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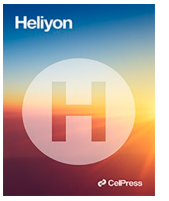

Research article

Pediatric massage therapy in infants and children under 5 years: An umbrella review of systematic reviews

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ABSTRACT

Objective: To systematically evaluate and synthesize quantitative evidence regarding the effects of pediatric massage in infants and children under five years.

Review methods: We conducted searches in databases including MEDLINE, Embase, Health Technology Assessment Database, the Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects, Allied and Complementary Medicine, Embase, the China National Knowledge Infrastructure, Wanfang Data, SinoMed, and CQVIP up to February 2024. Two reviewers independently screened articles, extracted data, and conducted quality appraisals on the included studies. We focused on systematic reviews with meta-analyses comparing pediatric *tuina* with a waitlist control, placebo, medication, massage combined with other interventions, and usual care. Outcomes analyzed included physical, psychological, developmental, and safety-related measures for children and their caregivers. Methodological quality was assessed using AMSTAR 2, and evidence quality was evaluated using the GRADE approach. Pooled effect estimates and heterogeneity were extracted for each meta-analyzed outcome. Evidence evaluated as 'high' and 'moderate' quality by GRADEpro with low heterogeneity are presented in the result section.

Results: Twenty-two systematic reviews with meta-analysis of 81 outcomes were included. Seven studies (31.8 %) were high quality, and the evidence of 6 (7.4 %) outcomes were evaluated as high quality. The meta-analysis results demonstrate significant benefits of pediatric massage for infants compared to routine care, with increased weight gain (MD 455.07 g; 95 % CI 86.33 to 823.8; $I^2 = 0$ %) based on 2 studies with 157 cases, length growth (MD 1.58 cm; 95 % CI 1.42 to 1.74; $I^2 = 25$ %) from 9 studies with 1294 cases, reduced fussing (MD -0.37 time; 95 % CI -0.53 to -0.21; $I^2 = 30$ %) according to 3 studies with 271 cases, and lower post-intervention bilirubin levels (3 studies/345 cases; MD -31.75 mmol/L; 95 % CI -40.05 to -23.46; $I^2 = 0$ %). Pediatric massage was associated with reduced diarrhea incidence compared to waitlist controls (2 RCTs/310 cases; RR 0.39; 95 % CI 0.2 to 0.76; $I^2 = 0$ %) and improved psychomotor development indices (4 RCTs/466 cases; SMD -0.35; 95 % CI -0.54 to -0.15; $I^2 = 1.06$ %). Additionally,

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pediatric massage significantly enhanced blood oxygen saturation variation post-procedure for pain management (5 RCTs/355 cases; MD 1.05; 95 % CI 0.51 to 1.58; $I^2 = 0$ %).
Conclusions: Pediatric massage significantly enhances mother-child attachment, promotes physical growth, reduces fussing, lowers bilirubin levels, improves motor and psychomotor development, as well as manages digestive conditions and pain in children under 5 years. Future research should improve study quality and comprehensively report adverse events.

1. Introduction

The health and developmental milestones of children under five years old are of global concern. Conditions like preterm birth complications, diarrhea, and congenital muscular torticollis can severely impact a child's development if not promptly treated [1]. Prompt diagnosis and appropriate interventions are essential for effectively managing and enhancing pediatric health conditions [2]. Despite the availability of evidence-based treatments, there has been a growing trend in the use of Complementary and Alternative Medicine (CAM) among pediatric patients. A 2016 survey revealed that 20 % of children in Canada had utilized CAM therapies [3], surpassing the 18.4 % prevalence reported in Australia [4]. More parents tend to choose CAM therapies due to prior experience with them or positive perceptions about their effectiveness, concerns about the side effects of conventional medications, and dissatisfaction with traditional medical treatments; therefore, such an increasing trend among children is expected to continue. Parents often opt for CAM modalities like skin-to-skin contact and mind-body therapies in pediatric care due to their perceived safety, cost-effectiveness, and ease of application [5].

Massage therapy is a common CAM modality used in the pediatric population. It involves the manipulation of soft tissues to enhance health conditions. This treatment requires specific techniques that vary in direction, pressure, manipulation, and frequency, which determine its effects on an individual's condition [2]. Massage has been employed to address various pediatric issues, including stomachache [6], diarrhea [7], digestion [8], autism [9], attention deficit hyperactivity disorder [10], eczema [11], congenital muscular torticollis (CMT) [12], and cancer [13]. Currently, there is no universally established guideline for the use of massage therapy in children. The underlying mechanisms of massage remain partially understood. Earlier clinical trials have investigated the potential benefits of massage for numerous pediatric conditions, including anxious disorders [14], discomfort [15], sleep disruption [16], digestive health [7], immune response [17], cognitive challenges [10] and mood problems [18,19]. Several systematic reviews have attempted to consolidate the evidence regarding massage therapy in pediatric care. A narrative review from 2019 that consolidated massage therapy research over the previous ten years suggested possible advantages for various pediatric conditions, including growth in preterm infants (e.g., weight gain), gastrointestinal problems (e.g., constipation, diarrhea), painful conditions (e.g., burns), muscle tone abnormalities (e.g., cerebral palsy), psychological conditions (e.g., aggression), and chronic diseases (e.g., asthma, HIV) [20]. However, the evidence on its effects is constrained by biases present in previous research. In 2021, an overview on 38 systematic reviews and non-systematic reviews qualitatively explored the evidence map of pediatric massage and provided a visualization of evidence of pediatric massage on various pediatric health outcomes, but the review did not focus on the quantitative data, such as the information on meta-analysis from the included studies [21]. An overview of systematic reviews is necessary specifically on pediatric massage for conditions in this age group and explore the previous evidence. Therefore, we conducted this umbrella review of systematic reviews to synthesize the existing evidence on pediatric massage.

2. Methods

Our study protocol was registered with the PROSPERO International Prospective Register of Systematic Reviews (CRD42020186003) and subsequently published in 2021 [22]. This umbrella review was performed in accordance with the *Cochrane Handbook for Systematic Reviews of Interventions,* [23] and adhered to the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)* guidelines [24].

2.1. Inclusion criteria

Studies were required to satisfy the eligibility criteria as outlined by the PICOS framework (Population, Intervention, Comparators, Outcomes, and Study design): (1) *Population* - Infants and children younger than 5 years. Medical conditions were categorized according to the International Classification of Diseases, 11th Revision (ICD-11) [25]. (2) *Intervention* – Pediatric massage that involves manipulative techniques on children's skin surface. Excluded were related but distinct interventions, such as manual therapy, chiropractic care, osteopathic treatments, reflexology, skin-to-skin care, and maternal hugging. (3) C*omparators* – The comparators included waitlist control, placebo, medication, or massage combined with other standardized treatments, as well as usual care. (4) *Outcomes* - The outcomes considered were physical, psychological, developmental, and safety-related measures [26]. (5) *Study design* - Only systematic reviews that included meta-analyses were eligible. Detailed inclusion criteria for the umbrella review can be found in Appendix 1.

