Dynamic splints do not reduce contracture following distal radial fracture: a randomised controlled trial

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Question: Do dynamic splints reduce contracture following distal radial fracture? Design: Assessor-blinded, randomised controlled trial. Participants: Forty outpatients with contracture following distal radial fracture. Intervention: The control group received routine care consisting of exercises and advice for 8 weeks. In addition to routine care, during the day the experimental group received a dynamic splint, which stretched the wrist into extension but allowed intermittent movement. Outcome measures: The primary outcomes were passive wrist extension and the Patient Rated Hand Wrist Evaluation (PRHWE). The secondary outcomes were active wrist extension, flexion, radial deviation, and ulnar deviation, and the performance and satisfaction items of the Canadian Occupational Performance Measure (COPM). All outcomes were measured at commencement, at the end of 8 weeks of treatment, and at 12 weeks (ie, 1 month follow-up). Results: The mean between-group difference for passive wrist extension and PRHWE at 8 weeks were 4 deg (95% CI –4 to 12) and –2 points (95% CI –8 to 4), respectively. The corresponding values at 12 week follow-up were 6 deg (95% CI 1 to 12) and 2 points (95% CI –5 to 9). There were no sufficiently important between-group differences for any of the secondary outcome measures at 8 or 12 weeks. Conclusion: It is unclear whether dynamic splints following distal radial fracture have therapeutic effects on passive wrist extension or PRHWE, but they clearly do not have any therapeutic effects on active wrist extension, flexion, radial or ulnar deviation, or on the performance or satisfaction items of the COPM. The ongoing use of dynamic splints following distal radial fracture is difficult to justify. Trial registration: ACTRN12608000309381. [Jongs RA, Harvey LA, Gwinn T, Lucas BR (2012) Dynamic splints do not reduce contracture following distal radial fracture: a randomised controlled trial. Journal of Physiotherapy 58: 173–180]

Key words: Distal radius fractures, Wrist injuries, Randomised controlled trials, Splints, Contracture, Physiotherapy

Introduction

Contracture is characterised by reduced active and passive range of motion and is a common complication of distal radial fracture. Various physiotherapy treatments, including splints in conjunction with advice and exercise, are used in an attempt to reduce contracture (Handoll et al 2006). Various types of splints are advocated but dynamic splints are used widely because they provide a low load and prolonged stretch whilst also enabling functional movement of the hand (Figure 1) (Flowers and Michlovitz 1988, Colditz 1983). There is good anecdotal evidence and evidence from animal studies, retrospective reviews (Berner and Willis 2010), and case series (Lucado et al 2008, Lucado and Li 2009, McGrath et al 2008) to suggest that splints are therapeutic for reducing wrist contracture after fracture. However, the effectiveness of dynamic splints has never been scrutinised within a randomised controlled trial.

There are at least 30 trials looking at the effectiveness of stretch administered in various ways to different patient populations (Katalinic et al 2010). Some of these trials administered stretch through splints. Collectively, the results of all 30 trials suggest that stretch is ineffective. However, most of the studies included in the review involved patients with neurological conditions, and it is therefore not known if the results of these trials can be generalised to stretch administered through dynamic splints for contracture of the wrist following fracture. Therefore, the research question of this clinical trial was:

Do dynamic splints reduce contracture following distal radial fracture over and above usual care?

Usual care involved advice and a home exercise program. This question is important because dynamic splints are expensive and inconvenient and can only be justified if they make a notable difference to outcome following distal radial fracture.

Method

Design

An assessor-blind randomised controlled trial was conducted. Patients were recruited as they were referred to physiotherapy at a Sydney metropolitan hospital (Royal North Shore Hospital) between June 2009 and December 2011. Patients were referred to physiotherapy by consultant...
A constant low-load stretch was applied in the direction of and incorporated an axis about the flexion-extension plane. The splint was custom-made from thermoplastic material.

In addition to the advice and exercises, participants in the experimental group received a dynamic splint (see Figure 1). The splint was considered to have entered the trial once his/her envelope was opened.

