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Prevailing head position to one side in early infancy—A population-based study

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Abstract

Aim: To determine the prevalence of prevailing head position to one side (PHP) in young infants and to evaluate its associations with reaching performance, neurological condition and perinatal and socio-economic factors.

Methods: Observational study in 500 infants (273 boys) 2-6 months corrected age, representative of the Dutch population (median gestational age 39.7 weeks (27-42); birthweight 3438 g (1120-4950). Prevailing head position to one side and reaching performance were assessed with the Infant Motor Profile; neurological condition with the Standardized Infant NeuroDevelopmental Assessment. Socio-economic information and perinatal information were obtained by questionnaire and medical records. Associations were analysed with uni- and multivariable statistics.

Results: Prevailing head position to one side was observed in 100 infants (20%), and its prevalence decreased from 49% at 2 months to 0% at 6 months. Only in infants aged 4-5 months PHP was significantly associated with worse reaching and an at-risk neurological score. Prevailing head position to one side was weakly associated with prenatal substance exposure, post-natal admission to a paediatric ward and paternal native Dutch background.

Conclusion: Prevailing head position to one side at 2-3 months is a frequently occurring sign with limited clinical significance. Yet, PHP at 4-5 months is associated with a worse functional and neurological condition. Therefore, PHP at 4-5 months could serve as a red flag indicating possible challenges in later development.

KEYWORDS

infancy, motor development, neurological condition, perinatal risk, prevailing head position

1 | INTRODUCTION

Head control is one of the prerequisites for young infants to learn and explore their environment.[1] In early infancy, proper head control is not yet fully established, reflecting that development needs time. In the first month after birth, head movements may be considered as an element of non–object-oriented exploratory behaviour, that is head movements against gravity and towards the midline or to the

Abbreviations: CA, corrected age; IMP, Infant Motor Profile; METc, Medical Ethical Committee; OR, odds ratio; PHP, prevailing head position to one side; SINDA, Standardized Infant NeuroDevelopmental Assessment; SPSS, Statistical Package for the Social Sciences; UMCG, University Medical Center Groningen.

contralateral side. This exploratory behaviour allows infants to learn to control their bodies.[2] This, in turn, is essential for the development of early behaviours in which vision and movements of trunk and arms are involved, such as reaching and grasping—behaviours that are largely dependent on adequate postural control.[3-5] Impaired head control is regarded as a manifestation of neurological non-optimality. Therefore, items evaluating head behaviour are included in all common infant neurological assessment methods.[6-8]

A frequently occurring clinical manifestation of non-optimal head control is a prevailing head position to one side (PHP).[9] The prevalence of PHP increased after the launch of the Back to Sleep campaign by the American Academy of Pediatrics in 1994, rising to 10%-11% in infants aged 2-4 months in the Netherlands in 2001.[10,11] PHP may lead to deformational plagiocephaly, a condition that has been associated with developmental delays in gross and fine motor function, problem-solving and personal social skills.[12-14] Although the studies reporting these associations have several limitations and only show tentative results, they do state that PHP could be a marker of conditions impeding typical development, such as neuromuscular conditions and environmental positioning limitations.[15] Professional awareness of these associations and caregivers' concerns about the asymmetric motor behaviour of the infant frequently results in referral to paediatric physiotherapy.[10]

Knowledge about the current prevalence of PHP in the general population is sparse. The data available are Dutch data of infants aged 2-6 months of the general population in 1995,[10] data of 4-month-olds in the general New Zealand population in 2004[16] and data of 2-3 months old term born infants from the Netherlands and Italy, studied in 2005[17] and 2015,[18] respectively. In addition, no data are available on PHP's association with functional abilities, such as reaching, and with perinatal risk factors. The IMP-SINDA project offered an excellent opportunity to fill this knowledge gap. In the IMP-SINDA project, we collected norm data for two novel infant assessments: the Infant Motor Profile (IMP)[19] and the Standardized Infant NeuroDevelopmental Assessment (SINDA)[7] in a large sample representative of the Dutch population. The current study focussed on infants aged 2-6 months. In these infants, we addressed the following questions: (a) What is the prevalence of PHP?; (b) Is PHP associated with worse performance in reaching, grasping and manipulation?; (c) Is PHP associated with an impaired neurological condition in general, and—more specifically—with impaired postural control reflected by an atypical performance during the pull-to-sit manoeuvre?; and (d) Is PHP associated with perinatal and socio-economic risk factors?

