

There is low level evidence to support the use of functional electrical stimulation to enhance function in the upper limb of children with neurological conditions.

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CLINICAL SCENARIO: There are a range of neurological conditions that affect upper limb function in children including: stroke, cerebral palsy, brain injury, brain tumour and spinal cord injury. These conditions impact a child's ability to perform activities of daily living and participate independently in age appropriate occupations. Current upper limb rehabilitation interventions for children include, but are not limited to, constraint induced therapy, bimanual treatment, goal directed training, neuro-developmental therapy, functional retraining and reconditioning (Sakzewski, Ziviani & Boyd, 2009).

Functional electrical stimulation (FES) has been used widely in adult populations for upper limb retraining and is considered best practice for adults following stroke (National Stroke Foundation, 2010). Interestingly, FES is not routinely used in upper limb rehabilitation for children. There is however, emerging evidence to support the use of FES for children in the lower limb (Kang, Bang & Jung, 2007; Van der Linden, Hazlewood, Hillman & Robb, 2008). We aimed to evaluate the evidence for FES to promote upper limb function in children with neurological conditions.

FOCUSED CLINICAL QUESTION:

What is the evidence that functional electrical stimulation/ electrical stimulation is effective in improving upper limb function in children with neurological conditions?

SUMMARY of Search, 'Best' Evidence' appraised, and Key Findings:

- Three studies investigating functional outcomes using functional electrical stimulation (FES) in the upper limb of children were identified.
- Only one randomised control trial was identified, the remaining studies used longitudinal single participant designs without control groups.
- The intensity and duration of intervention varied between the three studies. In all three studies FES was applied to the wrist extensors, although one study also involved the elbow extensors.
- Two studies included the use of a dynamic brace in conjunction with FES.
- The outcome measures used were not consistent across studies, although all 3 studies had measures of active range of motion.
- There were statistically significant improvements in hand function, as measured with the Jebsen Taylor Hand Function (JTHF), and active range of motion following FES to wrist extensor muscles in a before and after study design (Wright, 2000)
- The participants with wrist contractures did not demonstrate changes post FES.

- An RCT reported that Dynamic bracing combined with Neuromuscular Electrical Stimulation (NMES) produced statistically significant improvement, however these outcomes were not maintained 3 months post treatment (Ozer, 2006).¹
- A further before and after study by Postans et al (2010) did not demonstrate any improvements in upper limb function or range of motion.
- Lack of consistency in study protocols, outcome measures and follow up makes it difficult to combine study results.

CLINICAL BOTTOM LINE:

There is no evidence to support or refute the use of FES to improve upper limb function in children with neurological conditions. Only one study (Wright, 2000) provided preliminary support for the use of FES to increase strength and range of movement in the upper limb for children. Further research is required to determine whether this improvement translates to increased functional performance.

Limitation of this CAT: This critically appraised paper (or topic) has been peer-reviewed by two other independent people.

SEARCH STRATEGY:

Terms used to guide Search Strategy:

- **P**atient/Client Group: Children, adolescents, neurological, rehabilitation, brain injury, stroke, cerebral palsy, hemiplegia, diplegia, quadriplegia, CVA, SCI, upper extremity, fingers, hand, upper limb
- **I**ntervention (or Assessment): Functional electrical stimulation, neuromuscular electrical stimulation (NMES), transcutaneous electric nerves stimulation, occupational therapy, physiotherapy, therapy
- **C**omparison: Nil
- **O**utcome(s): Nil

Databases and sites searched	Search Terms	Limits used
OTSeeker Cinahl Cochrane OT-CATS Medline	Children Adolescents neurological, rehabilitation, brain injury, stroke, cerebral palsy, hemiplegia, diplegia, quadriplegia, CVA,	Child, preschool 2 -5 yrs, Child 6 – 12yrs, Adolescence, 13-18yrs

	SCI, upper extremity, fingers, hand, upper limb Paediatric occupational therapy Occupational therapy practice Occupational therapy practice, evidence based Occupational therapy practice, research based Functional electrical stimulation, neuromuscular electrical stimulation, transcutaneous electric nerves stimulation, occupational therapy, physiotherapy,therapy	
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INCLUSION and EXCLUSION CRITERIA

- Inclusion: Outcome studies that investigated the use of electrical stimulation for upper limb rehabilitation of children with neurological conditions, including the use of a functional outcome measure.
- Exclusion: Adults, lower limb, gross motor/gait, non-english studies, discussion papers, no follow up period

