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Effectiveness of reduction maneuvers in the treatment of nursemaid's elbow: A systematic review and meta-analysis

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ABSTRACT

Background/Aim: Nursemaid's elbow usually occurs in young children when longitudinal traction is placed on the arm. Several manipulative maneuvers have been described, although, the most effective treatment technique is yet unclear. The aim of this systematic review and meta-analysis was to compare the two most commonly performed maneuvers (supination-flexion and hyperpronation) in the treatment of nursemaid's elbow.
Methods: A literature search was performed in PubMed, Embase, and Cochrane databases to identify randomized controlled trials comparing supination-flexion and hyperpronation. Data were extracted and pooled independently by two authors. Methodological quality assessment of included studies was performed. Meta-analysis was performed using a fixed-effect model in case of homogeneity across studies, and using a random-effect model in case of heterogeneity. Heterogeneity was calculated with the χ^2 test and inconsistency in study effects across trials was quantified by I^2 values.
Results: Seven randomized trials, including 701 patients (62% female), were included. A total of 350 patients were treated with the hyperpronation maneuver versus 351 patients who underwent the supination-flexion maneuver. Meta-analysis showed that hyperpronation was more effective than supination-flexion (risk ratio, 0.34; 95% confidence interval, 0.23 to 0.49; I^2, 35%). The absolute risk difference between maneuvers was 26% in favor of hyperpronation, resulting in a number needed to treat of 4 patients. Trials lacked blinding of assessors and universal pain measures.
Conclusions: Hyperpronation was more effective in terms of success rate and seems to be less painful compared to the supination-flexion maneuver in children with nursemaid's elbow.

1. Introduction

Nursemaid's elbow is a common pediatric injury representing approximately 20% of upper extremity conditions [1] with peak incidence being between two and three years of age [2-4]. This condition typically occurs when axial traction is placed on the forearm, causing elbow extension and pronation. The applied forces and resulting arm movements permit subluxation of the radial head by partially tearing or entrapping the annular ligament between the radial head and capitellum [3,5]. The most frequent causal mechanism is when an adult abruptly pulls while holding the hand of a child [3,5,6]. Clinical presentation suggestive of nursemaid's elbow includes typical mechanism of injury, limb in incomplete extension with a pronated wrist, and the child not wanting to use the arm or protecting it at their side. There is no edema, ecchymosis or deformity associated with the injury, and pain may be present on movement but usually not during palpation [3,5].

Various manipulative interventions can be performed to reduce nursemaid's elbow [7-10]. The traditional supination-flexion (SF) maneuver involves outward rotation of the forearm followed by elbow flexion [11-13]. The hyperpronation (HP) maneuver, where the forearm is rotated inwards (child's thumb pointing downwards) is gaining popularity, as studies have shown that it may be more effective [7-10].

The purpose of this systematic review and meta-analysis was to compare SF and HP in the treatment of nursemaid's elbow reported in randomized controlled trials. The primary outcome was failure rate at the first reduction attempt. The secondary outcomes were pain during or after reduction, adverse effects, and recurrence rate.

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2. Methods

2.1. Protocol

We reported our findings according to the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines, including the PRISMA checklist and algorithm [14].

2.2. Selection Criteria

Studies eligible for inclusion were any quasi-randomized or randomized controlled trials that compared SF and HP for primary or recurrent nursemaid's elbow in any healthcare setting. Quasi-randomization is an allocating method of patients to a specific intervention group that is not strictly random: e.g. date of birth, alternation, or hospital record number. Studies were excluded from the systematic review if children over the age of eight were the main participants or if trials included patients with a clinical presentation consistent with a complete dislocation or possible fracture. Papers not written in English or Dutch were only included if translation was possible.

2.3. Search Strategy

Two reviewers independently searched PubMed/MEDLINE, Embase, and Cochrane databases on June 6th, 2016. The PubMed search strategy (Table 1) was adjusted to fit the format for Embase and Cochrane databases. Two reviewers independently filtered the search results based on title and abstract to find all trials potentially eligible for inclusion. The trials that were deemed potentially eligible were evaluated via full text review. Eligible trials were chosen if they met the criteria and disagreement was resolved by discussion with the senior authors. The references of retrieved papers were manually searched for potential trials meeting the inclusion criteria.