Key notes

- In the general Dutch population, the prevalence of prevailing head position (PHP) steeply decreases from 49% at 2 months to 0% at 6 months.
- PHP at 2-3 months has limited clinical significance, but PHP at 4-5 months is associated with worse functional and neurological condition.
- PHP in the general population is only weakly associated with perinatal risk factors.

2 | PATIENTS AND METHODS

2.1 | Study population

In this cross-sectional study, we evaluated motor behaviour of 500 infants (273 boys and 227 girls) aged 2-6 months corrected age (CA). The infants were the youngest infants of the IMP-SINDA project. Inclusion criteria of the IMP-SINDA project were as follows: age 2-18 months CA living in the northern part of the Netherlands (covering about a quarter of the surface area of the Netherlands) and having caregivers with sufficient comprehension of the Dutch language. Infants were only excluded if they were too ill to be assessed (eg severe congenital heart disease with insufficient oxygen saturation). We achieved the aim to recruit 100 infants per age month, whose socio-economic background is representative of the general Dutch population. Recruitment took place at well-baby clinics and by advertisements. Each infant was assessed once. The infant's age in a specific age month category ranged from 2 weeks prior to the exact age in months CA to 2 weeks after that exact age, for example the age of 3 months CA ranged from 2 months and 15 days to 3 months and 14 days. The Medical Ethical Committee of the University Medical Centre Groningen (UMCG) approved the study design (approval number: METc 2016/294). All caregivers provided written informed consent.

2.2 | Procedures

Infants were assessed between January 2017 and March 2019 at the Institute of Developmental Neurology of the UMCG, at well-baby clinics or at the infant's home, depending on caregivers' preferences. A team of trained assessors examined the infants. The entire assessment was video-recorded. The videos served two goals: (a) enabling the assessors to perform the IMP-assessment, which is a video-based assessment; and (b) serving as a means for supervision of the SINDA. The assessors were supervised by two experts (MHA and KRH for the IMP; MHA for the SINDA), who were not aware of the socio-economic background and clinical history of the infant. The experts are reliable assessors of the IMP and SINDA; the good reliability of their performances was reported elsewhere.[7,19]

2.3 | Measurements

2.3.1 | Perinatal and socio-economic characteristics

Caregivers filled out a standardised questionnaire on prenatal, perinatal and neonatal (in short: perinatal) and socio-economic history.

If the questionnaire revealed complications, medical records were consulted. Based on these data, a perinatal risk score was calculated (Table 1).

2.3.2 | Infant Motor Profile

Prevailing head position to one side was determined on the basis of the IMP, a valid and reliable video-based assessment of self-produced motor behaviour in different positions in infants aged 3-18 months. Its 80 items provide information on the domains variation, adaptability, symmetry, fluency and motor performance.[19] The IMP includes three items on PHP, that is items evaluate the presence of asymmetrical head position in supine, prone and (supported) sitting position. These IMP items are scored as no or mildly/moderately/strongly PHP. Prevailing head position to one side was defined as the presence of a moderately or strongly prevailing head position in at least two of the three positions mentioned above. The infant's ability to reach, grasp and manipulate was based on the IMP-performance item assessing this ability when the infant sits on the caregiver's lap (score range 1-7; a higher score denotes a better performance; Table 2).

