

---

# Assessment of Motor Milestones in Twins

---

Jacqueline M. Langendonk,<sup>1</sup> C. E. M. van Beijsterveldt,<sup>1</sup> Silvia I. Brouwer,<sup>1</sup> Therese Stroet,<sup>1</sup> James J. Hudziak,<sup>1,2</sup> and Dorret I. Boomsma<sup>1</sup>

<sup>1</sup> Department of Biological Psychology, Vrije Universiteit, Amsterdam, the Netherlands

<sup>2</sup> Department of Psychiatry and Medicine (Division of Human Genetics), Center for Children, Youth and Families, and University of Vermont, College of Medicine, Burlington, United States of America

The aim of this study was to investigate the reliability of obtaining through mailed surveys maternal reports of specific major motor milestones achievement. To accomplish this aim we compared and contrasted mailed survey data and telephone interview data on a series of questions about age at which motor milestones were achieved. We used monthly telephone interviews with mothers of 238 twin pairs, beginning at age 6 months, which ascertained the age at which each specific milestone was met. The contrasting 'through the mail' survey was sent after the second birthday of an independent group of children, and included 463 twin pairs. All twins were born between March 2003 and March 2004. Comparisons were made for the following 5 milestones: sitting without support, hands and knees crawling, turning from back to belly, standing without support, and walking without support. There was no difference between the concurrent telephone interviews and the retrospective through the mail survey on any of the landmarks, except 'standing without support'. From this work we conclude that data on achieving milestones can be reliably obtained through the mail using retrospective surveys when the children are 2 years of age.

---

The assessment of motor development and of the achievement of milestones is one of the earliest and most reliably used measures of child development. A delay in motor development is often associated with less optimal emotional-behavioral development (Hardoff et al., 2005), and can also be an indication of a central or peripheral neurological disorder (Palmer, 2004). The detection of a possible defect and the assessment of delayed motor development depend critically on the parents' and caretakers' accurate ability to recall when a specific developmental milestone is reached.

General motor development is relatively well evaluated by parents, as it is one of the more objective changes during infancy (Bodnarchuk & Eaton, 2004). However, over time, the ability to accurately recall the month in which a child meets a milestone may become more difficult. Most parents remember their child's first step well; however, other landmarks such as sitting without support, and age at the time of the

child's first word, are more difficult for parents to recall (Hart et al., 1978; Majnemer & Rosenblatt, 1994). There are interesting trends in the reporting of milestone achievement, for instance, there is a tendency to report that milestones were met on even months more often than odd months (Neligan & Prudham, 1969). The status of development of the children is of substantial influence on the memory of the parents. For children with a 'normal' development there is a tendency to slightly underestimate their motor achievements. In contrast, for slow developers, the attainment of motor milestones is more often overestimated and far less accurate than for 'normal' developers (Majnemer & Rosenblatt, 1994). These findings are based on developmental studies in singletons. There is a possibility that recall of milestone achievement may be different for parents of twins. Accurate recall may be more difficult for parents because they must remember which twin achieved which milestone on which date. In addition, parents may compare and contrast their twins and thus either over or underestimate differences between the twins and their milestone achievements. On the other hand, it could be that having twins makes parents better reporters, as they can use the date on which one of the twins attained a milestone as a reference for the other.

In this article, we report a study in which the reliability of recalling motor milestones in twins is assessed using two methods; telephone interviews (TI) and mailed surveys (MS). Through the use of cross-sectional-prospective telephone interviews (TI), monthly ages at which each milestone was reached were obtained by talking with mothers each month, beginning with the sixth month of age. Although this approach is costly and time consuming, because it is cross sectional, it typically is considered the most accurate way to collect this type of data. We thus use the TI data as the 'gold standard' for comparison with the through the mail retrospective survey data (MS). We compare means and variances between the

---

Received 3 September, 2007; accepted 11 September, 2007.

Address for correspondence: C. E. M. van Beijsterveldt, Department of Biological Psychology, Vrije Universiteit, Van der Boechorststraat 1, 1081 BT Amsterdam, The Netherlands. E-mail: toos@psy.vu.nl

**Table 1**

Characteristics (Mean and Standard Deviation or Frequency) of the Mailed Survey (MS) and the Telephone Interview (TI) Group and Tests Between the MS and TI Group