2.4. Quality Assessment

Two reviewers independently appraised the methodological quality of included trials using the Joanna Briggs Institute-Meta Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI) [15]. This instrument has been widely used to increase methodological accuracy and to evaluate potential sources of bias and threats to validity. Critical appraisal included assessment of patient allocation, randomization, blinding, baseline characteristics, and completeness of outcome data (Table 2). Disagreements were resolved by discussion with the senior authors. Trials were not blinded for author, affiliation and source.

2.5. Outcome Measures

The primary outcome measure of this meta-analysis was failure rate of reducing nursemaid's elbow at first attempt. The intervention was considered failure if another reduction attempt was deemed necessary or if the child did not demonstrate a fully functional and pain-free arm after the maneuver. Secondary outcome measures included pain during or after the maneuver, adverse effects (hematoma, infection, nerve injury, and subsequent surgery), and recurrence rate.

Table 1
PubMed search strategy.

Pulled elbow or radial head subluxation or nursemaid's elbow or annular ligament displacement or RHS or slipped elbow or toddler elbow or babysitter's elbow
Supination-flexion or supination flexion or hyper-pronation or hyperpronation or hyper pronation or forced pronation or manipulation or manipulative
1 and 2

2.6. Data Extraction

Two reviewers independently extracted the following study data: first author, year of publication, demographics, inclusion and exclusion criteria, interventions, and outcomes (failure rates, pain scores, adverse effects, and recurrence rates). Disagreements were resolved through discussion and if consensus could not be made, issue was taken to the senior authors. We intended to contact authors if additional information was needed.

2.7. Statistical Analysis

Individual and pooled data were reported as risk ratios with 95% confidence intervals (CI) for dichotomous outcomes (failure or success at first attempt) using the Mantel-Haenszel method. Continuous outcomes (e.g., pain scales) were reported as weighted mean differences (WMD) or if different scales were used as standardized mean differences (SMD).

Heterogeneity was calculated with the χ^2 test and inconsistency in study effects across trials was quantified by I^2 values. The results of individual trials were pooled using a fixed-effect model in case of homogeneity across trials ($I^2 < 25\%$) and using a random-effect model in case of heterogeneity ($I^2 \geq 25\%$). Statistical analyses were performed with the use of Stata® 13.0 (StataCorp LP, College Station, TX, USA).

3. Results

3.1. Baseline Characteristics

Seven trials published between 1998 and June 6th, 2016 met the criteria and were included in this systematic review [7-10,16-18] (Fig. 1). There were a total of 701 patients (62% female), of which 350 patients were treated with the HP maneuver and 351 patients underwent the SF maneuver. All included studies were (quasi-)randomized controlled trials which were performed in either the emergency department or outpatient clinic. Detailed findings of study characteristics are displayed in Table 3.

3.2. Critical Appraisal

A summary of the critical appraisal of included trials is displayed in Table 4. The total MAStARI score ranged from 4 to 6 (out of 10), with a mean of 5.7 points. No trials fulfilled all criteria to be considered as a high-quality trial. As the method of group assignment was not truly random or not mentioned in 5 studies [7,9,10,16,17], and allocation concealment was not reported or not implemented in 6 studies [8-10,

Table 2
MAStARI critical appraisal tool for randomized control/pseudo-randomized trials.

Critical appraisal tool question	Potential bias
1. Was the assignment to treatment group truly random?	Selection bias
2. Were participants blinded to treatment allocation?	Selection bias
3. Was allocation to treatment groups concealed from the allocator?	Selection bias
4. Were the outcomes of people who withdrew described and included in the analysis?	Attrition bias
5. Were those assessing outcomes blind to treatment allocation?	Ascertainment bias
6. Were the control and treatment groups comparable at entry?	Design bias
7. Were groups treated identically other than the named intervention?	Systematic difference/contamination bias
8. Were outcomes measured in the same way for all groups?	Psychometric veracity of instruments
9. Were outcomes measured in a reliable way?	Detection/instrument/measurement bias
10. Was appropriate statistical analysis used?	Performance/detection bias

MAStARI, Meta Analysis of Statistics Assessment and Review Instrument.

