

# Comparison of 2 Exercise Rehabilitation Programs for Multidirectional Instability of the Glenohumeral Joint

## A Randomized Controlled Trial

Sarah A. Warby,<sup>\*†‡§</sup> PhD, B Physio (Hons), Jon J. Ford,<sup>†</sup> PhD, M Physio, B AppSci (Physio), Andrew J. Hahne,<sup>†</sup> PhD, B Physio (Hons), Lyn Watson,<sup>†‡§</sup> DProf., B AppSci (Physio), GradDip, Simon Balster,<sup>‡§</sup> BPhy (Hons), BSc(Hons), Ross Lenssen,<sup>†‡§</sup> BHSc, and Tania Pizzari,<sup>†</sup> PhD, B Physio (Hons)  
*Investigation performed at La Trobe University, Bundoora, Australia*

---

**Background:** The recommended initial treatment for multidirectional instability (MDI) of the shoulder is a rehabilitation program, yet there is very low-quality evidence to support this approach.

**Purpose/Hypothesis:** The purpose was to compare the Watson MDI program and Rockwood Instability program among patients with nontraumatic, nonstructural MDI. The hypothesis was that the Watson MDI program would produce clinically and statistically superior outcomes over the Rockwood Instability program.

**Study Design:** Randomized controlled trial; Level of evidence, 2.

**Methods:** Forty-one participants with MDI were randomly allocated to the Watson MDI or Rockwood Instability program. Participants attended 12 weekly physiotherapy sessions for exercise prescription. Outcomes were assessed at baseline and 6, 12, and 24 weeks after randomization. Primary outcomes were the Melbourne Instability Shoulder Score (MISS) and the Western Ontario Shoulder Index (WOSI). Secondary outcomes included the Orebro Musculoskeletal Pain Questionnaire, pain, muscle strength, scapular upward rotation, scapular coordinates, global rating of change, satisfaction scales, limiting angle in abduction range, limiting factor in abduction range, and incidence of dislocation. Primary analysis was by intention to treat based on linear mixed models.

**Results:** Between-group differences showed significant effects favoring the Watson program for the WOSI (effect size [ES], 11.1; 95% CI, 1.9-20.2;  $P = .018$ ) and for the limiting factor in abduction (ES, 0.1; 95% CI, 0.0-1.6;  $P = .023$ ) at 12 weeks, and for the WOSI (ES, 12.6; 95% CI, 3.4-21.9;  $P = .008$ ), MISS (ES, 15.4; 95% CI, 5.9-24.8;  $P = .002$ ), and pain (ES, -2.0; CI: -2.3 to -0.7,  $P = .003$ ) at 24 weeks.

**Conclusion:** For people with MDI, 12 sessions of the Watson MDI program were more effective than the Rockwood program at 12- and 24-week follow-up.

**Registration:** ACTRN12613001240730 (Australian New Zealand Clinical Trials Registry).

**Keywords:** multidirectional instability; MDI; shoulder; rehabilitation; randomized controlled trial; scapula

---

Multidirectional instability (MDI) of the shoulder is commonly defined as symptomatic glenohumeral subluxation or dislocation in at least 2 directions.<sup>2,4,16</sup> MDI is typically attributed to a history of microtrauma imposed on a congenitally lax and redundant joint capsule.<sup>1,16,28,36</sup> In addition, patients with MDI have altered muscle patterning,<sup>35,39</sup> reduced muscle strength,<sup>20</sup> and reduced scapular upward

rotation.<sup>20,38</sup> MDI can affect quality of life owing to pain and activity limitation.<sup>1,2</sup> The true prevalence of MDI is unknown,<sup>60</sup> although the incidence is reported to peak in the second and third decades of life.<sup>36</sup>

The most commonly recommended initial treatment for MDI is a rehabilitation program, with the rationale that strengthening the shoulder muscles compensates for a lack of passive stability and assists in active control.<sup>53</sup> Surgery may be considered if nonoperative management fails.<sup>2,4,16</sup> However, the long-term outcomes of surgery on a capsule that has a high susceptibility to stretch<sup>54</sup> are still unknown; therefore, rehabilitation is considered the primary treatment option.<sup>16</sup> Systematic reviews<sup>53,54</sup> have

reported benefits of rehabilitation programs for patients with MDI; however, the quality of this evidence is very low because of heterogeneous patient samples and outcome measures nonspecific or not sensitive to measuring change in people with MDI.<sup>53,54</sup>

Apart from 1 instability program<sup>3</sup> whose published protocol was released after the commencement of the current trial, the Rockwood Instability program<sup>7</sup> was the only published MDI program that provided enough detail for practitioners to replicate it in the clinical setting. Burkhead and Rockwood<sup>7</sup> demonstrated that 87% of their participants with MDI (n = 6) had good to excellent results on the Constant score with this program. The Rockwood program focuses on strengthening the deltoid and the glenohumeral rotators with the arm at low degrees of shoulder elevation. There is no specific retraining of faulty scapular biomechanics. It is commonly used clinically when treating MDI, yet there is little evidence for its efficacy.<sup>53,54</sup>

The Watson MDI program<sup>58,59</sup> focuses on reestablishing patient-specific scapular motor control, typically scapular upward rotation, before any rotator cuff or deltoid strengthening. Scapular motor control is emphasized throughout the program, and exercises progress into functional and sport-specific ranges depending on patient requirements. A pre- and post-test study<sup>56</sup> showed significant improvements on the Melbourne Instability Shoulder Score (MISS) and the Western Ontario Shoulder Index (WOSI) for people with MDI.

No randomized controlled trial (RCT) has been published comparing the effect of 2 rehabilitation programs for MDI.<sup>53</sup> The primary aim of this RCT was to compare the effectiveness of the Rockwood Instability program and the Watson MDI program on the functional and instability-specific outcomes, scapular biomechanics, and muscle strength of participants with nontraumatic nonstructural MDI. The researchers hypothesized that the Watson MDI program would produce clinically and statistically superior outcomes over the Rockwood Instability program.

## METHODS

### Trial Design

This multicenter RCT was prospectively registered (ACT RN12613001240730; Australian New Zealand Clinical Trials Registry) and the protocol published.<sup>52</sup> The flow of participants through the trial is outlined in Figure 1. The

La Trobe University Human Ethics Committee (FHEC12/201) approved this trial. Participants read a detailed information sheet and signed a written consent form.<sup>52</sup> Participants were randomly allocated to one of two 12-week exercise programs: the Rockwood Instability program or the Watson MDI program.