2.2. Search strategy

A comprehensive search was conducted across multiple databases including MEDLINE, Embase, Health Technology Assessment Database, Cochrane Database of Systematic Reviews, Database of Abstracts of Reviews of Effects, Allied and Complementary Medicine, China National Knowledge Infrastructure, Wanfang Data, SinoMed, and CQVIP, from their inception to February 2024. The search strategy employed the following keywords: (massag* OR touch OR tactile stimulat* OR anmo OR acupressure OR tuina) AND (newborn* OR child* OR baby OR babies OR infant* OR youth OR pediatric* OR paediatric* OR toddler* OR preschool* OR pre-school*). Equivalent Chinese keywords were utilized for searches in Chinese databases. Additionally, free text searches and manual searches of "grey" literature were performed to supplement the database searches. The reference lists of pertinent articles were also reviewed. The search was limited to articles published in English and Chinese. Two reviewers (SCC and JGL) independently conducted the search, and any discrepancies were resolved by consulting a third reviewer (WFY).

2.3. Data extraction and management

One reviewer (SCC) independently performed data extraction using a standardized data extraction form, which was subsequently verified by a second reviewer (SLL). The extracted information included the surname of the first name, published year, target conditions, number of RCTs included, number of samples, details of the interventions and control interventions, outcomes, main conclusions, adverse effects, and quality appraisal tools. Where applicable, data on meta-analysis were also extracted, such as the number of studies included in the meta-analysis, the number of participants, the interventions compared, and the pooled effect estimates. Any disagreements between reviewers were resolved by consulting a third reviewer (WFY).

2.4. Assessment of quality of the included reviews

Two reviewers (SCC and SLL) conducted independent assessments of the quality of the included studies. The methodological quality of the systematic reviews was appraised using the AMSTAR 2 (A MeaSurement Tool to Assess systematic Reviews 2) instrument [27,28]. The quality of the systematic reviews was classified as "High", "Moderate", "Low", or "Critically low" [28]. The overall quality of evidence was assessed using the GRADE (Grading of Recommendations Assessment, Development and Evaluation) system [29]. A summary of findings (SoF) table was generated, categorizing the quality of evidence as "high", "moderate", "low", or "very low". Any disagreement between reviewers were solved through consultation with the corresponding author (WFY).

2.5. Data synthesis

Data synthesis was conducted for each category of medical conditions as classified by ICD-11 [25]. To reduce the redundancy of information from overlapping trials, if multiple reviews contained overlapping studies, we selected only one review for each disease or condition. In such instances, we included the most comprehensive review with the highest quality, as determined by the AMSTAR-2 assessment. If the quality of these reviews was comparable, the review with a larger number of participants was chosen. We gathered and summarized pooled effect estimates for meta-analyzed outcomes from each review that satisfied our inclusion criteria. For dichotomous outcomes, we compiled relative risks (RRs) along with 95 % confidence intervals (CIs). For continuous outcomes, we reported mean differences (MDs) with 95 % CIs for identical outcome measures, or standardized mean differences (SMDs) with 95 % CIs for varying outcome measures [23]. An overall meta-estimate was not computed due to variations in effect measures. Sub-group meta-analyses were not combined. For overlapping reviews excluded for meta-analysis extraction, general information was provided in Table 1 for reference. Adverse events related pediatric massage reported were documented and summarized narratively.

3. Results

3.1. Literature search

Using our search strategy, we identified a total of 2397 citations (2381 through databases/registers and 5 through other sources). After eliminating 1082 duplicate entries and 1047 irrelevant records, 268 articles remained for screening based on their titles and abstracts. This screening process yielded 81 articles, which were then reviewed in full text, resulting in the inclusion of 22 articles. The selection process is illustrated in Fig. 1.

3.2. Description of included studies

Table 1 provides a summary of the characteristics of the 22 studies included, which were published between 2009 and 2023, with 18 published in English and 4 in Chinese. The number of studies incorporated into these systematic reviews ranged from 6 to 34, and the number of participants included in these reviews varied from 308 to 3981. One study did not report the number of participants [30]. Target conditions included preterm/low-birth infants [30–34], feeding intolerance [35], neurologic development [36], physical and mental development [37–40], neonatal hyperbilirubinemia [41–45], congenital muscular torticollis [12], pain [46,47], and rotavirus diarrhea [7,48]. We also identified more than one published systematic reviews on the same target condition in our inclusion list. Comparisons included pediatric massage versus routine care, pediatric massage versus waitlist, pediatric massage versus

Table 1
Characteristics of the included systematic reviews with AMSTAR-2 evaluation.

First author (yr)	No. of studies	No. of cases	Language	Target condition	Age range	Individual studies included in the systematic review		Main conclusion	Adverse event	Quality assessment	Amstar-2
						Intervention and control interventions	Outcomes				
Conditions originating in the perinatal period											
Zhang (2023)	15	643	English	preterm infants	Under 37wks (GA) or with low birth weight	Massage vs routine treated	Mother-infant attachment/ oxygen saturation/motor/ reflex/temperature/calorie intake	Massage therapy can significantly improve oxygen saturation and strengthen maternal-infant attachment. However, prior to making a recommendation, additional research with a larger sample size and more rigorous design should be conducted due to the heterogeneity of studies in several outcomes.	None	RoB	High
Vickers (2009)	14	597	English	Preterm/low birth-weight infants	< 37wks (GA)	Massage vs routine care	Weight gain/Length of stay/Brazelton scale/stress behavior/time awake/time in movement/length/head circumference/Bayley scale/postnatal complication scale/Brazy postnatal complication scale/Newfounded postnatal compilation scale/infant feeding behaviors	Massage for preterm infants is of benefit for developmental outcomes is weak.	None	RoB	High
Seiiedi-Biarag (2020)	8	353	English	Feeding intolerance	< 37wks (GA)	Massage vs routine care	GVR/no. of gastric residual/mean frequency of vomiting/abdominal circumference	Massage therapy significantly reduces gastric residual volume and vomiting in preterm infants.	None	RoB/Grade	Low
Badr (2015)	34	1745	English	Preterm infants	NR	Massage vs waitlist/routine care/non-massage	Weight gain/length of stay/ caloric intake/gastric motility/digestion/infant development/ neurodevelopment, Length of stay, mother and infant behaviors, breastfeeding, pain	Preterm infant massage is associated with better infant outcomes.	None	RoB	Low
Lu (2020)	19	NR	English	Weight gain	28–37wks (GA)	Massage vs routine care	Weight gain	Massage therapy is beneficial for preterm infant to weight gain.	None	RoB	High
Erçelik (2022)	6	308	English	Growth in premature babies	< 35wks (GA)	Massage vs non-massage	Head circumference/ Length/Weight gain	Massage increased head circumference and total	None	JBI	Critially Low

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Table 1 (*continued*)

