Response to Pediatric Physical Therapy in Infants With Positional Preference and Skull Deformation

Renske M. van Wijk, Maaike Pelsma, Catharina G.M. Groothuis-Oudshoorn, Maarten J. IJzerman, Leo A. van Vlimmeren, Magda M. Boere-Boonekamp

Background. Pediatric physical therapy seems to reduce skull deformation in infants with positional preference. However, not all infants show improvement.

Objective. The study objective was to determine which infant and parent characteristics were related to responses to pediatric physical therapy in infants who were 2 to 4 months old and had positional preference, skull deformation, or both.

Design. This was a prospective cohort study.

Methods. Infants who were 2 to 4 months old and had positional preference, skull deformation, or both were recruited by pediatric physical therapists at the start of pediatric physical therapy. The primary outcome was a good response or a poor response (moderate or severe skull deformation) at 4.5 to 6.5 months of age. Potential predictors for responses to pediatric physical therapy were assessed at baseline with questionnaires, plagiocephalometry, and the Alberta Infant Motor Scale. Univariate and multiple logistic regression analyses with a stepwise backward elimination method were performed.

Results. A total of 657 infants participated in the study. At follow-up, 364 infants (55.4%) showed a good response to therapy, and 293 infants (44.6%) showed a poor response. Multiple logistic regression analysis resulted in the identification of several significant predictors for a poor response to pediatric physical therapy at baseline: starting therapy after 3 months of age (adjusted odds ratio [aOR] = 1.50, 95% confidence interval [95% CI] = 1.04–2.17), skull deformation (plagiocephaly [aOR = 2.64, 95% CI = 1.67–4.17] or brachycephaly [aOR = 3.07, 95% CI = 2.09–4.52]), and a low parental satisfaction score (aOR = 2.64, 95% CI = 1.67–4.17). A low parental satisfaction score indicates low parental satisfaction with the infant’s head shape.

Limitations. Information about pediatric physical therapy was collected retrospectively and included general therapy characteristics. Because data were collected retrospectively, no adjustment in therapy for individual participants could be made.

Conclusions. Several predictors for responses to pediatric physical therapy in infants who were 2 to 4 months old and had positional preference, skull deformation, or both were identified. Health care professionals can use these predictors in daily practice to provide infants with more individualized therapy, resulting in a better chance for a good outcome.
Skull deformation in infants is a diverse condition with variations in clinical presentation and treatment policy. The 2 most common types of deformities are deformational plagiocephaly (unilateral occipital flattening of the skull)1-3 and deformational brachycephaly (symmetrical occipital flattening).3 Skull deformation seems to be most prevalent between 2 (16%-22%) and 4 (20%) months of age.4,5 An important risk factor is positional preference.5-7 Positional preference affects up to 18% of Dutch infants younger than 4 months and is defined as “the condition in which the infant, in supine position, shows head rotation to either the right or the left side for approximately three quarters of the time of observation. Active rotation of the head over a range of 180 degrees cannot be accomplished.”6(p340) In a recently published guideline (2012), the Netherlands Centre of Preventive Child Health Care advised pediatric physical therapy for infants with positional preference, skull deformation, or both starting at 2 months of age.8 A standardized pediatric physical therapy program was proven more effective than usual care in preventing or diminishing skull deformation in infants with positional preference, skull deformation, or both starting at 2 months of age.9 Despite the evidence supporting pediatric physical therapy, a considerable percentage (30% [10/33]) of infants who received therapy still had skull deformation at 6 months.9

Skull deformation is generally considered to be a cosmetic disorder that improves in time for most infants.4,6,10,11 However, because parents worry that skull deformation might influence their child’s attractiveness, with an increased risk of teasing or poor self-perception, they seek treatment.12 Treatment modalities are conservative and include parental counseling on handling and positioning or repositioning their infants. In the Netherlands, most infants (95%) are monitored by preventive child health care professionals during well-baby visits. When parental counseling at well-baby clinics does not result in improvement of skull deformation, infants are referred for pediatric physical therapy at a young age (2-4 months).8,9 Because skull deformation might serve as a marker for developmental delays in infants,13-15 both positional preference and skull deformation are medical grounds for starting pediatric physical therapy.

