Additional early active repetitive motor training did not prevent contracture in adults receiving task-specific upper limb training after stroke: a randomised trial

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KEY WORDS
Randomised controlled trial
Stroke
Contracture
Upper extremity
Active motor training

ABSTRACT

Question: In adults undergoing rehabilitation after stroke, does 1 hour of additional active repetitive reaching per day prevent or reduce upper limb contracture? Design: Multi-centre, randomised controlled trial with concealed allocation, assessor blinding, and intention-to-treat analysis. Participants: Fifty adults undergoing rehabilitation after stroke who were unable to actively extend the affected wrist past neutral or were unable to flex the affected shoulder to 90 deg. Setting: Three inpatient rehabilitation units in Australia. Intervention: Both groups received usual upper limb therapy 5 days a week for 5 weeks. In addition, the experimental group received up to 1 hour a day of active, intensive, repetitive upper limb training using the SMART Arm device 5 days a week for 5 weeks. Outcome measures: Measures were collected at baseline (Week 0), after intervention (Week 5) and at follow-up (Week 7). The primary outcomes were passive range of wrist extension, elbow extension, and shoulder flexion at Week 5. The secondary outcomes were: the three primary outcomes measured at Week 7; passive range of shoulder external rotation; arm function; and pain at rest, on movement and during sleep measured at Weeks 5 and 7. Results: Following an average of 2310 reaching repetitions, the mean effect at Week 5 on passive range of wrist extension was 1 deg (95% CI -6 to 8), elbow extension -6 deg (95% CI -12 to -1), and shoulder flexion 5 deg (95% CI -8 to 17). There were no statistically significant or clinically important effects of the intervention on any secondary outcomes. Conclusion: In adults who are already receiving task-specific motor training for upper limb rehabilitation following stroke, 5 weeks of up to 1 hour of additional daily active repetitive motor training using the SMART Arm device did not prevent or reduce contracture in upper limb muscles. Trial registration: ACTRN12614001162606. [Horsley S, Lannin NA, Hayward KS, Herbert RD (2019) Additional early active repetitive motor training did not prevent contracture in adults receiving task-specific upper limb training after stroke: a randomised trial. Journal of Physiotherapy 65:88-94] © 2019 Australian Physiotherapy Association. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Muscle contractures occur when muscles are immobilised in shortened positions, and severe muscle weakness has been shown to be associated with development of contracture after stroke. Therefore, it appears plausible that intensive practice of active repetitive movements or intensive active motor training after stroke could prevent the development of contracture or reverse existing contracture. The challenge for the people at greatest risk of contracture after stroke – those with little to no arm movement (severe upper limb weakness) – is to undertake intensive active practice. The SMART Arm device combines a non-robotic device with electrical stimulation to make it possible to retrain intensive, repetitive upper limb movements in patients with severe weakness after stroke. This study examined the effectiveness of intensive active motor retraining with the SMART Arm device on contracture after stroke.

Therefore, the research questions for this multi-centre, randomised controlled trial were:

1. In adults undergoing rehabilitation after stroke, does 1 hour of daily practice of intensive, active, repetitive reaching prevent or reduce upper limb contracture, decrease pain, or improve upper limb function?
2. If so, are these effects maintained two weeks after cessation of the intervention?

**Methods**

**Design**

A multi-centre, parallel-group, randomised controlled trial with blinding of assessors and concealed allocation was conducted. The study was conducted in accordance with the Declaration of Helsinki. In addition to prospective registration, the detailed research protocol is available in Appendix 1 on the eAddenda. Participants were randomised to an experimental or control group. Participants in the experimental group received active repetitive motor training in addition to usual upper limb therapy for 5 weeks. Participants in the control group received usual upper limb therapy only. The primary outcomes were passive range of wrist extension, elbow extension, and shoulder flexion at 5 weeks.

**Participants**

Participants were recruited to the trial on admission to one of three participating inpatient rehabilitation units located at Caloundra Hospital, The Townsville Hospital, and Sunshine Coast University Hospital. All patients with stroke or stroke-like brain injury were screened for eligibility. Patients were included if they were: aged ≥ 18 years, at least 10 days and no more than 6 months post-onset, and unable to actively extend the affected wrist past neutral or unable to flex the affected shoulder to > 90 deg with the elbow extended. Patients were excluded if they: had language, comprehension or cognitive problems that prevented informed consent; had co-existing upper-limb problems that directly affected movement (eg, fractures, inflammatory arthritis, peripheral nerve injury or burns); or were unable to participate in upper limb rehabilitation.