First author (yr)	No. of studies	No. of cases	Language	Target condition	Age range	Individual studies included in the systematic review		Main conclusion	Adverse event	Quality assessment	Amstar-2
						Intervention and control interventions	Outcomes				
								weight gain in premature babies but did not affect the length and daily weight gain.			
Li (2019)	6	611	Chinese	Neuropsychologic development	NR	Massage + routine care vs routine care	Neuropsychology/TBIL/DBIL/no. of apnea/sleep time	Pediatric *tuina* combined with routine care are good for neuropsychologic development, bilirubin, breathing, and sleep.	None	RoB	Critially Low
Factors influencing health status or contact with health services											
Priyadarshi (2022)	31	3860	English	Growth and neurodevelopment in term healthy newborns:	< 28d	Whole-body massage vs routine care	Neonatal mortality/systemic infections/growth/behaviour (crying or fussing time, sleep duration)/and neurodevelopment	Whole-body massage may improve the infant length at the end of the intervention period (median age 6 weeks, range 1–6 months) but the effect on other short- or long-term outcomes is uncertain. There is a need for further well-designed trials in future.	None	RoB	Low
Underdown (2010) a	23	2636	English	Physical and mental health	< 6m	Massage vs waitlist	Weight/Length/Head circumference/sleep/bilirubin	The evidence of massage on mother-infant interaction, sleeping, crying, and hormones influencing stress levels is weak. The use of infant massage in the community is supported.	None	RoB	High
Underdown (2010) b	22	2587	English	Physical health	< 6m	Massage vs waitlist	Stress hormones/circadian rhythms/sleep and wake behaviors/infant interactions/o, of illness and clinic visits/growth/habituation	The evidence of massage on mother-infant interaction, sleeping, crying, and hormones influencing stress levels is weak. The use of infant massage in the community is supported.	None	CASP	Low
Bennent (2013)	34	3981	English	Physical and mental health	< 6m	Massage vs waitlist	Weight/Length/Developmental quotient/Attachment Q set scored/PSI/Infant temperament/PACR/head circumference/BSID/RITQ/Eyberg's Child Behavior Inventory/NCATS/Home Inventory/chest circumference/length of sleep/bilirubin/	Findings do not currently support the use of infant massage with low-risk groups of parents and infants. Available evidence is of poor quality.	None	RoB	High

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Table 1 (*continued*)

First author (yr)	No. of studies	No. of cases	Language	Target condition	Age range	Individual studies included in the systematic review		Main conclusion	Adverse event	Quality assessment	Amstar-2
						Intervention and control interventions	Outcomes				
							abdominal circumference/ thigh circumference/ICQ/ Distractibility/Anxiety (SSAI)/Bonding scores/ Depressive symptoms (EPDS)/Assessment of mother-infant interaction/ Salivary cortisol (μg/dL)				
Fauzia (2022)	16	1418	English	Quality of Sleep and Infant Body Weight	0-3y	1.Baby massage vs other (NR) intervention 2. Baby massage vs waitlist	Quality of sleep/infant body weight	Baby Massage has an effect on improving the quality of sleep and baby's weight	None	CASP	Critially Low
Jabraeili (2023)	9	421	English	Cortisol level	Infants	Skin massage vs routine care or intervention other than massage	Cortisol levels (plasma, urine, saliva)	Massage therapy reduced the mean cortisol level in infants, also infant massage with Yakson technique for 15 days significantly reduces urine cortisol level.	None	RoB	High
Shahbazi (2022)	34	1195	English	Neonatal jaundice	< 28d	Massage therapy vs routine comprehensive treatment	Serum bilirubin level/ transcutaneous bilirubin level on each day of the intervention.	The presence of a dose-response relationship favors the causal relationship between massage therapy and reduction of neonatal jaundice.	None	RoB	High
Zhang (2018)	6	357	English	Neonatal hyperbilirubinemia	NR	Pediatric massage + routine care vs routine care	Serum bilirubin level/ transcutaneous bilirubin	Massage therapy can significantly reduce serum bilirubin level and transcutaneous bilirubin level within 4d, but no influence on serum bilirubin level and transcutaneous bilirubin level on 2d, frequency of defecation daily on 2 and 4d.	None	Jaded scale	High
Lv (2019)	19	2699	Chinese	Neonatal hyperbilirubinemia	NR	1. TCM massage + routine care vs routine care 2. TCM massage vs waitlist	Icteric index/ hyperbilirubinemia incident rate	Touch is effective for the reduction of the incidence of neonatal hyperbilirubinemia and the reduction of percutaneous jaundice index .	None	Jaded scale	Moderate

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Table 1 (*continued*)

First author (yr)	No. of studies	No. of cases	Language	Target condition	Age range	Individual studies included in the systematic review		Main conclusion	Adverse event	Quality assessment	Amstar-2
						Intervention and control interventions	Outcomes				
Lin (2021)	19	2406	Chinese	Neonatal jaundice	NR	1. TCM massage + routine care vs routine care 2. TCM massage vs routine care	Improvements/no. of cure patients/bilirubin level/ length of the cure/safety	Pediatric *tuina* is effective and safe for neonatal jaundice.	Anemia, diarrhea, fever, respiratory and digestive system infection	RoB	Moderate
Conditions of the musculoskeletal system and connective tissues											
Chen (2020)	7	475	English	Congenital muscular torticollis	0-3y	Massage vs ultrasound therapy/usual care/stretching	Improvements/range of motion	TCM massage is beneficial for treating CMT in infants and children.	None	RoB/Grade	Moderate
Conditions of the digestive system											
Lai (2018)	26	2410	English	Acute diarrhea	0-5y	TCM massage vs western medicine	No. of cure patients	Massage appears is effective and safe in improving clinical cure rate and shortening diarrhea duration of acute diarrhea in children under 5.	None	RoB	Moderate
Lai (2019)	17	1468	Chinese	Rotavirus Diarrhea	(1.41 ± 0.48) y	TCM massage vs western medicine	Improvements/no. of cure patients/the length of the cure	Compared with conventional treatment for rotavirus diarrhea in children, *tuina* has better effects of improving the cure rate and may reduce the duration of diarrhea	None	RoB	Moderate
Symptoms, signs or clinical findings, not elsewhere classified											
Liu (2022)	11	755	English	Procedural pain	24h to 42wks	Massage vs standard care	Neonates' painful response/heart rate, blood oxygen saturation/ respiration rate during and after painful examination/ variations of the crying time/cortisol levels/ occurrence of adverse events between before and after the painful procedure	Massage may have a positive effect on pain relief of neonate, and rigorous trials are needed in the future to determine the most effective massage method.	None	RoB	Low
Costa (2022)	12	981	English	Pain	24h to 42wks	Massage vs non-pharmacological interventions	Pain score/duration of crying	The reduction of neonatal pain scores, reduction of procedure time, reduction of crying duration and stabilization of vital signs (less change in heart rate and oxygen saturation) in newborns submitted to puncture who received the intervention of massage.	None	RoB/Grade	Moderate

GA: gestational age; CASP: Critical Appraisal Skills Programm; RoB: Cochrane risk of bias assessment tool; JBI: Joanna Briggs Institute Critical Appraisal Checklist; RTI: respiratory tract infection; TCM: traditional Chinese medicine; CMT: congenital muscular torticollis; TBIL: total bilirubin; DBIL: direct bilirubin; LOS: length of stay; GVR: gastric residual volume; PPV: positive pressure ventilation. NR: not reported; NK: natural killer; PIPP: Premature Infant Pain Profile; PSI: Parenting stress Index; PACR: Parental attitudes toward child rearing; BSID: Bayley Scales of Infant Development; RITQ: Revised Infant Temperament Questionnaire; NCATS: Nursing Child Assessment Teaching Scales; ICQ: Infant Characteristic Questionnaire; SSAI: Spielberger State Anxiety Index; EPDS: Edinburgh Postnatal Depression Scale.