RESULTS OF SEARCH

Sixty-six articles were identified in CINAHL, Cochrane database, OTCATS, Medline and OT Seeker using the search terms listed. From these, 19 were selected from the titles and abstracts as meeting the above selection criteria. The remaining 47 were excluded as not meeting the criteria. The 19 articles were critically appraised and the reference lists reviewed for further relevant articles. Of the 19 articles appraised three met the inclusion/exclusion criteria, and were categorised as shown in Table 1 (based on Levels of Evidence, Oxford Centre for Evidence-Based Medicine, 2011)

Table 1: Summary of Study Designs of Articles retrieved

Study Methodology Articles Retrieved	Design/ of	Level	Number Located	Author (Year)
Randomised trial	control	II	1	Ozer, Chesher & Schecker (2006)
Case-series / before & after design		IV	2	Wright & Granat (2000)
				Postans, Wright, Bromwich, Wilkinson, Farmer & Swain (2010)

SUMMARY OF BEST EVIDENCE

Table 2: Description and appraisal of 'Neuromuscular electrical stimulation and dynamic bracing for the management of upper extremity spasticity in children with cerebral palsy', randomised control trial by Ozer, Chesher & Scheker (2006).

Aim/Objective of the Study: To determine whether the combined use of Neuromuscular Electrical Stimulation (NMES) and dynamic bracing was more effective than use of either alone in reducing upper extremity spasticity in children with spastic hemiplegic cerebral palsy.¹

Study Design: The study was a randomised control trial with three study arms. There was no non-treatment control group. Outcome measures were completed monthly by a blinded assessor.

Setting: Participants were recruited through a tertiary hand clinic at the centre for Orthotic and Prosthetic Care, Louisville KY USA between 1997 – 2000.

Participants: Thirty-one participants were recruited. Six patients did not comply with the protocol and one family moved interstate and were therefore excluded from the study. The remaining 24 participants (12 females, 12 males) were aged between 3 – 18 years and presented with a spastic hemiplegia including upper limb involvement and minimal cognitive impairment.

Intervention Investigated

The study investigated the effectiveness of NMES combined with dynamic bracing compared to dynamic bracing and NMES alone. Three treatment groups were allocated for a 6 month treatment period.

1. Group 1 protocol consisted of NMES only to the antagonistic muscles applied for 2 x 30 minute sessions daily for 6 months
2. Group 2 protocol consisted of 2 x 30 minute sessions of dynamic bracing daily for 6 months
3. Group 3 followed a regime of 2 x 30 min sessions of NMES to the antagonist extensors and dynamic bracing daily for 6 months

Patients in all groups used a static brace at night. Treatment was applied to only the affected extremity. The intervention was completed in the home environment under parental supervision following a training session in the hospital setting.

Neuromuscular Electrical Stimulation

The electrical stimulation was delivered by a system consisting of a stimulator unit, electrodes and connecting wires. Electrodes were placed over the muscle bellies of the wrist and finger extensor muscles on the child's forearm (including Extensor Carpi Radialis Longus, Extensor Carpi Radialis Brevis, Extensor Carpi Ulnaris & Extensor Digitorum Profundus). The amplitude was determined by increasing the amplitude of the stimulus until muscles contracted. The amplitude was gradually reduced until no contractions were apparent. This threshold was then doubled and used routinely. If it was not tolerated the amplitude was decreased. There was a 5 second on ramp, 2 second off ramp, 10 second on duty and 7 off on duty, pulse rate ranged between 40 –

60 pulses/sec and the stimulus amplitude was adjusted to produce tolerable muscle contractions (30 – 40ma).

Dynamic Bracing

The Ultraflex orthotic device is reported to consist of a wrist/hand unit and an elbow unit (Postans, 2010, p.12). The wrist/hand unit had a dynamic dual hinge with adjustable tension (0-12 lb) and an adjustable lockout to maintain the wrist in extension, with static tension of the flexor muscles. It also had an adjustable dynamic handpiece that locked PIP's and DIP's in an extended position and allowed movement only at the MCP joints against resistance. The wrist was locked into a submaximal stretch at extension. The elbow unit had a dynamic dual hinge with adjustable tension (0-16 lbs) and an adjustable lockout. At night time it was locked in extension to resist contracted extrinsic flexors in all groups.

Outcome Measures

The Melbourne Assessment of Unilateral Limb function was used to assess upper limb function. This is a criterion referenced test for children between 5-15 years old with neurological impairment. It was developed to measure change over time in children where change can be slow or subtle and scores the quality of unilateral upper limb motor function.