### Intervention

Both the control and the experimental groups received usual care, consisting of general advice and a home exercise program, which was monitored but not supervised. The advice and exercises were standardised and provided by a therapist blinded to the allocation. For example, both control and treatment groups received a program consisting of the same type of exercises which participants were instructed to perform at least three times throughout the day. Participants were shown the exercises and given a copy in written format. These exercises were directed at increasing active and passive wrist flexion, wrist extension, radial deviation, ulnar deviation, forearm pronation, and supination. They were also aimed at increasing wrist and grip strength. Verbal advice was given about how quickly participants could expect pain to resolve, and their strength and function to return. The participants were also advised to use the hand of the affected wrist as much as possible in day-to-day activities.

In addition to the advice and exercises, participants in the experimental group received a dynamic splint (see Figure 1). The splint was custom-made from thermoplastic material and incorporated an axis about the flexion-extension plane of the wrist. The fingers and thumb were unrestricted. A constant low-load stretch was applied in the direction of wrist extension via an elastic band, with the stretch set as high as tolerated by each participant. This stretch was adjusted once every two weeks to maintain the wrist at maximal tolerated extension. Participants were instructed to wear the splint for as long as possible during the day, aiming for at least six hours a day of cumulative splint wear. They were encouraged to actively flex their wrist against the splint intermittently, and were advised to continue activities of daily living whilst wearing the splint wherever possible.

Both control and experimental participants were asked to record in diaries how often they performed their exercises. Experimental participants were also asked to record each day whether they had worn the splint and, if so, to indicate whether they had worn the splint for less than 3 hours, between 3 and 6 hours, or for more than 6 hours. All participants were reviewed fortnightly by an unblinded therapist, who contacted them either by phone or in person to monitor and record adherence to their programs. The splint intervention was ceased following assessments at 8 weeks, and all participants continued with the exercises and advice unsupervised until 12 weeks.

### Outcome measures

Outcomes were measured immediately before randomisation (ie, baseline) and then at 8 weeks, with a follow-up measure at 12 weeks after randomisation. A blinded assessor performed assessments at 8 weeks, at least 12 hours after the splint was last worn; an assessor not blinded to group allocation performed assessments at 12 weeks. The success of blinding at 8 weeks was examined using an assessor questionnaire administered at the completion of each participant’s assessment.

Eight outcome measures were used. The two primary outcome measures reflected impairment and participation restriction, namely: passive wrist extension, and the Patient Rated Hand Wrist Evaluation (PRHWE). Secondary outcome measures were active wrist extension, flexion, radial and ulnar deviation, and the performance and satisfaction items of the Canadian Occupational Performance Measure (COPM). The details of each follow.

**Passive wrist extension:** Passive wrist extension was measured with the application of a standardised torque using a device specifically designed for this purpose (Figure 2). The device consisted of a wheel mounted on the side of an arm board that was hinged to a mobile plate. With the device on a horizontal surface, the hand was strapped to the mobile plate rotating about the axis of the wrist with the forearm pronated. The fingers were allowed to lie over the distal end of the plate to prevent finger flexor tightness confounding the measurement. The wheel acted to ensure the moment arm remained constant (9 cm) regardless of wrist angle. 250 g weights were serially added with 30 seconds of pre-stretch until a final weight of 1.25 kg was reached, corresponding to 0.22 Nm increments in torque with a final torque of 1.10 Nm. Passive wrist extension was measured as the angle between the mobile plate and a vertical drop-line 30 seconds after the application of the final torque. The reliability of the device was evaluated before the commencement of the trial by having two assessors measure the passive wrist extension of 11 people with contracture following fracture. An ICC of 0.98 (95% CI, 0.96 to 0.99) was established. A between-group difference of 10 deg was deemed sufficiently important to justify the expense and inconvenience of the splinting regimen.
Patient Rated Hand and Wrist Evaluation (PRHWE): The PRHWE (MacDermid and Tottenham 2004) is a 15-item questionnaire designed to reflect the implications of upper limb injuries on activities of daily living. It contains questions related to pain, hand activities such as turning a doorknob and fastening buttons, and day-to-day activities such as household work and recreational activities. The responses are tallied and aggregated into one score with a total possible score of 100. A high score reflects a poor outcome. The ICC reflecting the reliability of the PRHWE is 0.97 (95% CI 0.95 to 0.98) (MacDermid et al 1998). A between-group difference of 5 points was deemed sufficiently important to justify the expense and inconvenience of the splinting regimen.