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16-18], there was a high risk of selection bias. In addition, as studies lacked blinding of patients, treating physicians, and outcome assessors, this resulted in a high risk of ascertainment bias in all studies [7-10, 16-18].

3.3. Reduction of Nursemaid's Elbow

Given the fact that in all 7 trials the reduction maneuvers were performed in a similar study population and setting [7-10,16-18], we decided to pool the data on reported failures at first attempt. Meta-analysis using a fixed-effect model showed that HP was more effective than SF for treatment of nursemaid's elbow (risk ratio, 0.34; 95% CI, 0.23 to 0.49; I^2, 35%) (Fig. 2). Absolute risk difference between maneuvers was 26.4%, which results in a number needed to treat of 3.8. This signifies that for every 4 children treated with HP rather than SP for nursemaid's elbow, there will be one less failure at first reduction attempt.

3.4. Secondary Outcomes

Five of seven studies reported pain perception related to the reduction maneuver [8-10,16,18], however, assessment across studies varied widely. Therefore, we were not able to pool the data for further analysis. McDonald and colleagues [8] reported less physician-perceived pain at first attempt in the HP group ($p = 0.013$) using an ordinal pain scale (0 to 3). This is in line with Bek and colleagues [10] who found that subjective physician-perceived pain for the HP technique was less painful ($p = 0.003$). In contrast, Gunaydin and colleagues [16] and Guzel and colleagues [18] found no difference in physician-perceived pain related to reduction maneuver. In addition, Green and colleagues [9] found no difference in physician-perceived pain using a visual analogue scale (0 to 10), whereas both nurses ($p = 0.03$) and parents ($p = 0.04$) distinguished HP technique as the less painful maneuver. Assessors were not blinded in all 5 studies.

Other secondary outcomes such as adverse events after manipulation (e.g., hematoma, infection, nerve injury, subsequent surgery) and recurrence rate were not reported in any of the included trials.

4. Discussion

In this systematic review, data were pooled from 7 randomized controlled trials to compare the effectiveness of two primary manipulative maneuvers for reduction of nursemaid's elbow in young children. The hyperpronation maneuver had a significantly lower failure rate at first attempt compared to the supination-flexion maneuver (risk ratio 0.34; 95% CI 0.23 to 0.49; $I^2 = 35\%$). Five of seven studies assessed pain perception and reported conflicting results regarding this issue. Due to lack of homogeneity of pain measures between studies, data was unable to be pooled for further analysis.

Our findings were consistent with the systematic review conducted by Krul and colleagues [19] who found that the HP maneuver had a significantly lower failure rate than the SF maneuver (risk ratio 0.45; 95% CI 0.28 to 0.73). The results of our meta-analysis indicated that the addition of the studies from Gunaydin [16], Guzel [18], and Garcia and colleagues [17] strengthened the evidence that HP is more effective in comparison to SF. Our findings were also in line with the conclusions of Neven and colleagues [20], however, they included the study by Taha [21], whereas we excluded this trial because it lacked a control group.

