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Guidance strategies for infantile asymmetry prevention: a systematic review

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Abstract

Background Infantile asymmetries of posture, movement and/or shape are common. Coincidence in the presentation of asymmetrical features can lead to a broad spectrum of descriptors. Published guidelines on prevention strategies are not currently available. The objective of this systematic review was to find, evaluate, and synthesise the available evidence regarding the effectiveness of prevention strategies for infantile asymmetries, specifically strategies involving paediatric screening and/or guidance to parents.

Methods This review has been reported based on Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) and the review protocol was prospectively registered on the Open Science Framework, (https://osf.io/rgzev/). Searches were conducted on Ovid Medline, Ovid AMED, and PEDro. Inclusion criteria of articles were infants < 28 weeks old who had received either an early musculoskeletal screen and/or education to parents on home care guidance/exercises to prevent asymmetry development. Any primary research was included. There was no limit placed upon date of publication. Data were screened, extracted and appraised in duplicate by at least two blinded reviewers. The Cochrane Collaboration's tool for assessing risk of bias available as part of Covidence was used by two reviewers independently.

Results Of the 878 papers retrieved, 19 studies were included: 9 randomised controlled trials, 6 cohort studies and 4 non-randomised experimental studies. The presenting conditions included head shape asymmetry in 16/19 studies, cervical range of motion in 10 studies and positional preference in 3. Due to a lack of homogeneity between all the studies, it was not possible to pool the data and conduct meta-analysis. Guidance strategies show better outcomes in asymmetry prevention when provided early (< 3 months) and under supervision of a healthcare professional. The overall risk of bias for cohort and non-randomised experimental studies was considered to be 'low', and 'adequate' or 'low' for randomised controlled trials. The GRADE level of evidence was found to be 'very low'.

Conclusion Early parental guidance may prevent infantile asymmetry when supervised by a trained healthcare professional and with good adherence from parents. Further studies with a higher methodological rigour are needed to identify and perform comparative interventions.

Clinical Trial Number Not applicable.

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Keywords Paediatric screen, Infantile asymmetry, Prevention, Guidance strategies

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Background

Asymmetry in infancy is a clinical condition which can affect posture, movement and shape. These three factors are interconnected and can influence and worsen each other synergistically [1] but remain poorly understood [2]. There is frequently an overlap of asymmetrical presentations and terms have been coined depending on the most pronounced features of asymmetry [3–5]. The interchangeable use of these terms, without unique defining descriptions, can be a challenge when interpreting the literature [5–7]. Asymmetry of shape is predominately seen in the infant head, i.e. head shape asymmetry (HSA) also referred to as deformational plagiocephaly and often determined by postnatal factors [8]. A recent systematic review from the United Kingdom identified several risk factors for HSA [9] amongst which positional and environmental factors feature prominently and include cervical range of motion (CROM) limitation [10] which may be active and/or passive [11]. Postural asymmetry (PA) is influenced by positioning preferences of the infant or the carer and usually affects active CROM only, e.g. positional preference (PP) or postural torticollis [12]. In movement asymmetry (MA) CROM is found to be restricted both actively and passively, as seen in congenital muscular torticollis (CMT) [12].

Reported prevalence of asymmetries can vary widely depending on the type of asymmetry and the descriptor used. Two cohort studies, one each from the Netherlands and Australia, estimated the detection of PA in < 3-month-old infants on clinical examination at 18% [13, 14] compared with another cohort study from Canada which reported parent observations of PA at nearly 50% [15]. In a large observational study from the Netherlands in 2001, PA, referred to in this study as postural torticollis, had a reported prevalence of 10% before 8 weeks of age [16]. The incidence of MA in newborns, as seen in CMT, ranges from 0.3% in a study from China [17] to 16% in 2 studies from the United States (US) [18, 19]. The variability in incidence has been associated with the inclusion of sternocleidomastoid muscle tumour involvement as a diagnostic feature [20]. The incidence of HSA in 7- to 12-week-old infants is reported at 38% [21] and 47% [22] with notable increases in the last 2 decades [23]. The considerable increase in incidence has been linked to supine sleeping practices consistent with American Academy of Pediatrics (AAP) guidelines [24] for prevention of sudden infant death syndrome. One prospective cross-sectional study from the US reported 73% of newborns presenting with one or more asymmetry [20].

HSA has traditionally been diagnosed via clinical assessment to determine the type and degree of deformation [25]. The cranial vault asymmetry index (CVAI), which can be measured directly with calipers, with a flexicurve, from a 2D photograph, from a thermoplastic band, or from a 3D image [26], is the measurement of choice for HSA diagnosis [27]. A CVAI cut-off of 3.5% indicates mild HSA, with increasing CVAI values corresponding to an increasing severity scale of moderate, severe and very severe (> 11.0) [28]. HSA has previously been considered as simply a cosmetic problem [29] which resolves spontaneously [30]. However, 4% of HSA remain severe at 3 to 4 years of age [29] and is seen to persist in > 10% of adolescents [31, 32]. There is evidence suggesting a possible association between HSA and developmental delay, although the direction of effect is up for debate with many suggesting HSA as a marker rather than cause of developmental delays [33, 34]. Visual assessment of MA is most commonly used in CMT diagnosis [35] with active cervical spine rotation and head tilt being the most reliable parameters [36]. Measurement scales for PA have been proposed [37, 38]. Although the validity and reliability of these scales was tested, only small sample sizes were used and these tools remain little utilised outside the original research teams. When one of the scales [37] was tested by a different research team, issues with validity and reliability were identified [39].

