Is Electrical Stimulation effective in preventing and/or reducing shoulder subluxation in children following stroke?

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CLINICAL SCENARIO

Shoulder subluxation is reported to occur in up to 81% of adults following a stroke (Ada & Foongchomcheay, 2002, pg 257). Limited literature currently exists regarding the prevalence of shoulder subluxation in children following an acquired brain injury. Based on clinical experience however, shoulder subluxation does occur in some children following a stroke and has a significant, and potentially long-term, impact on function. Therefore, it is of clinical importance to determine the best practice for prevention and management of shoulder subluxation in children.

Electrical stimulation (ES) is the use of an electrical current to stimulate a muscle contraction and produce movement. There is some evidence to support the use of ES to reduce shoulder subluxation in adults however less information exists regarding the use of ES with children.

The aim of this CAT was to review the current evidence for the use of ES in preventing or reducing shoulder subluxation in children.

FOCUSSED CLINICAL QUESTION

Is electrical stimulation effective in preventing or reducing shoulder subluxation in children following stroke?

SUMMARY OF SEARCH

A meta-analysis of 7 studies supported the use of early electrical stimulation for adults who had sustained a stroke, applied to the supraspinatus and deltoid muscles to produce a motor response, in preventing 6.5mm of should subluxation when used in conjunction with conventional upper limb therapy. The studies included in Ada & Foongchomcheay (2002) applied ES at a stimulation frequency greater than 30Hz and increased ES duration from 1.5-2hours to 4-6 hours per day for 5-7 days per week for a total of 4-6 weeks.

Contradictory evidence exists regarding the efficacy of electrical stimulation to reduce shoulder subluxation once it has occurred. The meta-analysis reported no evidence to support the late application (more than 2 months post stroke) of ES to reduce shoulder subluxation. An RCT (Koyuncu, E., Nakipoglu-Yuzer, GF., Dogan, A., & Ozgirgin, N, 2010)involving 50 patients reported that ES applied to the supraspinatus and posterior deltoid muscles, in combination with conventional treatment, was superior to conventional treatment alone in reducing shoulder subluxation for adult patients who were 30-1440 days post stroke. The positive effects reported by the RCT may be influenced by at least part of the sample still being in the acute recovery phase. It is possible that the patients who received ES early post stroke may have produced positive results but the patients who received ES late after stroke may have produced negative or no change.

It is unclear whether the effects of ES on shoulder subluxation reduction are maintained following withdrawal of treatment. Koyuncu, Nakipoglu-Yuzer, Dogan & Ozgirgin (2010) did not follow- up participants and therefore did not measure the long-term effects of ES. The meta-analysis did not report on whether the benefits of ES were maintained, this is likely due to variability between the studies in the time measurements were taken post ES withdrawal.

CLINICAL BOTTOM LINE

While strong evidence exists to support the use of ES in preventing shoulder subluxation in adults when applied in the first two months post stroke, no evidence was found that specifically addressed the effectiveness of ES in preventing and reducing shoulder subluxation in children. Additionally, less information is available about the aetiology of shoulder subluxation in children following stroke and the impact of ES on developing neurological and musculoskeletal systems. Therefore, results should be generalised with caution.

Important note on the limitation of this CAT

This critically appraised paper (or topic) has /has not been peer-reviewed by one other independent person/lecturer

SEARCH STRATEGY

Terms used to guide the search strategy
• **P**atient/Client Group: Neurological disorder, stroke, brain injury, traumatic brain injury, acquired brain injury, hemiplegia, hemiparesis, children, paediatric, child, young person, infant, • **I**ntervention (or Assessment): Rehabilitation, occupational therapy, physiotherapy, physical therapy, • **C**omparison: FES, functional electrical stimulation, electrical stimulation. • **O**utcome(s): Subluxation, increased ROM, pain, independence, functional gains, upper limb motor function, activities of daily living, ADL's, participation.

Databases and Sites Searched	**Search Terms**	**Limits Used**
Cochrane Database Medline Embase CINAHL- Ebsco Pedro OT Seeker	Hemiplegia Hemiparesis Stroke Brain Injury Traumatic brain injury Acquired brain injury Neurological disorder Electrostimulation Electrostimulation therapy Functional electrical stimulation Electrical stimulation Subluxation Shoulder Occupational Therapy Physiotherapy Paediatric Children Young Person	Published between 2000 and 2012 Written in English

INCLUSION and EXCLUSION CRITERIA

Inclusion Criteria
• English • Articles post 2000 • Studies investigating the use of ES on shoulder subluxation