Active range of motion: Active range of wrist flexion, extension, radial deviation, and ulnar deviation were measured with a goniometer using a standardised technique (Adams et al 1992). The ICCs reflecting the reliability of goniometric measures of active wrist range are: extension, 0.85 (95% CI 0.77 to 0.93); flexion, 0.9 (95% CI 0.85 to 0.95); radial deviation, 0.86 (95% CI 0.79 to 0.93); and ulnar deviation, 0.78 (95% CI 0.67 to 0.89) (Horger 1990). A between-group difference of 10 degrees was deemed sufficiently important to justify the expense and inconvenience of the splinting regimen.

Canadian Occupational Performance Measure (COPM): The COPM (Law et al 1990) is designed to quantify patients’ perspectives about self-care, productivity and leisure. Participants were asked to identify key activities important to them that they were unable to perform as a consequence of wrist contracture. The participant then provided two scores on a 10-point scale: for the ability to perform the activity, and for the satisfaction with their ability to perform the activity. The Spearman Rho correlation coefficient reflecting the reliability of the testing procedure to measure performance is 0.89, and satisfaction is 0.88 (Cup et al 2003). A between-group difference of 2 points for performance and satisfaction was deemed sufficiently important to justify the expense and inconvenience of the splinting regimen (Law 2004).

Data analysis

A power calculation indicated that a sample size of 40 was required to provide a 95% probability of detecting a 10 deg between-group difference in passive wrist extension. This calculation was based on the best available evidence indicating an expected standard deviation of 10 deg. These calculations assume an alpha of 0.05 and drop-out of 15%.

All data were reported as means (SD) unless otherwise stated. Data for passive wrist extension, active wrist extension, flexion, radial and ulnar deviation, and PRHWE were analysed using separate linear regression models with initial values entered as covariates. The performance and satisfaction items of the COPM were analysed using the ‘cendif’ routine in the Stata software to derive the 95% CIs for median between-group differences. This method does not make assumptions about the distribution of the data. The results were interpreted with respect to sufficiently important differences.

Table 1. Baseline characteristics of participants.

<table>
<thead>
<tr>
<th>Participant characteristics</th>
<th>Randomised</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Exp (n = 19)</td>
</tr>
<tr>
<td>Age (yr), median (IQR)</td>
<td>66 (56 to 72)</td>
</tr>
<tr>
<td>Gender, n (%)</td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>4 (21)</td>
</tr>
<tr>
<td>female</td>
<td>15 (79)</td>
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<tr>
<td>Hand dominance, n (%)</td>
<td></td>
</tr>
<tr>
<td>right</td>
<td>18 (95)</td>
</tr>
<tr>
<td>left</td>
<td>1 (5)</td>
</tr>
<tr>
<td>Side of injury, n (%)</td>
<td></td>
</tr>
<tr>
<td>right</td>
<td>11 (58)</td>
</tr>
<tr>
<td>left</td>
<td>8 (42)</td>
</tr>
<tr>
<td>Acute management, n (%)</td>
<td></td>
</tr>
<tr>
<td>cast</td>
<td>10 (53)</td>
</tr>
<tr>
<td>ORIF</td>
<td>9 (47)</td>
</tr>
<tr>
<td>K-wires</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Days immobilised, median (IQR)</td>
<td>25 (11 to 38)</td>
</tr>
<tr>
<td>Days from fracture until recruitment, median (IQR)</td>
<td>76 (72 to 108)</td>
</tr>
</tbody>
</table>

Exp = experimental group, Con = control group, ORIF = open reduction and internal fixation with volar plate.
**Results**

**Flow of participants through the study**

The characteristics of the participants in each group are detailed in Table 1. The flow of participants through the trial is shown in Figure 3. Four participants were lost to post-intervention measures at 8 weeks: two each from the experimental group and the control group. An additional four participants were lost to follow-up at 12 weeks: three from the experimental group, and one from the control group.