Because most infants show symmetry in posture at 5 to 6 months of age,6,9 no effects of continued pediatric physical therapy can be expected. Infants with persistent moderate or severe skull deformation at this age may then be treated with an orthotic helmet or headbands.16-18 This type of treatment has not yet been proved effective and can be a burden for both infants and their parents because of costs, improper fit of the helmet, pressure sores, and problems with acceptance.19,20

If more infants could benefit from pediatric physical therapy, fewer infants would need to be treated with helmet therapy. We believe that current pediatric physical therapist practice leaves room for improvement because of the high prevalence of positional preference and skull deformation, the malleability of young infants’ skulls, and the potential benefits of pediatric physical therapy started at 2 months of age. So that therapists can provide more targeted, individualized therapy, it is important for them to know the characteristics of infants who respond poorly to pediatric physical therapy and those of their parents. In the present study, a poor response to pediatric physical therapy was defined on the basis of the criterion used in the Netherlands for prescribing helmet therapy: moderate or severe skull deformation at 4.5 to 6.5 months of age.

The Bottom Line

What do we already know about this topic?

A standardized pediatric physical therapy program started in 7-week-old infants is effective in preventing or diminishing skull deformation. Nevertheless, a considerable number of infants who received therapy have skull deformation at age 6 months.

What new information does this study offer?

Visible skull deformation or a low parental satisfaction with their infant’s appearance at the start of therapy or starting therapy after 3 months of age predicted poor response (defined as skull deformation to such a degree that helmet therapy could be prescribed) to pediatric physical therapy.

If you’re a parent or a caregiver, what might these findings mean for you?

When health professionals are aware of these predictors and act accordingly, infants with positional preference or skull deformation are provided with better chances of a good outcome of pediatric physical therapy.
As yet, no studies of predictors for responses to pediatric physical therapy in infants at risk of skull deformation have been performed. The outcomes of studies on risk factors for skull deformation have suggested several infant factors that may serve as predictors for a poor response to pediatric physical therapy: male sex, low activity levels, bottle feeding, and tummy time when awake fewer than 3 times per day.4–6,21 Parental level of education, level of anxiety, and expectations of therapy are known to influence therapy adherence and outcome.22,23 Additionally, we expect that parents’ prior experiences with the condition also will influence responses to therapy. Finally, clinical factors such as severity of the condition and age at baseline are likely to be related to therapy outcome.24

The objective of the present study was to determine which early (measured at baseline) infant and parent characteristics were related to a poor response to pediatric physical therapy in infants with positional preference, skull deformation, or both.

### Method

#### Design and Setting

The present study of predictors for responses to pediatric physical therapy marks the first part of the comprehensive HEADS (HElmet therapy Assessment in infants with Deformed Skulls) study. The HEADS study is a prospective cohort study with a nested randomized controlled trial of helmet therapy in infants who are 4.5 to 6.5 months old.25 In this first part of the HEADS study, infants at risk of skull deformation (positional preference) or with existing deformation were monitored from 2 to 4 months of age (baseline) until 4.5 to 6.5 months of age. Table 1 shows the means and standard deviations for the characteristics of the participants.

Infants were included from April 2009 to November 2011. In the eastern part of the Netherlands, 70 pediatric physical therapists working in primary care or in general hospitals recruited participants for the present study. All therapists had experience with the outcome measurement instrument used in the present study (plagiocephalometry). Additionally, they received 3 instruction sessions: theory lessons on positional preference and skull deformation, a refresher course in plagiocephalometry,26,27 and instructions on how to recruit participants for research.