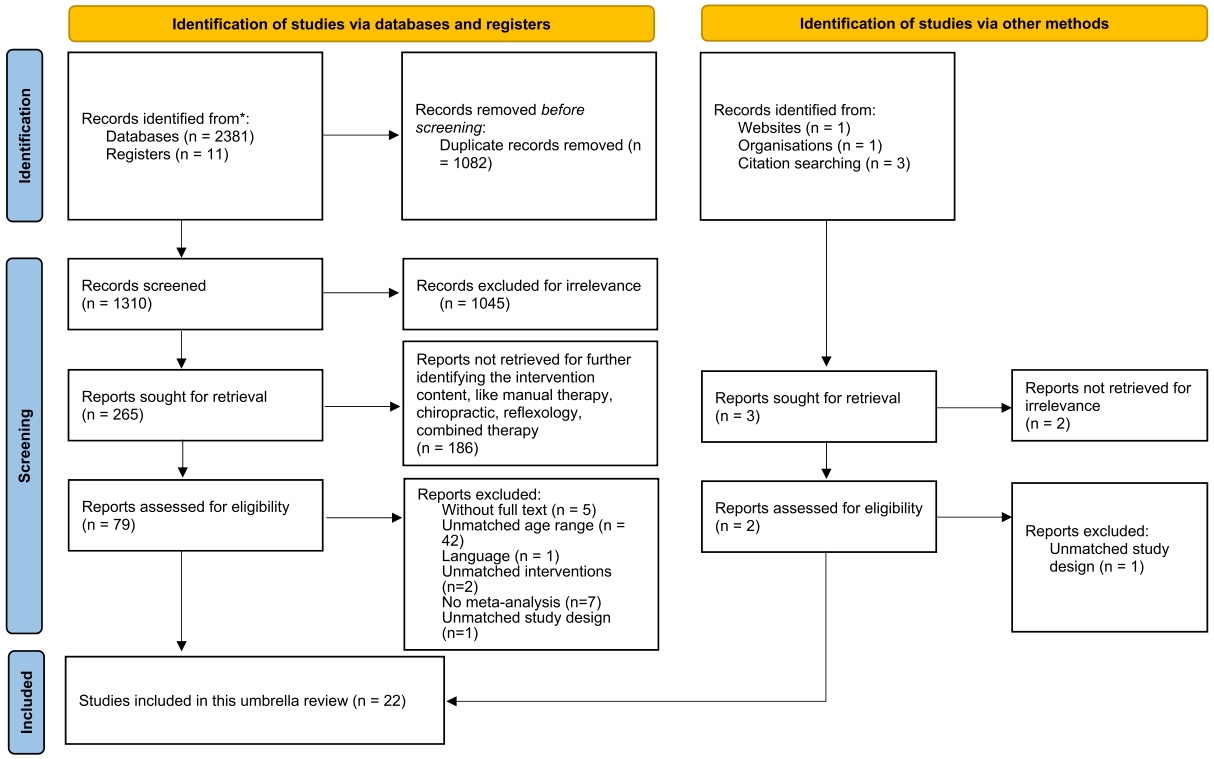

Fig. 1. PRISMA flow diagram.

non-massage, combination of pediatric massage and routine care versus routine care, pediatric massage versus ultrasound therapy, pediatric massage versus stretching, and pediatric massage versus western medicine. Only one study reported the adverse event of pediatric massage [45]. Quality appraisal tools included Cochrane risk of bias tool [7,12,30,31,33–38,40,41,43,45–48], Joanna Briggs Institute Critical Appraisal Checklist [32], Critical Appraisal Skills Programm [39], Jaded Scale [42,44], and Grade [12,35,46]. The number of meta-analyses for outcomes in the included studies are from 1 to 29. For each meta-analyzed outcomes, the number of studies included are from 2 to 18 and the number of cases included are from 49 to 2271. There are 81 outcomes for 5 kinds of children's conditions were summarized (Table 2).

3.3. Excluded studies

Forty-two articles focused on the effects of massage on children, but not limited to children under 5 years. Five studies were published without full text. Seven studies were conducted without meta-analysis. A study was published in French. Four studies used interventions, comparators, or study design that did not satisfy the inclusion criteria. Studies excluded can also be found in Appendix 2.

3.4. Methodological quality assessment

Overall scores of AMSTAR for each published systematic review are shown in Table 1, with the single items summarized in Appendix 3. The conduct of the systematic review was rated as high for 31.8 % of the included studies (n = 7), moderate for 31.8 % (n = 7), low for 22.7 % (n = 5), and critically low for 13.6 % (n = 3). In general, the main limitations included no list of excluded studies, grey literature not counted in searching, funding information not reported, publication bias was not assessed, and the study quality not assessed when doing meta-analysis or writing the discussion part. Details of the outcomes containing meta-analysis and the evaluation score of each outcome using GRADEpro are shown in Appendix 4. Among the 81 outcomes analyzed, 6 were determined to be of high quality (7.4 %), 28 of moderate quality (34.6 %), 22 of low quality (27.2 %), and 25 of very low quality (30.9 %) in terms of evidence quality for all outcome measures. The primary factors leading to the downgrading of evidence quality were study limitations, imprecision, publication bias, and inconsistency in the data.

3.5. Amendments to registration information

The inclusion of criteria of study type was change from "Systematic reviews with randomized controlled trials (RCTs), quasi-RCTs, or non-randomized studies" to "Systematic reviews of randomized controlled trials (RCTs)". We focused exclusively on RCTs to maintain a more homogeneous set of studies, as well as enhance the reliability and validity of our conclusions.

Table 2
Certainty of evidence for various outcomes reported by systematic reviews.