2.3.3 | SINDA's neurological scale

The SINDA is a novel neurodevelopmental screening instrument applicable for infants aged 6 weeks to 12 months. SINDA's neurological scale consists of 28 items, scored as typical or atypical. It results in a score ranging from 0 to 28, with 28 indicating best performance. A total score of ≤ 21 (the at-risk neurological score) was associated with an increased risk of a developmental disorder.[7] One of the items evaluates the infant's behaviour during the pull-to-sit manoeuvre. Atypical performance implies the presence of head lag, active head retroflection and/or insufficient hip flexion. The first study on SINDA's neurological scale indicated that it is a reliable and valid assessment tool.[7]

2.4 | Statistical analysis

To calculate the study's power a two-sample *t* test for the reaching parameter was performed, assuming that the overall prevalence of PHP at 2-6 months was 6%.[10] Considering a 1-point difference in the reaching score as clinically relevant, the sample size of 500 results in a power of 80% (α = .05).

Associations between PHP on the one hand and reaching behaviour and SINDA's total neurological score on the other were evaluated with the Mann-Whitney *U* test; those between PHP and an at-risk neurological score and atypical pull-to-sit manoeuvre with the chi-square test, with Phi as the measure of the effect size. Associations between PHP and perinatal risk factors were assessed with the chi-square test and the Mann-Whitney *U* test. Next, we performed backward multivariable logistic regression analysis to determine which factors contributed most to PHP; only factors that reached $P < .15$ in the univariable analyses were entered into this analysis. Throughout the analyses, confidence intervals (CI) were set at 95%, and *P*-values < .05 were considered statistically significant (two-tailed). In case of missing data on perinatal characteristics, cases were omitted from the association analyses. Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS), version 23 (SPSS IC., Chicago, IL).

3 | RESULTS

The background characteristics of the study group are shown in Table 1. They reflect the low-risk nature of the group with a median gestational age of 39.7 weeks (range 27-42) and a median birthweight of 3438 g (range 1120-4950). The study group contained two infants with a known syndrome: one was diagnosed with trisomy 21 and one with Gorlin syndrome. The background characteristics resemble those of the general Dutch population, including the prevalence of preterm birth (6.2% in our study and 6.8% in the general population)[20] and the infants' socio-economic background (prevalence of highly educated mothers 40% in our study and 37% in the general population).[21]

3.1 | Prevalence of PHP

The prevalence of PHP in our total study group was 20%, with a steady and significant decrease from 49% at 2 months to 0% at 6 months (Table 2, Figure 1A).

3.2 | PHP and performance on reaching, grasping and manipulation

Prevailing head position to one side was significantly associated with worse reaching, grasping and manipulation (in short: reaching; $P < .001$; Table 2). This association was age dependent (Figure 1B): only infants aged 4-5 months with PHP scored significantly lower on reaching than their peers without PHP ($P < .001$).

3.3 | SINDA's neurological scale scores and PHP

SINDA's neurological scores ranged from 11 to 28 points, with a median value of 25. This reflects the low-risk nature of the study group. Prevailing head position to one side was associated with a significantly lower SINDA neurological score; this held true for all ages (Figure 1C). Fifty-five infants of the total group (11%) had an at-risk neurological score. Also, the at-risk score was associated with PHP ($P < .001$). The association was age dependent. In the infants aged 2-3 months, the at-risk score was not associated with PHP