	Mailed survey		Telephone interview		<i>t</i> value	<i>p</i>
	<i>N</i>	<i>M</i> ( <i>SD</i> )	<i>N</i>	<i>M</i> ( <i>SD</i> )		
Birth weight						
First-born	455	2541 (521.66)	218	2682 (477.53)	-3.369	.001
Second-born	456	2511 (522.17)	218	2587 (487.70)	-1.788	.074
Gestational age	459	36.5 (2.17)	218	37.3 (1.94)	-4.457	<.001
Age mother at twin birth	456	31.41 (3.82)	218	31.82 (4.27)	-1.236	.217
	Mailed survey		Telephone interview		$\chi^2$	<i>p</i>
	<i>N</i>	<i>M</i> ( <i>SD</i> )	<i>N</i>	<i>M</i> ( <i>SD</i> )		
Sex first-born						
Boy	236	51.0%	119	51.3%	.006	.936
Girl	227	49.0%	113	48.7%		
Sex second-born						
Boy	232	50.1%	113	48.7%	.121	.728
Girl	231	49.9%	119	51.3%		
Zygosity						
SS-twin	311	67.2%	150	64.7%	.438	.508
DOS-twin	152	32.8%	82	35.3%		
Smoking during pregnancy (cigarettes per day)						
Nonsmoking	394	85.7%	197	84.9%	.173	.982
0-5 cigarettes	40	8.7%	22	9.5%		
5-10 cigarettes	17	3.7%	8	3.4%		
> 10 cigarettes	9	2.0%	5	2.2%		
Alcohol use during pregnancy						
Nonusage	405	87.9%	195	87.8%	.085	.958
< 1 glass a week	49	10.6%	23	10.4%		
> 1 glass a week	7	1.5%	4	1.8%		

TI data with a large, independent, group of mothers of twins who only received a MS. We investigated whether there was any difference on criteria that might influence the time a motor milestone is reached, namely birth weight, gestational age (Goyen & Lui, 2002; Palisano, 1986), age of the mother, smoking during pregnancy, as this influences the fetal growth (Cnattingius, 1989), and alcohol use during pregnancy.

### Subjects and Methods

The Young Netherlands Twin Register (YNTR) collects data on young twins from birth onwards (Bartels et al., 2007; Boomsma et al., 2006). After a child is born in the Netherlands the parents can indicate if they want to be visited by the baby service 'Felicitas'. If there is a multiple birth in a family the employee of Felicitas asks the parents if they are interested in being registered with the YNTR. When parents are willing to participate they receive in the following months a registration card and the first survey about the twins' birth. If both the registration card and the first questionnaire have been returned by the time the twins reach their second birthday, the parents receive a survey that includes questions about motor development.

The following motor milestones are included: sitting without support, hands and knees crawling, turning from back to belly, standing without support, and walking without support (Brouwer et al., 2006). The parents (usually the mother of the twins) are asked to give the age at which a milestone is reached in half months. The survey is mailed after the second birthday of the children, as the last motor milestones we want to study are not reached at an earlier age by the children in the lowest percentiles of development. As a consequence, data may be collected a relatively long time after some children reached their first milestone(s). To improve recall, the first survey, which is sent after registration, includes a memory aid. On a one-page sheet, a list with milestones is given, so that parents can write down the month as soon as the milestone is reached. Ideally, when the family receives the second survey the milestones can be copied from this sheet. Of course, if the parents/caretakers do not take any notes, milestones must be recalled from memory. Data on twin pregnancy and birth, gestational age (GA), birth weight, maternal smoking and alcohol use during pregnancy, and age of the mother at twin birth were obtained from the first survey.

**Table 2**  
Comparisons Between the Survey and Interview Group for Motor Milestone Attainment

	Mailed survey		Telephone interview		$\Delta$ in days	F value ( $p$ )
	N	M (SD)	N	M (SD)		
Sitting without support						
Oldest	441	8.55 (1.78)	218	8.51 (1.53)	0.9	< 1 (.580)
Youngest	443	8.56 (1.76)	218	8.51 (1.46)	1.5	< 1 (.999)
Hands-and-knees crawling						
Oldest	439	10.06 (2.40)	210	10.21 (2.16)	4.6	1.145 (.285)
Youngest	440	10.11 (2.46)	213	10.27 (2.01)	4.9	1.058 (.304)
Turning from back to belly						
Oldest	441	6.09 (1.69)	218	5.84 (1.40)	7.6	1.332 (.249)
Youngest	442	6.07 (1.70)	218	5.99 (1.67)	2.4	< 1 (.881)
Standing without support						
Oldest	444	12.54 (2.56)	217	13.43 (2.41)	27.1	23.656 (< .001)
Youngest	445	12.58 (2.70)	217	13.50 (2.26)	28.0	23.006 (< .001)
Walking without support						
Oldest	446	15.05 (2.34)	216	14.92 (2.21)	4.0	< 1 (.921)
Youngest	449	15.05 (2.45)	217	14.97 (2.10)	2.4	< 1 (0.974)