The first author(yr)	Outcomes	No. of studies	No. of cases (I/C)	Comparison	Effect size (95%CI)/ Model	Heterogeneity	Grade quality
Conditions originating in the perinatal period							
Zhang (2023)	Mother-child attachment	2	120 (60/60)	Routine care	SMD 2.83 [2.31, 3.35] Random	P = 0.34; I^2 = 0 %	⨁⨁⨁◯ Moderate
	Calorie intake	5	172 (86/86)	Routine care	SMD 0.60 [-0.46,1.67] Random	P < 0.00001; I^2 = 90 %	⨁◯◯◯ Very low
	Motor function	4	112 (54/58)	Routine care	SMD 0.11 [-0.16, 0.38] Random	P = 0.64; I^2 = 0 %	⨁⨁◯◯ Low
	Reflex	2	60 (28/32)	Routine care	SMD 0.18 [-0.30,0.65] Random	P = 0.18; I^2 = 45 %	⨁⨁◯◯ Low
	Body temperature	2	108 (54/54)	Routine care	SMD 0.11 [-0.08,0.31] Random	P = 0.18; I^2 = 45 %	⨁⨁◯◯ Low
	Oxygen saturation	3	570 (285/285)	Routine care	SMD 2.00 [1.17,2.83] Random	P < 0.00001; I^2 = 86 %	⨁⨁⨁◯ Moderate
Vickers (2009)	Daily weight gain (g/day)	6	274 (139/135)	Routine care	MD 5.06 [3.45, 6.67] Fixed	P = 0.05; I^2 = 55.42 %	⨁⨁⨁◯ Moderate
	Length of stay (days)	6	176 (88/88)	Routine care	MD -4.45 [-6.48, −2.43] Fixed	P = 0.97; I^2 = 0 %	⨁⨁◯◯ Low
	Brazleton scale: habituation	3	103 (51/52)	Routine care	MD 0.58 [-0.45, 1.60] Random	P = 0; I^2 = 88.59 %	⨁◯◯◯ Very low
	Brazleton scale: orientation	3	157 (83/74)	Routine care	MD 0.62 [-0.35, 1.59] Random	P = 0.02; I^2 = 73.31 %	⨁◯◯◯ Very low
	Brazleton scale: range of state	3	110 (55/55)	Routine care	MD 0.56 [0.19, 0.94] Fixed	P = 0.68; I^2 = 0 %	⨁⨁◯◯ Low
	Brazleton scale: motor maturity	3	110 (55/55)	Routine care	MD 0.85 [0.17, 1.53] Random	P = 0; I^2 = 82.44 %	⨁⨁◯◯ Low
	Brazleton scale: state regulation	3	110 (55/55)	Routine care	MD 0.48 [-0.07, 1.02] Fixed	P = 0.1; I^2 = 56.6 %	⨁⨁◯◯ Low
	Brazleton scale: autonomic stability	3	110 (55/55)	Routine care	MD -0.13 [-0.57, 0.31] Fixed	P = 0.49; I^2 = 0 %	⨁◯◯◯ Very low
	Brazleton scale: number of abnormal reflexes	3	110 (55/55)	Routine care	MD -0.61 [-1.59, 0.37] Fixed	P = 0.69; I^2 = 0 %	⨁◯◯◯ Very low
	Postnatal Complications Scale	2	70 (35/35)	Routine care	MD 16.14 [11.32, 20.96] Fixed	P = 0.26; I^2 = 21.6 %	⨁⨁◯◯ Low
Seiiedi-Biarag (2020)	Gastric residual volume	3	152 (76/76)	Routine care	MD -2.11 [-2.78, −1.45] Fixed	P = 0.6; I^2 = 0 %	⨁◯◯◯ Very low
	Number of gastric residuals	2	49 (25/24)	Routine care	MD -0.05 [-0.34, 0.24] Fixed	P = 0.79; I^2 = 0 %	⨁◯◯◯ Very low
	Vomiting frequency	2	87 (44/43)	Routine care	MD -0.84 [-1.37, −0.31] Random	P = 0.05; I^2 = 75 %	⨁◯◯◯ Very low
	Abdominal circumference	4	171 (86/85)	Routine care	MD -1.51 [-4.86, 1.84] Random	P < 0.00001; I^2 = 90 %	⨁◯◯◯ Very low
Badr (2015)	Caloric intake (kg/day)	5	224 (117/107)	NR	MD 7.70 [-3.03, 20.73] Random	P = 0.0004; I^2 = 74 %	⨁◯◯◯ Very low
	Mental development on the Bayley scale	3	261 (128/133)	NR	MD 7.89 [0.96, 14.82] Random	P = 0.0003; I^2 = 88 %	⨁⨁◯◯ Low
Erçelik (2022)	Head circumference	2	87 (44/43)	Non-massage	MD 0.97 [0.73, 1.21] Fixed	P = 0.40; I^2 = 0 %	⨁⨁⨁◯ Moderate
	Total weight gain	2	87 (44/43)	Non-massage	MD 129.09 [79.58, 178.60] Fixed	P = 0.48; I^2 = 0 %	⨁⨁◯◯ Low
Factors influencing health status or contact with health services							
Priyadarshi (2022)	Weight (at the end of intervention)	17	2182 (1089/1093)	Non-massage	MD 340.3 [239.81, 440.79] Random	P < 0.00001; I^2 = 86 %	⨁⨁⨁◯ Moderate
	Weight (follow-up 8–12 months)	2	157(74/83)	Non-massage	MD 455.07 [86.33, 823.80] Random	P = 0.89; I^2 = 0 %	⨁⨁⨁◯ Moderate
	Length	9	1294 (647/647)	Routine care	MD 1.58 [1.42, 1.74] Random	P = 0.22; I^2 = 25 %	⨁⨁⨁⨁ High
	Head circumference	6	1000 (500/500)	Routine care	MD 0.85 [0.57,1.14] Random	P = 0.03; I^2 = 60 %	⨁⨁⨁◯ Moderate
	Sleep duration	3	534 (266/268)	Routine care	MD 0.62 [0.12,1.21] Random	P = 0.0007; I^2 = 86 %	⨁⨁⨁◯ Moderate

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Table 2 (*continued*)