Grip and pinch strength was evaluated using a standard dynamometer (JAMAR II). Grip and pinch strength testing are commonly used to evaluate hand strength for disability ratings and to assess responses to various forms of therapy.

The Melbourne assessment and grip and pinch strength measure were administered at baseline, monthly during treatment, and monthly intervals for 3 months post treatment.

Zancolli's classification of deformity was used to evaluate posture of the wrist and fingers at baseline and follow up. This classification describes posture and active control of the wrist and fingers and is widely used to guide and evaluate results before and after surgery.

The assessments were administered and scored by a single blinded rater.

Main Findings:

Melbourne Assessment: Group 3 showed a significant improvement at the completion of the treatment period (compared to either NMES or bracing alone) ($p=0.02$), however the treatment effect was not sustained two months post treatment. There was a mean score difference of 21 (CI 17.54 to 24.46) between Group 1 (NMES only) and Group 3 (NMES + brace), and a mean score difference of 19 (CI 15.54 to 22.46) between Group 2 (Brace only) and Group 3 (NMES + brace) at the end of the treatment period.

Group 3 demonstrated a significant improvement from the 1st to the 6th month of treatment with a mean score difference of 13. The confidence interval can be calculated at 8.3515 to 17.6485. This represents a clinically significant change during the treatment period only.

Grip Strength: Group 3 showed an increase immediately post treatment, compared with groups 1 and 2, however these treatment effects were not sustained two months

post treatment ($p=0.1$).

Zancolli's Classification of Deformity: the combined treatment group showed a statistically significant change during the treatment period compared with the other groups ($p=0.02$) but changes were not maintained when treatment was withdrawn. . In the other groups there were positive changes in mean scores that were not statistically significant

Original Authors' Conclusions

The authors concluded that the use of electrical stimulation combined with dynamic bracing was a quick and effective treatment, which may potentially reduce the need for multiple surgical procedures. They did acknowledge that more research is needed to determine appropriate electrical stimulation protocols and supplemental treatment modalities.

Critical Appraisal:

Validity: The use of three randomly allocated treatment groups strengthens the results of this study which scored 7 using the PEDro scale. The study design was limited by lack of a control group. Confounding factors including standard therapy interventions were not described. Night-time bracing for all participants was also not justified, and may be an influencing factor impacting on the results of the Melbourne and Zancolli assessments. The authors reported that they completed a power analysis using the Melbourne Assessment as the primary outcome but did not specify whether this was reached, and the group sizes were small and with a large age range. There was minimal demographic data with no description of the children's cognition and/or level of function, such as Gross Motor Functional Classification Scale (GMFCS), Manual Ability of Classification System (MACS) or IQ levels. The heterogeneity between groups could affect the outcome.

Five participants were reported as dropouts due to non-compliance with the protocol, these participants were not followed up. The groups that they had been allocated to were not specified.

The measures used were reliable and valid, and it was a strength of the study design that there was regular follow up. The administration protocol of grip and pinch strength was not described. The use of standardised outcome measures repeatedly on a monthly basis may have a practice effect; however we can assume that this effect would be equal across the three groups. This effect may have been minimised by the use of strength, or another objective measure, as a primary outcome. Statistical analysis and confidence intervals were reported. Of concern is the repeated statistical analysis on small groups for multiple outcomes. Statistical analysis was not stated *a priori*, which could lead to probability of statistical error.

Height and weight were not presented or accounted for in analysis of grip strength for the between group comparisons. Therefore, the impact of the child's weight and or height could impact the strength data, which is of particular concern with between group comparisons.

The intervention was not clearly described and would not be repeatable in practice or research. It was unclear how the bracing was applied and how it was used therapeutically. Education provided to the parents on the application of both the brace and NMES at home was also not clearly described. Furthermore, it was not stated if

compliance diaries were used in the study.

Interpretation of Results

The results were stated; however there was limited explanation to support the findings. Although there were some statistically significant changes, particularly in the combined NMES and bracing group, all groups returned to baseline on all assessment outcome measures within three months. Interestingly group 2 (brace only) showed decreased grip strength following the treatment period, although they regained some of this strength 2 and 3 months post treatment.