TABLE 1 Socio-economic and perinatal characteristics

Sex (boy/girl), n (%)	273 (55)/227 (45)
Maternal education level[*,a]	
I/II/III/IV, n (%)	10 (2)/53 (11)/234 (47)/202 (40)
Paternal education level[*,a]	
I/II/III/IV, n (%)	18 (4)/42 (9)/228 (48)/189 (40)
Maternal occupation level[*,b]	
I/II/III/IV, n (%)	110 (22)/121 (24)/116 (23)/150 (30)
Paternal occupation level[*,b]	
I/II/III/IV, n (%)	63 (13)/190 (40)/92 (19)/130 (27)
Maternal age	
in years, mean ± SD	29.9 ± 4.7
<20/20-34/**≥35**, n (%)	2 (0.4)/416 (83)/82 (16)
Paternal age[*]	
in years, mean ± SD	32.9 ± 6.3
<20/20-39/≥40	0/427 (88)/57 (12)
Maternal ethnicity[c]: native Dutch/**non-native Dutch**, n (%)	447 (89)/53 (11)
Paternal ethnicity[*,c]: native Dutch/**non-native Dutch**, n (%)	440 (90)/48 (10)
Pre-pregnancy maternal BMI[*]	
in kg/m^2, median (range)	24.1 (17.2-48.4)
<25/**25-29**/**≥30**, n (%)	285 (57)/134 (27)/79 (16)
Assisted reproduction[*], n (%)	36 (7)
hormonal treatment, n (%)	11 (2)
intrauterine insemination, n (%)	15 (3)
IVF/ICSI, n (%)	10 (2)
Maternal smoking[*], n (%)	53 (11)
Prenatal substance exposure (alcohol and/or drugs)[*], n (%)	5 (1)
Maternal medication[*,d], n (%)	58 (12)
Diabetes[*], n (%)	37 (7)
without medication, n (%)	18 (4)
with medication, n (%)	19 (4)
Hypertension[*], n (%)	68 (14)
without medication, n (%)	49 (10)
with medication, n (%)	19 (4)
Thyroid disease[*], n (%)	15 (3)
without medication, n (%)	3 (0.6)
with medication, n (%)	12 (2)
Instrumental delivery, n (%)	123 (25)
caesarean section, n (%)	85 (17)
vacuum or forceps extraction, n (%)	38 (8)
Gestational age	
in weeks, median (range)	39.7 (27.3-42.1)
preterm/term, n (%)	31 (6)/469 (94)
Birthweight	
in grams, median (range)	3438 (1120-4950)
SGA (<P10)/APA (P10-90)/LGA (≥P90), n (%)	60 (12)/384 (77)/56 (11)
Twin, n (%)	12 (2)
Meconium in amniotic fluid[*], n (%)	73 (15)
Non-optimal start[*,e], n (%)	43 (9)
Admission to neonatal ward, n (%)	101 (20)
Jaundice requiring phototherapy, n (%)	21 (4)
Perinatal risk score[*], median (range)	2 (0-7)

Note: Bold: factors included in the perinatal risk score and their criteria; score range 0-23; a higher score denotes a higher risk; at the bottom of the table.

[a]I = no or only primary education/II = primary or secondary vocational education and training/III = secondary vocational training, senior general secondary education and university preparatory education/IV = vocational college and university.

[b]Based on the International Standard Classification of Occupations, ISCO.[28] I = ISCO1 and unemployed/II = ISCO2/III = ISCO3/IV = ISCO4.

[c]Native Dutch: location of birth is the Netherlands. Non-native Dutch: location of birth is not the Netherlands.

[d]Used one of the following: insulin; antihypertensive medication; thyroid-stimulating medication; antidepressants/antipsychotics/benzodiazepines; anti-epileptic medication.

[e]The presence of delayed onset of crying, respiratory difficulties requiring monitoring on the neonatal ward and/or respiratory intervention, short-lasting floppiness or cyanosis.

[*]Missing: maternal education level n = 1; paternal education level n = 23; maternal occupation level n = 3; paternal occupation level n = 25; paternal age n = 16; paternal ethnicity n = 12; maternal BMI n = 2; [pregnancy characteristics n = 1;] assisted reproduction n = 4; maternal smoking, prenatal substance exposure, maternal medication, diabetes, hypertension, thyroid disease n = 1; meconium in amniotic fluid n = 2; non-optimal start, admission to neonatal ward, jaundice requiring phototherapy n = 1; perinatal risk score n = 34.