The first author(yr)	Outcomes	No. of studies	No. of cases (I/C)	Comparison	Effect size (95%CI)/ Model	Heterogeneity	Grade quality
	Crying or fussing time	3	271 (136/135)	Routine care	MD -0.37 [-0.53, −0.21] Random	P = 0.24; I^2 = 30 %	⊕⊕⊕⊕ High
	Mental development indices	3	388 (234/154)	Routine care	SMD 0.29 [-0.18, 0.77] Random	P = 0.02; I^2 = 76 %	⊕⊕◯◯ Low
	Bilirubin levels	3	345 (168/177)	Routine care	MD -31.75 [-40.05, −23.46] Random	P = 1; I^2 = 0 %	⊕⊕⊕⊕ High
Bennent (2013)	Mid arm circumference	2	225 (150/75)	Waitlist	MD -0.47 [-0.80, −0.13] Random	P = 0.03; I^2 = 79.69 %	⊕⊕⊕◯ Moderate
	Mid leg/thigh circumference	2	225 (150/75)	Waitlist	MD -0.31 [-0.49, −0.13] Random	P = 0.48; I^2 = 0 %	⊕⊕⊕◯ Moderate
	Upper Respiratory Tract Infection	2	310 (208/102)	Waitlist	RR 1.19 [0.86, 1.65] Random	P = 0.82; I^2 = 0 %	⊕⊕⊕◯ Moderate
	Anemia	2	310 (208/102)	Waitlist	RR 1.49 [0.79, 2.82] Random	P = 0.93; I^2 = 0 %	⊕⊕⊕◯ Moderate
	Diarrhea	2	310 (208/102)	Waitlist	RR 0.39 [0.20, 0.76] Random	P = 0.86; I^2 = 0 %	⊕⊕⊕⊕ High
	Infant temperament-activity	3	121 (57/64)	Waitlist	SMD 0.39 [-0.34, 1.13] Random	P = 0.02; I^2 = 75.02 %	⊕◯◯◯ Very low
	Infant temperament-persistence	2	81 (40/41)	Waitlist	SMD 0.24 [-0.20, 0.67] Random	P = 0.34; I^2 = 0 %	⊕⊕◯◯ Low
	Infant temperament-soothability	2	80 (37/43)	Waitlist	SMD -0.30 [-0.94, 0.35] Random	P = 0.15; I^2 = 52.12 %	⊕⊕◯◯ Low
	Mother and child interaction - Total NCATS and Murray Global	3	131 (65/66)	Waitlist	SMD -0.26 [-1.01, 0.48] Random	P = 0.02; I^2 = 75.09 %	⊕◯◯◯ Very low
	Maternal sensitivity - warm to cold (Murray)	2	84 (41/43)	Waitlist	MD -0.34 [-1.07, 0.40] Random	P = 0; I^2 = 90.69 %	⊕◯◯◯ Very low
	Maternal sensitivity - non-intrusive to intrusive (Murray)	2	84 (41/43)	Waitlist	MD -0.10 [-0.85, 0.66] Random	P = 0; I^2 = 89.85 %	⊕◯◯◯ Very low
	Infant interactions - infant performance - attentive to non-attentive (Murray)	2	84 (41/43)	Waitlist	MD -0.47 [-1.47, 0.52] Random	P = 0.01; I^2 = 84.35 %	⊕◯◯◯ Very low
	Infant interactions - lively to inert (Murray)	2	84 (41/43)	Waitlist	MD -0.46 [-1.45, 0.53] Random	P = 0.01; I^2 = 86.31 %	⊕◯◯◯ Very low
	Infant interactions - happy to distressed (Murray)	2	84 (41/43)	Waitlist	MD -0.35 [-1.29, 0.59] Random	P = 0.01; I^2 = 83.51 %	⊕◯◯◯ Very low
	Parenting stress	2	55 (24/31)	Waitlist	MD -10.85 [-53.86, 32.16] Random	P = 0; I^2 = 89.88 %	⊕◯◯◯ Very low
	Psychomotor Development Indices	4	466 (283/183)	Waitlist	SMD -0.35 [-0.54, −0.15] Random	P = 0.39; I^2 = 1.06 %	⊕⊕⊕⊕ High
	Mental Development Indices	4	466 (283/183)	Waitlist	SMD -0.27 [-0.64, 0.11] Random	P = 0.02; I^2 = 69.12 %	⊕⊕◯◯ Low
	Gessel/Capital-gross motor	2	237 (117/120)	Waitlist	SMD -0.44 [-0.70, −0.18] Random	P = 0.44; I^2 = 0 %	⊕⊕⊕◯ Moderate
	Gessel/Capital-fine motor	2	237 (117/120)	Waitlist	SMD -0.61 [-0.87, −0.35] Random	P = 0.96; I^2 = 0 %	⊕⊕⊕◯ Moderate
	Gessel/Capital-language	2	237 (117/120)	Waitlist	SMD -0.82 [-1.67, 0.03] Random	P = 0.01; I^2 = 85.59 %	⊕◯◯◯ Very low
	Gessel/Capital-personal-social behaviour	2	237 (117/120)	Waitlist	SMD -0.90 [-1.61, −0.18] Random	P = 0.03; I^2 = 79.65 %	⊕⊕◯◯ Low
Fauzia (2022)	Quality of sleep	6	552 (276/276)	Non-massage	SMD 0.70 [-0.05, 1.46] Random	P < 0.00001; I^2 = 94 %	⊕◯◯◯ Very low
Jabraeili (2023)	Cortisol level	6	343 (176/167)	Routine care	MD -0.66 [-1.21, −0.10] Random	P < 0.00001; I^2 = 84 %	⊕⊕⊕◯ Moderate
Zhang (2018)	Serum bilirubin level within 4 d (mg/dl)	2	54 (21/33)	Routine care	MD -2.31 [-2.92, −1.70] Random	P = 0.59; I^2 = 0 %	⊕⊕⊕◯ Moderate
	Transcutaneous bilirubin level within 4 d (mg/dl)	3	133 (63/70)	Routine care	MD -1.97 [-2.55, −1.39] Random	P = 0.92; I^2 = 0 %	⊕⊕⊕◯ Moderate
	Serum bilirubin level on 2 d (mg/dl)	2	168 (85/83)	Routine care	MD -0.82 [-2.16, 0.52] Random	P = 0.05; I^2 = 75 %	⊕◯◯◯ Very low
	Transcutaneous bilirubin level on 2 d (mg/dl)	2	83 (38/45)	Routine care	MD -0.17 [-1.34, 1.00] Random	P = 0.09; I^2 = 64 %	⊕◯◯◯ Very low
	Frequency of defecation daily on 2 d	4	189 (90/99)	Routine care	MD 0.57 [-0.03, 1.16] Random	P = 0.02; I^2 = 80 %	⊕◯◯◯ Very low
Lv (2019)	Percutaneous jaundice index	9	1191 (601/590)	Routine care or waitlist	MD -2.56 [-2.81, −2.31] Fixed	P = 0.82; I^2 = 0 %	⊕⊕⊕◯ Moderate
Lin (2021)	Effective rate	9	752 (380/372)	Routine care	RR 1.19 [1.13, 1.26] Fixed	P = 0.29; I^2 = 17 %	⊕⊕◯◯ Low

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Table 2 (*continued*)