**Randomisation**

A person who was not otherwise involved in the day-to-day conduct of the trial generated the allocation schedule using the ‘ral-loc’ user-written routine in Stata. Allocation was in random permuted blocks. The allocation schedule was concealed in sealed envelopes kept by a person who was remote from the study site and not involved in recruitment. Participant allocation was revealed to the local site trainer, by telephone, after eligibility and consent had been confirmed and baseline measures had been collected.

**Intervention**

**Experimental group**

Participants in the experimental group were encouraged to complete repetitive active reaching training using the SMART Arm device for up to 1 hour per day, 5 days a week for 5 weeks (a goal of 25 sessions, 1500 minutes), in addition to the usual upper limb therapy provided by treating occupational therapists and physiotherapists. The SMART Arm provides visual and auditory feedback of performance and external support to achieve physical practice using outcome-triggered electrical stimulation. It enables repetitive practice of forward reaching involving shoulder flexion, external rotation and elbow extension with the hand and forearm supported in the functional position by a splint. It can also incorporate practice of hand tasks such as grasp/release involving forearm supination, wrist extension, radial deviation and hand movements. The effectiveness of the device in promoting upper limb recovery following stroke has previously been demonstrated.

For each training session using the SMART Arm device, a record was kept of the time spent training (including set up) and the number of reaching repetitions completed. Time taken to set up the device was usually 5 to 10 minutes, but varied between participants and decreased after the initial sessions. Time spent participating in usual upper limb therapy was recorded daily, and was categorised as either active (eg, practice of active movements); passive (eg, stretching, splinting, passive ranging, oedema management, electrical stimulation without targets or counting repetitions); functional (eg, part or whole task practice, tasks that actively included affected arm); or electrical stimulation for shoulder subluxation.

**Control group**

Participants in the control group received usual upper limb therapy from occupational therapists and physiotherapists for the 5-week intervention period. Upper limb therapy usually involved both group and individual sessions conducted 5 days a week, and consisted of strengthening and task-specific practice of upper limb activities.

For the 2 weeks immediately after the 5-week intervention period, participants in both the control group and experimental group received only the usual upper limb therapy provided by occupational therapists and physiotherapists.

**Outcome measures**

All outcome measures were collected by therapists trained in the measurement procedures and blind to group allocation. Baseline measures were collected prior to randomisation (Week 0). After 5 weeks, the intervention was ceased and outcome measures for both groups were collected (Week 5). Follow-up outcome measures were collected 2 weeks after cessation of the intervention (Week 7). Further detail about the outcome measures than that provided below is available in Appendix 2 on the eAddenda.

**Primary outcomes**

The co-primary outcomes were passive range of wrist extension, elbow extension, and shoulder flexion at Week 5. Torque-controlled measures of passive wrist extension were obtained using the procedure described by Harvey et al. The procedure has been used in previous research investigating contracture following stroke. Passive range of shoulder flexion and torque-controlled passive range of elbow extension were measured with an Acumar digital goniometer using standardised procedures. The procedure for torque-controlled measurement of elbow extension has been previously used to investigate upper limb contracture.

**Secondary outcomes**

The secondary outcomes were passive wrist extension, elbow extension, and shoulder flexion at Week 7, as well as passive range of movement of shoulder external rotation, arm function (upper limb items 6, 7 and 8 of the Motor Assessment Scale), and measures of pain.
at rest, pain on movement (during measurement), and the effect of pain on sleep at Weeks 5 and 7. Torque-controlled passive range of shoulder external rotation was measured with an Acumar digital goniometer using a standardised procedure. Upper limb function was measured using a composite score of the three upper limb items of the Motor Assessment Scale,34,35 upper arm function (Motor Assessment Scale item 6), hand function (Motor Assessment Scale item 7), and advanced hand function (Motor Assessment Scale item 8). A score between 0 points (no function) and 18 points (best possible score/good functional ability) was obtained. The Motor Assessment Scale is widely used by clinicians to monitor upper limb function, has been used in previous studies investigating effectiveness of interventions to improve upper limb function following stroke (eg, the studies by Horsley et al20 and Lannin et al23), and has demonstrated validity and reliability in this population.36–39 Pain at rest and on movement (during each of the upper limb range of motion measures) was measured using a 10-cm vertical visual analogue scale,40 which is a valid and reliable measure in stroke and elderly populations.41–44 The effect of pain on ability to sleep at night was assessed using the relevant question contained in the DASH (Disabilities of the Arm, Shoulder and Hand) questionnaire.45