### Participants and Recruitment

Participants were recruited from physiotherapists, sports physicians, and orthopaedic surgeons, as well as public advertising. Eligible participants were aged 12 to 35 years and had symptomatic glenohumeral joint subluxation or dislocation in >1 direction.<sup>2,4,52</sup> Diagnosis was based on a positive sulcus sign and a positive test (drawer test and/or apprehension test) for anterior and/or posterior instability.<sup>52</sup> Apprehension was the criterion for a positive instability test, not just pain or signs of laxity.<sup>52</sup> These tests are valid and reliable for diagnosing instability when apprehension is used as the criterion for a positive test.<sup>52</sup>

Eligible participants must have reported no history of significant trauma to the affected shoulder. A significant history of trauma was defined as contact with an external object (eg, a fall, impact with another body or surface) with lockout of the glenohumeral joint and conscious awareness by the patient of a sudden onset of pain.<sup>52</sup> Magnetic resonance imaging was performed to rule out any structural lesion of the glenohumeral joint (eg, labral tear, bony Bankart).<sup>52</sup> Participants with a history of trauma and/or structural lesions were more likely to have unidirectional instability.<sup>30</sup> Appendix 1 (available in the online version of this article) details a full list of inclusion and exclusion criteria. All eligible participants signed a consent form, and for those <18 years old, a guardian signed an additional consent form.

### Randomization Process

Using a web-based program (<http://www.randomisation.com>), one of the researchers (A.J.H.) prepared the randomization sequence with random block sizes, stratified per treating practitioner,<sup>45</sup> and allocated participants to interventions (allocation ratio, 1:1).<sup>33</sup> This researcher was the only person with access to the allocation spreadsheet and had no contact with any participants throughout the trial. The spreadsheet was located remotely to the treating clinics. To enroll a participant in a concealed manner, the primary researcher (S.A.W.) emailed the consenting participant's name, date

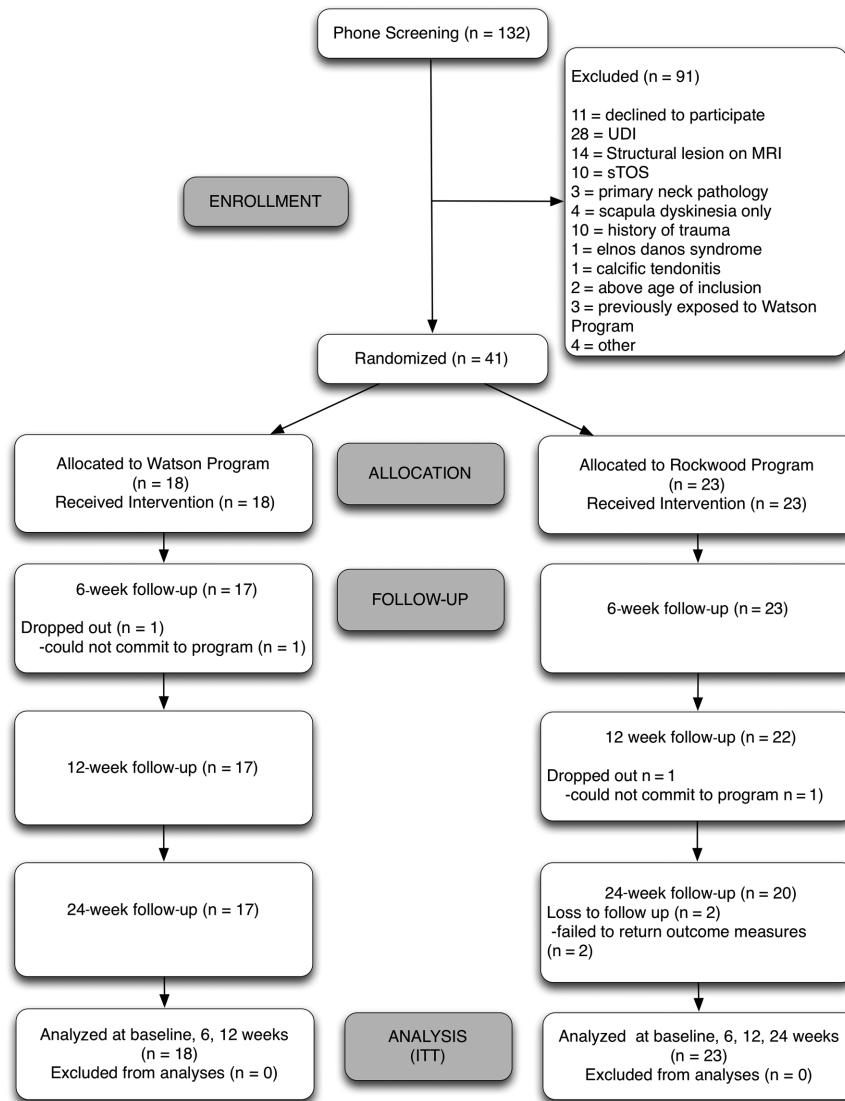
\*Address correspondence to Sarah A. Warby, PhD, B Physio (Hons), LifeCare Prahran Sports Medicine, 316 Malvern Rd, Prahran, Victoria 3181, Australia (email: S.Warby@latrobe.edu.au).

†Department of Rehabilitation, Nutrition and Sport, School of Allied Health, College of Science, Health and Engineering, La Trobe University, Bundoora, Australia.

‡LifeCare Prahran Sports Medicine Centre, Prahran, Australia.

§Melbourne Orthopedic Group, Windsor, Australia.

One or more of the authors has declared the following potential conflict of interest or source of funding: LifeCare Clinics of Victoria and Mill Park Physiotherapy provided facilities and recourses to allow treatment of trial participants free of charge. Imaging@Olympic Park provided magnetic resonance imaging for study participants at a reduced fee. Sports Medicine Australia and Shoulder and Elbow Physiotherapists Australasia awarded grants to assist with this project. Trobe University awarded internal research funding to S.A.W. S.A.W. also received funds from the Australian Postgraduate Awards Scheme for her PhD scholarship and funding. S.A.W., J.J.F., L.W., S.B., A.J.H., and R.L. subcontract to one of the study's funding sources (LifeCare). T.P. is the managing director of one of the funding sources (Mill Park Physiotherapy). Two of the authors (L.W., S.B.) instruct physiotherapy shoulder courses that cover some of the treatments included in this trial. Three of the authors (S.A.W., T.P., R.L.) are occasionally employed on a casual basis by L.W. to assist on these courses.