The first author(yr)	Outcomes	No. of studies	No. of cases (I/C)	Comparison	Effect size (95%CI)/ Model	Heterogeneity	Grade quality
	Cure rate	5	403 (203/200)	Routine care	RR 1.60 [1.31, 1.96] Fixed	$P = 0.57$; $I^2 = 0$ %	⊕⊕◯◯ Low
	Jaundice resolution time	13	1919 (974/945)	Routine care	SMD -1.91 [-2.58, −1.24]	$P < 0.00001$; $I^2 = 97$ %	⊕◯◯◯ Very low
Conditions of the musculoskeletal system and connective tissues							
Chen (2020)	Overall improvements	2	95 (48/47)	Stretching	RR 1.00 [0.94, 1.06] Random	$P = 0.96$; $I^2 = 0$ %	⊕◯◯◯ Very low
Conditions of the digestive system							
Lai (2018)	Clinical cure rate at 3 days	10	722 (NR)	Western medicine	RR 1.45 [1.29 to 1.62] Random	$P = 0.87$; $I^2 = 0$ %	⊕⊕⊕◯ Moderate
	Clinical cure rate at 5 days	2	295 (NR)	Western medicine	RR3.23 [2.15 to 4.84] Random	$P = 0.5$; $I^2 = 0$ %	⊕⊕⊕◯ Moderate
	Diarrhea duration (hrs)	6	410 (NR)	Western medicine	MD -10.40 [-15.31 to −5.48] Random	$P = 0.26$; $I^2 = 23$ %	⊕⊕◯◯ Low
	Clinical cure rate at 6 days	5	631 (NR)	Western medicine	RR 1.52 [1.34 to 1.73] Random	$P = 0.96$; $I^2 = 0$ %	⊕⊕⊕◯ Moderate
	Daily stool frequency	3	217 (NR)	Western medicine	MD -1.71 [-2.37 to −1.04] Random	$P = 0.93$; $I^2 = 0$ %	⊕⊕◯◯ Low
Symptoms, signs or clinical findings, not elsewhere classified							
Liu (2022)	Pain response score (NIPS)	6	483 (242/241)	Routine care	MD -2.02[-2.63, 1.42] Random	$P = 0.002$; $I^2 = 74$ %	⊕⊕◯◯ Low
	Pain response score (PIPP)	5	349 (169/180)	Routine care	MD -3.43 [-6.05, −0.80] Random	$P < 0.00001$; $I^2 = 93$ %	⊕⊕⊕◯ Moderate
	Gestational age of neonates	2	483 (242/241)	Routine care	MD -2.21 [-2.50, −1.91] Random	$P = 0.002$; $I^2 = 74$ %	⊕⊕⊕◯ Moderate
	Heart rate during the painful examination	3	249 (120/129)	Routine care	MD 3.39 [-1.14, −7.92] Random	$P = 0.16$; $I^2 = 45$ %	⊕⊕◯◯ Low
	Heart rate after the painful examination	5	355 (178/177)	Routine care	MD -2.15 [-8.82, −4.52] Random	$P = 0.002$; $I^2 = 82$ %	⊕⊕⊕◯ Moderate
	Blood oxygen saturation variation during the procedure	3	249 (120/129)	Routine care	MD 2.52 [0.28, 4.76] Random	$P = 0.03$; $I^2 = 71$ %	⊕⊕⊕◯ Moderate
	Blood oxygen saturation variation after the procedure	5	355 (178/177)	Routine care	MD 1.05 [0.51, 1.58] Random	$P = 0.55$; $I^2 = 0$ %	⊕⊕⊕⊕ High
	Respiratory rate variation after the procedure	2	136 (68/68)	Routine care	MD 0.11 [-2.61, 2.84] Random	$P = 0.65$; $I^2 = 0$ %	⊕⊕⊕◯ Moderate
	Respiratory rate variation during the procedure	3	238 (119/119)	Routine care	MD -48.60 [-64.32, −32.88] Random	$P = 0.34$; $I^2 = 8$ %	⊕⊕⊕◯ Moderate
Costa (2022)	Pain score	3	202 (101/101)	Routine care	MD -0.38 [-0.84, 0.08] Random	$P = 0.98$; $I^2 = 0$ %	⊕⊕⊕◯ Moderate
	Duration of crying	3	258 (129/129)	Routine care	MD -56.30 [-85.51, −27.09] Random	$P = 0.02$; $I^2 = 73$ %	⊕⊕◯◯ Low

Notes: I: intervention group; C: control group; RR: risk ratio; SMD: standard mean difference; MD: mean difference; NR: not reported; NIPS: neonatal infant pain scale; PIPP: premature infant pain profile.

3.6. Effects of pediatric massage

Quantitative results of the effects of pediatric massage on pediatric conditions were extracted. The conditions and diseases were divided into five categories: conditions originating in the perinatal period, factors influencing health status or contact with health services, conditions of the musculoskeletal system and connective tissues, conditions of the digestive system, as well as symptoms, signs or clinical findings, not elsewhere classified. Detailed individual meta-analysis with the evidence quality assessments is presented in Table 2. Outcomes evaluated as 'high' and 'moderate' quality by GRADEpro with no or low heterogeneity are presented below.

3.6.1. Pediatric massage for conditions originating in the perinatal period

Pooled analysis of 2 studies with 120 cases showed that compared to routine care, pediatric massage significantly performed better on enhancing maternal-infant attachment (SMD 2.83; 95 % CI 2.31 to 3.35) with no heterogeneity. The data from two studies with 87 participants demonstrated head circumference (MD 0.97; 95 % CI 0.73 to 1.21; $I^2 = 0$ %) in the massage group was significantly larger than in the non-massage group.

3.6.2. Pediatric massage for factors influencing health status or contact with health services

The results of meta-analysis measuring infants' weight in 8–12 months follow-up period (2 studies/157 case; MD 455.07g; 95 % CI 86.33 to 823.8; $I^2 = 0$ %), length (9 RCTs/1294 cases; MD 1.58 cm; 95 % CI 1.42 to 1.74; $I^2 = 25$ %), crying or fussing time (3 RCTs/271 cases; MD -0.37time; 95 % CI -0.53 to -0.21; $I^2 = 30$ %), and bilirubin levels (3 RCTs/345 cases, MD -31.75 mmol/L; 95 % CI -40.05 to -23.46; $I^2 = 0$ %) were statistically significant, favoring the massage group. The meta-anslysis compared the effects of infant massage to

waitlist on mid-leg circumference (2 RCTs/225 cases; MD -0.31 cm; 95 % CI -0.49 to -0.13), upper respiratory tract infection (2 RCTs/310 cases; RR 1.19; 95 % CI 0.86 to 1.65), anemia (2 RCTs/310 cases; RR 1.49; 95 % CI 0.79 to 2.82), diarrhea (2 RCTs/310 cases; RR 0.39; 95 % CI 0.2 to 0.76), and Psychomotor Development Indices (4 RCTs/466 cases; SMD -0.35; 95 % CI -0.54 to -0.15), yielding statistically significant results with minimal or no heterogeneity. A meta-analysis showed that less crying or fussing time in the massage group (4 RCTs/341 cases; MD -0.36; 95 % CI -0.52 to -0.19; $I^2 = 0$ %). The Gessel/Capital-gross motor function (SMD -0.44; 95 % CI -0.70 to -0.18; $I^2 = 0$ %) and Gessel/Capital-fine motor (SMD -0.61; 95 % CI -0.87 to -0.35; $I^2 = 0$ %) was significantly better in the massage group compared to the waitlist group (2 RCTs/237 cases). The aggregated estimates from the included studies indicated that, in comparison to routine care or a waitlist, pediatric massage is linked to a significant reduction in 4-day serum bilirubin level (2 RCTs/54 cases; MD -2.31; 95 % CI -2.92 to -1.70; $I^2 = 0$ %), 4-day transcutaneous bilirubin level (3 RCTs/133 cases; MD -1.97; 95 % CI -2.55 to -1.39; $I^2 = 0$ %), and the percutaneous jaundice index (9 RCTs/1191 cases; MD -2.56; 95 % CI -2.81 to -2.31; $I^2 = 0$ %).

3.6.3. Conditions of the digestive system

The combined data revealed a significantly higher clinical cure rate for pediatric massage compared to the montmorillonite group at various time points: 3 days after treatment (10 RCTs/722 cases; RR 1.45; 95 % CI 1.29 to 1.62), 5 days after treatment (2 RCTs/295 cases; RR 3.23; 95 % CI 2.15 to 4.84), and 6 days after treatment (5 RCTs/631 cases; RR 1.52; 95 % CI 1.34 to 1.73), with no observed heterogeneity.