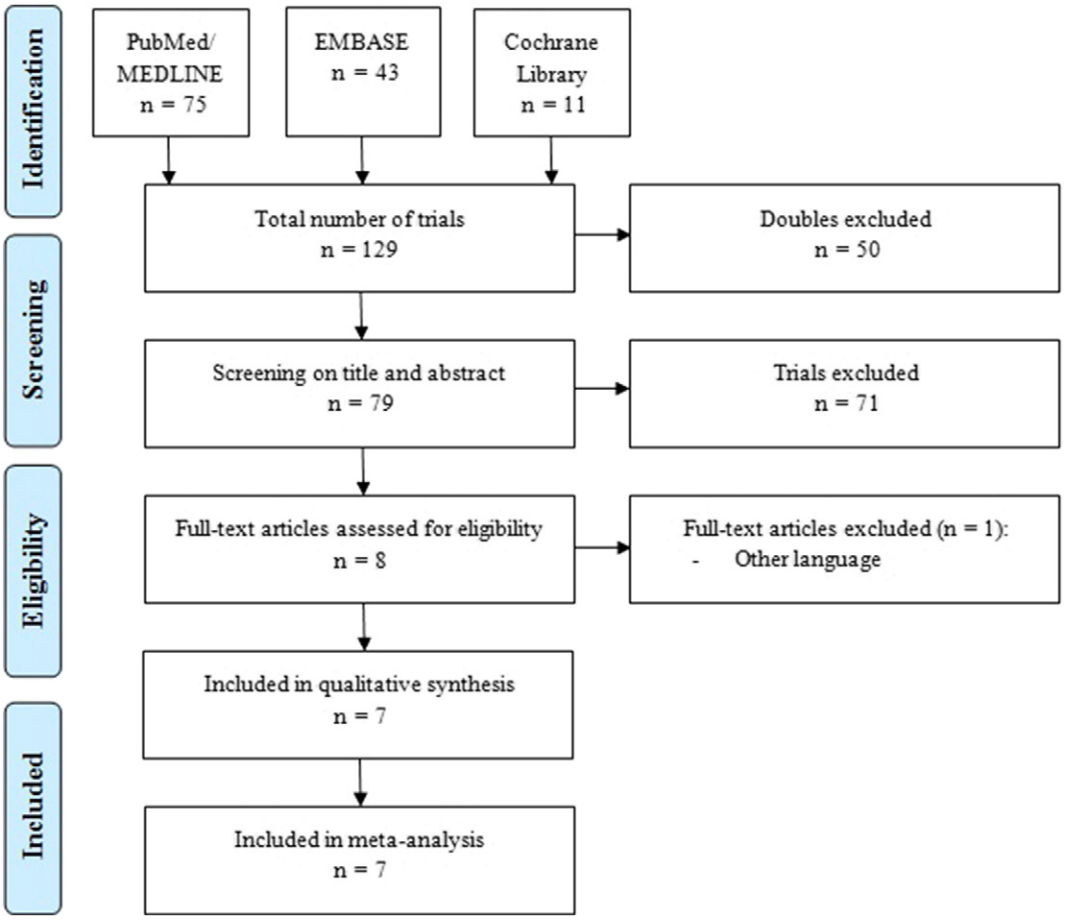

Fig. 1. Flowchart of search strategy following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

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Table 3
Study characteristics.

First author (year)	Participants	Interventions	Outcomes
Macias et al. (1998)[11]	Mean age, 27.7 months; boys, 34; girls, 51 Inclusion criteria: <6 years, clinical presentation suggestive of NE Exclusion criteria: elbow deformity, edema, ecchymosis, pain during palpation, fracture	Hyperpronation versus supination-flexion	Success rate at 1st and 2nd attempt; then, success rate at 3rd attempt (other maneuver)
McDonald et al. (1999)[13]	Age range, 3 months to 6 years; boys, 58; girls, 77 Inclusion criteria: <7 years old, clinical presentation suggestive of NE Exclusion criteria: history of neurological disorder, elbow deformity or edema, congenital bony malformation	Rapid pronation and flexion versus rapid supination and flexion	Success rate at 1st and 2nd attempt; then, success rate at 3rd attempt (other maneuver) Pain during manipulation measured by physician and parent using an ordinal scale (0–3)
Green et al. (2006)[4]	Mean age, 26.7 months; boys, 29; girls, 41[a] Inclusion criteria: age between 6 months and 7 years, typical NE presentation Exclusion criteria: edema or tenderness during palpation of elbow	Forced pronation versus supination-flexion	Success rate at 1st attempt; then, success rate at 2nd attempt (other maneuver) Pain before, during, and 1 min after successful reduction measured by parent, nurse and physician
Bek et al. (2009)[2]	Mean age, 28.6 months; boys, 26; girls, 40 Inclusion criteria: pts. <5 years old presenting with NE Exclusion criteria: history of NE, elbow deformity, edema, ecchymosis, polytraumatized patients	Hyperpronation versus supination-flexion	Success rate at 1st and 2nd attempt; then, success rate at 3rd attempt (other maneuver) Subjective physician rating of maneuver difficulty (easy, moderate, difficult)
Gunaydin et al. (2013)[6]	Mean age, 27.3 months; boys, 51; girls, 99 Inclusion criteria: clinical presentation suggestive of NE Exclusion criteria: elbow deformity, edema, ecchymosis, fracture	Hyperpronation versus supination-flexion	Success rate at 1st and 2nd attempt; then, success rate at 3rd attempt (other maneuver) Pain before, during, and after reduction measured by assisting physician using mCHEOPS scale
Garcia-Mata et al. (2014)[4]	Mean age, 25 months; boys, 33; girls, 82 Inclusion criteria: no musculoskeletal condition, upper-extremity, injury history, or systemic diagnosis Exclusion criteria: patients diagnosed with bone injuries	Hyperpronation versus supination-flexion	Success rate at 1st attempt; then, success rate at 2ndattempt (other maneuver); then, success rate at 3rd attempt (original maneuver)
Guzel et al. (2014)[7]	Mean age, 30 months; boys, 38; girls, 40 Inclusion criteria: age between 1–5 years old with clinical presentation suggestive of NE Exclusion criteria: elbow deformity, edema, ecchymosis, pain during palpation, fracture	Hyperpronation versus supination-flexion	Success rate at 1st and 2nd attempt; then, success rate at 3rd attempt (other maneuver) Pain before and after reduction measured using WBFPRS scale (if child able to communicate) and FLACCS scale (if child unable to communicate)