Summary/Conclusion:

Children who received NMES combined with dynamic bracing demonstrated statistically significant improvement over 6 months, however these outcomes were not maintained 3 months post treatment. Despite the intensive protocol there was no prolonged functional outcomes for these children which calls into question the clinical relevance of the results. The study design and the use of a combined group make it difficult to generalise these study findings and should be interpreted with caution.

Table 3: Description and appraisal of Therapeutic effects of Functional Electrical Stimulation of the upper limb of 8 children with Cerebral Palsy', by Wright & Granat, 2000).

Aim/Objective of the Study: To investigate the effects of cyclic FES on wrist extension of children with cerebral palsy

Study Design: The study was a before and after design involving 3 week baseline, 6 week treatment period and 6 week follow up. There was no control group.

Setting: Southern General Hospital NHS Trust, Glasgow, Scotland

Participants: Eight participants were recruited (3 girls, 5 boys) with spastic hemiplegia, cerebral palsy. The mean age was 10 years. Participants were recruited from existing referrals to the service. Patients who had undergone upper limb surgery were excluded. Patients did not have behavioural, visual or cognitive impairments. They had varying functional ability of the upper limb.

Intervention Investigated

The intervention protocol consisted of a 30 minute daily session of functional electrical stimulation (FES) to the wrist extensors, completed by the parents in the home. Application of FES reviewed at each assessment session. The FES machine was set with an on-time of 10 seconds, ramp of 1 second, and off time of 10 seconds, frequency of 30Hz and a pulse width of 300µs. The intensity varied from 10 – 40 mA and was adjusted to enable maximum wrist extension without discomfort.

Outcome Measures

Jebesen-Taylor Hand Function Test (JTTHF): The JTTHF test was used in a modified format. Three subtests were used; 'turn over 5 cards', 'stack four draughts' and 'place 6 small objects'. The time limit for each item was reduced to 40 seconds. This was

completed weekly during the baseline period and fortnightly thereafter.

Active wrist extension and wrist extension moments: Were measured using a modified PC based system fabricated by the facilities bioengineering unit. The mean value of 6 measurements for both wrist extension range and wrist extension moments was recorded. Three measurements were completed prior to the JTHF and three after completing this test. Maximum wrist extension moments were measured by restricting the moveable arm. This was completed weekly during the baseline period and fortnightly thereafter. Two children were not measured using the machine as their contractures could not be accommodated, and they were measured using goniometry instead.

Main Findings:

Jebsen-Taylor Hand Function Test (JTHF): There were significant decreases in the time taken to complete the 3 subtests. Draughts $p=0.031$; Cards $p=0.039$; Objects component $p=0.054$. Furthermore, 6 participants gained the ability to complete some component of the JTHF that they were previously unsuccessful in.

Active wrist extension and wrist extension moments:

A statistically significant increase in active wrist extension was observed between the baseline and treatment periods ($p=0.031$) and between baseline and follow-up periods ($p=0.037$). Two children with severe wrist contractures did not gain any active movement.

There was no significant change in wrist extension moment after FES ($p=0.274$).

Original Authors' Conclusions

The authors concluded that "FES may be a useful adjunct therapy to complement existing management techniques available. Hand function in this group of children improved after exposure to FES of wrist extensor muscles." (p.727).

Critical Appraisal:

Validity:

- There was no control group to compare treatment effects. It is therefore difficult to determine the impact of FES compared to placebo treatment effects.
- The description of participant's demographics was limited, and included only brief information from the abstract. An age range was not included. Although it was stated that the children presented with a 'wide range of impaired upper-limb functional ability' (p. 724-725), there was limited descriptive data to support this, making it difficult to translate to other settings.
- The process of education to parents on administration of the FES in the home was not well described therefore it is hard to determine the reliability of use at home.
- The JTHF test was used in a non-standard way with little justification and no indication of steps taken to increase its validity and reliability. Although it was stated that child's attention span was an issue for the test, the time limits specified are short and within the capabilities of most children. This makes it difficult to assume that it is a test reflective of a child's overall hand function.
- The authors included a baseline period, in which no significant difference in performance was noted, although there may be a learning effect in the tests, particularly the JTHF, due to the number of repetitions.
- The reliability of the PC Based system used to measure active wrist extension and

wrist extension moment was unclear. The authors state that it did not isolate wrist extension moment accurately but included components of upper body rotation. The inadequate stabilisation of the upper limb during measurement impacts on the reliability of the results reported. It was also an added bias that two children were unable to complete this assessment due to contractures.