**Figure 1.** Flow of participants through the trial. ITT, intention to treat; MRI, magnetic resonance imaging; sTOS, symptomatic thoracic outlet syndrome; UDI, unidirectional instability.

of birth, and treating physiotherapist to the allocator (A.J.H.), who enrolled the participant and notified the treating physiotherapist of the treatment allocation.

**Interventions**

Participants attended a weekly 30-minute physiotherapy session for 12 weeks in either the Watson MDI program<sup>58,59</sup> or the Rockwood Instability program,<sup>7</sup> where they were prescribed and progressed through a set program of specific exercises to perform at home (Table 1). Physiotherapists spent each 30-minute session in its entirety with the participant, regardless of treatment allocation. Equipment for the relevant program was supplied. All participants were educated regarding the nature of their injuries, the rationale for exercise treatment, and the importance of compliance to the program.

*Rockwood Instability Program.* The Rockwood program<sup>7</sup> focused on concurrently strengthening all 3 parts of the deltoid and internal and external rotators of the glenohumeral joint in 2 phases. Phase 1 involved 5 exercises for the rotator cuff and deltoid with 6 progressive levels of Theraband resistance. Phase 2 of strengthening began when the participant progressed through all the resistance bands in phase 1. The participant was then asked to perform the same exercises as for phase 1 using a 4-kg weight with a pulley kit. Weights were progressed in increments of 1 kg.

*Watson MDI Program.* The Watson program<sup>58,59</sup> was primarily based around retraining and maintaining good scapula and humeral head motor control before any rotator cuff and deltoid strengthening. The program was divided into 6 stages, with the first stage focusing on retraining faulty scapular biomechanics. Assessment of the individual participant<sup>52,58</sup> determined the exact scapular position that the

TABLE 1  
Treatment Programs<sup>a</sup>

Rockwood Program	Watson Program
Focus: Concurrent rotator cuff and deltoid strengthening and push-ups for scapular stability. Majority of exercises performed at 0° of elevation.	Focus: Retraining specific scapular motor control before any rotator cuff/deltoid strengthening. Exercises progress into functional/sports specific ranges.
Aims and exercise drills	
Phase 1: Strength through progressive levels of Theraband (Theraband Hygenic Corporation) resistance. Load: Tan, yellow, red, green, blue Theraband. Patient standing <ul style="list-style-type: none"> <li>• ER (0°-45° ER) at 0° abduction</li> <li>• IR (0°-45° IR) at 0° abduction</li> <li>• Extension row to 45°</li> <li>• Flexion</li> <li>• Short-lever abduction to 45°</li> <li>• Wall, knee, or full push-ups (no Theraband resistance)</li> </ul>	Stage 1a: Retrain scapular motor control Load: 0-1 kg <ul style="list-style-type: none"> <li>• Scapular upward rotation/elevation drills in standing</li> </ul> Stage 1b: Controlling arcs of motion (0°-45° elevation) Load: yellow-red Theraband Patient standing <ul style="list-style-type: none"> <li>• Extension rows (from 45° flexion to neutral)</li> <li>• ER (0°-45° ER) at 0° abduction</li> <li>• IR (0°-45° IR) at 0° abduction</li> </ul>
Phase 2: Strength through resistance with weights <ul style="list-style-type: none"> <li>• Exercises as above with a weights-and-pulley system.</li> <li>• Addition of shoulder shrug</li> </ul>	Stage 2: Building posterior GHJ muscle bulk Load: green Theraband/1-2 kg <ul style="list-style-type: none"> <li>• Standing bent over rows</li> <li>• Side-lying ER</li> <li>• Standing Theraband rows</li> </ul> Stage 3: Sagittal plane (flexion motor control) Load: yellow-green Therabands/1-3 kg Patient standing <ul style="list-style-type: none"> <li>• Flexion with Therabands and weights</li> </ul> Stage 4: Controlling arcs of motion (45°-90° elevation) Patient standing Load: yellow-green Therabands/2-5 kg <ul style="list-style-type: none"> <li>• ER at 90°</li> <li>• IR at 90°</li> <li>• Flexion at 90°</li> </ul> Stage 5: Specific deltoid strengthening Load: 1-4 kg+ Patient standing <ul style="list-style-type: none"> <li>• Bent-over rows</li> <li>• Supine and sitting flexion</li> <li>• Short-lever abduction 45°-60°</li> </ul> Stage 6: Sports specific and functional stage. Load: depends on participant's requirements. Drills mimic specific sporting or functional activities Part to full practice
Load commences at 4 kg Progresses in 1 kg increments 9 kg max for females, 11 max for males	
Not all exercises need to be progressed at the same time, and participants may be on a different band or weight/resistance for different exercises.	
Pain and progression of program	
Exercises must be pain free to perform. Band or weight resistance is progressed once the participant reports that the current resistance is "relatively easy" to perform.	Exercises must be pain free to perform. Progression through the components of a particular stage or to the next stage is dependent on achieving scapular and glenohumeral joint motor-control without the presence of pain for a full set of any one exercise
Dosage	
All exercises: 5 repetitions with a 5-s hold at the end range of the exercise. All exercises are performed twice a day.	Depends on the functional needs of the patient. Typically start with a recruitment dosage for motor relearning (3 × 20, 2×/day), <sup>5</sup> followed by an endurance dosage (3 × 10-15, 2×/day), then strength dosage in later stages (4 × 8-12, every second day). <sup>25</sup> For most exercises, repetitions are held for 3 s.

<sup>a</sup>ER, external rotation; GHJ, glenohumeral joint; IR, internal rotation.

TABLE 2  
Outcome Measures<sup>a</sup>

Outcome Measure	Method of Assessment	Time Point for Assessment
Primary outcomes		
Melbourne Instability Shoulder Score	Online link/booklet	Baseline and 6, 12, 24, and 52 wk after randomization
Western Ontario Shoulder Index	Online link/booklet	
Secondary outcomes		
Orebro Musculoskeletal Pain Questionnaire	Online link/booklet	Baseline and 6, 12, 24, and 52 wk after randomization
Global Rating of Change	Online link/booklet	Baseline and 6, 12, 24, and 52 wk after randomization
Patient Satisfaction Score (with treatment and results)	Online link/booklet	Baseline and 6, 12, 24, and 52 wk after randomization
Incidence of complete glenohumeral joint dislocation	Online link/booklet	Baseline and 6 and 12 wk after randomization
Scapular coordinates (online supplementary, Appendix 2)	Blinded researcher in clinic	Baseline and 12 wk after randomization
Scapular upward rotation	Blinded researcher in clinic	Baseline and 12 wk after randomization
Muscle strength	Blinded researcher in clinic	Baseline and 12 wk after randomization
Symptomatic onset, limiting factor, and angle of limiting factor in abduction	Blinded researcher in clinic	Baseline and 12 wk after randomization
Compliance	Recorded in clinical notes by physiotherapist	Recorded in the clinical notes from sessions 2-12
Adverse events	Online link/booklet	Recorded in the clinical notes for every session and formally assessed at 6, 12, 24, and 52 wk after randomization
Success of blinding	Online link/booklet	12 wk after randomization