Data analysis

The minimum clinically worthwhile effect on the primary outcome measures (ie, maximum passive range of wrist extension, elbow extension and shoulder flexion) was nominated a priori to be 10 deg. The sample size of 50 was designed to give a 90% power to detect a 10-deg effect (ie, a 10-deg between-group difference in means) on each of the primary outcome variables, assuming a SD of 10 deg and a two-tailed alpha of 0.05.

The primary analyses estimated the mean effect of the intervention on passive wrist extension, elbow extension and shoulder flexion at Week 5. The mean effect of the experimental intervention was estimated from the difference between the mean outcomes of the experimental and control groups. The mean effects and their 95% confidence intervals were estimated using a linear regression model in which the independent variables included a dummy coded group variable and the baseline value of the outcome. All analyses were conducted on an intention-to-treat basis.

Table 1

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Exp (n = 25)</th>
<th>Con (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (male:female)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>16:9</td>
<td>12:13</td>
</tr>
<tr>
<td>%</td>
<td>64.36</td>
<td>48.52</td>
</tr>
<tr>
<td>Age (years), mean (SD)</td>
<td>65.9 (12.7)</td>
<td>68.5 (13.0)</td>
</tr>
<tr>
<td>Indigenous:non-Indigenous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>1:24</td>
<td>0:25</td>
</tr>
<tr>
<td>%</td>
<td>4:96</td>
<td>0:100</td>
</tr>
<tr>
<td>Time since onset (days), mean (SD)</td>
<td>28.3 (27.1)</td>
<td>24.9 (14.1)</td>
</tr>
<tr>
<td>Diagnosis, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ischaemic stroke</td>
<td>18 (72)</td>
<td>23 (92)</td>
</tr>
<tr>
<td>haemorrhagic stroke</td>
<td>7 (28)</td>
<td>2 (8)</td>
</tr>
<tr>
<td>FIM on admission, mean (SD)</td>
<td>53.6 (22.9)</td>
<td>44.7 (14.9)</td>
</tr>
<tr>
<td>Mini-mental score on admission, mean (SD)</td>
<td>24.7 (6.6)</td>
<td>23.1 (8.0)</td>
</tr>
<tr>
<td>Affected arm (right:left)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>9:16</td>
<td>10:15</td>
</tr>
<tr>
<td>%</td>
<td>36:64</td>
<td>40:60</td>
</tr>
</tbody>
</table>

Con = control group, Exp = experimental group, FIM = Functional Independence Measure.
The shaded cells indicate the primary outcomes.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Exp (n = 25)</th>
<th>Con (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of usual therapy (days)</td>
<td>23 (18 to 24)</td>
<td>23 (17 to 25)</td>
</tr>
<tr>
<td>Active time in usual therapy, total (min)</td>
<td>1075 (450 to 1310)</td>
<td>955 (580 to 1530)</td>
</tr>
<tr>
<td>Passive time in usual therapy, total (min)</td>
<td>165 (75 to 375)</td>
<td>260 (120 to 525)</td>
</tr>
<tr>
<td>Amount of SMART Arm training (days)</td>
<td>25 (22 to 25)</td>
<td>0</td>
</tr>
<tr>
<td>Time in SMART Arm training, total (min)</td>
<td>1065 (805 to 1430)</td>
<td>0</td>
</tr>
<tr>
<td>Reaches in SMART Arm training, total (n)</td>
<td>2310 (1790 to 2840)</td>
<td>0</td>
</tr>
</tbody>
</table>

Con = control group, Exp = experimental group.

The secondary analysis estimated the mean effect of intervention on passive wrist extension, elbow extension and shoulder flexion at Week 7, as well as the effects, at both Weeks 5 and 7, on passive range of movement of shoulder external rotation, pain at rest, pain on movement, effect of pain on sleep, and arm function (composite of scores for upper limb items of the Motor Assessment Scale).