- Data collectors and their blinding status were not described and therefore it is difficult to determine the reliability of the results.
- Two children withdrew from the study during the study period. It was not stated whether their data was included in the results.
- The statistical results reported for active wrist extension and wrist extension moment did not include the two children in the study who had wrist flexion contractures. This greatly biases the results presented.

Interpretation of results:

There were statistically significant changes noted in the JTHF and active wrist extension between base line and follow up. The authors presented means and confidence intervals for each assessment week in table format. The means and standard deviations were not provided to allow calculation of confidence intervals for the changes between baseline and follow up. Despite the positive trends seen within the study it is also important to note there is no evidence to support a change in participants function in everyday tasks. The authors did not discuss the clinical significance of the observed changes.

It appears that children with the least active wrist extension, but without contractures, made the greatest improvement in active range. It was not stated how this impacted on their JTHF scores. Due to the small sample size it is difficult to generalise these results.

Summary/Conclusion:

Hand function in this group of patients improved after exposure to FES of wrist extensor muscles, however due to the limited number of participants in this study and the limited details regarding the disability, it is hard to generalise the findings. The participants with wrist contractures did not demonstrate changes post FES.

Table 4: ‘The combined effect of dynamic splinting and neuromuscular electrical stimulation in reducing wrist and elbow contractures in 6 childrens with Cerebral Palsy’, by Postons, Wright, Bromwich, Wilkinson, Farmer –& Swain, 2010).

Aim/Objective of the Study: To investigate the feasibility of applying the combination of dynamic splinting (DS) and neuromuscular electrical stimulation (NMES) in order to improve wrist and elbow function and range of motion in children with upper limb contractures secondary to Cerebral Palsy.¹

Study Design: The study was a before and after design involving 12 week baseline, 12 week treatment period and 12 week follow up. There was no control group. A longitudinal single participant study design was used.

Setting: The Robert Jones and Agnes Hunt RJA Orthopaedic and District Hospital NHS Trust, Orthotic Research and Locomotor Assessment Unit (ORLAU), Oswenstry, Shropshire and Department of Clinical Sciences and Engineering, Salisbury District Hospital, NHS Foundation Trust, Salisbury, Wiltshire, UK.

Participants: Six participants were recruited (2 girls, 4 boys) with a diagnosis of spastic CP, aged between 7 and 16 years with a restricted range of movement at either the wrist, elbow, or both due to a fixed contracture. Participants were recruited from regular paediatric clinics. Patients did not have behavioural, visual or cognitive impairments. Children with dystonia, uncontrolled epilepsy and those who had undergone any upper limb surgery or anti spasticity treatment, in the previous six months were excluded.

Intervention Investigated

The intervention protocol consisted of using a custom moulded dynamic splint (DS) for one hour a day, combined with NMES for the second half hour of the treatment session. NMES was applied with surface electrodes asymmetric biphasic waveform with a frequency of 40Hz. A 10 seconds on/off ratio was used. Stimulation intensity was set at a level to illicit a contraction sufficient to cause movement at the joint, and was tolerable for participants. Three participants received FES for elbow contractures, and three for wrist contractures. The participants attended clinic twice during the study to review the fit and torque of the DS and the application of NMES.

Outcome Measures

The Melbourne Assessment of Unilateral Limb function was used to assess upper limb function twice at baseline, once following the intervention period and at 12 weeks follow up.

Passive range of motion was measured using a protractor goniometer

Active range of motion was measured using twin axis electrogoniometers

Pediatric Evaluation of Disability Index (PEDI) was used to assess physical disability. This is a norm referenced measure of key functional capabilities including self-care, mobility and social function tasks. It is standardised for children 6 months to 7 years old.

Activity Scale for Kids (ASK) assesses the physical function of children. It is a self report measure for children 5 to 15 years old, and has proven validity, reliability and responsiveness.

Pediatric Quality of Life Scale (PedsQL) was used to assess quality of life.

The PedsQL™ Measurement Model is a modular approach to measuring health-related quality of life (HRQOL) in healthy children and adolescents and those with acute and chronic health conditions.

A Diary was used to monitor compliance with the protocol

Main Findings:

Only four participants returned completed diaries. Three of these indicated good compliance, the remaining had compliance of 50%. The remaining two gave verbal indication of compliance.

Melbourne Assessment

There were no changes in scores for the three children with elbow contractures. Two children had small increases in their performance but these were not clinically significant.

ASK

Three participants did not show any change on the ASK. Two participants had some increase but this was not maintained at the follow up period. One participant demonstrated improvements that were maintained at follow up.