**Compliance with trial method**

There was one notable violation of the trial protocol. One participant was randomly allocated to the experimental group but ended up in the control group within 10 min of allocation because of an error. It is not clear how this error occurred because the allocation process required a member of the research team to ring an independent person for each participant’s allocation schedule. The independent person was then responsible for opening an envelope and reading its content. The contents of the envelopes were checked on completion of the trial and were correct. Either the independent person responsible for opening the participant’s envelope wrongly read the contents of the envelope to the member of the research team, or the member of the research team misheard the participant’s allocation. Regardless, the error was made at random within 10 minutes of allocation. This participant’s data were included in the control group according to the recommendations of others about acceptable deviations for intention to treat analyses (Holli and Campbell 1999, Fergusson et al 2002). This made minimal difference to the baseline characteristics of each group, as presented in Table 2 (see eAddenda for Table 2.) Also, as a precaution all analyses were performed two more times; once with this participant’s data included in the experimental group and once with this participant’s data excluded altogether. There was minimal difference in any of the three sets of analyses on any outcome. Therefore, only the original set of analyses with the participant’s data included in the control group is reported here. The other two sets of analyses are presented in Table 3 (see the eAddenda for Table 3.)

The study protocol dictated that all participants in the control and experimental groups be given advice and adhere to an exercise program. The participants did not accurately record adherence to the exercise program despite our best efforts to encourage this. Our impression is that some diligently adhered to the exercise program and others did not, as typically occurs in clinical practice. Importantly, there was no indication from the diaries that there was a systematic difference between the adherence to the exercise program of the experimental and control participants.

![Diagram of participant flow](image_url)
Similarly, compliance by experimental participants with the splinting regimen was poorly recorded with only 14 of the 19 participants providing data. Their data indicate that of the total possible number of splinting days (ie, 14 participants × 56 days = 784 days), the splints were not worn on 55 days; worn for less than 3 hours a day on 266 days; worn between 3 and 6 hours a day on 310 days; and worn for more than 6 hours a day on 96 days. It is not known how often the remaining 5 participants wore their splints. Two of the dynamic splints required repairs at some stage during the trial, and two required modifications for pressure. This resulted in four participants being without their splints for between 1 and 13 days.

Effect of intervention

Table 4 shows the results for all primary and secondary outcomes. Individual patient data are presented in Table 5 (see the eAddenda for Table 5). The mean between-group differences for wrist extension and PRHWE at 8 weeks were 4 deg (95% CI –4 to 12) and –2 points (95% CI –8 to 4), respectively. The corresponding values at 12 weeks were 6 deg (95% CI 1 to 12) and 2 points (95% CI –5 to 9). The imprecision of these estimates indicates that it is unclear whether dynamic splints increase passive wrist extension at 8 or 12 weeks, or decrease PRHWE at 12 weeks. However, dynamic splints clearly have no clinically important effect on PRHWE at 8 weeks. The mean (95% CI) between-group differences for active wrist flexion, extension, radial deviation, and ulnar deviation, and COPM at 8 and 12 weeks were less than the pre-determined sufficiently important treatment effects indicating that dynamic splints do not have a clinically meaningful effect on active range of motion or COPM.

There were few adverse events associated with the splints. One participant reported transient numbness in the index finger secondary to the sustained pressure from the splint, and another participant reported an inability to wear the splint secondary to pain in the wrist with the application of the stretch. These adverse events resolved immediately when the splints were removed, and no long-term effects were noted at the end of the study.

Discussion

This is the first randomised controlled trial to investigate the efficacy of splints for contracture of the wrist following distal radial fracture. The results indicate uncertainty about whether 8 weeks of wearing a dynamic splint increases passive wrist extension at 8 or 12 weeks (the 95% CI spans the sufficiently important treatment effect). That is, it is not possible to rule out a therapeutic treatment effect on passive wrist extension. The results are similar for the PRHWE at 12 weeks. In contrast, the results conclusively show no effect of dynamic splints on PRHWE at 8 weeks and no effect of dynamic splints on active wrist extension, flexion, radial deviation, or ulnar deviation, and no effect on the performance or satisfaction items of the COPM at 8 or 12 weeks.