The statistical analysis code is available as Appendix 3 on the eAddenda.

Results

Compliance with the study protocol

The protocol states that the Halo goniometer was used for passive range of motion measures; however, the Halo goniometer was not available at the time of commencement of the study so an Acumar digital goniometer was used.

Flow of participants through the trial

The flow of participants through the trial is shown in Figure 1. Across the three participating inpatient rehabilitation units, 359 patients consecutively admitted following stroke or stroke-like brain injury were screened for eligibility. Of the 297 patients excluded, the majority (n = 249) were ineligible because upper limb movement was not severely affected. The first participant was randomised on 28 July 2015 and the last participant's Week-7 follow-up was on 26 October 2017. The two groups appeared to be well matched except that more participants with haemorrhagic stroke were allocated to the experimental group (28%) than the control group (8%) (Table 1). Outcome measures were obtained from 96% of participants at Week 5 and from 90% at Week 7.

Table 2

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Exp (n = 25)</th>
<th>Con (n = 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median (IQR) compliance with the intervention and usual therapy by group.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of usual therapy (days)</td>
<td>23 (18 to 24)</td>
<td>23 (17 to 25)</td>
</tr>
<tr>
<td>Active time in usual therapy, total (min)</td>
<td>1075 (450 to 1310)</td>
<td>955 (580 to 1530)</td>
</tr>
<tr>
<td>Passive time in usual therapy, total (min)</td>
<td>165 (75 to 375)</td>
<td>260 (120 to 525)</td>
</tr>
<tr>
<td>Amount of SMART Arm training (days)</td>
<td>25 (22 to 25)</td>
<td>0</td>
</tr>
<tr>
<td>Time in SMART Arm training, total (min)</td>
<td>1065 (805 to 1430)</td>
<td>0</td>
</tr>
<tr>
<td>Reaches in SMART Arm training, total (n)</td>
<td>2310 (1790 to 2840)</td>
<td>0</td>
</tr>
</tbody>
</table>

Con = control group, Exp = experimental group.

The mean effect of intervention on passive range of shoulder and wrist flexion at Week 7 was 5 deg (95% CI –8 to 17) in favour of the experimental group, which was also not significant (p = 0.45). These effects decreased between Week 5 (post intervention) and Week 7 (follow-up). For passive range of wrist extension, the effect at Week 7 was –5 deg (95% CI –12 to 2, p = 0.16) in favour of the control group. The effect on passive elbow extension at Week 7 was –11 deg (95% CI –21 to –1) in favour of the control group, which was marginally significant (p = 0.04). The estimated effect on range of passive shoulder flexion at Week 7 was 2 deg (95% CI –10 to 14) in favour of the experimental group and not statistically significant (p = 0.72).

There were no statistically significant or clinically important effects of the intervention on any of the secondary outcome measures (passive range of shoulder external rotation; pain at rest, sleep or on movement; and upper limb function) at Weeks 5 or 7 (Table 3). Individual participant data are available in Table 4 on the eAddenda.

Table 3

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Week 0</td>
</tr>
<tr>
<td>Passive range of motion (deg)</td>
<td></td>
</tr>
<tr>
<td>wrist extension</td>
<td>56 (18)</td>
</tr>
<tr>
<td>elbow extension</td>
<td>183 (10)</td>
</tr>
<tr>
<td>shoulder flexion</td>
<td>128 (33)</td>
</tr>
<tr>
<td>shoulder external rotation</td>
<td>39 (34)</td>
</tr>
<tr>
<td>Pain VAS (0 to 100 mm) at rest</td>
<td>44 (25)</td>
</tr>
<tr>
<td>Pain on sleeping (1 to 5)</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Arm function (0 to 18)</td>
<td>1.5 (3.6)</td>
</tr>
</tbody>
</table>

Effects are differences in means adjusted for baseline scores (95% confidence intervals). The shaded cells indicate the primary outcomes. Con = control group, Exp = experimental group, VAS = visual analogue scale.