Interventions previously investigated for their effectiveness in preventing the progression of infantile asymmetry have highlighted early detection as an important factor. Physical therapy has a recognised role in the recovery of children with CMT [40]. It has been found to result in complete resolution of CMT within 4–6 weeks if implemented within the critical first 3 months of life [41]. Early assessment, diagnosis and timing of treatment for PA is crucial, not only for consequential impact on HSA [4], but also for possible clinically significant differences in gross motor development [18, 42]. In addition to early detection, parental adherence to guidance has also been identified as noteworthy in infantile asymmetry management. Evidence suggests that conservative strategies, such as practitioner-led hands-on treatment and stretching, can effectively minimize the degree of HSA [43]. However this relies largely on evidence-informed guidance and parental compliance to optimal infant positioning and handling strategies [7]. Studies have also shown favourable outcomes for targeted parent education strategies in reducing the prevalence of PA and HSA [2] with a reliance on clear and consistent information to ensure parental adherence [39, 44].

Infantile asymmetries represent a significant portion of complaints leading to consulting a healthcare professional (HCP) [45, 46]; as an example, 5 to 10% of patients seen by osteopaths are < 6-months-old [47]. Strategies aimed at preventing infantile asymmetries could save on healthcare time as well as distress and cost to parents. Both primary prevention (interventions aimed at preventing the initial onset of positional preferences and movement limitations) and secondary prevention (early detection and timely management of mild asymmetries before they progress to more severe structural deformities) [48, 49] are particularly relevant for infantile asymmetries, given their progressive nature and the critical developmental window within the first few months of life when intervention is most effective. There is a lack of standardisation in infant care practices across the globe, including who it is provided by, e.g. paediatrician, general practitioner, health visitor, midwife etc. While limited guidelines exist for treatment approaches for asymmetries of head shape and movement [50, 51], strategies for preventing infantile asymmetries remains poorly researched [7, 52] with guidelines for HSA only available in one country [12]. The prevalence of HSA peaks between 2 and 4 months [53] when the newborn skull is maximally deformable and prolonged periods of time are spent in supine position [54]. This time frame supports the causative association identified between MA and PA, which are both detectable at birth, and HSA [11, 55]. It also provides a logical time for implementation of prevention strategies for young infants. Comprehensive musculoskeletal assessments of movements and posture in the early stages of infancy could allow the opportunity for infant-specific parental guidance. This could include optimal infant positioning, handling and home exercises to be delivered in a clear and meaningful way to parents, however these are not performed routinely. This systematic review aimed to find, evaluate, and synthesise the available evidence regarding effectiveness of prevention strategies for asymmetries of posture, movement and/or shape in infants (< 28-weeks-old), specifically strategies involving paediatric screening and/or guidance to parents. This may inform clinical practice, education and the focus of future research projects.

Methods

This review was reported based on Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). The protocol was prospectively registered on the Open Science Framework (https://osf.io/rgzev/). To accommodate the age ranges in selected studies and maintain consistency, there was a slight deviation from the protocol population inclusion criteria. Studies of infants with a mean age of < 28 weeks were included, rather than the originally specified < 16 weeks.

Inclusion criteria

The systematic review followed the Population, Intervention, Comparator, Outcomes and Study (PICOS) framework as detailed in Table 1 below.

For the purposes of this study, a paediatric musculoskeletal screen was identified as any examination which included the assessment of biomechanical range of motion actively and passively in infants, identification of postural preferences and/or head shape measurement. Guidance strategies referred to HCP delivered guidance to parents. This was specific to their infant's examination findings and could include positioning advice, handling strategies, strengthening or stretching exercises and ongoing support. Guidance strategies for infantile asymmetry prevention differ from 'usual care' which is the provision of basic preventative measures with no additional education. The provision of 'usual care' is often in the form of an information leaflet.

Because of factors identified to increase the risk of asymmetries in infants, infant populations with the following criteria were excluded: born before 37 weeks, low birth weight (less than 2500 g), APGAR scores < 7 at 5 min, with identified neurological insult or with medical issues that may impact infant movement and posture (e.g. leading to specialist care or prolonged stay in hospital, congenital or neurological disorders affecting e.g., muscle tone etc.), or a medical or orthopaedic condition (including developmental hip dysplasia, positional talipes, craniosynostosis, scoliosis, clavicular or brachial plexus injury,

Table 1 Inclusion criteria

Population	Infants < 28 weeks old (mean age)
Intervention	Paediatric musculoskeletal screening and/or guidance to parents/caregivers as primary or secondary preventions for infantile asymmetries of shape, posture or movement. The intervention may be used in conjunction with other interventions
Comparator	Any, including none
Outcomes	Any outcome measure used to assess (a)symmetries in infants, including CROM, trunk convexity, cranial shape (a)symmetry, postural (a)symmetry, movement (a)symmetry (e.g. limb movement)
Studies	Prospective, retrospective, observational studies, case–control studies, randomized and non-randomized clinical trials, with a minimum of 30 participants and written or translated into the English language

Legend: *CROM* cervical range of motion

congenital anomalies of the cervical spine, apparent ocular torticollis, or neurologic or auditory problems).

Information sources and Search strategy

The online bibliographic searches were conducted on OVID Medline, AMED, and PEDro between 1st March 2023 and 31st May 2023. Searches were updated up to and including 22nd March 2025. An inclusive approach was used in PEDro due to the limited search function of the database. The reference list of all included sources of evidence was screened for additional studies. There was no limit placed upon date of publication. The search strategy was cocreated with a team of experts in systematic reviews to maximise the yield and relevance of the search. The review team consisted of experienced osteopathy, physiotherapy and medical doctor clinicians, educators and researchers. All were broadly familiar with the literature offering an insider perspective, no omission of key terms and retrieval of incorrectly indexed studies. Search strings were piloted in PubMed and due to the limited number of clinical trials returned, it was decided to include cohort studies. All identified citations were uploaded into Endnote (version X9.2) and duplicates removed. Potentially relevant sources were retrieved in full, and their citation details imported into Covidence online software.