- Studies with shoulder subluxation as a primary outcome

Exclusion Criteria

- Literature before 2000
- Percutaneous neuromuscular electrical stimulation
- Surgical interventions
- Lower Limb

RESULTS OF SEARCH

Medline, CINAHL, Pedro and OTCATS were searched. From these

32 articles were identified in CINAHL - Ebsco (9), Medline (5), Embase (8), Cochrane database (1), Pedro (8) and OT Seeker (1) using the search terms listed. 21 articles were then selected from the titles and abstracts as meeting the above selection criteria. The remaining 10 were excluded as not meeting the criteria. Articles were then hand searched and further excluded if shoulder subluxation was not a primary outcome measure. 4 articles were identified as having shoulder subluxation as a primary outcome measure and were categorised as shown in Table 1 (based on Levels of Evidence, Centre for Evidence Based Medicine), 2 articles were then selected and were critically appraised.

Table 1: Summary of Study Designs of Articles Retrieved

Study Design/Methodology of Articles Retrieved	Level	Number Located	Author (Year)
Meta-analysis	1a	1	Ada & Foongchomcheay (2002).
Randomised Control Trial	1b	3	Koyuncu, E., Nakipoglu-Yuzer, GF., Dogan, A., & Ozgirgin, N. (2010) Wang, R., Chan, R., & Tsai, M. (2000) Fil A., Armutlu ,K,, Atay, A.O., Kerimoglu, U., & Elibol, B. (2011)

BEST EVIDENCE

The following studies were identified as the 'best' evidence and selected for critical appraisal. Reasons for selection:

- Ada, L., & Foongchomcheay, A. (2002). Efficacy of electrical stimulation in preventing or reducing subluxation of the shoulder after stroke: a meta-analysis. *Australian Journal of Physiotherapy*, 48(4), 257-267.

- Koyuncu, E., Nakipoglu-Yuzer, G.F., Dogan, A., Ozgirgin, N. (2010). The effectiveness of functional electrical stimulation for the treatment of shoulder subluxation and shoulder pain in hemiplegic patients: A randomized control trial. *Disability and Rehabilitation*, 32(7), 560-566.

These studies were selected as they specifically investigated the effectiveness of electrical stimulation in preventing or reducing shoulder subluxation and used shoulder subluxation as a primary outcome measure. The meta-analysis by Ada & Foongchomcheay (2002) was selected as it was the highest level of evidence. The study completed by Koyuncu, Nakipoglu-Yuzer, Dogan & Ozgirgin (2010) was included as it was the only study completed after the meta-analysis which looked at ES and conventional therapy in preventing and reducing

shoulder subluxation. The article by Wang, Chan & Tsai (2000) was excluded as it was completed prior to the meta-analysis and data from this study was included in the meta-analysis. The article by Fil, Armutlu, Atay, Kerimoglu & Elibol (2011) was excluded as it examined the effectiveness of ES in conjunction with Bobath techniques and did not use a standard or 'conventional' treatment comparison group.

Given shoulder subluxation was the outcome of interest for this CAT, data for other outcome measures (e.g. pain, upper limb function etc) included in the meta-analysis by Ada & Foonchomcheay (2002) and the RCT by Koyuncu et al (2010) is not reported in this review.

SUMMARY OF BEST EVIDENCE

Table 2: Description and appraisal of study by Koyuncu, Nakipoglu-Yuzer, Dogan &Ozgirgin, 2010.

Aim/Objective of the Study/Systematic Review
The aim of the study was to examine the effectiveness of functional electrical stimulation for the treatment of shoulder subluxation and shoulder pain in patients with a hemiplegia.
Study Design
Randomised Control Trial.
Setting
Participants were all inpatients in the rehabilitation program at the Republic of Turkey Ministry of Health, Ankara Physical Treatment and Rehabilitation Training and Research Hospital between November 2006 and January 2008.
Participants
50 patients with a hemiplegia due to stroke with shoulder subluxation and shoulder pain were included. Study Group: - 25 participants. 20 (80%) female Mean age 60.7 - Median hemiplegia duration (time from onset to the time they entered rehab) = 180 days - Etiology: Thromboemboli in 17 (68%) and hemorrhage in 8 (32%) patients - Hemiplegic side: 8 (32%) right hemiparesis - Control Group: - 25 participants. 16 (64%) female - Mean age 62 - Median hemiplegia duration = 90 days - Etiology: Thromboemboli in 15 (60%) and hemorrhage in 10 (40%) patients - Hemiplegic side: 10 (40%) right hemiparesis No statistically significant differences between the two groups for age, gender, etiology, hemiplegia duration or hemiplegic side were reported.
Intervention Investigated
Control
Patients received conventional rehabilitation. No information was provided regarding the type of intervention,

setting or frequency/duration.