(at-risk score in infants with PHP: 18/81 (22%); in infants without PHP 16/119 (13%)) ($\chi^2(1) = 2.631$, Phi = 0.115, $P = .105$). However, in infants aged 4-5 months the at-risk score was associated with PHP (at-risk score in infants with PHP: 6/19 (32%); in infants without PHP: 10/181 (6%); $\chi^2(1) = 15.859$, Phi = 0.282, $P < .001$). An atypical performance on the pull-to-sit manoeuvre was present in 172 infants (34%). It was clearly associated with PHP ($\chi^2(1) = 33.318$, Phi = 0.258, $P < .001$). This association was not age dependent.

3.4 | Perinatal risk factors and PHP

Univariable analyses revealed that PHP was significantly associated with prenatal substance exposure ($\chi^2(1) = 5.015$, Phi = 0.100, $P = .025$), post-natal admission to the neonatal ward ($\chi^2(1) = 4.611$, Phi = 0.096, $P = .032$), jaundice requiring phototherapy ($\chi^2(1) = 7.087$, Phi = 0.119, $P = .008$), a lower paternal occupation level ($U = 15\,569$, $P = .022$), and

TABLE 2 Neuromotor performance from 2 to 6 mo

	Age in months					
Neuromotor behaviour	2 (n = 100)	3 (n = 100)	4 (n = 100)	5 (n = 100)	6 (n = 100)	Total (n = 500)
PHP[a], n (%)	49 (49)	32 (32)	16 (16)	3 (3)	0 (0)	100 (20)
Reaching, grasping and manipulation[b], n (%)						
1. No prereaching or reaching	44	17	3	0	0	64 (13)
2. No reaching, but prereaching	48	56	39	12	0	155 (31)
3. Reaching, but no grasping	7	22	15	7	1	52 (10)
4. Reaching, grasping and holding but no manipulation	1	4	7	5	0	17 (3)
5. Reaching, holding and manipulation of 1 object	0	1	27	40	19	87 (17)
6. Reaching, holding and manipulation of 2 objects	0	0	9	35	79	123 (25)
7. Reaching, holding and manipulation of ≥3 objects	0	0	0	1	1	2 (0.4)
SINDA						
Neurological score[c], median (25-75th percentile)	24 (22-26)	25 (23-26)	25 (23.25-27)	25 (24-26)	25 (24-26)	25 (23-26)
At-risk neurological score (≤ 21), n (%)	20 (20)	14 (14)	9 (9)	7 (7)	5 (5)	55 (11)
Atypical pull-to-sit manoeuvre[d], n (%)	71(71)	46 (46)	26 (26)	17 (17)	12 (12)	172 (34)

Note: Associations between PHP and (a) reaching, grasping and manipulation: $U = 7750.5$, $P < .001$; (b) SINDA neurological score: $U = 13\,013.5$, $P < .001$; (c) SINDA at-risk neurological score: $\chi^2(1) = 21.478$, Phi = 0.207, $P < .001$; (d) atypical pull-to-sit manoeuvre: $\chi^2(1) = 33.318$, Phi = 0.258, $P < .001$.

[a]Prevalence decreased with increasing age: $H(4) = 105$, $r = -.45$, $P < .001$.

[b]Score increased with increasing age: $r_s = .818$, $P < .001$.

[c]Score increased with increasing age: $r_s = .212$, $P < .001$.

[d]Prevalence decreased with increasing age: $H(4) = 103.9$, $r = -.437$, $P < .001$.

paternal native Dutch background ($\chi^2(1) = 6.098$, Phi = 0.112, $P = .014$). The perinatal risk score was not associated with PHP ($P = .748$). Multivariable logistic regression analysis indicated that prenatal substance exposure (OR = 10.08, 95% CI 1.02-99.77), post-natal admission to neonatal ward (OR = 1.72, 95% CI 1.02-2.91) and paternal native Dutch background (OR = 3.89, 95% CI 1.18-12.86), explained PHP best. Note that these variables together only explained 5.3% of the variance. The infant's age did not play a role.