### Table 1.

Demographic Characteristics of Participants

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total Sample (N=657)</th>
<th>Infants With a Good Response to Therapy (n=364)</th>
<th>Infants With a Poor Response to Therapy (n=293)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. (%) of male participants</td>
<td>424 (64.5)</td>
<td>222 (61.0)</td>
<td>202 (68.9)</td>
</tr>
<tr>
<td>Mean (SD) baseline age (mo)</td>
<td>2.8 (0.6)</td>
<td>2.8 (0.5)</td>
<td>2.9 (0.6)</td>
</tr>
<tr>
<td>Mean (SD) follow-up age (mo)</td>
<td>5.1 (0.3)</td>
<td>5.1 (0.3)</td>
<td>5.1 (0.3)</td>
</tr>
<tr>
<td>Mean (SD) pediatric physical therapy duration (mo)</td>
<td>2.3 (0.6)</td>
<td>2.3 (0.6)</td>
<td>2.2 (0.6)</td>
</tr>
<tr>
<td>No. (%) of participants who were first born</td>
<td>341 (52.4)</td>
<td>195 (54.0)</td>
<td>146 (50.3)</td>
</tr>
<tr>
<td>No. (%) of participants with health problems</td>
<td>58 (8.8)</td>
<td>33 (9.1)</td>
<td>25 (8.5)</td>
</tr>
<tr>
<td>Mean (SD) maternal age (y)</td>
<td>30.4 (4.5)</td>
<td>31.8 (4.5)</td>
<td>31.1 (4.2)</td>
</tr>
<tr>
<td>Parental level of education, no. (%) of participants</td>
<td>108 (16.5)</td>
<td>51 (14.1)</td>
<td>57 (19.5)</td>
</tr>
<tr>
<td>Low</td>
<td>108 (16.5)</td>
<td>51 (14.1)</td>
<td>57 (19.5)</td>
</tr>
<tr>
<td>Medium</td>
<td>242 (37.0)</td>
<td>131 (36.2)</td>
<td>111 (38.0)</td>
</tr>
<tr>
<td>High</td>
<td>304 (46.3)</td>
<td>180 (49.7)</td>
<td>124 (42.5)</td>
</tr>
<tr>
<td>Ethnicity (ethnic minority), no. (%) of participants</td>
<td>31 (5.0)</td>
<td>9 (2.6)</td>
<td>22 (8.0)</td>
</tr>
</tbody>
</table>

*Groups were compared with the Student t test or chi-square test.

* P < .05.

Numbers do not add up to the total sample because of missing data.

Problems with sight and hearing, esophageal reflux, developmental dysplasia of the hip, congenital heart disease, and inguinal hernia.

Low—lower level of technical and vocational education and lower level of general secondary education, medium—intermediate level of vocational education and advanced secondary education, and high—higher level of vocational education and university.

At least 1 parent was not Dutch.
Between the baseline and follow-up assessments, all infants received pediatric physical therapy. Responses to therapy were determined from the outcome of the follow-up assessment at 4.5 to 6.5 months of age. Therapy and therapist characteristics were collected retrospectively in a questionnaire for pediatric physical therapists. This separate data collection took place after inclusion in the cohort had ended (from November 2011 to February 2012).

**Participants**

Infants who were 2 to 4 months old, who had positional preference, skull deformation, or both, and who were seen for pediatric physical therapy were included in the cohort study. Positional preference was determined as defined by Boere-Boonekamp and van der Linden-Kuiper. Skul deformation was determined by clinical diagnosis by the pediatric physical therapist. Infants were excluded from participation if their gestational age was less than 36 weeks or if they had congenital muscular torticollis, craniosynostosis, dysmorphic features, or a combination of these. Such infants need individualized diagnostics and treatment. All parents provided written informed consent before participation of their infants in the study.

A total of 704 infants were recruited for the study (Fig. 1). At follow-up, 3 infants did not meet the age criteria (between 4.5 and 6.5 months) and, therefore, were excluded. For 44 infants (6.3%), no follow-up information was available because of loss to follow-up, withdrawal, or loss of data during transport to the researcher. This dropout group differed from the study cohort in the following way: the parents had lower levels of state anxiety and, more often, no experience with positional preference, and the infants had more severe skull deformation and were less often bottle-fed. The remaining 657 participants were included in the present study.

**Data Collection**

The baseline assessment at 2 to 4 months of age consisted of a parental questionnaire and a clinical assessment by the pediatric physical therapist; the clinical assessment included an anthropometric assessment of the shape of the skull. The pediatric physical therapists collected all of the data and sent the gathered assessment data to the researcher (R.M.W.). All infants and their parents were invited by their pediatric physical therapists for follow-up assessments; if these follow-up assessments were performed when the infants were between 4.5 and 5.6 months of age, they were eligible for inclusion in the present study. Baseline and follow-up assessments were performed by the same pediatric physical therapist. Because they were involved in the treatment of the infants, the therapists were not unaware of infant and parent characteristics. Details about the therapy were collected in a questionnaire for the pediatric physical therapists.