### Telephone Interview study (TI)

For the interview study, monthly telephone interviews were conducted, starting when the twins were 6 months of age. Initially, parents who were registered with the YNTR were approached by phone, and asked to participate in the interviews when the twins were 5 months old. This phone call was made regardless of whether parents had returned the registration card and the first questionnaire. After the telephone intake, and after verbal consent was obtained, the first interview was scheduled a month later. Later in the study, parents were approached for participation when their twins were 6 months of age, and the first interview was done immediately if parents gave verbal consent. The telephone interviews started in October 2003 and finished in October 2005. In total, 238 twin pairs enrolled in the study; 5 twin pairs pulled out of the study without a known reason, and 1 twin pair was not included in the data analysis because of a severe medical condition. Data from 232 twin pairs were used in the analysis, 75 same-sex (SS) male, 75 SS female and 82 dizygotic opposite sex (DOS). The twins were born between March 2003 and March 2004. In the selection of twins only one criterion was taken into account; the SS/DOS ratio.

After consenting verbally by phone, the parents received a letter with information about the study, plus an informed consent form, which they were asked to sign and return. In the same mailing there was a list with the dates and the time on which the parents were to be contacted. If they could not be reached at the agreed time another call was made later on the same day. If this was unsuccessful a third attempt was made a week later. If unsuccessful, at last one letter was sent to the family with a request that they contact the YNTR if they wished to go through with the study. In the telephone interviews, five motor

milestones were included: (1) Turning from back to belly, (2) Sitting without support, (3) Crawling on hands and knees, (4) Standing without support, and (5) Walking without support. When a child reached a milestone, the researcher asked for the exact date. The time was written down in half months. In the next interview, the attained milestone was included one more time. After the second confirmation, the milestone was not included in any following interview. Nearly all phone interviewers were done by the same researcher (SB). The duration of the study per child was between 6 and 20 months from the start of the study until the criterion 'walking without support' was reached.

### Mailed Survey study (MS)

In the comparison group, twins were included if their parents/ caretakers returned the registration card, the first questionnaire and the second questionnaire received after the second birthday of the twins. We included data from surveys filled in when the twins were between 23 and 30 months. This group consists of 463 twin pairs and is comparable to the interview group with respect to date of birth, sex, SS/DOS ratio, number of mothers smoking and using alcohol during pregnancy, and age of the mother at twin birth. Twin pairs in which one or both of the children are severely handicapped (physical and/ or mental) were excluded from the study.

### Statistical Analyses

Analysis of variance (ANOVA) was used to test whether the moment when twins achieved a motor milestone differed between the TI and MS groups. The analyses were done separately for the first- and the second-born twins. Before ANOVA, we tested if there were any differences between the groups regarding sex,

SS/DOS ratio, smoking and alcohol use during pregnancy (Chi<sup>2</sup> test), birth weight, gestational age, and the age of the mother (*t* test). SPSS version 14.0 was used to conduct the statistical tests.

## Results

For the TI group, 217 twin pairs had complete motor milestone data; 15 twin pairs had data missing for one or two motor milestones. The MS group contained complete data on 401 twin pairs; one or two motor milestones were missing for 62 twin pairs. Table 1 shows the background variables for the TI and MS groups regarding birth weight, gestational age (GA), age of mother at twin birth, sex, SS/ DOS ratio, smoking, and alcohol use during pregnancy. The only difference between groups was found for birth weight (for the first-born twin) and GA. In the TI group the mean GA was 37.3 weeks versus 36.5 weeks in the MS group ( $p < .001$ ). In the TI group the mean birth weight was 2682 grams for the first-born versus 2541 grams in the MS group ( $p = .001$ ). As GA and birth weight of the oldest ( $r = .695$ ,  $p < .001$ ) and youngest ( $r = .620$ ,  $p < .001$ ) correlate highly, only birth weight was taken as a covariate in the comparisons between the two groups for motor milestone attainment. The results of these tests are shown in Table 2. Five milestones were evaluated (sitting without support, hands and knees crawling, turning from back to belly, standing without support, and walking without support). Only standing without support differed significantly between the two groups. The mean difference between the two groups was 27.1 days ( $p < .001$ ) for the first-born and 28.0 days ( $p < .001$ ) for the second-born twin.