4 | DISCUSSION

In our low-risk study group, 20% of infants showed PHP, with a prevalence that decreased from 49% at 2 months to 0% at 6 months. Prevailing head position to one side in infants aged 2-3 months was not related to reaching nor to an at-risk neurological score. However, in infants aged 4-5 months PHP was associated with less optimal reaching and an at-risk neurological condition. Perinatal factors were only weakly associated with PHP.

The prevalence of PHP at 4 months in our study (16%) is somewhat higher than the 11% previously reported in a large study group of infants younger than 6 months assessed in 1995 that was relatively representative of the Dutch population.[10] The different figures could imply that the prevalence of PHP in young infancy has increased during the last two decades. However, Hutchison and colleagues who studied PHP in a cohort of 200 infants—being qualified by the presence of plagiocephaly and brachycephaly—in New Zealand in 2004, reported a PHP prevalence at 4 months of 19.7%.[16] This would argue against an evident increase over the years. Most likely, the different prevalence percentages reported in the studies may be attributed to the differences in criteria for PHP and cultural differences in infant handling and positioning. The data do not allow for a conclusion on the effect of culture on PHP over time.

Our data indicated that PHP in infants aged 2-3 months was not associated with reaching performance and neurological condition, whereas in infants aged 4-5 months it was. It is conceivable that this age-related difference is brought about by the major transition in the brain occurring at this time. Around 3 months of age the primary

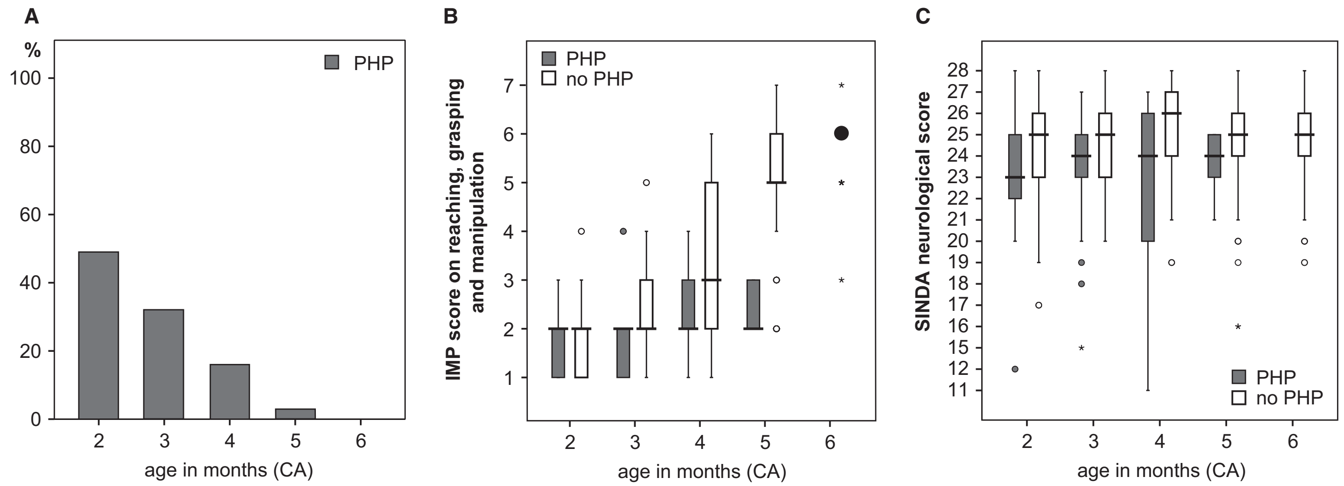

FIGURE 1 Prevalence of PHP, scores on reaching performance and SINDA's neurological scale. (A) Prevalence of PHP at various ages. Panels B and C: Bold horizontal lines indicate median values, boxes present 25th and 75th centiles, vertical lines indicate ranges, and outliers are represented by dots or asterisks. (B) Box plot of IMP-scores on reaching, grasping and manipulation in infants with and without PHP at the various ages. The large black dot at 6 mo indicates that the vast majority of infants obtained score 6, implying that they could hold and manipulate two objects (infants 2-3 mo: difference between infants with and without PHP: Mann-Whitney, $P = .107$; infants 4-5 mo: difference between infants with and without PHP: Mann-Whitney, $P < .001$). (C) SINDA's neurological scale scores in infants with and without PHP at the various ages (difference between infants with and without PHP: Mann-Whitney, $P < .001$)