Dynamic splints are believed to reduce contracture because of the constant low-force stretch provided through the splint over prolonged periods of time. No clinical trials have specifically looked at dynamic splints for reducing wrist contracture but case series suggest that other types of splints that also apply stretch are effective. In particular, studies by Lucado et al (2008), Lucado and Li (2009), and McGrath et al (2008) have shown clinically important gains in passive range of motion with the use of serial progressive splints (where the joint is incrementally maintained at the limits of motion, and the amount of displacement increased regularly). However, the design of these studies may increase their susceptibility to bias. Interestingly, results from high quality randomised controlled trials investigating stretch administered in various ways to different types of patients have consistently failed to demonstrate treatment effects (Katalinic et al 2010). Of course, we cannot assume that results utilising different types of patients and stretch have direct implications for the use of dynamic splints following distal radial fracture; nonetheless, the results of this current study add further weight to the growing evidence which suggests that stretch is ineffective regardless of how it is administered and irrespective of to whom it is administered.

The imprecision around our estimates for passive wrist extension reflects an insufficient sample size despite the recruitment of 40 homogeneous participants over a 3-year period and a priori power calculations for this outcome. The imprecision may be due to measurement error or real variability in the way participants responded to the intervention. We attempted to minimise measurement error by utilising a purpose-built device to standardise the testing torque. The reliability of the device was good (ICC = 0.98, 95% CI 0.96 to 0.99). Possibly, however, during the trial some participants actively flexed the wrist in an attempt to avoid discomfort and others actively extended the wrist to increase range during testing. These factors may not have systematically biased the results but may have added imprecision to our estimate of passive wrist extension. Alternatively, our results may reflect variability in the way participants responded to the splints. Responses may depend on a range of factors such as age, sex, severity of injury, and type of injury. For example, some injuries may be associated with more soft tissue trauma, scarring, and contracture than others, rendering them more responsive to dynamic splints. Responses may also be determined by the type of activities and exercises that participants performed day-to-day. All these factors may influence participants’ responses to dynamic splints, adding noise to results and making it difficult to get precise estimates of the effects of the splinting protocol on passive wrist extension. The solution is either a more homogeneous or a larger sample. Both solutions will pose challenges for future trialists.

Interestingly, although our results suggest an insufficient sample size for passive wrist extension, they do not suggest an insufficient sample size for our other outcome measures (except PRHWE at 12 weeks). That is, the 40 participants were sufficient to rule out a sufficiently important treatment effect for active wrist extension, flexion, radial deviation, and ulnar deviation, as well as the performance or satisfaction items of the COPM. The results for all these outcomes conclusively indicate no therapeutic benefit from dynamic splints. Of course, the interpretation of these results relies on the definition of a sufficiently important treatment effect. We articulated a sufficiently important treatment effect for each outcome prior to commencement of the study based on clinical judgement and the recommendations of others. These were set at 10 degrees for all active wrist movements and 2 points for the two COPM items. Some may argue that we set these too high in which case the interpretation of our results would differ and leave open the possibility of...
Table 4. Mean (SD) of groups, mean (SD) difference within groups, and mean (95% CI) difference between groups.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Groups</th>
<th>Difference within groups</th>
<th>Difference between groups</th>
<th>Sufficiently important treatment effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Week 0 (Exp = 19, Con = 21)</td>
<td>Week 8 (Exp = 17, Con = 19)</td>
<td>Week 12 follow-up (Exp = 14, Con = 18)</td>
<td>Week 8 minus Week 0 (Exp = 17, Con = 19)</td>
</tr>
<tr>
<td>Passive wrist extension (deg)</td>
<td>57 (14) 61 (12)</td>
<td>67 (11) 61 (11)</td>
<td>66 (9) 61 (11)</td>
<td>9 (13) 6 (11)</td>
</tr>
<tr>
<td>PRHWE (point/100)</td>
<td>35 (18) 34 (17)</td>
<td>16 (11) 17 (9)</td>
<td>14 (11) 12 (9)</td>
<td>-21 (14) -16 (11)</td>
</tr>
<tr>
<td>Active wrist extension (deg)</td>
<td>54 (7) 55 (6)</td>
<td>55 (12) 59 (12)</td>
<td>63 (11) 65 (9)</td>
<td>1 (11) 3 (5)</td>
</tr>
<tr>
<td>Active wrist flexion (deg)</td>
<td>38 (8) 37 (7)</td>
<td>45 (10) 46 (11)</td>
<td>49 (8) 48 (12)</td>
<td>5 (10) 9 (11)</td>
</tr>
<tr>
<td>Active wrist radial deviation (deg)</td>
<td>18 (6) 17 (5)</td>
<td>21 (7) 17 (4)</td>
<td>22 (8) 20 (5)</td>
<td>3 (6) -1 (5)</td>
</tr>
<tr>
<td>Active wrist ulnar deviation (deg)</td>
<td>20 (7) 17 (7)</td>
<td>23 (9) 21 (6)</td>
<td>21 (9) 24 (9)</td>
<td>4 (8) 4 (6)</td>
</tr>
<tr>
<td>COPM – performancea (point/10)</td>
<td>5 (2) 4 (2)</td>
<td>8 (2) 7 (2)</td>
<td>8 (2) 8 (2)</td>
<td>3 (2) 3 (2)</td>
</tr>
<tr>
<td>COPM – satisfactiona (points/10)</td>
<td>5 (2) 5 (2)</td>
<td>8 (2) 8 (2)</td>
<td>8 (2) 8 (2)</td>
<td>3 (2) 3 (2)</td>
</tr>
</tbody>
</table>