NE, nursemaid's elbow; mCHEOPS, modified Eastern Ontario Children's Hospital pain scale; WBFPRS, Wong-Baker Faces Pain Rating Scale; FLACCS, Face, Legs, Activity, Cry, Consol Ability Scale.
[a] Sex of two patients not mentioned.

Studies included in this review report conflicting data regarding pain evaluation of manipulative interventions for reduction of nursemaid's elbow [8-10,16,18]. In two out of five studies [8,10], the HP maneuver was less painful than SP maneuver according to the subjective observation of the treating physician. Additionally, Green and colleagues reported a difference in pain evaluation by nurses and parents in favor of HP [9], whereas no difference in physician-perceived pain was reported in 3 studies [9,16,18]. Knowing that pain assessment in young children can be very difficult and the fact that assessors were not blinded in the included studies, made it difficult to draw conclusions on this topic.

Overall, our systematic review strengthens the evidence supporting the HP maneuver as the preferred technique for reduction, but our study had limitations and was susceptible to bias. Although trial setting and study population were very similar across the included studies, we were not able to pool data on pain perception due to heterogeneity of pain measures. Furthermore, the quality of evidence was low in all of the studies due to the impossibility of blinding subjects, providers, and assessors after allocation of treatment intervention. Implications for future research include completely randomized controlled clinical trials with larger study populations and subpopulations, longitudinal outcome studies comparing recurrence rates between HP and SF groups, creating a gold-standard pain scale adapted to young children, and incorporating blinding if possible, to minimize potential bias.

Table 4
Results of methodological appraisal.

MAStARI question	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Score
Authors											
Macias et al. [7]	u	n	y	n	n	y	y	y	y	y	6
McDonald et al. [8]	y	n	u	u	n	y	y	y	y	y	6
Green et al. [9]	u	n	u	u	n	y	y	n	y	y	4
Bek et al. [10]	n	n	u	y	n	y	y	y	y	y	6
Gunaydin et al. [16]	n	n	n	y	n	y	y	y	y	y	6
Garcia-Mata et al. [17]	u	n	u	y	n	y	y	y	y	y	6
Guzel et al. [18]	y	n	u	n	n	y	y	y	y	y	6

y, yes; n, no; u, unclear.

5. Conclusion

We conclude that the hyper-pronation technique is more effective than the supination-flexion maneuver to manually reduce nursemaid's elbow in young children. The included studies, however, were low in quality and susceptible to bias due to the inability to blind physicians and study participants after treatment intervention allocation. Future research with larger study populations and a universal, child-specific pain scale is needed to strengthen the evidence supporting our finding.