sensory and motor cortices no longer involve the temporary structure of the subplate; from that age onwards, they only rely on the permanent circuitries of the cortical plate.[22] This developmental change is accompanied by a transition in the infant's behaviour: the general movements are in their final phase and are getting replaced by goal-directed behaviour.[23,24] Simultaneously the infant has achieved the ability to balance the head.[25] Proper head balance is one of the prerequisites for goal-directed reaching.[3,5]

Interestingly, having a non-native Dutch father was associated with a lower risk of PHP, which supports the suggestion that ethnic background and cultural habits may play a role in the genesis of PHP.[18,26] PHP was only associated with two perinatal risk factors: prenatal substance exposure and post-natal admission to the neonatal ward. The latter suggests that PHP is associated with an impaired capacity to cope with the transition from intra- to extrauterine life, which in turn corresponds to the less optimal neurological condition of infants with PHP (Figure 1). In contrast to other reports,[10,17] we did not find an association between PHP and preterm birth and male sex. The reason that we did not find an association with preterm birth could be that in our sample, that was representative of the Dutch population, only a few children had been born very preterm. Especially infants who have been born very preterm have an increased risk of PHP. For instance, Nuysink et al[27] reported that the prevalence of PHP at 3 months CA in infants born before 30 weeks gestational age was 37% and that of deformational plagiocephaly 50%. Similar to PHP in term infants, PHP in very preterm infants mostly has a favourable prognosis.

A major strength of our study is the relatively large group of well-documented infants that—despite being recruited in the northern parts of the Netherlands—is representative of the general Dutch population in terms of perinatal and demographic characteristics. This supports the generalisability of the study's findings to the general population of Dutch infants aged 2-6 months. An additional strength is the use of two standardised assessments—the IMP and SINDA—to evaluate PHP, reaching and neurological condition. It may be considered a limitation that we performed the IMP in infants aged 2 months, whereas the IMP has been designed for infants aged 3-18 months. Two-month-olds were included to facilitate the calculation of norm curves. It turned out that the IMP could be well assessed in all 1.5- to 2.5-month-old infants. Another limitation is the absence of information on daily life activities, such as positioning during sleeping, feeding and playing, as these activities may have acted as effect mediators.[17]

5 | CONCLUSION

We found a 20% overall prevalence of PHP in young infants. Our study confirms that PHP in young infants is largely age dependent. In our representative Dutch sample, it had a high prevalence at 2 months and it had disappeared at 6 months, suggesting that it is a transient form of neurological non-optimality. Prevailing head position to one side was only weakly associated with perinatal risk factors. Prevailing head position to one side at 2-3 months had a high prevalence and was not associated with reaching and an at-risk neurological condition. This indicates that PHP at 2-3 months has limited clinical significance. Yet, PHP at 4-5 months was associated with worse reaching skills and with an at-risk neurological condition. The latter may imply PHP in infants aged 4-5 months may serve as a red flag indicating possible challenges for later development. We therefore suggest the following: (a) when the infant does not show clear neurological dysfunction accompanying PHP, caregivers may be reassured by receiving information on the transient nature of PHP; yet, caregivers also need to be informed that when PHP persists until 4-5 months, physiotherapeutic intervention is warranted; (b) that health professionals provide caregivers of all young infants with PHP with information on how they can promote the infant's ability to achieve symmetric head positioning and symmetric and varied head movements in all directions, how they can promote the infant's head balancing abilities and how they can encourage the infant's reaching and grasping activities; and (c) that 4- to 5-month-old infants with PHP receive physiotherapeutic intervention.

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CONFLICT OF INTEREST

The authors have stated that they had no interests that might be perceived as posing a conflict or bias.

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