Experimental

Patients received conventional rehabilitation in addition to ES to supraspinatus and posterior deltoid muscles at a stimulation frequency of 36 Hz. Patients received ES "five times a day, 1h daily for 4 weeks and a total of 20 sessions to the hemiplegic side supraspinatus and posterior deltoid muscles" (Koyuncu et al, 2010, pg 562).

Outcome Measures

- **Shoulder Subluxation**

- Classification of shoulder subluxation using the classification by Van Langenberge. Van Langenberge classification system uses 5 grades of subluxation; 0=normal, 1=V-shaped widening, 2=moderate subluxation, 3=advanced subluxation, 4= dislocation. Scores were calculated from anteroposterior shoulder x-rays which were taken pre and post rehabilitation.
- Measurement in mm of the shortest distance between two parallel lines drawn from the inferior border of the acromion and the superior border of the humerus head on the anteroposterior shoulder X-ray as described by Hall et al. Anteroposterior X-rays were taken while the patient sat straight with their arms by their side and with no arm support. X-rays were not taken until at least 24 hrs after the electrical stimulation to eliminate any possible short term effects. X-rays were taken pre and post rehabilitation.

All measurements were completed by the same investigator, however details of this investigator are not provided.

Main Findings

The 95% confidence intervals were unable to be calculated due to the limited data provided by the authors.

Comparison of pre and post rehabilitation shoulder subluxation stages (according to Van Langenberghe classification) of study and control groups.

	Pre-rehabilitation	Post-rehabilitation	Statistical Significance	Change amount
Study Median	2	1	P<0.001	-1 (-2 to 0)
Control Median	2	2	P=0.052	0 (-2 to 1)
	P=0.428	P=0.194		P = 0.003

Comparison of pre and post rehabilitation shoulder subluxation values (according to mm measurement by Hall et al.) of study and control groups.

	Pre-rehabilitation	Post-rehabilitation	Statistical Significance	Change amount
Study Median	10	5	P<0.001	-3 (-19 to 2)
Control Median	10	10	P=0.077	-2 (-11 to 5)
	P=0.763	P=0.042		P = 0.025

Original Authors' Conclusions

Koyuncu et al (2010) concluded that ES in addition to conventional treatment is more beneficial than conventional treatment alone in the treatment of shoulder subluxation in adult patients with a hemiplegia post

stroke.

Critical Appraisal

Validity

[Methodology, rigour, selection, bias, provide PEDro socre/PEDro partitioned score and sub-test items 1-10 for RCTs; other study designs, follow headings used in critical appraisal checklist forms.

Comment on missing information in original paper.

Limitations

- Patients were not classified according to duration of hemiplegia, therefore there were no results regarding whether ES had a different effect on long term vs. short term hemiplegia.
- Difficult to replicate study interventions due to unclear reporting of study group intervention and no detail regarding the control group intervention of a "rehabilitation program using ocnventional methods".
- No information regarding whether patients were taking medication (e.g. pain medication) simultaneously was provided.
- No information was provided regarding patient scores or means; only medians were reported.

Potential biases

- Attention bias: Patients in ES group would have been aware of ES on which may have resulted in favourable responses (e.g. on VAS scale)
- Selection bias may be in effect, no information was provided regarding how patients were approached to participate in the study, or by whom.
- All measurements were taken for the control and study group by the same investigator which provided data standardization but may have also resulted in results bias towards study group. Does not state whether "investigator" was part of the research or treatment team.
- Therapist bias: Does not state whether there was the same therapist treating all patients in the control and study groups.
- Although it was reported that there were no significant differences between the two groups, the median hemiplegia duration of the study group was 180 days (range= 30-1440 days) compared to 90 days (range=45-240 days)in the control group. This may have positively influenced the results of the control group.

Missing information

- No information regarding what "conventional therapy" involved was included (e.g. type of therapy, duration, frequency, location, therapists involved etc).
- Information regarding the application of ES and duration/frequency in the study group was unclear.
- No follow up was provided therefore unable to determine the long-term effect of ES treatment.

Pedro score = 5/10. Points were allocated for random allocation, baseline comparability between groups, adequate follow-up, between group statistical comparisons and point measures/measures of variability. Points were not assigned for concealed allocation, blinding of subjects, blinding of therapists, blinding of assessors or intention-to-treat analysis.