**Baseline assessment.** The parental questionnaire included both infant and parent characteristics. Infant characteristics were sex, gestational age, birth rank, and health problems (eg, problems with sight or hearing, reflux, hip abnormalities, or congenital defects). Furthermore, the method of feeding and positioning of the infant while awake were assessed. Additionally, the age at the start of therapy was measured in months; early start and late start of pediatric physical therapy were...
defined as a start before or a start after the age of 3 months, respectively.

Parent characteristics were maternal age; level of education of 1 parent (the parent who had the highest level of education, according to the Dutch equivalent\textsuperscript{28} of the International Standard Classification of Education\textsuperscript{29}); experience with positional preference, skull deformation, or both in older children; satisfaction with their infant’s head shape; concern for their infant’s future; expectations of the outcome of pediatric physical therapy; and level of anxiety. Parental satisfaction with their infant’s head shape was assessed with a 5-point Likert scale ranging from 1 (“not satisfied at all”) to 5 (“very satisfied”). A score below 4 represented a low level of parental satisfaction. Parental concern for their infant’s future was also measured with a 5-point Likert scale ranging from 1 (“very concerned”) to 5 (“hardly concerned”). A score below 4 represented parental concern. The level of parental anxiety was measured with the Dutch version of the Spielberger State-Trait Anxiety Inventory (STAI).\textsuperscript{30} In the present study, general anxiety disposition was assessed (trait anxiety; 20 items). Scores ranged from 20 to 80; a higher score represented a higher level of anxiety. The STAI Trait Scale has an internal consistency represented by a Cronbach alpha of greater than .80.\textsuperscript{30}

For the clinical assessment, the pediatric physical therapist assessed the presence of positional preference according to the definition of Boere-Boonekamp and van der Linden-Kuiper.\textsuperscript{6} Next, the pediatric physical therapist measured skull deformation using plagiocephalometry. Plagiocephalometry is a noninvasive, valid (in agreement with measurements from 3-dimensional computed tomographic scanning\textsuperscript{26}), and reliable (intraclass correlation coefficients of interrater and intrarater reliability for all indexes were >.90\textsuperscript{27}) method for measuring 2-dimensional skull shape at the widest transverse head circumference with a thermoplastic measuring ring (Fig. 2).\textsuperscript{26,27} The oblique diameter difference index (ODDI) from the plagiocephalometry is an indicator of plagiocephaly, and the cranial proportional index (CPI) from the plagiocephalometry is an indicator of brachycephaly. The ODDI was calculated by dividing the longest oblique diameter by the shortest oblique diameter and multiplying by 100%. A value of 100% represented a purely symmetric head shape; the higher the score above 100%, the more severe the deformation. The CPI was calculated by dividing the width of the skull by the length of the skull and multiplying by 100%. A score of 80% represented an average head shape in Western countries\textsuperscript{31}; a higher value represented a larger width-to-length ratio.

The presence of skull deformation as a predictor at baseline was determined with the plagiocephalometry cutoff values for visible skull deformation. Skull deformation was considered to be clearly visible and clinically meaningful when the ODDI was greater than or equal to 104% or the CPI was greater than or equal to 90% (Fig. 2).\textsuperscript{9}

Additionally, the pediatric physical therapist assessed the qualitative gross motor movement repertoire with the Alberta Infant Motor Scale (AIMS), a valid, norm-referenced measurement. The AIMS raw scores were converted to standardized \( z \) scores: (individual score − average score)/standard deviation.\textsuperscript{32} A score of less than −1 standard deviation was considered to indicate moder-
ate delayed motor development. High interrater and intrarater reliability values have been reported for the AIMS; intraclass correlation coefficients for both were .98 to .99.5,8,35,36 Concurrent validity testing of the AIMS with both the Bailey Scales of Infant Development II and the Peabody Developmental Motor Scales also generated high values ($r \geq .90$).5,8