Selection process

There were three phases of the review conducted: title and abstract screening, full text review and data extraction. The screening was done in accordance with the inclusion criteria using Covidence through each phase of the review. Titles and abstracts were screened by two independent reviewers (JE, IR). Full texts included for data extraction were then screened by two independent reviewers from the research team (JE, KSK, IR, LT), and reasons for exclusion were recorded at this stage. Any disagreements between reviewers at any stage of the selection process were resolved through consensus and discussion.

Data extraction

Data extraction was conducted by two independent reviewers from the research team (JE, KSK, IR, LT) using the standardised data extraction tool from JBI-MAStARI. The Joanna Briggs checklist, suitable for each individual study design, was applied to each included full text and conducted independently by two blinded members of the research team (JE, KSK, IR, LT). Disagreement was resolved by consensus between the two reviewers involved, or the mediation of a third reviewer was applied.

Data items

The data extracted described the PICOS of the evidence discussed and was used to inform a narrative synthesis of results. The following were extracted: (A) Study characteristics: ID, year, country, setting, design, follow-up (B) patient characteristics: age, gender, number, condition (asymmetry, plagiocephaly, torticollis, etc.) (C) Intervention characteristics: duration, modalities of exercises, posture, advice, recommendations (D) Outcome/data.

Risk of bias

The Cochrane Collaboration tool for assessing risk of bias [56, 57] available as part of Covidence was used independently by two reviewers from the research team (JE, KSK, IR, LT) to assess the risk of bias in the randomised controlled trials (RCT). Further, the reliable JBI Critical Appraisal tool [58] was used to assess the risk of bias in cohort studies and non-RCTs. Any disagreement was resolved through consensus by a third blinded reviewer. A study was considered to have low risk of bias when the groups were similar and recruited from the same population, exposure measured in a valid and reliable way, confounding factors were reported, generated by random sequence, concealment was allocated, and incomplete outcome data domains were adequately met.

Data synthesis

The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system [59] was used to determine with reliability the overall quality of the evidence (high, moderate, low and very low). A summary of the judgments of each methodological quality item for each study is provided in the following results section in Tables 4, 5 and 6.

Results

The database search retrieved a total of 878 studies. Twelve duplicates were detected and removed by Covidence resulting in 857 references for title and abstract screen, then 88 for full text review, and finally 19 studies included in the final selection (Fig. 1). Two of the included studies [60, 61] were combined for data extraction as they examined the same population of infants resulting in 18 datasets from 19 studies.

Summary of included studies

A full description of included studies has been provided in the 'characteristics of included studies' (Table 2). Of the 19 studies (18 datasets) included in the final selection, 9 (8 datasets) were RCTs [2, 60–67], 6 were cohort