<sup>a</sup>A detailed description of all outcome measures and their validity, reliability, and method of administration, as well the definitions of adverse events for this trial, has already been published.<sup>52</sup> Medications used and any cointerventions were also recorded by the physiotherapist in the clinical notes and by the participant using the online link at baseline and 6, 12, 24, and 52 weeks after randomization.

patient must retrain and maintain throughout the program. The stages progressed via an increase in load and an increase in range of glenohumeral joint elevation. The final stages incorporated functional and/or sport-specific exercises.<sup>58,59</sup>

### Blinding

Participants, the researcher scoring and entering outcome measures, and the assessor of scapular coordinates (for method, see Appendix 2, available online), upward rotation, and strength were all blinded to the treatment allocation of participants.<sup>6</sup> The nature of the interventions prevented blinding of trial physiotherapists.

### Treating Physiotherapists and Treatment Fidelity

Treating physiotherapists were provided with a treatment manual and were involved in an initial 2-day training program and quarterly workshops to review participant cases. Treating physiotherapists were also required to complete standardized electronic clinical notes at every treatment session. To evaluate treatment fidelity, these were reviewed at 3, 6, and 12 weeks by researchers (T.P., J.J.F., R.L.) unblinded to participant treatment allocation, to ensure compliance with the protocol.<sup>52</sup>

### Outcomes

Outcome measures are summarized in Table 2. The primary outcomes were the MISS<sup>57</sup> and the WOSI,<sup>23</sup> which are valid, reliable, and sensitive tools for measuring changes in the shoulder instability population.<sup>40</sup> All secondary outcomes also have good reliability and validity.<sup>52</sup> The majority of outcomes were assessed via a set of self-administered questionnaires that were delivered to the participants via email as a secure online link or as a mailed hard copy. The set of questionnaires were sent to participants 1 week before their first physiotherapy session (baseline time point) and at 6, 12, and 24 weeks after randomization. Compliance with the home program was scored weekly by each participant's treating physiotherapist (Appendix 3). The remaining outcomes were collected at the participant's treatment clinic by a researcher (S.A.W. or T.P.) who was blinded to treatment allocation.

### Sample Size

It was calculated a priori that a definitive RCT would require a sample size of 328 participants (164 in each group) to detect a minimal clinically important difference (MCID) of 5 points on the MISS outcome measure, assuming a standard deviation of 16 (alpha of 0.05 and a power of 80%).<sup>11,57</sup> This large estimated sample size could be due to

TABLE 3  
Baseline Characteristics of Participants in the Trial<sup>a</sup>

	Watson Group	Rockwood Group
Participants	18	23
Age, y	21.8 ± 6.5	23.0 ± 6.5
Female	15 (83.3)	18 (78.3)
Duration of symptoms, mo	43.28 ± 87	46.8 ± 45.8
Dominant:nondominant shoulders in trial	15:3	17:6
Unilateral: bilateral symptoms	5:13	8:15
Instability directions		
Two	7 (38.9)	5 (21.7)
Three	11 (61.1)	18 (78.3)
Presence of generalized ligament laxity	10 (55.6)	16 (69.6)
Main sporting participation		
Overhead/throwing sport	7 (38.9)	6 (26.1)
Dance/yoga/Pilates	1 (5.6)	4 (17.4)
Weight lifting at gym	6 (33.3)	4 (17.4)
Lower limb dominated sport	2 (11.1)	1 (4.3)
Other	1 (5.6)	3 (13)
Nil	1 (5.6)	5 (21.7)
Primary outcome measures, total score		
WOSI	37.9 ± 17.5	41.8 ± 16.0
MISS	47.6 ± 16.8	48.7 ± 15.3

<sup>a</sup>Values are presented as No. (%) or mean ± SD, unless noted otherwise. MISS, Melbourne Instability Shoulder Score; WOSI, Western Ontario Shoulder Index.

the large standard deviation, which was the only available measure of variance for the primary outcomes measures.<sup>57</sup> Based on PhD time lines and the trial funding being exhausted, a decision was made to stop the trial after 2 years. The researchers had no knowledge of the results when making this decision.

### Statistical Methods

The primary method for data analysis was via intention to treat.<sup>27,34</sup> Analyses focused on detecting between- and within-group treatment effects (with effect sizes and 95% CIs) at each follow-up time point (6, 12, and 24 weeks). Continuous data were analyzed with linear mixed models, given its advantages in modeling repeated measures over time and adjusting for baseline scores.<sup>26</sup> Missing continuous data were accounted for by restricted maximum likelihood estimation within the linear mixed models.<sup>31</sup> Ordinal data were analyzed with the Mann-Whitney *U* test<sup>42</sup> and categorical data with chi-square tests.<sup>10</sup> Analysis was performed with SPSS (v 22; IBM). All tests were 2-tailed with alpha set at 0.05.

A responder analysis was conducted on the primary outcome measures (MISS and WOSI) to aid in determining the clinical importance of the effects.<sup>13,15</sup> At each time point (6, 12, and 24 weeks), cases were dichotomized as either “responders” or “nonresponders” based on whether participants improved from baseline by more than the MCID on the MISS (5 points) or the WOSI (10.4%).<sup>13,47</sup> Risk ratio, risk difference, and number needed to treat were calculated with 95% CI and statistical significance evaluated with the chi-square test.<sup>8,33,46</sup>

### RESULTS

This trial recruited 41 participants between November 2013 and December 2015. Groups were well matched at baseline (Table 3). The mean (SD) number of treatments attended over the 12-week program was 11.3 (2.1) for the Watson group and 11.2 (2.3) for the Rockwood group. One participant in the Watson group (5.6%) and 1 in the Rockwood group (4.3%) discontinued treatment before the end of the program. Over the 12-week program, 14 minor adverse events were reported (5 Watson, 9 Rockwood), which were all attributed to postexercise soreness and resolved with 48 hours of rest and modification of exercise. No serious adverse events were reported. For success of blinding in the Watson group, 2 of 16 (12.5%) correctly guessed their treatment allocation; 1 (6.3%) incorrectly guessed; and 13 (81.3%) were unsure. For the Rockwood group, 5 of 22 (22.7%) correctly guessed their treatment allocation, and 18 (81.8%) were unsure. During the 12-week program, participants in the Watson group were less compliant than participants in the Rockwood group (−2.5; 95% CI, −5.0 to −0.1; *P* = .042) (Appendix 3).