**Pediatric physical therapists and therapy.** The pediatric physical therapy program consisted of positioning and handling in the direction opposite the observed positional preference and activities or exercises that facilitated positions or movements opposite the positional preference. Parents were taught how to incorporate the program into daily activities, such as playing, nursing, changing, dressing, feeding, and sleeping. The aims of the therapy included achieving full active cervical range of motion and symmetrical motor development. Parents were advised to apply tummy time as early, as long, and as frequently as advised to apply tummy time as motor development. Parents were included achieving full active cervical range of motion and symmetrical movements opposite the positional preference and activities or exercises that facilitated positions or movements opposite the positional preference and activities or exercises that facilitated positions or movements opposite the observed positional preference. The associations between responses to therapy and infant and parent characteristics were analyzed with univariate logistic regression analysis. Next, all variables were tested simultaneously in a multiple logistic regression analysis. The baseline characteristics of participants with each other ($\alpha < .01$ and Pearson $r > .80$). The likelihood ratio statistic was used for variable removal, and the criteria for entry or removal of a variable in the model were set at .20 and .05, respectively. The exclusion of 10% of participants with missing data in the multivariate analysis was allowed. Adjusted odds ratios (aORs) and 95% confidence intervals (95% CIs) were used as estimates of association. We also examined the variance explained by the multiple logistic regression model with the pseudo (Nagelkerke) $R^2$ statistic. The level of significance was set at the 5% level (2-tailed). Statistical analyses were carried out with IBM SPSS Statistics for Windows version 21.0 (IBM Corp., Armonk, New York).

A poor response was reported as an ODDI of greater than or equal to 108% (plagiocephaly), a CPI of greater than or equal to 95% (brachycephaly), or an ODDI of greater than or equal to 106% and a CPI of greater than or equal to 92% (mixed form).25,37 These cutoff points are useful for clinical decision making.

**Data Analysis**

The baseline characteristics of the study sample were described for the total sample and for the outcome groups separately (good and poor responses to therapy). Groups were compared with the Student $t$ test or chi-square test. The associations between responses to therapy and infant and parent characteristics were analyzed with univariate logistic regression analysis. Next, all variables were tested simultaneously in a multiple logistic regression analysis with stepwise backward elimination. Before multiple regression, we ruled out relevant correlations of any of the predictors with each other (alpha=.01 and Pearson $r > .80$). The likelihood ratio statistic was used for variable removal, and the criteria for entry or removal of a variable in the model were set at .20 and .05, respectively. The exclusion of 10% of participants with missing data in the multivariate analysis was allowed. Adjusted odds ratios (aORs) and 95% confidence intervals (95% CIs) were used as estimates of association. We also examined the variance explained by the multiple logistic regression model with the pseudo (Nagelkerke) $R^2$ statistic. The level of significance was set at the 5% level (2-tailed). Statistical analyses were carried out with IBM SPSS Statistics for Windows version 21.0 (IBM Corp., Armonk, New York).

Role of the Funding Source

The HEADS study was funded by ZonMw, the Netherlands Organization for Health Research and Development (grant number 170.992.501). Besides the initial review process before funding and amendments, ZonMw did not have any involvement in the design and management of the study and publications.

**Results**

**Participants**

Participants were split into 2 groups on the basis of the outcome of the follow-up assessment: 364 infants (55.4%) responded well to therapy, and 293 infants (44.6%) responded poorly. Table 1 shows the baseline characteristics of the total sample and of the outcome groups separately. Male infants (64.5% of the sample) were more likely to respond poorly to therapy than female infants. Additionally, infants with a poor response were more likely to have parents with a lower level of education and parents with a non-Dutch background.

Both groups had a mean age of 5.1 months (SD=0.3 month) at follow-up. The mean time between baseline and follow-up measurements was 2.3 months (SD=0.6 month); this time was similar for the 2 groups.

**Predictors for Responses**

The baseline characteristics male sex (odds ratio [OR]=1.42, 95% CI=1.03–1.97), starting therapy after 3 months of age (OR=1.49, 95% CI=1.08–2.05), skull deformation (plagiocephaly [OR=2.14, 95% CI=1.41–3.26] or brachycephaly [OR=3.42, 95% CI=2.46–4.76]), being bottle-fed (OR=1.81, 95% CI=1.24–2.62), and low level of parental satisfaction with their infant’s head shape (OR=3.26, 95% CI=2.15–4.93) were significantly associated with a poor response to therapy (Tab. 2). Delayed motor
development did not appear to be associated with a poor response to therapy.