Interpretation of Results

The study reported that there was a:

- Statistically significant difference between the pre and post rehabilitation shoulder subluxation values of the study group ($p < 0.001$).
- No statistically significant difference between pre and post rehabilitation shoulder subluxation values of the control group ($p>0.05$)
- Statistically significant difference between the study and control group for pre and post rehabilitation shoulder subluxation values, in favour of the study group ($p<0.05$)

Limited information was provided in the results section; while medians and p values were provided there was no

reporting of means, confidence intervals or standard deviations. The use of medians made it difficult to gain a good representation of the data set and limited the ability to critically interpret the data. Therefore, medians may not have been the most appropriate value to use to report the data.

The range in 'change amount' for both of the subluxation measures across both groups (study and control) includes both positive and negative values. This means that there was both positive and negative change in regards to shoulder subluxation in both groups. This would suggest that while the median change value was positive, in that it reduced shoulder subluxation, there were also some patients whose subluxation increased following treatment. This may potentially be explained by the large range in time post stroke (30-1440 days); however it is difficult to draw conclusions due to insufficient data. It is possible that early ES for patients with a hemiplegia may have produced positive results but late ES may have produced negative or no change.

Summary/Conclusion

Application of ES to supraspinatus and posterior deltoid muscles in addition to conventional treatment is more beneficial than conventional treatment alone for the treatment of subluxation in adult hemiplegic patients.

Table 3: Description and appraisal of study by Ada & Foonchomcheay, 2002.

Aim/Objective of the Study/Systematic Review:

The main aim of the study was to examine the effectiveness of surface electrical stimulation, applied to supraspinatus and posterior deltoid muscles to produce a motor response, in:

1. Preventing shoulder subluxation
2. Reducing shoulder subluxation.

The secondary aims were to examine the effectiveness of surface electrical stimulation in improving function of the shoulder early and late after stroke. The study also examined the effectiveness of ES in preventing and reducing pain in the shoulder.

Ada & Foongchomcheay (2002) reviewed previous literature and noted that previous systematic reviews about the use of ES did not review shoulder subluxation as the primary outcome measure. Therefore, Ada and Foonchomcheay reported there was a need for a meta-analysis to examine the efficacy of electrical stimulation, producing a motor response in supraspinatus and posterior deltoid, in preventing and reducing shoulder subluxation.

Study Design

Meta-analysis.

Location: The Meta-analysis was completed in Sydney, Australia.

Search strategy: Details of the databases searched and the inclusion/exclusion criteria were provided by the authors in the method (pg. 258), however specific search terms were not provided.

Methods

Sample characteristics were reported to be similar across all 7 trials.

Diagnosis: Stroke with either shoulder subluxation, shoulder muscle paralysis or a upper limb manual muscle test of less, than or equal to 2.

Age: <50 years old

Intervention:

- **Control Group:** Conventional Therapy

- **Study Group:** Surface electrical stimulation applied to supraspinatus and deltoid muscles to produce a muscle contraction, in addition to conventional therapy. Stimulation frequency was more than 30 Hz or it was stated that a motor response was obtained. Both the trials (early ES and late ES) increased the application of ES by increasing both the duration and the work/rest cycle. Increases were made to the ES program when participants were able to complete a session without fatigue of the muscles being stimulated.

    - Early Electrical Stimulation Trial
      Stroke occurred less than 2 months prior to start of study.
      Age: 55-73 years old
      Gender: 49% male
      Hemiplegia: 61% left side hemiplegia
      Time post stroke: 2-49 days
      Intervention: Intervention was carried out over 4-6 weeks, 5-7 days per week. Duration of ES was increased over time from between 1.5-2 hours/day to between 4-6 hours/day.

    - Late Electrical Stimulation Trial
      Stroke occurred more than 2 months prior to start of study.
      Age: 53-69 years old
      Gender: 76% male
      Hemiplegia: 53% left side hemiplegia
      Time post stroke: 60-434 days
      Intervention: Intervention carried out over 6 weeks, 5 days/week. Duration of ES was increased from between 0.2-1.5 hours/day to 0.5 and 6 hours/day.

Outcome Measures: Subluxation was the primary outcome measure across all trials. Subluxation was measured in mm from plain antero-posterior x-rays of the shoulder in all 7 trials, however, slightly different measurement point s were used between trials. Also, 4 trials compared the affected side to the non affected side and 3 only measured the affected side. Whilst Baker measured subluxation in mm, the method of measurement used by Baker is unknown. Pain (included in all 7 trials) and arm function (included in 6 trials) were also measured as secondary outcome measures.

Results

Subluxation:

- Early ES plus conventional therapy is superior to conventional therapy and prevents 6.5mm of subluxation of the shoulder after stroke.
- Late ES plus conventional therapy only reduces subluxation of the shoulder after stroke by 1.9mm and the 95% CI indicates that there is no evidence that it is superior to late conventional therapy and suggests that ES is not effective in reducing shoulder subluxation once it has occurred.

