahren erreicht. Eine vollständige Harnkontinenz am Tag und in der Nacht wurde von keinem Kind bis zum Alter von 1 Jahr erreicht, von 20 Prozent zwischen 2 und 3 Jahren und von 90 Prozent bis zum Alter von 4 Jahren. Eine vollständige Darm- und Blasenkontrolle am Tage und in der Nacht konnte bei 5 Prozent der Kinder im Alter bis zu 2 Jahren nachgewiesen werden, bei 11 Prozent mit 3 Jahren, bei 77 Prozent mit 4 Jahren und bei 91 Prozent im Alter von 6 Jahren.

Die signifikante Beziehung zwischen Darmkontrolle, Blasenkontrolle am Tage und Blasenkontrolle in der Nacht ($p < 0,001$), die in dieser Studie gefunden wurde, spricht dafür, daß bei der Darm- und Blasenkontrolle die gleichen Entwicklungsvorgänge eine Rolle spielen. Zuerst entwickelt sich die Kontrolle über den Stuhlgang, danach über die Harnkontinenz am Tage und zum Schluß erst über die Harnkontinenz in der Nacht. Es wird über die Bedeutung dieser Wechselbeziehungen für das Stuhl- und Blasentraining und für die Behandlung von Kindern mit einer Enuresis und einer Enkopresis diskutiert.

RESUMEN

Estudio longitudinal del control de intestino y vejiga durante el día y la noche en los primeros seis años de vida: II. Epidemiología e interrelaciones entre el control de vejiga y de intestino

Se describe con detalle el desarrollo del control de vejiga e intestino durante el día y la noche en los primeros seis años de vida en 320 niños, utilizando un sistema de puntaje que incluye estados intermediarios de control. El entrenamiento a la limpieza se inició en el 96 por ciento de los niños en el primer año de la vida; el control intestinal se consiguió en el 32 por ciento al año de edad, en el 75 por ciento a los dos años y en el 97 por ciento a los tres años. Un control completo de la vejiga durante el día y la noche no se estableció en ninguno de los niños al año de edad, en el 20 por ciento a los años dos y tres y en el 90 por ciento al año cuarto de la vida. Un control completo intestinal y urinario durante el día y la noche se encontró en un 5 por ciento de niños a la edad de dos años, en un 11 por ciento a los tres años en un 77 por ciento a los cuatro años y en un 91 por ciento a los seis años.

Las refaciones significativas entre el control de vejiga y de intestino durante el día y el control de vejiga durante la noche ($p < 0.001$) encontrados en el presente estudio sugieren que el mismo proceso de desarrollo actúa en ambos controles de intestino y de vejiga. El control de intestinos se desarrolla primero y después el de vejiga durante el día y finalmente ocurre el control de vejiga durante la noche. Se discute la relevancia de estas relaciones para el entrenamiento de la limpieza y para el tratamiento de niños enuréticos y encopréticos.

REFERENCES

- Bellman, M. (1966) 'Studies on encopresis.' *Acta Paediatrica Scandinavica*, suppl. 170.
- Douglas, J. W. B. (1973) 'Early disturbing events and later enuresis.' In Kolvin, I., Mac Keith, R. C., Meadow, S. R. (Eds.) *Bladder Control and Enuresis. Clinics in Developmental Medicine nos. 48/49*. London: S.I.M.P. with Heinemann Medical. pp. 109-117.
- Blomfield, J. M. (1958) *Children under Five*. London: Allen & Unwin.
- Falkner, F. (Ed.) (1960) *Child Development. An International Method of Study. Modern Problems in Pediatrics*, no. 5. Basel: Karger.
- Hindley, C. B. (1968) 'Growing up in five countries: a comparison of data on weaning, elimination training, age of walking and IQ in relation to social class from European longitudinal studies.' *Developmental Medicine and Child Neurology*, 10, 715-724.
- Jonge, G. A. de (1973) 'Epidemiology of enuresis: a survey of the literature.' In Kolvin, I., Mac Keith, R. C., Meadow, S. R. (Eds.) *Bladder Control and Enuresis. Clinics in Developmental Medicine Nos. 48/49*. London: S.I.M.P. with Heinemann Medical. pp. 39-46.
- Klackenberg, C. (1971) 'Expectations and reality concerning toilet-training.' *Acta Paediatrica Scandinavica*, suppl. 224, 85-127.

- Largo, R. H., Stutzle, W. (1977) 'A longitudinal study of bowel and bladder control by day and at night in the first six years of life. II: The rôle of potty-training and the child's initiative.' *Developmental Medicine and Child Neurology*, **19**, 607-613.
- Levine, M. D. (1975) 'Children with encopresis: a descriptive analysis.' *Pediatrics*, **56**, 412-416.
- Lovibond, S. H. (1964) *Conditioning and Enuresis*. Oxford: Pergamon.
- Mac Keith, R. C., Meadow, S. R., Turner, R. K. (1973) 'How children become dry.' In Kolvin, I., Mac Keith, R. C., Meadow, S. R. (Eds.) *Bladder Control and Enuresis. Clinics in Developmental Medicine nos. 48/49*. London: S.I.M.P. with Heinemann Medical. pp. 3-22.
- Roberts, K. E., Schoellkopf, J. A. (1951) 'Eating, sleeping and elimination practices of a group of two-and-one-half-years-old children.' (Parts I-V.) *American Journal of Diseases of Children*, **82**, 121-152.
- Silber, D. L. (1969) 'Encopresis: discussion of etiology and management.' *Clinical Pediatrics*, **8**, 225-231.
- Young, G. C. (1964) 'The relationship of the age of "potting" to enuresis.' *Journal of the Royal Institute of Public Health and Hygiene*, **27**, 23-24.