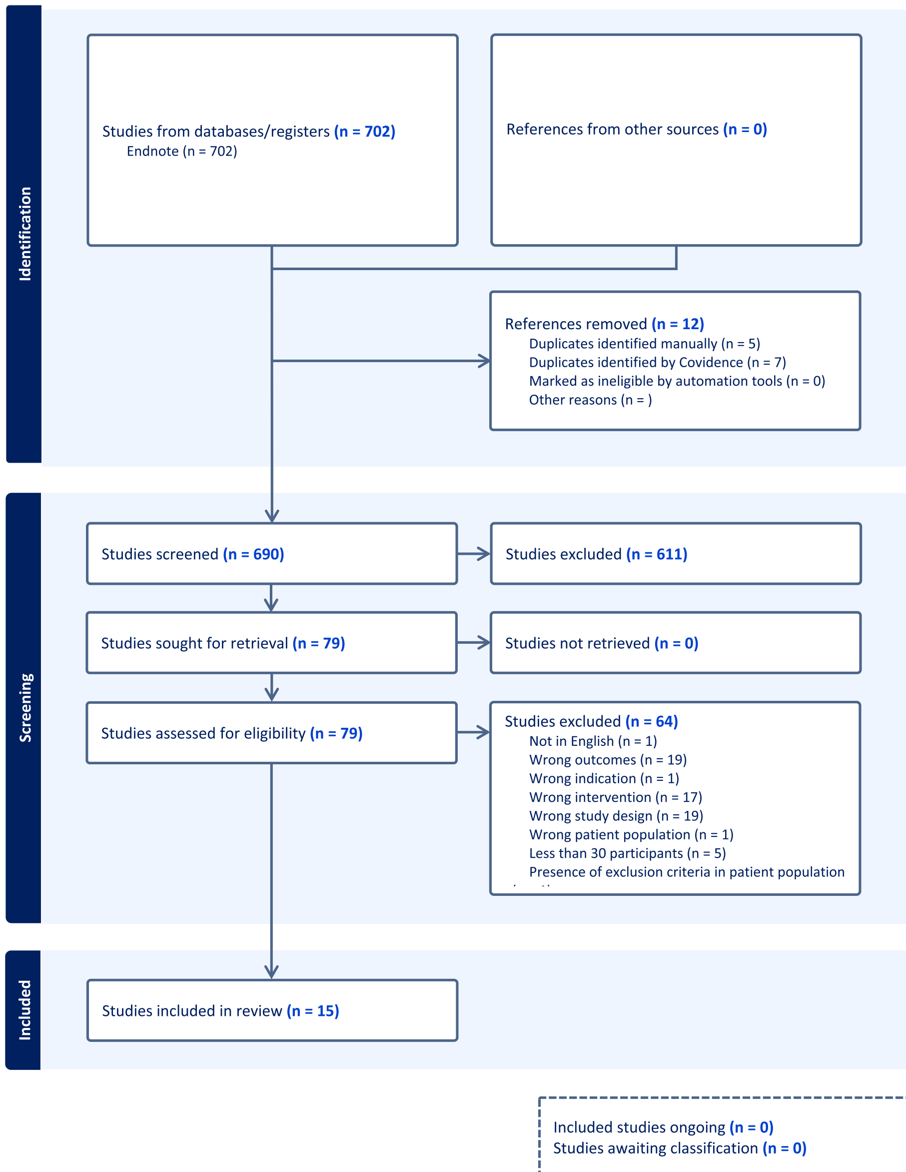

Fig. 1 PRISMA Flow Diagram of Included Studies

studies [13, 14, 68–71] and 4 non-RCTs [4, 72–74]. The extracted data from the combined RCTs [60, 61] are treated as 1 RCT dataset for the remainder of this analysis, i.e. we will discuss 8 RCT datasets from the 9 studies included. The studies included in this systematic review span difference geographical zones. The asymmetry of interest in 11/18 studies was HSA and MA/CMT in the remaining 7 studies. In 7 studies the population was recruited from hospital settings, the remaining 11 from outpatients, specialist referrals or primary care centres. The study population in 5 studies included infants in the newborn stage (1 month or younger) only, while in the remaining 13 studies all infants had a mean age of 28 weeks or younger. All but 2 studies included a guidance strategy and/or home exercises as either the intervention or control arm, and instead examined the association between infant positioning and asymmetry over time [13, 14] (Table 2).

Due to a lack of homogeneity between all the studies, it was not possible to pool the data and conduct meta-analysis. The data was therefore synthesised and reported in a narrative fashion. All but 3 studies reported head shape as an outcome measure [4, 67, 69], 10/18 reported CROM, and 6/18 reported PP. The final

Table 2 Characteristics of included studies

Lead Author Year	Condition Setting Country	Population N(I/C) N = number of participants I = intervention C = control	Intervention Description, who provided, training required	Control Description, who provided, training required
Randomised Controlled Trials				
Wilbrand 2013 [62]	HSA Hospital Germany	< 5 months (mean 4 months) N = 50 (37 M 13F) I = 25 C = 25 plagiocephaly 20 brachycephaly 10 combination 20	Repositioning pillow + guidance strategies (N = 25 20 M 5F) Duration: n/a	Home care stretching exercises + guidance strategies (N = 25 17 M 8F)
Van Vlimmeren 2008 [63]	HSA Hospital Netherlands	7 weeks N = 65 (40 M 25F) I = 33 C = 32	Standardized paediatric PT + guidance strategies Duration: 8 sessions	Usual care: Information leaflet with no education or instruction
Hutchison 2010 [64]	HSA Hospital New Zealand	10% < 3 months old; 60% 3–6 months N = 126 (Gender not specified) I = 65 C = 61	Safe T Sleep positioning wrap + guidance strategies	Guidance strategies
Aarnivala 2015 [2]	HSA Hospital Finland	36–72 h from birth (> 35w gestation) N = 96 (50 M 46F) I = 45 C = 51	Guidance strategies	Usual care: standard hospital discharge information
Ohman 2011 [65]	CMT Hospital Sweden	1–10 months (mean 4.5 months) N = 33 (Gender not specified) Gp1: 9 Gp 2: 13 Gp 3: 11 I = 24 C = 9	G2: Guidance strategies + specific strength exercises (by caregiver) G3: Guidance strategies + specific strength exercises (by caregiver) + weekly training with PT	G1: Guidance strategies
Giray 2017 [66]	CMT Outpatients Turkey	3–12 months N = 33 (19 M 14F) Gp 1: 11 Gp2: 12 Gp 3: 10 I = 22 C = 11	G2: Exercises (as in G1) + kinesiology taping to affected side G3: Exercises (as in G1) + kinesiology taping to affected and unaffected sides	G1: Exercises (× 2/week by PT for 3 weeks, then by parents at home for 3 months)
Pastor-Pons 2021 [60, 61]	HSA Health service/ Paediatrician referrals Spain	< 28 weeks N = 34 (53%M 47%F) I = 17 C = 17	Paediatric MT + guidance strategies Duration: 10 × 20 min sessions Protocol applied by paediatric physical/physiotherapists (specialised training + 4 years of experience)	Guidance strategies Duration: 1 session Training delivered by trained paediatric physical/physiotherapist and usual care (information booklet)
Sacher 2022 [67]	PA/MA Outpatients Germany	14–24 weeks (mean 17 weeks) N = 171 (Gender not specified) I = 83 C = 88	Single manual medicine treatment Duration: 1 session + guidance strategies (video-based home exercise) Duration: × 3/day > 10 years paediatric PT experience	Guidance strategies (video-based home exercise) Duration: × 3/day
Cohort studies				
Van Vlimmeren 2007 [14]	HSA Hospital Netherlands	Newborns N = 380 (178 M 202F)	NA	
Leung 2018 [13]	HSA Home/Comm Health Center Australia	3 weeks N = 94 (Gender not specified)	NA	

Table 2 (continued)