3.6.4. Symptoms, signs or clinical findings, not elsewhere classified

Results indicated significant benefits of pediatric massage over routine care in terms of blood oxygen saturation variation after the procedure (5 RCTs/355 cases; MD 1.05; 95 % CI 0.51 to 1.58, $I^2 = 0$ %) and respiratory rate variation during the procedure (3 RCTs/238 cases; MD -48.6; 95 % CI -64.32 to -32.88 $I^2 = 8$ %).

3.6.5. Adverse event of pediatric massage

Among the 22 systematic reviews, only 1study reported adverse event of pediatric massage. The systematic review assessing pediatric massage on neonatal jaundice reported that pediatric massage was associated with the appearance of anemia, diarrhea, fever, and skin rash [45].

4. Discussion

This research is the first umbrella review to offer a comprehensive overview of pediatric massage for medical conditions in infants and children under 5. We synthesized the quantitative data on the impacts of pediatric massage across various conditions and evaluated both the methodology and evidence quality of the included studies.

The quantitative data collected support the effects of pediatric massage in several conditions. The results and conclusion of this umbrella review were extracted and according to the meta-analysis of the original studies included. The outcomes and outcome measures of the original RCTs varied among systematic reviews; as a result, data types also varied including dichotomous data, continuous data, and count/rates. Due to the difference in effect measures [49], the quantitative data could not be merged, recalculated, or compared to present the magnitude of the intervention effect. We adopted a conservative approach for rating large effect sizes because the indistinctive results might be related to the modest number of clinical trials, modest sample size, unsuitable outcome measure selection, and inappropriate data analysis and combination methods. Further studies might continue to examine the impacts of pediatric massage on relevant outcomes (e.g., meta-analysis of the outcomes with large effects size and high heterogeneity).

While positive effects were observed in several pediatric conditions, the interpretation of the quantitative findings must consider the quality of the methodology and evidence included. The low methodological quality of the systematic reviews may be attributed to improper statistical data combination, failure to evaluate the potential impact of bias in individual studies on the meta-analysis, and insufficient justification for the heterogeneity seen in the results. Most systematic reviews included were rated as having moderate, low, or very low quality of evidence. It is also likely to be influenced by the limitations of the individual RCTs, such as lack of blinding in the outcome assessors and selective reporting. Further studies should be conducted rigorously, considering the aforementioned problems. Systematic reviews should be reported following the PRISMA guideline [24]; multiple and comprehensive search strategies should be applied; key information, a list of excluded articles, publication bias, and funding information should be fully reported; meta-analysis data should be combined in an appropriate way, and the heterogeneity of studies should be discussed to explain the quantitative findings derived from the meta-analysis. RCTs should be strictly reported based on the CONSORT guideline [50,51]; randomization and allocation concealment should be applied rigidly; adverse event detection and report procedure should be well-established; blinding of outcome assessors should be carried out to prevent detection bias; and conflicts of interest on any aspect should be reported in detail. Researchers should guarantee the quality of study in each step because high-quality original trials are the fundamental and vital step of research.

Details regarding adverse events in pediatric patients were gathered to provide a balanced perspective on evaluating this intervention. The study only reported the adverse events but did not provide evidence of the exact relationship between the adverse events and pediatric massage. Lack of information on adverse events might be related to selective reporting or less rigorous conduction of the RCTs, skills of manipulators, selection of manipulations. Several previous studies explored the adverse events of massage using comprehensive methodologies. For example, a systematic review on 60 primary studies conducted in 2020 specifically explored the adverse events of pediatric massage by using a grading system for severity and divided the adverse events of pediatric massage into 5 grades, from mild to death related to adverse events [52]. The study concluded with warranting caution in using abdominal massage in

preterm infants and provided a practical method for researchers to collect information on adverse events of interventions. Further clinical studies, not limited to RCTs or systematic reviews, should be conducted to explore this issue, considering the manipulations, manipulators, context, and other factors. A rigorous methodology should be applied for collecting information on adverse events [53].

Our results also provided valuable information for children's caregivers, pediatricians, and policy makers. Pediatricians could combine conventional interventions with massage in certain aspects to achieve improved effects. As a complementary therapy, children's caregivers might be trained to practice some easy and safe manipulations on their children for health keeping and development purpose. Policy makers may provide trainings on promoting caregiver-administered pediatric massage, possible adverse effects knowledge, and the accordingly solution for using this intervention. Several previous clinical trials have examined the feasibility of parent/caregiver-administered pediatric massage [6,54–58]. Standardized training, meanwhile, is necessary. A comprehensive systematic review on the adverse events of pediatric massage mentioned that no adverse events associated with pediatric massage were reported when the manipulations were provided by a licensed or registered therapist of pediatric massage [52]. Therefore, comprehensive and rigorous training on caregivers may have positive impacts on community and primary health care of infants and children.

While several reviews on pediatric massage exist, our study offers several key advantages. First, our umbrella review systematically covers a wide range of pediatric conditions, providing a broad and holistic understanding of the benefits of pediatric massage therapy. Second, we rigorously assessed the quality of the included studies using AMSTAR-2 and GRADEpro tools, identifying gaps needing further research from the best available evidence. Additionally, unlike previous overviews that mainly summarize qualitative information, we focused on the quantitative data provided by the systematic reviews, filling an meaningful gap in the literature.

This study has some limitations. First, we excluded systematic reviews that included children older than 5 years, which might have inevitably missed some potential studies, but such an approach ensured that the included studies were homogenous. Second, the strength of the evidence was constrained by the methodological quality of the systematic reviews and RCTs included, and some missing data of the meta-analysis were impossible to recalculate. This situation led to uncertainty of the results of the umbrella review. Third, although we pooled the estimated effects size from the meta-analysis of different clinical trials, the data could not be combined or compared because various outcomes, outcome measures, and statistical analysis methods were chosen; approximately 45.7 % of meta-analysis data were with high heterogeneity ($I^2 > 30$ %) [59], which all limited the significance of the results. Finally, our inclusion criteria were limited to articles published in English and Chinese, which may have resulted in the exclusion of relevant data available in other languages.

5. Conclusion

The findings indicate that pediatric massage significantly enhances mother-child attachment, promotes physical growth (weight and length), reduces crying or fussing time, lowers bilirubin levels, improves motor functions and psychomotor development, and effectively manages digestive conditions and pain in infants and children under 5. However, the methodological quality of the included systematic reviews and individual RCTs varied. Future research should address these limitations by employing more rigorous methodologies and comprehensive adverse event reporting.

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Ethical approval

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Dissemination to participants and related patient and public communities

Not applicable.

Data availability statement

Data associated with the study has not been deposited into a publicly available repository. Data will be made available on request.

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CRediT authorship contribution statement

Shu-Cheng Chen: Writing – original draft, Methodology, Formal analysis, Conceptualization. **Shuang-Lan Lin:** Writing – review & editing, Methodology. **Mian Wang:** Investigation, Formal analysis. **Denise Shuk-Ting Cheung:** Investigation, Formal analysis. **Jia-Gui Liang:** Software, Data curation. **Zi-Yao Cheng:** Investigation. **Chun Sum Yuen:** Formal analysis. **Wing-Fai Yeung:** Writing – review & editing, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e35993.

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