Table 2 shows the results of the multiple logistic regression analysis with stepwise backward elimination. Sixty-one participants (9.3%) were excluded from further analysis because of missing values for 1 of the variables included in the model. No strong correlations were found between the various characteristics (the Pearson r value for all variables was ≤ .30).

The significant independent predictors for a poor response to therapy were starting therapy after 3 months of age (aOR=1.50, 95% CI=1.04–2.17), skull deformation (plagiocephaly [aOR=2.64, 95% CI=1.67–4.17] or brachycephaly [aOR=3.07, 95% CI=2.09–4.52]), and a low parental satisfaction score regarding the infant’s head shape (OR=2.46, 95% CI=1.67–4.17). Sex, method of feeding, and frequency of tummy time at baseline had P values just above the level of significance in the stepwise backward elimination multivariate model (P=.07, P=.07, and P=.06, respectively).

**Pediatric Physical Therapists and Therapy**

Of the 70 pediatric physical therapists, 67 (96%) returned the questionnaire concerning therapist and therapy details. One therapist reported a lack of time to fill out the questionnaire because of a heavy workload, and 2 others did not return the questionnaire. Most of the pediatric physical therapists were women (96%), and their ages ranged

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**Table 2.**

Univariate and Multivariate Analyses of Possible Predictors for Responses to Therapy at Baseline

<table>
<thead>
<tr>
<th>Possible Predictor</th>
<th>No. of Participants for Whom Data Were Missing</th>
<th>Infants With a Good Response to Therapy (n=364)</th>
<th>Infants With a Poor Response to Therapy (n=293)</th>
<th>Univariate Analysis</th>
<th>Multivariate Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infant characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male participants</td>
<td>0</td>
<td>222 (61.0)</td>
<td>202 (68.9)</td>
<td>1.42 (1.03–1.97)</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>≥3 mo of age</td>
<td>0</td>
<td>118 (32.4)</td>
<td>122 (41.6)</td>
<td>1.49 (1.08–2.05)</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Skull deformation</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plagiocephaly (ODDI≥104%)</td>
<td></td>
<td>278 (76.4)</td>
<td>256 (87.4)</td>
<td>2.14 (1.41–3.26)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Brachycephaly (CPI90%)</td>
<td></td>
<td>90 (24.7)</td>
<td>155 (52.9)</td>
<td>3.42 (2.46–4.76)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Positional preference</td>
<td>7</td>
<td>259 (72.1)</td>
<td>207 (71.1)</td>
<td>0.95 (0.68–1.34)</td>
<td>.78</td>
</tr>
<tr>
<td>Motor development (AIMS z score &lt;−1 SD)</td>
<td>5</td>
<td>98 (26.9)</td>
<td>93 (32.3)</td>
<td>1.30 (0.92–1.82)</td>
<td>.14</td>
</tr>
<tr>
<td>Only bottle feeding</td>
<td>8</td>
<td>254 (70.8)</td>
<td>236 (81.4)</td>
<td>1.81 (1.24–2.62)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>&lt;3 times/d tummy time before therapy</td>
<td>4</td>
<td>232 (64.3)</td>
<td>205 (70.2)</td>
<td>1.31 (0.94–1.82)</td>
<td>.11</td>
</tr>
<tr>
<td><strong>Parent characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of education</td>
<td>3</td>
<td></td>
<td></td>
<td>1.62 (1.04–2.52)</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>51 (14.1)</td>
<td>57 (19.5)</td>
<td>1.23 (0.88–1.73)</td>
<td>.23</td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td>131 (36.2)</td>
<td>111 (38.0)</td>
<td>1.24 (0.97–2.52)</td>
<td>.19</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td>180 (49.7)</td>
<td>124 (42.5)</td>
<td>0.91 (0.61–1.37)</td>
<td>.65</td>
</tr>
<tr>
<td>Experience with positional preference</td>
<td>10</td>
<td>51 (14.3)</td>
<td>56 (19.4)</td>
<td>3.26 (2.15–4.93)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Low level of parental satisfaction</td>
<td>6</td>
<td>247 (68.4)</td>
<td>254 (87.6)</td>
<td>2.64 (1.64–4.17)</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Parental concern</td>
<td>3</td>
<td>67 (18.5)</td>
<td>70 (24.1)</td>
<td>1.40 (0.96–2.04)</td>
<td>.08</td>
</tr>
<tr>
<td>Low expectations of outcome of pediatric physical therapy</td>
<td>12</td>
<td>51 (14.1)</td>
<td>56 (19.4)</td>
<td>1.45 (0.96–2.20)</td>
<td>.08</td>
</tr>
<tr>
<td>Trait anxiety</td>
<td>9</td>
<td>29 (25–35)</td>
<td>30 (25–30)</td>
<td>1.01 (0.99–1.03)</td>
<td>.25</td>
</tr>
</tbody>
</table>