Lead Author Year	Condition Setting Country	Population N(I/C) N = number of participants I = intervention C = control	Intervention Description, who provided, training required	Control Description, who provided, training required
Aarnivala 2016 [68]	HSA Population-based Finland	3 months N = 99 (52 M 47F)	Guidance strategies	
Lee J-Y 2013 [69]	CMT Medical Centre Korea	< 3 months N = 54 (30 M 24F)	PT led exercises (stretching, massage, strengthening, therapeutic ultrasonography) Duration: 30 min × 3 times/week	
Cheng 2000 [70]	CMT Primary care centre China	21% < 1 month, 40% 1—3 months N = 1086 (652 M 434F) Gp1: 266 Gp2: 820 Gp3:unsolved Gp1 + Gp2	Gp1: Guidance strategies Gp 2: Manual stretching with trained PT × 3/week (mean duration 118 days) Gp 3: Surgical—for significant asymmetry (head tilt and CROM deficit)	
Celayir 2000 [71]	CMT Outpatient setting Turkey	38.6 days (range 15–120) N = 45 (26 M 19F)	Intensive passive stretching exercises – Duration: maintained 10secs × 10 times each, every 3 h	
Non-randomised experimental studies				
Lennartsson 2019 [72]	HSA Primary healthcare centers (26) Sweden	1–2 weeks N = 268 (145 M 123F) I = 182 C = 92	Guidance strategies (nurses educated on HSA). Weekly cranial assessment during the first months and then monthly until 6 months old	Usual care: unspecific tummy time advice Nurses without HSA training
Lennartsson 2011 [73]	HSA Primary Care Sweden	1–6 months; N = 99 (Gender not specified) I = 59 C = 40	Guidance strategies + 6 × cranial assessment	Control: No assessment or education provided
Cavalier 2011 [74]	HSA Hospital France	24–72 h from birth N = 139 (Gender not specified) I = 88 C = 51	Guidance strategies + usual care	Usual care only
Sacher 2021 [4]	PA/MA Specialist clinic Germany	14–24 weeks (mean 17 weeks) 44 M 18F N = 62 I = 30 C = 32	Single Manual Medicine Treatment Duration: 1 session In addition to guidance strategies (home exercise) Duration: × 3/day for 4–6 weeks Therapists > 15 years paediatric experience	Guidance strategies (home exercise) Duration: × 3/day for 4–6 weeks

Legend: *HSA* head shape asymmetry (includes all non-synostotic head shape asymmetry e.g. deformational plagiocephaly and brachycephaly), *CMT* congenital muscular torticollis, *PA* Postural asymmetry, *MA* Movement asymmetry, *PT* physical therapy/physiotherapy, Guidance strategies—detailed guidance on optimal infant positioning, handling, environment provided by healthcare professional and/or caregiver administered home exercises, *CROM* cervical range of motion, *I* intervention, *C* control

Table 3 Summary of findings

Lead Author Year	Outcome name/ Measure used	Key findings	Adverse Events
Randomised Controlled Trials			
Wilbrand 2013	Head shape	Guidance strategies on positioning with device superior to guidance strategies on home stretching	Not reported
Van Vlimmeren 2008	Head shape, CROM, PP	Guidance strategies + PT delivered stretching superior to usual care	Yes – [1 drop out from control (increasing HSA)]
Hutchison 2010	Head shape	Safe T Sleep positioning wrap + guidance strategies show no benefit over guidance strategies alone	No adverse events
Aarnivala 2015	Head shape, CROM	Guidance strategies (prior to hospital discharge) reduces HSA prevalence and severity and improves CROM at 3 months HSA associated with poorer motor development	Yes – [2 dropouts (guidance instructions too difficult to follow)]
Ohman 2011	Head shape, CROM, PP	Guidance strategies alone equal to guidance strategies + strengthening exercises, or guidance strategies + strengthening exercises and PT follow-up	Not reported
Giray 2017	Head shape, CROM	PT exercise followed by guidance strategies equal to kinesiology taping	No adverse events
Pastor-Pons 2021 (×2)	Head shape, CROM	Paediatric practitioner delivered MT + guidance strategies superior to guidance strategies alone for CROM (right side only) and head shape (in 5 out 6 outcomes)	No adverse events
Sacher 2022	CROM and PP (Symmetry-Score)	Paediatric practitioner delivered MT (single session) + guidance strategies (video based home exercises) superior to guidance strategies (video based home exercises) alone for Symmetry-Score	No adverse events
Cohort Studies			
Van Vlimmeren 2007	Head shape, PP, AIMS	At 7 weeks infant positioning in sleeping, feeding and awake time associated with severe flattening Early achievement of motor milestones was a protective factor HSA was more prevalent when the mother was educated at the lowest level	Not reported
Leung 2018	Head shape, PP	Severe HSA associated with longer total supine positioning times	Not reported
Aarnivala 2016	Head shape	Statistically significant risk factors for HSA were PP and less motor milestones reached PP at 3 months major risk factor for HSA persisting to 12 months	Not reported
Lee J-Y 2013	CROM	Severe limitation CROM and late diagnosis associated with longer treatment duration in CMT	Not reported
Cheng 2000	Head shape, CROM	Passive CROM limitation < 10° showed excellent outcomes with guidance strategies	Not reported
Celayir 2000	Head shape, CROM	100% achieved full passive CROM after guidance strategies (intense home stretching protocol)	Not reported
Non-Randomised Experimental Studies			
Lennartsson 2019	Head shape	Nursing HSA guidance strategies + frequent cranial assessments—> ×3 reduced risk of HSA at 12 months	Not reported
Lennartsson 2011	Head shape	Improved outcomes for preventing HSA when guidance strategies provided and followed as intended	Not reported

Table 3 (continued)

Lead Author Year	Outcome name/ Measure used	Key findings	Adverse Events
Cavalier 2011	Head shape, CROM	× 2.3 reduced risk of HSA in guidance strategies at birth group (c/w usual care)	Not reported
Sacher 2021	CROM and PP (Symmetry-Score)	Paediatric practitioner delivered MT (single session) + guidance strategies (video based home exercises) superior to guidance strategies (video based home exercises) alone for Symmetry-Score and CROM	No adverse events

Legend: *CROM* cervical range of motion, *HSA* head shape asymmetry, *PP* positional preference, *AIMS* Alberta infant motor scale, *PT* physical/physiotherapy, *IG* intervention group, *CG* control group, *MT* manual therapy

synthesis was agreed by all members of the research team (Table 3).