Range of Motion:

Passive elbow extension increased for two of three participants at the end of the treatment period. However active elbow range did not change.

Passive wrist extension increased for one participant but active range of movement did not change. One participant declined in both active and passive range but increased at follow up period. The remaining participant had no change in range of motion following treatment, but active range of motion did increase at follow up.

PEDI

There was no change in the PEDI scores for four of the six participants. One participant increased PEDI score after treatment and during the follow up period. The remaining participant had some improvement related to caregiver assistance following treatment, but this declined at follow up.

PedsQL

Two participants demonstrated improvement in their health related QOL following treatment, however three of the participants scores declined and the remaining showed no change. There was not adequate statistical data provided to calculate confidence intervals between groups.

Original Authors' Conclusions

The authors concluded that the treatment protocol was 'feasible' for children with fixed upper limb contractures. They have suggested further research would be most beneficial targeting wrist contractures, and investigation of treatment parameters is warranted.

Critical Appraisal:

Validity:

- Recruitment is only described for three participants. It is not clear how the remaining three were recruited.
- There was no control group to compare treatment effects. It is therefore difficult to determine the impact of FES and DS compared to placebo treatment effects.
- The use of NMES combined with DS makes it difficult to determine whether the intervention would be effective when used alone.
- The results were presented in a narrative form, there was no statistical information presented to support the findings. This makes it difficult to draw any conclusions in relation to the intervention protocol, or to comment on clinical significance of the results.
- The authors did not discuss the validity of the PEDI for their client group, or provide the participants scores to determine if the ceiling was reached. The PEDI is primarily validated for use with children under 7 years, and therefore its inclusion as an outcome measure for this client group (7 – 16yrs) requires further explanation. Furthermore the ASK was also used with one child who did not fit into the standardised age group for this assessment.
- The information provided about the participants elbow range of motion was unclear and difficult to draw conclusions from. It is hard to interpret the extent of contracture from the information provided. Additionally, it is not appropriate to compare wrist contractures to elbow contractures.

- There was a very small sample size, also limited information regarding participants' level of disability prior to intervention was provided.
- It is hard to distinguish how much education was given to both the parents and the children about applying the NMES. This may limit the safety and effectiveness of using this device and the ability to transfer it across settings.
- The evidence for the use of NMES in children with contractures is not clear or well presented. The authors do not provide any background literature supporting the use of NMES in children with fixed joint contractures.

Interpretation of results:

The authors attempted to investigate the effect of FES on a range of impairment factors, as well as functional outcomes through the use of a number of outcome measures addressing all parameters of the ICF. However, with such varying results, a small sample size and no control group it is hard to draw clinically significant conclusions about the effectiveness of using this combined treatment program.

Summary/Conclusion:

Due to the limited number of participants in this study and the limited details regarding the treatment, it is hard to generalise the findings. Overall the results were inconclusive with no significant trends toward improved range of movement or functional performance found. Further research is required.

IMPLICATIONS FOR PRACTICE

- FES was tolerated and used without side-effects or difficulties with children aged 3 – 18 years in the presented studies.
- There were some positive trends within the three studies for children who have reduced active range of motion and muscle weakness compared to those children with reduced passive range of motion (ie contractures).
- There are extensive costs involved with the use of FES as a therapy tool. These costs may include; the purchase FES equipment, professional development of therapists in the application of the FES as well as time educating families on the use.
- No studies investigating the use of FES for rehabilitation following acute neurological impairment in children were identified. This is particularly important due to the evidence supporting FES with the adult stroke population.

IMPLICATIONS FOR EDUCATION and FUTURE RESEARCH

- Although a randomized control study was included, the results need to be reviewed with caution due to limitations of the study. It should be noted that an RCT receives a level II grade of evidence regardless of its quality.
- It was difficult to draw clinical recommendations on the use of FES due to the limited number of studies identified. Further, these studies had poorly defined population groups, small sample sizes and used different treatment protocols and outcome measures making it difficult to reach a conclusion about what may be recommended for specific clinical groups.

- It is important to note that procedural and educational information could be found in the collection of articles, for example, an article by Carmick, (1997), provides guidelines for the clinical application of FES for children.
- There is a need for further research with clearly defined participant groups, stronger methodologies and consistent treatment protocols. This would assist in further development of clinical practice guidelines to guide therapists in the application of upper limb FES with children with a range of neurological conditions. This would enable an evidence based approach and consistency with clinical care specific to occupational therapy practice.

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