The effect at Week 7 was –11 deg (95% CI –21 to –1) in favour of the control group, which was marginally significant (p = 0.04). The estimated effect on range of passive shoulder flexion at Week 7 was 2 deg (95% CI –10 to 14) in favour of the experimental group and not statistically significant (p = 0.72).

Compliance with the intervention

Overall compliance with the intervention was good, but there was variation with respect to the total number of reaching repetitions completed by participants (IQR 1790 to 2840) (Table 2). On average, participants in the experimental group completed 100 more repetitions per session, 100% of the allotted SMART Arm training sessions and 70% of allotted SMART Arm training time (median 1065 minutes, IQR 805 to 1430). The median amount of usual upper limb therapy provided to the two groups was similar (control group 955 minutes, intervention group 1075 minutes) (Table 2).

Effect of the intervention

On average, both groups lost small amounts of passive range at the shoulder and wrist over the 7-week trial period. There were no clinically significant effects of the intervention on the three primary outcome measures at Week 5 (Table 3). However, the intervention may have had a small negative effect on passive range of elbow flexion at the elbow, the control group maintained passive range of elbow extension at the end of the treatment period and at follow-up, while the experimental group lost a small amount of range at both Weeks 5 and 7.

After intervention, at the end of Week 5, there was no significant difference in mean passive range of wrist extension between the control and experimental group. The non-significant mean effect was 1 deg (95% CI –6 to 8, p = 0.79) in favour of the experimental group. There was a small negative mean effect on passive range of elbow extension of –6 deg (95% CI –12 to –1) in favour of the control group, which was statistically significant (p = 0.03) but not clinically important given it did not reach the pre-specified 10-deg threshold. The mean effect on passive range of shoulder flexion at Week 5 was 5 deg (95% CI –8 to 17) in favour of the experimental group, which was also not significant (p = 0.45). These effects decreased between Week 5 (post intervention) and Week 7 (follow-up). For passive range of wrist extension, the effect at Week 7 was –5 deg (95% CI –12 to 2, p = 0.16) in favour of the control group. The effect on passive elbow extension at Week 7 was –11 deg (95% CI –21 to –1) in favour of the control group, which was marginally significant (p = 0.04). The estimated effect on range of passive shoulder flexion at Week 7 was 2 deg (95% CI –10 to 14) in favour of the experimental group and not statistically significant (p = 0.72).

There were no statistically significant or clinically important effects of the intervention on any of the secondary outcome measures (passive range of shoulder external rotation; pain at rest, sleep or on movement; and upper limb function) at Weeks 5 or 7 (Table 3). Individual participant data are available in Table 4 on the eAddenda.
Figure 2. Primary outcomes by time. Symbols show individual participants’ outcomes. Lines join group means at baseline and at Weeks 5 and 7. Control and experimental group data have been slightly offset for clarity.
Discussion

The main finding of this trial was that in adults undergoing rehabilitation following stroke, active repetitive motor training using the SMART Arm device in addition to usual upper limb therapy did not prevent or reduce contracture in upper limb muscles more than usual upper limb therapy alone. This finding is fairly clear, given the precision of the estimates (Table 2). The results are in line with a previous trial, which found no effect of active repetitive motor training using electrical stimulation and splinting in addition to tilt-table standing compared with tilt-table standing alone on ankle contracture after brain injury.46

The results of this trial also demonstrated a small negative effect of the intervention on passive range of elbow extension (–6 deg). However, since both groups had on average >180 deg of elbow extension at baseline and after intervention (Week 5), and even at Week 7 the experimental group still had an average of 175 deg of passive elbow extension, the mean effect is probably of little functional importance. Figure 2 shows that three participants in the experimental group lost a substantial range of elbow motion. It is unlikely that upper limb pain contributed to the difference in passive range of elbow extension because there was no between-group difference for any of the pain measures over the study period or at follow-up, and there was no correlation between pain and range of motion (data not shown).

This study investigated the effect of providing additional intensive active motor training on upper limb contracture early after stroke. These findings do not necessarily contradict the recommendations of the Australian Clinical Guidelines for Stroke Management 2017 Practice Statement that ‘for stroke survivors at risk of developing contracture or who have developed contracture, active motor training or electrical stimulation to elicit muscle activity should be provided’.29 However, the findings of the present study do suggest that the provision of additional intensive active motor training using the SMART Arm device after stroke, over and above current standard care, does not prevent or reduce contracture.