Guidance strategies, when provided to infants under 3-months-old reduced the prevalence and severity of HSA [2, 72–74], improved CROM [2, 70, 71] and resulted in shorter treatment duration [69]. Infant positioning in the first 3 months was identified as a risk factor for persistent HSA in three other studies [13, 14, 68]. Guidance strategies showed better outcomes when provided by a HCP and were followed as intended [62, 72, 73] when compared with usual care. Poorer outcomes in secondary prevention of HSA were found in parents at the lowest level of education [14].

Guidance strategies in addition to paediatric practitioner led manual therapy (MT) had superior outcomes in all studies for CROM, head shape and PP when compared with guidance strategies alone [4, 60, 61, 67] and usual care [63], except for one where the outcomes were equal [65]. Guidance strategies also demonstrated equal outcomes when compared with an additional intervention arm such as repositioning pillow [62], kinesiology taping [66] and positioning sleep wrap [64]. In addition to our outcomes of interest, 3 included studies showed an association between HSA and poor motor development [2, 14, 68]. One study suggested early motor milestone development as a primary prevention of HSA

Table 4 Risk of Bias in RCTs

Lead Author Year	True randomisation	Concealed allocation	Baseline similarity	Blinding of participants All outcomes	Blinding of Therapist All outcomes	Blinding of outcome assessors	Treatment groups treated identically	Follow up complete	Participants analysed to group allocated	Outcomes measured similarly	Outcomes measured reliably	Appropriate statistical analysis	Deviations from protocol
Aarnivala 2015	+	+	+	-	?	+	?	+	+	+	+	+	+
Giray 2017	?	+	+	-	-	+	+	+	+	+	+	+	+
Hutchison 2010	+	+	+	-	-	?	+	+	+	+	+	+	+
Ohman 2011	?	-	+	-	-	-	-	+	+	+	+	+	+
van Vlimmeren 2008	+	+	+	?	+	+	-	+	+	+	+	+	+
Wilbrand 2013	+	-	+	-	-	+	+	-	+	+	+	+	+
Pastor-Pons 2021a and 2021b	+	+	+	-	-	?	-	+	+	+	- +	+	+
Sacher 2022	+	+	+	+	-	+	+	+	+	+	+	?	+

Legend: Each study's RoB is evaluated about the 13 items. Green bubbles mean minor RoB (+ is an adequate methodological quality) – Red bubbles mean major RoB (- is an inadequate methodological quality) – Orange (? is unclear in the methodological quality) development [14]. This supports our hypothesis about the importance of early screening and guidance to parents.

Risk of bias in included studies

A risk of bias judgement summary of each methodological quality item for included RCTs is provided in Table 4. Except for two studies [65, 66], true randomization was 'low' risk. Allocation concealment was considered 'high' risk in two studies [62, 65]. Blinding of participants may not be possible and was considered 'high' risk in all the RCTs except one [67]. Except for one study [63], blinding of therapist was considered 'high' risk in all studies. Blinding of outcome assessors was explicit and considered 'low' risk in five studies [2, 62, 63, 66, 67], 'unclear' risk in three studies (two datasets) [60, 61, 64] and 'high' risk in one study [65]. Follow-up of participants was considered 'low' risk in all but one study [62]. Other domains were considered 'low' risk in all the studies.

The risk of bias of five cohort studies [13, 14, 68, 70, 71] is reported in Table 5. Their overall risk of bias was considered to be 'low'.

Table 5 Risk of bias in cohort studies

Lead Author Year	Were the two groups similar and recruited from the same population?	Were the exposures measured similarly to assign people to both exposed and unexposed groups?	Was the exposure measured in a valid and reliable way?	Were confounding factors identified?	Were strategies to deal with confounding factors stated?	Were the groups/ participants free of the outcome at the start of the study	Were the outcomes measured in a valid and reliable way?	Was the follow up time reported and sufficient to be long enough for outcomes to occur?	Was follow up complete?	Were strategies to address incomplete follow up utilized?	Was appropriate statistical analysis used?
Van Vlimmeren 2007	NA	NA	+	+	+	-	+	+	+	+	+
Leung 2018	NA	NA	+	+	+	+	+	+	+	+	+
Cheng 2000	NA	+	+	+	+	+	+	+	+	+	+
Celayir 2000	NA	NA	?	+	-	+	?	+	+	-	?
Aarnivala 2016	NA	+	+	+	?	-	+	+	-	?	+

Legend: Each study's RoB is evaluated about the 11 items. Green bubbles mean minor RoB (+ is an adequate methodological quality) – Red bubbles mean major RoB (- is an inadequate methodological quality) – Orange (? is unclear in the methodological quality)—*N/A* Not Applicable