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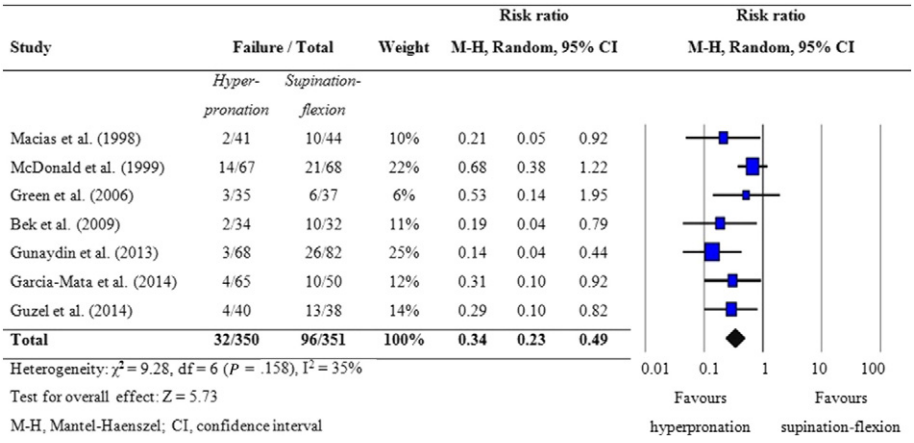

Fig. 2. The risk ratio on the failure rate at first attempt is shown between supination-flexion and hyperpronation.

References

[1] Egol KA, Strauss EJ. Emergency room orthopaedic procedures: an illustrative guide for the house officer. JP Medical Ltd; 2012.
[2] Schunk JF. Radial head subluxation: epidemiology and treatment of 87 episodes. Ann Emerg Med 1990;19(9):1019–23.
[3] Schutzman SA, Teach S. Upper-extremity impairment in young children. Ann Emerg Med 1995;26(4):474–9.
[4] Vitello S, et al. Epidemiology of nursemaid's elbow. Western Journal of Emergency Medicine 2014;15(4):554.
[5] Hardy R. Nursemaid's elbow. J R Coll Gen Pract 1978;28(189):224–6.
[6] Matles A, Eliopoulos K. Internal derangement of the elbow in children. Int Surg 1967;48(3):259–63.
[7] Macias CG, Bothner J, Wiebe R. A comparison of supination/flexion to hyperpronation in the reduction of radial head subluxations. Pediatrics 1998;102(1):e10.
[8] McDonald J, Whitelaw C, Goldsmith LJ. Radial head subluxation: comparing two methods of reduction. Acad Emerg Med 1999;6(7):715–8.
[9] Green DA, et al. Randomized comparison of pain perception during radial head subluxation reduction using supination-flexion or forced pronation. Pediatr Emerg Care 2006;22(4):235–8.
[10] Bek D, et al. Pronation versus supination maneuvers for the reduction of 'pulled elbow': a randomized clinical trial. Eur J Emerg Med 2009;16(3):135–8.
[11] Stoll BJ, Kliegman R. Blood disorders. Nelson text book of pediatrics; 2004. p. 601–6.
[12] McMillan JA, et al. Oski's pediatrics: principles & practice. Lippincott Williams & Wilkins; 2006.
[13] Meckler GD, Spiro DM. Technical tip: radial head subluxation. Pediatr Rev 2008;29(7):e42–3.
[14] Liberati A, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. Ann Intern Med 2009;151(4):W-65–94.
[15] Institute JB. Joanna Briggs Institute reviewers' manual: 2014 edition. Adelaide: The Joanna Briggs Institute; 2014.
[16] Gunaydin YK, et al. Comparison of success and pain levels of supination-flexion and hyperpronation maneuvers in childhood nursemaid's elbow cases. Am J Emerg Med 2013;31(7):1078–81.
[17] García-Mata S, Hidalgo-Ovejero A. Efficacy of reduction maneuvers for "pulled elbow" in children: a prospective study of 115 cases. J Pediatr Orthop 2014;34(4):432–6.
[18] Guzel M, et al. Comparison of hyperpronation and supination-flexion techniques in children presented to emergency department with painful pronation. Niger J Clin Pract 2014;17(2):201–4.
[19] Krul M, et al. Manipulative interventions for reducing pulled elbow in young children. Cochrane Database Syst Rev 2012;1.
[20] Neven AK, Eekhof J. Zondagmiddagarmpje. Huisarts en wetenschap 2008;51(13):688–90.
[21] Taha AM. The treatment of pulled elbow: a prospective randomized study. Arch Orthop Trauma Surg 2000;120(5–6):336–7.

Please cite this article as: Bexkens R, et al, Effectiveness of reduction maneuvers in the treatment of nursemaid's elbow: A systematic review and meta-analysis, American Journal of Emergency Medicine (2016), http://dx.doi.org/10.1016/j.ajem.2016.10.059