It is possible that the duration and/or the intensity of the additional intervention were insufficient to produce an effect on contracture. The SMART Arm device enabled participants with severe upper limb weakness to participate in high-intensity, active, upper-limb motor training that would otherwise be impossible. It was expected that participants in the experimental group would complete high numbers of reaching repetitions in each training session (250 to 350 repetitions per session); however, there was significant between-person variation in the number of repetitions performed (Table 2) and the average number of repetitions completed per session was only 100. Given that the amount and type of ‘usual upper limb therapy’ completed by both groups was similar, the difference in the intensity of motor training between the experimental and control groups was, on average, 100 repetitions per session. Such a between-group difference may be insufficient to have a therapeutic effect. Higher numbers of repetitions50,51 and larger differences in the amount of intervention52 may be required to improve motor function following stroke. Similarly, large numbers of repetitions may be needed to prevent or reduce contracture. While we speculate that a larger duration or intensity of intervention may have been necessary to induce a beneficial effect, this speculation was based on our interpretation of data from outside the trial. The trial data do not and cannot demonstrate that more intervention would have been effective. Indeed, it is possible that no amount of additional intervention would be effective, and it is even possible (though we think unlikely) that additional intervention may have been harmful, for example, by reducing elbow extension range of motion.

Previous research has shown that robotics can provide the opportunity for more intensive practice.50 The current study demonstrates that use of the SMART Arm does not guarantee a consistent and large increase in intensity in isolation. The variation in intensity of training on the SMART Arm may have been influenced by both patient and therapist factors. Since the number of repetitions to be completed per session was not prescribed in the research protocol, the individual therapist providing or supervising the training was able to influence the intensity of practice within each session. Different therapists had different levels of experience, skills and knowledge, and may have had differing opinions about what they considered high intensity (in this case, high numbers of repetitions within a session). It is also possible that the variation between participants in the number of reaching repetitions completed on the SMART Arm may have been influenced by a corresponding variation in upper limb pain. The development of upper limb pain during this trial was similar to that reported following stroke in previous studies (Gustafsson and McKenna 2006, Horsley et al 2007).20,51 While there were no between-group differences, both groups demonstrated small, non-significant increases in pain at rest and pain on movement over the intervention and follow-up periods (Table 3).

While this trial protocol included concealed allocation and blinding of assessors, which minimised possible bias, patients were aware if they were receiving SMART Arm training or not. We acknowledge that this is a potential source of bias. A further limitation to this study is that usual therapy was not standardised and daily activity data were not collected, so the possible influence on outcomes of variations between participants regarding these factors cannot be determined.

There have now been many clinical trials that have investigated the effects of physical interventions involving stretch and movement on development of contracture after stroke. Most have found little or no effect of intervention.53 Like previous trials, the current trial found little or no effect of physical intervention. Given the failure of so many trials to find a beneficial effect of physical interventions designed to prevent and treat contracture, it may be necessary to more closely examine the presumed mechanisms of contracture. Intervention research may need to be informed by more research on the mechanisms of muscle contracture.

In summary, provision of up to 1 hour of additional repetitive motor training using the SMART Arm in conjunction with usual care did not reduce or prevent contracture after stroke compared to usual care alone.

What was already known on this topic: Contracture is common after stroke. No intervention has been shown, in randomised trials, to prevent or produce sustained reductions in contracture after stroke. Muscle contractures occur when muscles are immobilised in shortened positions.

What this study adds: In adults who are already receiving task-specific motor training of the upper limb rehabilitation following stroke, adding up to 1 hour of additional daily active repetitive motor training using the SMART Arm device for 5 weeks did not prevent or reduce contracture in the arm.

Footnotes: 4 Acumar, Lafayette Instrument Company, Lafayette, USA.

Addenda: Table 4 and Appendices 1, 2 and 3 can be found online at DOI: https://doi.org/10.1016/j.jphys.2019.02.005.

Ethics approval: Townsville Hospital and Health Service Human Research Ethics Committee approved the study protocol (HREC reference number: HREC/14/QTHS/124). All participants gave written informed consent before data collection began.

Competing interests: KS Hayward is a research consultant for SMART Arm Pty Ltd.

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Provenance: Not invited. Peer reviewed.
References