## Discussion

We tested the reliability of recalling motor milestones in young twins reported by their parents/caretakers. We compared ages at which a series of motor milestones were reached, as reported by telephone interview (TI) and mailed surveys (MS). For four out of five motor milestones (turning from back to belly, sitting without support, crawling on hands and knees, and walking without support) no significant difference was found in the data obtained from the MS and the TI study. The fifth motor milestone, standing without support, showed a significant difference between the two datasets. Parents in the TI group indicated that their twins reached this particular milestone at a later age than parents in the MS group. Otherwise, our data also provide evidence that the retrospective MS is as accurate as the TI method. Of the five milestones tested, even the earliest landmarks (turning from back to belly) are recalled and reported correctly. The fact that parents remember the particular milestones correctly could be due to the fact that the first questionnaire, which is sent after registration, includes a memory aid. On a one-page sheet, a list with the motor milestones is listed, so that parents can write down the month as soon as a milestone is reached.

Ideally, when the family receives the second survey, the milestones are copied from this sheet. Of course, if parents do not take any notes, milestones must be recalled from memory. The finding that whole months are reported more often than half months for the milestones standing without support, walking without support and sitting without support, suggests that parents do not note the month (or half month) as soon as a milestone is reached. This finding suggests that these milestones are often recalled from memory.

The less exact recall of the milestone standing without support could be due to the not so noticeable difference between standing with, and standing without, support. The distinction between with and without support could be more obvious for the other two milestones — sitting and walking. Another explanation for the lack of agreement in the recollection of this milestone could be the order of the milestones in the questionnaire — these are not asked in chronological order, instead appearing as sitting without support, crawling on hands and knees, turning from back to belly, standing without support, and walking without support.

We conclude that data obtained through the MS approach at 2 years of age is a valid, inexpensive, and efficient way to collect accurate data on the acquisition of motor milestones. In every case the agreement between data collected by TI and MS is high, with one outlier, 'standing without support'. However, the difference (approximately one month) is small and not important from a medical-neurological point of view. Thus, we conclude that this method is at least as good as the expensive cross-sectional telephone interview approach.

## Acknowledgment

Supported by Spinozapremie NWO/SPI 56-464-14192; Twin-family database for behavior genetics and genomics studies. NWO-MagW 480-04-004; Developmental Study of Attention Problems in Young Twins (NIMH, RO1 MH58799-03)

## References

- Bartels, M., Hudziak, J. J., Derks, E. M., van Beijsterveldt, C. E. M., Stroet, T. M., Polderman, J. C., Hudziak, J. J., & Boomsma, D. I. (2007). Young Netherlands Twin Register (Y-NTR): A Longitudinal Multiple Informant Study of Problem Behavior. *Twin Research and Human Genetics*, 10, 3–11.
- Bodnarchuk, J. L., & Eaton, W. O. (2004). Can parent reports be trusted? Validity of daily checklists of gross motor milestones attainment. *Applied Developmental Psychology*, 25, 481–490.
- Boomsma, D. I., de Geus, E. J., Vink, J. M., Stubbe, J. H., Distel, M. A., Hottenga, J. J., Posthuma, D., van Beijsterveldt, T. C., Hudziak, J. J., Bartels, M., & Willemsen, G. (2006). Netherlands Twin Register: From twins to twin families. *Twin Research and Human Genetics*, 6, 849–857.

- Brouwer, S. I., van Beijsterveld, C. E. M., Bartels, M., Hudziak, J. J., & Boomsma, D. I. (2006). Influences on achieving motor milestones: A twin singleton study. *Twin Research and Human Genetics, 9*, 424–430.
- Cnattingius, S. (1989). Does age potentiate the smoking-related risk of fetal growth retardation? *Early Human Development, 20*, 203–211.
- Goyen, T. A., & Lui, K. (2002). Longitudinal motor development of 'apparently normal' high risk infants at 18 months, 3 and 5 years. *Early Human Development, 70*, 103–115.
- Hardoff, D., Jaffe, M., Cohen, A., Jonas, R., Lerrer-Amisar, D., & Tirosh, E. (2005). Emotional and behavioral outcomes among adolescents with mild developmental deficits in early childhood. *Journal of Adolescent Health, 36*, 70, e14-e19.
- Hart, H., Bax, M., & Jenkins, S. (1978). The value of a developmental history. *Developmental Medicine Child Neurology, 20*, 442–452.
- Majnemer, A., & Rosenblatt, B. (1994). Reliability of parental recall of developmental milestones. *Pediatric Neurology, 10*, 304–308.
- Neligan, G., & Prudham, D. (1969). Norms for four standard developmental milestones by sex, social class and place in the family. *Developmental Medicine and Child Neurology, 11*, 413–422.
- Palisano, R. J. (1986). Use of chronological and adjusted ages to compare motor development of healthy preterm and fullterm infants. *Developmental Medicine and Child Neurology, 28*, 180–187.
- Palmer, F. B. (2004). Strategies for the early diagnosis of cerebral palsy. *The Journal of Pediatrics, 145*, S8-S11.
-