a Data are presented as number (percentage) of participants unless otherwise indicated. OR=odds ratio, 95% CI=95% confidence interval, ODDI=oblique diameter difference index, CPI=cranial proportional index, AIMS z score=standardized score on the Alberta Infant Motor Scale.

b Pseudo (Nagelkerke) R²=.201; predicted percentage correct=67.3%; 61 participants (9.3%) with missing data were excluded from the analysis.

c Low=lower level of technical and vocational education and lower level of general secondary education, medium=intermediate level of vocational education and advanced secondary education, and high=higher level of vocational education and university.

d Total score on the Trait Scale of the Dutch version of the Spielberger State-Trait Anxiety Inventory; values are reported as median (interquartile range).
from 20 to more than 60 years; 28 therapists were younger than 40 years of age (42%), and 39 therapists were 40 years of age or older (58%). Ninety-four percent of the therapists had at least 3 years of clinical experience.

Almost all (96%) of the infants received between 3 and 8 sessions of pediatric physical therapy within a mean time frame of 2.3 months (SD=0.6 month). Most therapists (67%) provided 2 or 3 sessions per month. The majority (61%) of therapy sessions lasted 31 to 45 minutes, and a minority (37%) lasted 16 to 30 minutes; 1 therapist reported “other” for this item. Almost all (98%) of the pediatric physical therapists advised tummy time for at least 3 times per day from the age of 2 months on. About half (52%) of the therapists provided a sheet or leaflet with information about the condition, exercises, or both.

Discussion

In this article, we reported infant and parent characteristics related to responses to pediatric physical therapy in infants with positional preference, skull deformation, or both. Independent predictors for a poor response to pediatric physical therapy were starting therapy after 3 months of age, skull deformation (ODD1=104% or CPI=90%) at the start of therapy, and a low parental satisfaction score regarding their infant’s head shape. It can be expected that infants with skull deformation at baseline (based on either anthropometric measurement or parental satisfaction) and infants who start therapy at an older age will be more likely to respond poorly to pediatric physical therapy.24 An older age at the start of therapy allows less time for pediatric physical therapy to improve the infant’s skull deformation.

The $P$ values for male sex, infants who were not used to frequent tummy time, and infants who were bottle-fed as predictors for therapy outcomes were just above the level of significance. Male sex is a known risk factor for the development of skull deformation and was identified as a predictor for a poor outcome in the univariate analysis in the present study.5,38,58 Because male infants tend to have larger heads than female infants, head control is expected to be more difficult and the weight of the larger head continues to function as an external molding force.7,38,39 It also has been suggested that male infants have poorer motor developmental outcomes than female infants.40,41 However, this association was not found in the present study. We expected that infants who had a low frequency of tummy time and were bottle-fed might be less responsive to therapy advice and exercises because they were not used to many variations in posture and position. This notion is in line with findings in the literature on risk factors for developing deformational plagiocephaly.5,6 Infants who are bottle-fed are often approached from 1 side and are more at risk of developing a positional preference.5 Because infants are fed frequently, this positioning factor can play an important role in the infant’s development.

Comparison With Other Studies

It has frequently been suggested that developmental delays exist in infants with skull deformation,10,13,15,21,41 but no association of motor development with skull deformation at 4.5 to 6.5 months of age was established in the present study. We did find a median AIMS $z$ score of $-0.50$ at baseline; this $z$ score was comparable to the $z$ score found in the randomized controlled trial of van Vlimmeren et al9 but slightly lower than expected for the general population. However, the reference values are based on a Canadian population and were established 20 years ago.32 Therefore, they may be inappropriate for Dutch infants, who appear to have lower scores.42