### Primary Intention-to-Treat Analyses

There were no significant between-group differences for any outcomes at 6 weeks. For the primary outcome measures, participants in the Watson MDI program demonstrated significantly greater improvements on the WOSI at 12 and 24 weeks and on the MISS at 24 weeks as compared with participants in the Rockwood program (Table 4). For continuous secondary outcome data (Appendix 4),

the Watson group demonstrated a significantly larger reduction in pain at 24 weeks and a significantly larger increase in flexion strength at 12 weeks. Significantly larger effects were seen for the Watson group for scapular coordinates of acromioclavicular joint  $y$ -axis at resting abduction and inferior angle of the scapula  $y$ -axis at 90° of glenohumeral joint abduction at 12 weeks. All other secondary continuous outcomes were not significant. For categorical secondary outcomes, significantly fewer participants in the Watson group reported pain as their limiting factor in abduction range of motion at 12 weeks (Table 5). Significance was not reached for differences between groups for incidence of dislocation, global rating of change scores, and satisfaction scores (Appendix 5).

Within-group analyses showed a significant improvement from baseline to each follow-up for both groups for the MISS, the WOSI, and all continuous secondary outcomes (Table 4, Appendix 4). There were no significant between-group differences in the proportion of participants who achieved more than the MCID on the MISS and the WOSI (Appendix 6).

## DISCUSSION

In this trial, 12 sessions of the Watson MDI program were more effective than 12 sessions of the Rockwood Instability program for functional instability-specific outcomes of the WOSI (at 12 and 24 weeks) and the MISS (24 weeks), pain (12 and 24 weeks), and limiting factor in abduction range of motion (12 weeks) for participants with nontraumatic, nonstructural MDI. Although there were no significant differences between groups for any outcome at 6 weeks, the magnitude of effect increased from a moderate size at 12 weeks to a large effect at 24 weeks for the MISS, the WOSI, and pain scores, indicating not only statistical significance but a clinically important difference between groups.<sup>15,37</sup> This difference is meaningful when considering the large and significant within-group treatment effects for both groups on the primary outcomes.<sup>18</sup> Because of the large treatment effects, this study can be considered a definitive RCT, as the effects for the MISS at 12 and 24 weeks were substantially larger than the MCID that was used to estimate the original sample size.<sup>57</sup>

One potential explanation for the between-group differences is the Watson program's progression of exercises into functional and sport-specific ranges. Functional gains are task and position specific,<sup>12,49</sup> and the larger between-group effects favoring the Watson program in the overhead and sporting subsections of the MISS and the WOSI reflect the potential importance of addressing these positions.

Another explanation for the greater improvements in the Watson group could be the effects of building proximal scapular stability for optimal distal control. The scapula thoracic joint provides the base of support from which the glenohumeral joint can adequately function.<sup>44</sup> In MDI, poor scapular control, particularly upward rotation, reduces joint congruency and therefore increases the potential for glenohumeral joint instability.<sup>2</sup> The Watson

program has a primary focus on ensuring that proximal scapular stability is achieved and maintained before adding glenohumeral joint movements throughout all stages of the program. In contrast, the Rockwood program strengthens the scapula, deltoid, and rotator cuff concurrently. The Watson program's development of specific proximal control may have enhanced bony congruency<sup>44</sup> and optimized glenohumeral joint function, resulting in improved functional outcomes. The results of this trial are similar to previous intervention studies in neck pain,<sup>22</sup> low back pain,<sup>9</sup> and subacromial impingement,<sup>19,48</sup> which showed significantly favorable effects when the deficit in stability muscles was specifically retrained, as opposed to being progressed through a more global strengthening program.

Another possible explanation could be the Watson program's focus on motor control training of the scapular muscles. Motor control training is the ability to consciously target a specific component of movement,<sup>5,51</sup> which requires increased levels of attention and precision than does contraction of more global muscles.<sup>5</sup> Motor control training has been shown to enhance reorganization of movement representation within the motor cortex,<sup>21,29,43</sup> which is associated with earlier activation of postural muscles,<sup>51</sup> task performance improvements,<sup>50</sup> and a significant reduction in pain.<sup>41,51</sup> The Watson program uses motor control training to restore a scapular deficit before initiating global shoulder strengthening. The potential effects of motor control training on the movement representation of the motor cortex and, therefore, peripheral motor control may explain the continued improvements of the Watson group on the MISS, WOSI, and pain scale from the 12- to 24-week outcomes, despite the exercise programming ceasing at 12 weeks. In contrast, the Rockwood group regressed on the WOSI and pain scale at 24 weeks. This rationale is speculative, and long-term central changes in response to an exercise program would need to be investigated in future research.

The greater effects in the Watson group were achieved despite lower compliance to exercise in that group. The lower compliance might be explained by the complexity and, hence, perceived effort to perform the exercises in the Watson program versus the Rockwood program. Blinding was successful in both groups owing to the high proportion of participants who were unsure of their treatment allocation.<sup>24</sup>

## Trial Limitations

There were no between-group differences for scapular upward rotation angles and strength at higher ranges. As the largest effects for the primary functional outcomes were detected at 24 weeks, the 12-week time point may have been too early to detect significant between-group differences for these outcomes. The significant result of flexion strength only (as well as 2 scapular coordinates points) could also reflect a Type I error based on multiple tests.<sup>14</sup> In addition, the inclinometer (used to measure scapular angles) provides a reliable measure for static upward rotation only<sup>55</sup>; it has limitations for evaluating dynamic scapular motor control. Other mechanisms responsible for changes in scapular motor control need to

**TABLE 4**  
**Effects of the Watson Multidirectional Instability Program vs the Rockwood Instability Program**  
**on Continuous Primary and Secondary Outcomes<sup>a</sup>**

