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ORIGINAL ARTICLE

Cross-Education for Improving Strength and Mobility After Distal Radius Fractures: A Randomized Controlled Trial

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Abstract

Objective: To evaluate the effects of cross-education (contralateral effect of unilateral strength training) during recovery from unilateral distal radius fractures on muscle strength, range of motion (ROM), and function.

Design: Randomized controlled trial (26-wk follow-up).

Setting: Hospital, orthopedic fracture clinic.

Participants: Women older than 50 years with a unilateral distal radius fracture. Fifty-one participants were randomized and 39 participants were included in the final data analysis.

Interventions: Participants were randomized to standard rehabilitation (Control) or standard rehabilitation plus strength training (Train). Standard rehabilitation included forearm casting for 40.4±6.2 days and hand exercises for the fractured extremity. Nonfractured hand strength training for the training group began immediately postfracture and was conducted at home 3 times/week for 26 weeks.

Main Outcome Measures: The primary outcome measure was peak force (handgrip dynamometer). Secondary outcomes were ROM (flexion/extension; supination/pronation) via goniometer and the Patient Rated Wrist Evaluation questionnaire score for the fractured arm.

Results: For the fractured hand, the training group (17.3±7.4kg) was significantly stronger than the control group (11.8±5.8kg) at 12 weeks postfracture ($P<.017$). There were no significant strength differences between the training and control groups at 9 (12.5±8.2kg; 11.3±6.9kg) or 26 weeks (23.0±7.6kg; 19.6±5.5kg) postfracture, respectively. Fractured hand ROM showed that the training group had significantly improved wrist flexion/extension (100.5°±19.2°) than the control group (80.2°±18.7°) at 12 weeks postfracture ($P<.017$). There were no significant differences between the training and control groups for flexion/extension ROM at 9 (78.0°±20.7°; 81.7°±25.7°) or 26 weeks (104.4°±15.5°; 106.0°±26.5°) or supination/pronation ROM at 9 (153.9°±23.9°; 151.8°±33.0°), 12 (170.9°±9.3°; 156.7°±20.8°) or 26 weeks (169.4°±11.9°; 162.8°±18.1°), respectively. There were no significant differences in Patient Rated Wrist Evaluation questionnaire scores between the training and control groups at 9 (54.2±39.0; 65.2±28.9), 12 (36.4±37.2; 46.2±35.3), or 26 weeks (23.6±25.6; 19.4±16.5), respectively.

Conclusions: Strength training for the nonfractured limb after a distal radius fracture was associated with improved strength and ROM in the fractured limb at 12 weeks postfracture. These results have important implications for rehabilitation strategies after unilateral injuries.

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Cross-education is a neural adaptation defined as the increase in strength or functional performance of the untrained contralateral limb after unilateral training of the opposite homologous limb.[1,2] The increase in strength in the untrained limb is related to the gain in magnitude of the trained limb, and is on average 52% of the strength gain observed in the trained muscle.[2] Cross-education is thought to be primarily controlled by neural mechanisms,[2-6] but the exact mechanisms are unknown.

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A large gap in the literature remains in applying cross-education to clinical rehabilitation settings. The potential benefit of cross-education for rehabilitation from unilateral injuries (ie, a fractured limb) is an obvious, clinically relevant extension of the work; however, little research has been conducted in clinical application of cross-education.[7] Stromberg[7] applied cross-education after wrist/forearm surgeries, but several limitations such as not including raw data, not accounting for baseline differences, and not reporting details of the training program have made it difficult to draw any conclusions from the results. Three studies have applied cross-education to unilateral immobilization in healthy (ie, nonfractured) limbs.[6,8,9] Farthing et al[6,8] found that cross-education strength training on the nonimmobilized limb provided a maintenance of strength in the immobilized healthy limb after wearing a forearm cast for 3 weeks. Similarly, Magnus et al[9] found that strength training of the nonimmobilized arm provided an increase in strength in the healthy immobilized arm after wearing an arm sling for 4 weeks. These studies suggest that cross-education can benefit a healthy immobilized limb. As yet, there are no randomized controlled clinical trials that have investigated these effects in real injuries that require limb immobilization. More research in this area may help improve the rehabilitation techniques clinicians use postinjury, and in turn may improve function for those with unilateral injuries such as distal radius fractures.