Limitations

Limitations

- There was no report of the number of subjects who dropped out in any trial except Linn.
- Conventional therapy was not consistent across trials. Limited information was provided to determine whether this could impact on the outcome.

Biases

- Attention bias: Patients in ES group would have been aware of ES on which may have resulted in favourable responses e.g. on VAS scale.

Summary/Conclusions

Early application of ES applied to produce a motor response in deltoid and supraspinatus muscles is effective in preventing 6.5mm of shoulder subluxation in adults. Therefore ES should be started as early as possible with adult patients who are at risk of developing shoulder subluxation as part of best practice.

Ada and Foonchomcheay recommend that ES should be applied daily for adult patients who score less than 4 on item 6 of the Motor Assessment Scale for stroke (Carr et al, 1985). It is recommended that ES be applied daily to posterior deltoid and supraspinatus at more than 30 Hz, beginning at 1 hr/day and progressing to 6hr/day and continuing until the score on item 6 of the Motor Assessment Scale reaches 4.

Although there is only a small number of trials included in Ada and Foongchomcheay's systematic review, they are of reasonable quality, suggesting that results can be generalised cautiously to an adult population.

Table 1: Characteristics of included studies

	Study 1 **Ada & Foonchomcheay (2002)**	**Study 2** **Koyuncu, Nakipoglu-Yuzer, Dogan &Ozgirgin (2010)**
Intervention investigated	Electrical Stimulation to supraspinatus and deltoid muscles in addition to conventional therapy. - **Early ES:** less than 2 months post stroke. ES 4-6 hours/day, 5-7 days/week for 4-6 weeks. - **Late ES:** more than 2 months post stroke. ES 0.5 to 6 hours/day, 5 days/week for 6 weeks.	Electrical stimulation to supraspinatus and posterior deltoid in addition to conventional therapy.
Comparison intervention	"Conventional therapy"	"Rehabilitation program using conventional methods"
Outcomes used	• Shoulder Subluxation • Pain • Function	• Shoulder Subluxation • Pain
Findings	Electrical stimulation is effective in preventing shoulder subluxation when applied early after stroke. Electrical stimulation is not effective at reducing shoulder subluxation when applied late after stroke, once the subluxation has occurred.	Electrical Stimulation to supraspinatus and posterior deltoid muscles in addition to conventional treatment is more beneficial than conventional treatment alone in treating shoulder subluxation.

IMPLICATIONS FOR PRACTICE, EDUCATION and FUTURE RESEARCH

Implications for practice and education

- None of the studies critically appraised included children. Therefore results need to be interpreted with caution due to the differences between adults and children. In particular, the impact of growth and developing neurological and musculoskeletal systems in children needs to be considered further in regards to ES use.
- ES should be applied early, as part of best practice, to adult patients at risk of developing shoulder subluxation in addition to conventional therapy.
- Initially additional time needs to be allocated to patients for ES set-up and education to allow time for ES in addition to "conventional therapy".
- Processes for early detection of patients at risk of developing shoulder subluxation need to be developed to ensure they are able to access ES as early as possible. Ada and Foongchomcheay suggested that the criteria for ES application should be loss of function due to paralysis of shoulder muscles post stroke. They recommend the Motor Assessment Scale is administered to 'at risk' patients. ES is then applied to patients who score less than 4 on item 6 (upper arm function) and is continued until their score on MAS reaches 4. Ada and Foongchomcheay recommend that ES be applied to supraspinatus and posterior deltoid daily for 6 hours at more than 30Hz.
- It is unclear whether treatment effects are maintained following withdrawal of ES therefore greater understanding of the indicators for ES withdrawal is required and further research into the long-term effectiveness of ES on shoulder subluxation prevention and treatment needs to be conducted.
- Regular opportunities for ES education with patients, caregivers, relevant professionals (e.g. nursing staff, current therapists, community therapists etc) needs to be provided to support consistent and ongoing ES use/monitoring.

Future research

- Future research into the use of ES to prevent and treat shoulder subluxation in children is required.
- Clear definitions are required regarding the different types of ES (e.g. FES, ES, TENS). ES is often examined as one intervention; however ES can vary significantly depending on whether it is used to produce a motor or a sensory response.
- ES is unlikely to be administered as a sole intervention. Generally it is used in conjunction with "conventional therapy". Greater understanding and definition of what constitutes "conventional therapy" is required to ensure results are replicable and comparable.
- Use of consistent standardised outcomes for the measurement of shoulder subluxation are required.

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