Exp = experimental group, Con = control group, PRHWE = Patient Rated Hand Wrist Evaluation, COPM = Canadian Occupational Performance Measure. aOne item in the functional domain was not scored by a participant in the control group and a participant in the experimental group at baseline. This item was excluded from measures at 8 and 12 weeks. bOne item was not scored by a participant in the control group at 8 weeks. This item was excluded from measures at 12 weeks, and the Week 0 score recalculated with the omitted item.
detecting a treatment effect with a larger sample. Others may argue that wrist extension should not have been the primary outcome but instead PRHWE. We nominated wrist extension as our primary outcome because we were concerned about power and reasoned that splints could not be expected to change more meaningful measures of activity limitation or participations restrictions without an underlying change in wrist extension. As it turned out these concerns were unfounded and our measures of PRHWE had greater precision than our measures of wrist extension.

Our failure to demonstrate a treatment effect may also have been due to poor compliance with the splinting regimen. Participants were instructed to wear the splint for at least 6 hours a day. It was difficult to attain accurate data on how often the splints were worn. However, our best estimate suggests that most participants did not wear the splints for 6 hours a day. Nonetheless, adherence reflects the realities of wearing splints and was probably better than could be expected in clinical practice especially as we regularly reviewed participants and instructed them to record adherence in diaries. Perhaps the results would have been different if the participants had worn the splints for more than 6 hours a day and/or more than 8 weeks. However, participants are unlikely to tolerate wearing splints for longer periods of time. For example, some disliked the look of the splints and others complained about the limitations the splints imposed on day-to-day activities. Alternatively, it is possible that the splints were ineffective because they did not provide a sufficient stretch. We do not know precisely how much stretch was applied but the splints were adjusted regularly to ensure they pulled the wrist into as much wrist extension as tolerated. This mimics current clinical practice and it is unlikely participants would have tolerated more stretch.

Interestingly, all participants showed improvements in all outcomes over time. While it is tempting to interpret these findings as evidence of the effectiveness of the advice and home exercise program given to all participants and/or evidence about the good typical recovery following wrist fractures, neither interpretation is valid. To determine the effectiveness of the advice and home exercise program, a control group receiving no intervention is required and to better understand typical recovery, a large cohort study utilising a representative sample needs to be recruited. Nonetheless, the pre-to-post changes demonstrated in both groups provide some indication of typical outcomes following distal radial fracture.

It is difficult to provide clinicians with clear guidelines for management of contracture following distal radial fracture on the basis of this study. However, the results suggest that dynamic splints are unlikely to be therapeutic. We do not know whether we would have found more promising results if the splints had been worn for more than 6 hours a day and for longer than 8 weeks, although any benefits would need to be substantial and weighed up against the possible detrimental effects associated with restricting hand function for such an extended period of time. Clearly, further work is required to provide answers to some of these complex but important clinical questions.

eAddenda: Tables 2, 3, and 5 available at jop.physiotherapy.asn.au

Ethics: The HARBOUR Human Research Ethics Committee (HREC) of the Northern Sydney Central Coast Health (NSCCH) Ethics Committee(s) approved this study. Informed consent was obtained from all participants.

Competing interests: No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit upon the authors or organisations with which the authors are associated.

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