Weeks <sup>b</sup>	Within-Group Mean Difference (95% CI)		Unadjusted Mean Score (SD)		Adjusted SMD (95 % CI) <sup>c</sup>	Adjusted Between-Group Difference (95 % CI) <sup>c</sup>	P Value
	Watson	Rockwood	Watson	Rockwood			
<b>Primary outcomes</b>							
WOSI total score (score from 0% to 100%, 100% = a normal shoulder; a higher percentage indicates a higher-functioning shoulder)							
Baseline			37.9 (17.5)	41.8 (16.0)			
6	16.3 (9.7 to 22.8)	14.3 (8.0 to 20.6)	54.0 (20.5)	56.1 (24.2)	0.1 (-0.5 to 0.7)	2.0 (-7.1 to 11.1)	.667
12	33.6 (27.1 to 40.2)	22.5 (16.1 to 28.9)	71.4 (18.5)	65.4 (23.2)	0.5 (-0.1 to 1.1)	11.1 (1.9 to 20.2)	<b>.018</b>
24	35.1 (28.6 to 41.6)	22.3 (15.6 to 28.9)	72.8 (15.7)	66.7 (22.5)	0.6 (0.0 to 1.3)	12.6 (3.4 to 21.9)	<b>.008</b>
WOSI physical (score from 0 to 100 points; a lower score indicates a higher level of shoulder physical disability)							
Baseline			64.4 (17.1)	61.3 (15.9)			
6			47.5 (19.6)	46.2 (24.8)	-0.1 (-0.7 to 0.6)	-1.6 (-10.8 to 7.5)	.722
12			30.4 (16.8)	36.2 (23.1)	-0.5 (-1.1 to 0.1)	-10.1 (-19.3 to -0.9)	<b>.031</b>
24			30.7 (15.3)	35.8 (22.1)	-0.6 (-1.2 to 0.1)	-10.9 (-20.2 to -1.6)	<b>.022</b>
WOSI sport (score from 0 to 40 points; a lower score indicates a higher level of shoulder sporting disability)							
Baseline			27.0 (7.6)	23.3 (8.2)			
6			21.4 (10.3)	18.2 (12.0)	-0.1 (-0.7 to 0.6)	-0.6 (-6.1 to 4.8)	.824
12			12.5 (10.1)	13.7 (10.4)	-0.5 (-1.1 to 0.1)	-5.3 (-10.7 to 0.2)	.060
24			10.1 (8.0)	13.0 (10.3)	-0.8 (-1.4 to -0.1)	-7.4 (-13.0 to -1.9)	<b>.009</b>
WOSI lifestyle (score from 0 to 40 points; a lower score indicates a higher level of shoulder lifestyle disability)							
Baseline			17.2 (9.5)	16.9 (8.8)			
6			12.6 (8.5)	12.3 (10.4)	-0.0 (-0.6 to 0.6)	-0.2 (-3.9 to 3.5)	.900
12			7.7 (7.8)	9.8 (9.8)	-0.3 (-1.0 to 0.3)	-3.0 (-6.7 to 0.7)	.108
24			6.7 (6.1)	7.9 (9.2)	-0.3 (-0.9 to 0.3)	-2.6 (-6.3 to 1.2)	.180
WOSI emotion (score from 0 to 30 points; a lower score indicates a higher level of shoulder emotional disability)							
Baseline			21.9 (6.2)	20.7 (6.8)			
6			14.9 (8.0)	15.5 (8.5)	-0.2 (-0.8 to 0.4)	-1.6 (-5.7 to 2.5)	.434
12			9.5 (7.1)	13.0 (8.7)	-0.6 (-1.2 to 0.00)	-4.8 (-8.9 to -0.7)	<b>.023</b>
24			9.6 (7.4)	13.3 (8.9)	-0.6 (-1.3 to -0.0)	-5.4 (-9.6 to -1.3)	<b>.011</b>
MISS total score (score from 0% to 100%, 100% = a normal shoulder; a higher percentage indicates a higher-functioning shoulder)							
Baseline			47.6 (16.7)	48.7 (15.3)			
6	12.4 (5.3 to 19.6)	11.2 (4.7 to 17.7)	60.1 (14.4)	59.9 (24.4)	0.1 (-0.6 to 0.7)	1.2 (-8.1 to 10.5)	.793
12	26.6 (19.5 to 33.8)	17.8 (11.2 to 24.4)	74.4 (17.6)	67.8 (20.7)	0.5 (-0.2 to 1.1)	8.8 (-0.5 to 18.2)	.064
24	31.1 (24.5 to 37.7)	15.6 (8.9 to 22.3)	78.8 (13.1)	66.6 (21.4)	0.8 (0.2 to 1.5)	15.4 (5.9 to 24.8)	<b>.002</b>
MISS section A: pain (score from 0 to 15 points; a higher score indicates a lower level of pain)							
Baseline			8.2 (3.1)	9.1 (2.8)			
6			10.8 (2.9)	11.2 (3.2)	0.2 (-0.4 to 0.8)	0.7 (-1.2 to 2.5)	.483
12			13.1 (2.2)	11.9 (2.9)	0.9 (0.2 to 1.5)	2.3 (0.4 to 4.1)	<b>.017</b>
24			13.1 (2.4)	11.3 (3.5)	1.0 (0.3 to 1.6)	3.0 (1.1 to 4.9)	<b>.002</b>
MISS section B: instability (score from 0 to 33 points; a higher score indicates fewer instability symptoms)							
Baseline			18.9 (7.4)	17.3 (8.6)			
6			23.1 (6.3)	21.0 (9.6)	0.0 (-0.6 to 0.6)	0.00 (-4.6 to 4.6)	.999
12			26.6 (6.4)	24.6 (7.6)	0.1 (-0.6 to 0.7)	0.5 (-4.2 to 5.2)	.827
24			28.9 (6.2)	23.9 (9.4)	0.5 (-0.2 to 1.1)	3.9 (-0.9 to 8.6)	.109
MISS section C: function (score from 0 to 32 points; a higher score indicates a higher level of general function)							
Baseline			12.2 (7.7)	13.0 (5.9)			
6			16.2 (7.0)	16.52 (9.64)	0.1 (-0.6 to 0.7)	0.5 (-3.3 to 4.3)	.801
12			21.8 (7.8)	19.18 (8.7)	0.5 (-0.2 to 1.1)	3.8 (-0.0 to 7.6)	<b>.048</b>
24			23.3 (6.4)	19.7 (8.4)	0.7 (0.0 to 1.3)	5.2 (1.3 to 9.0)	<b>.009</b>
MISS section D: occupational and sporting demands (score from 0 to 20 points; a higher score indicates a higher level of sporting/occupational function)							
Baseline			8.3 (3.6)	9.4 (3.4)			
6			10.1 (3.9)	11.2 (4.7)	0.0 (-0.6 to 0.7)	0.1 (-2.1 to 2.3)	.905
12			12.9 (3.5)	12.2 (3.9)	0.6 (-0.1 to 1.2)	2.1 (-0.1 to 4.3)	.061
24			13.5 (2.6)	11.8 (4.8)	0.8 (0.1 to 1.4)	3.1 (0.9 to 5.4)	<b>.007</b>
<b>Secondary outcomes</b>							
Orebro Musculoskeletal Pain Questionnaire (21 items scored out of 210; higher scores indicate greater psychological risk)							
Baseline			93.7 (31.9)	89.3 (25.1)			
6	-19.9 (-27.9 to -11.9)	-16.0 (-24.2 to -7.7)	73.8 (23.8)	73.3 (7.0)	-0.2 (-0.9 to 0.4)	-3.9 (-15.9 to 8.0)	.517
12	-33.9 (-42.1 to -25.8)	-24.3 (-32.6 to -15.9)	59.3 (24.5)	64.9 (29.8)	-0.3 (-1.0 to 0.3)	-9.7 (-21.8 to 2.5)	.119
24	-33.7 (-42.1 to -25.3)	-21.4 (-30.4 to -12.5)	59.5 (24.7)	67.1 (30.3)	-0.4 (-1.1 to 0.2)	-12.1 (-24.5 to 0.2)	.053
Symptomatic onset angle in abduction range of motion (range of motion from 0° to 190°; a higher value indicates a greater range in abduction reached at symptom onset)							
Baseline			113.3 (38.2)	111.7 (31.8)			
12	50.0 (35.6 to 64.5)	45.5 (30.5 to 60.5)	160.6 (12.8)	157.2 (27.6)	0.2 (-0.4 to 0.8)	4.45 (-16.4 to 25.3)	.672
Limiting angle in abduction range of motion (range of motion from 0° to 190°; a higher value indicates a greater range in abduction reached at limiting range)							
Baseline			158.8 (11.4)	158.4 (17.2)			
12	6.8 (2.2 to 11.3)	5.5 (-2.2 to 13.3)	165 (8.5)	164.0 (15.9)	0.1 (-0.5 to 0.7)	1.2 (-8.4 to 10.8)	.799