The effectiveness of a standardized pediatric physical therapy program was studied in the randomized controlled trial by van Vlimmeren et al (N=65).9 The number of participants in that trial was sufficient for an effectiveness study but not for identifying predictors for responses to pediatric physical therapy in daily practice—which is what we set out to do in the present study (N=657). This number of participants is needed to explore relationships between various characteristics and pediatric physical therapy outcomes. However, to enable us to draw conclusions about predictors in the cohort in the present study, it was also important to report details about the pediatric physical therapy program. Details about the therapy in the present study matched the description of the therapy under study in the randomized controlled trial of van Vlimmeren et al.9 Additionally, therapists gave advice to parents about the frequency of tummy time, in line with the recommendations of the recently published Dutch guideline on positional preference and skull deformation (≥3 times per day).8

The responses to therapy in the present study could not be compared with the results found by van Vlimmeren et al9 because different outcome cutoff points were used, the ages at follow-up were different, and the participants in the 2 studies were not comparable in terms of the severity of skull deformation at baseline. The differences could be explained by the use of different study designs: The inclusion criteria in the present study included positional preference, skull deformation, or both, and all of the infants were either referred...
for pediatric physical therapy by health care professionals or self-referred, whereas the sample in the randomized controlled trial of van Vlimmeren et al was nested in a birth cohort, and the infants were screened for positional preference for inclusion.

Strengths and Limitations

A strength of the present study was the large number of included infants; this large cohort was necessary to explore relationships between various characteristics and outcomes. In addition, the fact that the study was conducted in a geographically widespread area and in both primary care and general hospitals improved external validity. Together with the large number of participating pediatric physical therapists, these characteristics made selection bias by therapists unlikely.

Loss to follow-up is problematic in most cohort studies and often leads to bias. However, only 6.3% of potential data were lost in this way in the present study. Even though the data lost to follow-up were “missing not at random,” we do not believe that this small selective loss to follow-up had a marked impact on the generalizability of the results.

The present study also had some limitations. First, the explained variance was 20% (pseudo [Nagelkerke] $R^2=.2$). We were able to identify predictors for outcomes, but other factors remain unknown.

We collected general information about therapy per therapist and not per infant and collected this information retrospectively. We expect that therapy characteristics collected per patient in a prospective manner might explain a large part of the remaining variance in outcome.

Furthermore, the fact that pediatric physical therapists who had taken a course on plagiocephalometry were invited to participate in the HEADS study might have generated a selective group of therapists more interested in and knowledgeable about positional preference or skull deformation than pediatric physical therapists in general. They might have provided a more targeted approach than pediatric physical therapists in general would have.

In conclusion, the factors found to be related to responses to pediatric physical therapy in the present study can be used in daily practice by health care professionals working with infants who have positional preference or skull deformation. Health care professionals working in preventive child health care ideally should refer infants with persistent positional preference or skull deformation to a pediatric physical therapist before the infants are 3 months old. When pediatric physical therapy is started at this age, infants may be more likely to respond well to therapy. Additionally, pediatric physical therapists should be alert to infants with characteristics matching the predictors found in the present study. Infants who begin receiving pediatric physical therapy when they are more than 3 months old, have skull deformation, or have parents with a low satisfaction score regarding their infant’s head shape appear to be less responsive to the therapy and are at risk for poor response to therapy.

To determine the prognostic strength of the characteristics discussed here, future research should involve a prospective approach in which individual therapy characteristics are taken into account. Finally, whether infants at risk will benefit from a more targeted pediatric physical therapy approach has yet to be determined.

All authors provided concept/idea/research design. Ms van Wijk and Ms Pelsma provided data collection and wrote the first draft of the manuscript. Ms van Wijk, Ms Pelsma, and Dr Groothuis-Oudshoorn provided data analysis. Ms van Wijk, Dr van Vlimmeren, and Dr Boere-Boonekamp provided project management. Professor IJzerman, Dr van Vlimmeren, and Dr Boere-Boonekamp provided fund procurement. Ms Pelsma, Dr Groothuis-Oudshoorn, Professor IJzerman, Dr van Vlimmeren, and Dr Boere-Boonekamp provided consultation and revision of the manuscript. All authors provided approval of the manuscript before submission. The authors thank the HEADS study pediatric physical therapists for participating in the present study and Mrs Laura Myles for proofreading and editing the manuscript.

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