Table 6 Risk of Bias of non-randomised controlled trials

Lead Author Year	Is it clear in the study what is the 'cause' and what is the 'effect'?	Were the participants included in any comparisons similar?	Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	Was there a control group?	Were there multiple measurements of the outcome both pre and post the intervention/ exposure?	Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	Were the outcomes of participants included in any comparisons measured in the same way?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?
Lennartsson 2019	+	-	+	+	+	+	+	+	+
LeeJ-Y \2013	+	+	-	-	+	+	+	+	+
Lennartsson 2011	+	-	+	+	+	+	+	-	+
Cavalier 2011	+	+	+	+	+	+	+	+	+
Sacher 2021	+	+	+	+	+	+	+	+	+

Legend: Each study's RoB is evaluated about the 9 items. Green bubbles mean minor RoB (+ is an adequate methodological quality) – Red bubbles mean major RoB (- is an inadequate methodological quality) – Orange (? is unclear in the methodological quality)

Table 7 GRADE quality of evidence

Question: Guidance program compared to any other intervention for infantile asymmetry												
Setting: Hospital/Clinic/Home												
Certainty assessment							**No. of patients**		**Effect**		**Certainty**	**Importance**
No. of studies	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**Guidance Programme**	**any other intervention**	**Relative (95%CI)**	**Absolute (95%CI)**		
Timing of intervention												
6	Randomised Controlled Trials (RCT)/non-RCT/Cohort Studies	not serious	serious[a]	very serious	serious[b]	none	685	1054	n/a	n/a	⊕◯◯◯ Very low	IMPORTANT
Educational led guidance												
4	Randomised Controlled Trials (RCT)/non-RCT/Cohort Studies	not serious	serious	serious	Serious	none	646	159	n/a	n/a	⊕◯◯◯ Very low	IMPORTANT
Guidance with additional intervention												
8	Randomised Controlled Trials (RCT)/non-RCT/Cohort Studies	not serious	serious[c]	serious[d]	serious[b]	none	304	275	n/a	n/a	⊕◯◯◯ Very low	IMPORTANT

Legend: a. Known heterogeneity, therefore, studies not pooled; b. Wide CI's; c. Studies not pooled due to known heterogeneity; d. Additional interventions were different. *CI* confidence interval

The risk of bias of five non-RCTs [4, 69, 72–74] is reported in Table 6. Their overall risk of bias was considered to be 'low'.

Effects of guidance strategies compared to any other intervention for infantile asymmetry:

A summary of findings table was created to summarise the overall quality of evidence using GRADE (Table 7). Three key factors were identified to be important which may influence outcomes in infantile asymmetry.

Intervention timing (infants < 3-months-old)

Data from six studies (total of 1,739 participants) (not pooled) demonstrated a 'very low' quality evidence for intervention timing (guidance strategies provided early) leading to better outcomes in children with infantile asymmetry (Table 7).

Guidance strategies

'Very low' quality evidence from four studies (total of 805 participants) (not pooled) demonstrated that guidance strategies, when delivered by a HCP, are more likely to be adhered to by parents and followed as intended and this leads to better outcomes in children with infantile asymmetry (Table 7).

Guidance with additional intervention

Data from five studies (total of 579 participants) (not pooled) demonstrated a 'very low' quality evidence that outcome measures from guidance strategies are not improved with additional interventions in children with infantile asymmetry (Table 7).

Discussion

This systematic review aimed to identify, appraise and synthesize the best available evidence for the effectiveness of prevention strategies for asymmetries of posture, movement and/or shape in infants (< 28-weeks-old), specifically strategies involving paediatric screening and/or guidance to parents on optimal infant positioning, handling, and home environment set-up and/or caregiver administered exercises, with the guidance provided by a paediatric trained healthcare professional. Nineteen studies (resulting in 18 datasets) were included, with evidence of low levels regarding the timing of the intervention, providing guidance with additional interventions and guidance with HCP provided education.

Quality of the evidence

The overall quality of the evidence of this review was 'low' to 'very low' for all outcomes as reflected in GRADE. The level of evidence was downgraded due to significant heterogeneity in the included studies incorporating a wide range of interventions, outcome measures, difference in study design, data collection techniques and post-intervention time points. Further, the sample size in some studies was less than 50. Taken together, the generalisability of these findings is limited. However, it is important to note that the 'low' quality of the evidence is a reflection of the small number of well-powered studies. This indicates the need for more robust research in this area, without dismissing the evidence currently available for being graded 'low'. Although included studies varied in study design, the risk of bias was considered to be 'low' across them all. Risk of bias was not downgraded for blinding therapists as this may be difficult in a health setting. Keeping in line with recent recommendations [75], future studies should consider adding a measure of blinding effectiveness.

Agreements and disagreements with other studies or reviews

Delivery of guidance strategies early in infancy (< 3-months-old) shows favourable outcomes in reducing the prevalence and severity of HSA and improving CROM when compared to usual care or no control. This is in line with evidence of other interventions for infantile asymmetry which have been found to be most effective when delivered early [76, 77]. However, it is unclear which factors can impact effectiveness for guidance strategies delivered alone as they were mostly tested in conjunction with other interventions, particularly paediatric practitioner led MT which enhanced the positive outcomes of the guidance strategies. One prospective study identified infants screened at 3 and 6 weeks for MA and PA and provided important information on the need for professional advice for HSA prevention strategies [78]. Further research should look at guidance strategies in isolation.

Standardised guidelines for the prevention of infantile asymmetries are lacking, with infant positioning included only as part of, and secondary to, the AAP infant safe sleep recommendations [79]. In contrast to the AAP recommendations for "a certain amount of prone positioning, or 'tummy time,' while the infant is awake and being observed" [80], parents have expressed the need for clear and precise messaging related to positioning strategies and optimal durations [81]. In fact, up to 50% of parents have claimed to either not be aware of 'tummy time' advice or the potential consequences of ignoring these [82]. Parents also report that the messenger of this information, i.e. being HCP or family/friend, can either facilitate or hinder their adherence to prevention strategies [81].