(continued)



TABLE 4  
(continued)

Weeks <sup>b</sup>	Within-Group Mean Difference (95% CI)		Unadjusted Mean Score (SD)		Adjusted SMD (95 % CI) <sup>c</sup>	Adjusted Between-Group Difference (95 % CI) <sup>c</sup>	P Value
	Watson	Rockwood	Watson	Rockwood			
	Pain scores (score from 0 to 10; a lower score indicates a lower level of pain)						
Baseline			5.6 (2.1)	4.4 (2.4)			
6	-2.3 (-3.3 to -1.4)	-1.54 (-2.3 to -0.7)	3.2 (2.1)	2.9 (2.3)	-0.3 (-1.0 to 0.3)	-0.8 (-2.0 to 0.5)	.240
12	-2.9 (-3.8 to -2.0)	-1.87 (-2.7 to -1.1)	2.7 (2.0)	2.4 (2.3)	-0.5 (-1.1 to 0.2)	-1.0 (-2.3 to 0.3)	.121
24	-3.7 (-4.7 to -2.7)	-1.7 (-5.6 to -0.9)	1.9 (1.6)	2.5 (2.1)	-1.0 (-1.7 to -0.4)	-2.0 (-2.3 to -0.7)	<b>.003</b>

<sup>a</sup>Positive SMDs (standardized mean differences) and between-group differences for the MISS (total score only), the WOSI (total score only), symptomatic onset angle, and limiting angle in abduction range of motion and negative SMDs and between-group differences for pain and the Orebro Musculoskeletal Pain Questionnaire represent greater improvement in the Watson program as compared with the Rockwood program.

<sup>b</sup>For each data row: Watson, n = 18; Rockwood, n = 23.

<sup>c</sup>Adjusted analyses were linear mixed models adjusted for baseline scores, with P values obtained from these adjusted linear mixed models. P values in bold highlight outcomes reaching between-group statistical significance (P < .05).

TABLE 5  
Effects of Watson MDI Program Versus Rockwood Instability Program on Categorical Secondary Outcomes<sup>a</sup>

Weeks	Watson, No. (%)	Rockwood, No. (%)	$\chi^2$	RR (95% CI)	NNT (95% CI)	P Value
	Incidence of dislocation					
6	1 of 17 (5.9)	3 of 23 (13)	0.557	0.5 (0.1 to 4.0)	14.0 (-6.0 to 4.0)	.624
12	1 of 17 (5.9)	0 of 22 (0)	1.328	3.9 (0.2 to 89.0)	-16.0 (-4.0 to -9.0)	.436
24	2 of 17 (11.8)	1 of 19 (5.3)	0.496	2.2 (0.2 to 22.5)	-15.0 (-3.0 to 7.0)	.593
	Limiting factor in abduction range of motion: proportion of participants with pain-limiting range as opposed to resistance					
Baseline	7 of 18 (38.9)	12 of 23 (52.2)	7.17	0.7 (0.3 to 1.5)	8.0 (-6 to 3)	.531
12	0 of 17 (0)	6 of 22 (27.3)	5.479	0.1 (0.0 to 1.6)	4.0 (59 to 2)	<b>.023</b>

<sup>a</sup>Chi-square presented in percentage with risk ratio (RRs) and 95% CI. P values in bold highlight outcomes reaching between-group statistical significance with the  $\chi^2$  test (P < .05). Positive risk differences and risk ratios >1 represent a higher proportion of Watson MDI program participants achieving the outcome relative to the Rockwood program. Positive NNT represents the number of participants that need to be treated with the Watson MDI program as opposed to the Rockwood program to achieve the specified outcome. MDI, multidirectional instability; NNT, number needed to treat.

be evaluated in future research. Based on our strict inclusion criteria, the results of this trial may be generalized only to patients with nonstructural, nontraumatic MDI.

### Trial Strengths and Comparisons With Previous Research

This RCT is the first to investigate the effect of 2 rehabilitation programs on MDI. Our strict diagnostic criteria adhered to recent MDI diagnostic recommendations<sup>32</sup> and ensured a more homogeneous sample.<sup>17</sup> The results of this trial are synonymous with the conclusions of previous studies that reported overall benefits of rehabilitation programs for MDI.<sup>3,53,54</sup> However, as compared with previous published literature, this definitive RCT provides higher-quality evidence on which practitioners can base their treatment choices.

### Clinical Implications and External Validity

Physiotherapists should implement the Watson MDI program when treating nontraumatic, nonstructural MDI. The larger effects found at 24 weeks serve to inform

practitioners of an approximate time at which they can expect their patients with MDI to show best functional improvements, which may assist in setting treatment outcome expectations with them.