Distal radius fractures are one of the most common types of fracture,[10] especially in older women.[11] Rehabilitation after a distal radius fracture is quite slow, and it can often be difficult for individuals to return to their normal level of functioning. Brogren et al[12] showed that 1 year postfracture, grip strength was 88% of the nonfractured limb. Similarly, Trumble et al[13] found that 2.4 years postfracture, grip strength was 69% of the nonfractured limb and range of motion (ROM) was 75% of the nonfractured limb. A Cochrane Review by Handoll et al[11] examined the effects of rehabilitation beginning both during and after immobilization in adults with distal radius fractures. Fifteen randomized controlled trials were included, whereby treatment was conservative and involved plaster cast immobilization. The review found that there was insufficient evidence to determine the best form of rehabilitation after distal radius fractures. New ways of improving rehabilitation to enhance recovery and to provide better functional outcome are important to investigate.

One way of improving strength and functional gains in the fractured hand may be to apply cross-education during recovery from unilateral distal radius fractures. Unilateral distal radius fractures represent an adequate clinical model to test the efficacy of cross-education due to the standard immobilization intervention of forearm casting for approximately 6 weeks. In our clinic, there is no rigorous therapeutic intervention prescribed for individuals beyond ROM exercises for the fractured limb, and potential referral to physical therapy for more severe fractures. To our knowledge, there are no rehabilitation protocols that incorporate a formal strength training program of the nonfractured side as part of the recovery for the fractured side after distal radius fractures.[11]

List of abbreviations:

ANOVA **analysis of variance**
MCAR **missing completely at random**
PRWE **Patient Rated Wrist Evaluation**
ROM **range of motion**

The purpose of this study was to apply cross-education to unilateral distal radius fractures in women 50 years of age and older and to evaluate the effects on grip strength, ROM, and function. The hypothesis was that strength training of the nonfractured limb in addition to standard rehabilitation of the fractured limb would provide better strength and functional outcome than standard rehabilitation alone after a unilateral distal radius fracture.

Methods

Participants

Women aged 50 years and older with a unilateral distal radius fracture were recruited for 1 year from the fracture clinic at Royal University Hospital in Saskatoon, Saskatchewan, Canada, under the direction of 1 orthopedic surgeon. Patients referred to the clinic who met inclusion criteria were invited to participate in the study before their first visit to the clinic. Exclusion criteria included any prior upper body injury or joint problem interfering with daily life, or any history of upper-extremity neurologic problems (eg, stroke, multiple sclerosis, Parkinson's disease, vestibular disorders, reflex neuropathy). Participants were also excluded if the fracture was >2 weeks old at the time of the first visit to the clinic or if there were multiple fractures of the wrist and forearm. All participants completed the Mini-Cognitive Assessment Instrument for Dementia[14] to screen for cognitive impairment. Those who were unable to remember any words in the word recall and those who scored an abnormal clock draw test and recalled only 1 or 2 words were not included in the study.

A sample size calculation was completed using G Power 3.1[15,a] for the primary outcome variable (ie, strength). On the basis of our previous immobilization cross-education studies involving forearm casting,[6,8] we anticipated a 13% difference in affected limb strength between training and control. Because we have no previous data on cross-education effects on injured participants, we used a much smaller effect size estimate based on a 5% difference between groups to achieve a more conservative sample size estimate. Using alpha of .05 at 80% power, and an effect size of 0.2, the total required sample size was 36 (ie, 18 per group). Before the commencement of the study, all participants completed written informed consent approved by the Biomedical Ethics Review Board at the University of Saskatchewan with subsequent operational approval from the Saskatoon Health Region. Participants completed the Waterloo Handedness Questionnaire[16] at the first clinic visit to determine handedness. The 10-item questionnaire is scored from −20 to +20, whereby negative scores indicate left-handedness and positive scores indicate right-handedness. Participant characteristics per group are shown in table 1.

Study design

Participants were randomly assigned to 1 of 2 groups using a computer random number generator (see fig 1 for participant enrollment flow diagram). Randomization was completed at the first visit to the clinic by a researcher who did not conduct any of the testing procedures. The orthopedic surgeon and all other testing staff were blinded to the randomization of groups to limit any bias, altered treatment, or encouragement during testing procedures. Group 1 participants received the standard clinical rehabilitation protocol after a distal radius fracture and strength trained their nonfractured limb throughout the duration of the study (Train), and