Guidance strategies are most effective when delivered by HCP and followed as intended. Our findings support previous research that show effective strategies are dependent on the provision of a focused educational approach by a relevant HCP [83, 84], which may be optimised with a strong therapeutic alliance between the HCP and parents. While positioning recommendations have long existed, a lack of awareness [85], knowledge, consistency [44], clarity [86] and motivation to comply [13] have been identified as key barriers. When parents fully understand the impact of posture and environment on HSA of their newborn infant [55, 87] as well as CROM in CMT [88] they are more likely to adhere to guidance strategies provided [44]. There is also evidence to suggest that extra vigilance would be prudent for parents who are less educated [83]. Prevention strategies should be described in a way that is easily understood by parents and customized to daily family routines intended to be implemented from birth [89].

Paediatric PT stretching combined with guidance strategies was superior to usual care in one study from the Netherlands [63]. Adding MT to an active control has been shown to improve CROM and symmetry in a recent large systematic review [90]. Similarly, this review demonstrates that the addition of paediatric PT or MT to guidance strategies shows greater benefits when compared with guidance strategies alone, indicating a further enhancement of guidance strategies with the addition of paediatric PT/MT [4, 60, 61, 67]. These benefits were demonstrated through a significant reduction in CVAI and increase in CROM reported in two studies from Spain [60, 61] in infants diagnosed with moderate to severe HSA. The combination of PT/MT and guidance strategies also reported superior outcomes compared with guidance strategies alone in two studies from Germany [4, 67], through the improvement of CROM and PP in infants diagnosed with MA and PA using the same reliable and valid 4-item Symmetry-Score [38]. The measurement of infantile symmetry in MA and PA has been previously examined by researchers in Germany using a validated asymmetry scale [37], who reported superior outcomes when treated with paediatric MT compared with usual care [3]. Another study from Germany reported a slight benefit of using a positioning device (bedding pillow) over guidance strategies [62]. This is not supported by a study from New Zealand which did not find a difference between the use of a positioning device (STS wrap) and guidance strategies [64].

There was a broad range in the timing of intervention in the included studies (24 h to 28-weeks) and, given the progressive nature of asymmetrical conditions during the first few months of life, it is not known if guidance strategies alone have limited impact as the infant gets older and are diagnosed with more severe forms of HSA. Further research should investigate the critical timing around when guidance strategies are most effective in younger infants, as well as alternative interventions for older infants and/or infants diagnosed with more severe presentations of HSA.

Adverse events were poorly reported, with only 7/18 recording this information. Among those that did report adverse events, only 2 studies identified any occurrences, and these were minor in nature [2, 63]..

Limitations

Bias in the review process was limited by having, as a minimum, two reviewers acting independently through the various phases of the review. A third reviewer was available if required. The search strategy and the search process were considered to be comprehensive and robust to identify relevant studies. A potential bias could be 'language bias' as only publications in the English language [91] were included, as English was the common language across the team. This may limit the usefulness of the review's findings, as important cultural contexts may have been missed [92, 93]. Due to the small number of clinical trials retrieved, we expanded the search to include cohort studies. This meant that 6/15 studies included in our analysis did not have a comparator making conclusions about the intervention more difficult to draw.

Conclusions/future outcomes

Early parental guidance may prevent infantile asymmetry when supervised by a trained HCP and with good adherence from parents. The current evidence is insufficient to inform clear and consistent guidelines on strategies for infantile asymmetry prevention, including if routine asymmetry screening of infants should be conducted, when and by whom this should be done, and whether supervision or follow-up of parental compliance to guidance is beneficial.

The findings from this systematic review may inform clinical practice, education and the focus of future research projects. Patients/parents would be directly impacted by the development of a routine exam aimed to detect asymmetry of movement, shape and/or posture within the first 3 months of an infant's life. This allows for the provision of guidance strategies from a HCP which is relevant to the examination findings, meaningful to parents, more likely to be adhered to and may ultimately prevent the development of asymmetry and compensatory effects. Further research in this field is required to better inform clinical guidance and practice.

Students of paediatric healthcare, and specifically MT, could benefit from the development and training of an early intervention routine exam which includes the provision of guidance strategies for parents. We hope that these interventions would reduce stress and cost to parents, demands on other healthcare practitioners, and long-term impacts of asymmetry in infants.

Future studies should focus on examining the prevention and treatment of infantile asymmetry in a consistent way to provide robust data that can be analysed statistically. The development of an early intervention routine exam for infantile asymmetry, which includes guidance to parents on home management strategies with accurate and consistent information and allows a process for questions to be asked for clarification or if difficulties are encountered, also needs exploration.

Abbreviations

HSA	Head shape asymmetry
CROM	Cervical range of motion
PA	Postural asymmetry
PP	Positional preference
MA	Movement asymmetry
CMT	Congenital muscular torticollis
CVAI	Cranial vault asymmetry index
HCP	Healthcare professional
RCT	Randomised controlled trial
PT	Physical/physiotherapy
MT	Manual therapy

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Supplementary Material 4.

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The authors declare that generative AI (Claude.ai) was used to edit this manuscript.

Authors' contributions
J.E. conceptualised the study, developed the protocol, extracted and analysed the data, drafted the initial manuscript, and critically reviewed and revised the manuscript. J.D.R. developed the protocol, extracted and analysed the data, and critically reviewed and revised the manuscript. K.K.S., L.T. and I.R. extracted and analysed the data, and critically reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agree both to be personally accountable for their own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which they are not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

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