### CONCLUSION

In this trial involving participants with nontraumatic MDI of the glenohumeral joint, the Watson program produced significantly better outcomes than the Rockwood program at 12 weeks for the WOSI and limiting factor in abduction and at 24 weeks for the WOSI, MISS, and pain scores.

### ACKNOWLEDGMENT

The authors acknowledge the trial assessors and physiotherapists who volunteered to assess and treat participants free of charge.

### REFERENCES

1. An YH, Friedman RJ. Multidirectional instability of the glenohumeral joint. *Orthop Clin North Am.* 2000;31(2):275-283.

2. Bahu MJ, Trentacosta N, Vorys GC, Covey AS, Ahmad CS. Multidirectional instability: evaluation and treatment options. *Clin Sports Med.* 2008;27(4):671-689.
3. Bateman M, Smith BE, Osborne SE, Wilkes SR. Physiotherapy treatment for atraumatic recurrent shoulder instability: early results of a specific exercise protocol using pathology-specific outcome measures. *Shoulder Elbow.* 2015;7(4):282-288.
4. Beasley L, Faryniarz DA, Hannafin JA. Multidirectional instability of the shoulder in the female athlete. *Clin Sports Med.* 2000;19(2):331-349.
5. Boudreau SA, Farina D, Falla D. The role of motor learning and neuroplasticity in designing rehabilitation approaches for musculoskeletal pain disorders. *Man Ther.* 2010;15(5):410-414.
6. Bridgman S, Dainty K, Kirkley A, Maffulli N. Practical aspects of randomization and blinding in randomized clinical trials. *Arthroscopy.* 2003;19(9):1000-1006.
7. Burkhead WZ, Rockwood CA. Treatment of instability of the shoulder with an exercise program. *J Bone Joint Surg Am.* 1992;74:890-896.
8. Busse JW, Guyatt GH. Optimizing the use of patient data to improve outcomes for patients: narcotics for chronic noncancer pain. *Expert Rev Pharmacoecon Outcomes Res.* 2009;9(2):171-179.
9. Byström MG, Rasmussen-Barr v, Grooten WJA. Motor control exercises reduces pain and disability in chronic and recurrent low back pain: a meta-analysis. *Spine.* 2013;38(6):E350-E358.
10. Campbell M, Swinscow T. *Statistics at Square One.* 9th ed. Singapore: Wiley-Blackwell; 2009.
11. Carlin J, Doyle L. Statistics for clinicians: sample size. *J Paediatr Child Health.* 2002;38(3):300-304.
12. De Vreede PL, Samson MM, Van Meeteren NLU, Duursma SA, Verhaar HJJ. Functional-task exercise versus resistance strength exercise to improve daily function in older women: a randomized controlled trial. *J Am Geriatr Soc.* 2005;53(1):2-10.
13. Dworkin RH, Turk DC, McDermott MP, et al. Interpreting the clinical importance of group differences in chronic pain clinical trials: IMMPACT recommendations. *Pain.* 2009;146(3):238-244.
14. Feise RJ. Do multiple outcome measures require p-value adjustment? *BMC Med Res Methodol.* 2002;2(8):1-4.
15. Ford JJ, Hahne AJ, Surkitt LD, et al. Individualised physiotherapy as an adjunct to guideline-based advice for low back disorders in primary care: a randomised controlled trial. *Br J Sports Med.* 2016;50(4):237-245.
16. Guerrero P, Busconi B, Deangelis N, Powers G. Congenital instability of the shoulder joint: assessment and treatment options. *J Orthop Sports Phys Ther.* 2009;39(2, special issue):124-134.
17. Higgins JPT. Cochrane handbook for systematic reviews. In: Green S, ed. The Cochrane Collaboration. 5.1.0 ed. Available at: www.cochrane-handbook.org. Updated March 2011. Accessed September 17, 2016.
18. Hill JC, Whitehurst DG, Lewis M, et al. Comparison of stratified primary care management for low back pain with current best practice (STarT Back): a randomised controlled trial. *Lancet.* 2011;378:1560-1571.
19. Holmgren T, Björnsson Hallgren H, Öberg B, Adolfsson L, Johansson K. Effect of specific exercise strategy on need for surgery in patients with subacromial impingement syndrome: randomised controlled study. *Br Med J.* 2012;344:e787.
20. Illyés Á, Kiss RM. Kinematic and muscle activity characteristics of multidirectional shoulder joint instability during elevation. *Knee Surg Sports Traumatol Arthrosc.* 2006;14(7):673-685.
21. Jensen JL, Marstrand PCD, Nielsen JB. Motor skill training and strength training are associated with different plastic changes in the central nervous system. *J Appl Physiol.* 2005;99(4):1558-1568.
22. Jull GA, Falla D, Treleaven J, Hodges P, Vicenzino B. Retraining cervical joint position sense: the effect of two exercise regimes. *J Orthop Res.* 2007;25(3):404-412.
23. Kirkley A, Griffin S, McLintock H, Ng L. The development and evaluation of a disease-specific quality of life measurement tool for shoulder instability: the Western Ontario Instability Index (WOSI). *Am J Sports Med.* 1998;26(6):764-772.
24. Kolahi J, Bang H, Park J. Towards a proposal for assessment of blinding success in clinical trials: up-to-date review. *Community Dent Oral Epidemiol.* 2009;37(6):477-484.
25. Kraemer WJ, Adams K, Cafarelli E, et al. Progression models in resistance training for healthy adults. *Med Sci Sports Exerc.* 2002;34(2):364-380.
26. Krueger C, Tian L. A comparison of the general linear mixed model and repeated measures ANOVA using a dataset with multiple missing data points. *Biol Res Nurs.* 2004;6(2):151-157.
27. Laude EA, Duffy NC, Baveystock C, et al. The effect of helium and oxygen on exercise performance in chronic obstructive pulmonary disease: a randomised crossover trial. *Am J Respir Crit Care Med.* 2006;173(8):865-870.
28. Lee HJ, Kim NR, Moon SG, Ko SM, Park JY. Multidirectional instability of the shoulder: rotator interval dimension and capsular laxity evaluation using MR arthrography. *Skeletal Radiol.* 2013;42(2):231-238.
29. Leung M, Rantalainen T, Teo WP, Kidgell D. Motor cortex excitability is not differentially modulated following skill and strength training. *Neuroscience.* 2015;305:99-108.
30. Lewis A, Kitamura T, Bayley JLL. (ii) The classification of shoulder instability: new light through old windows! *Curr Orthop.* 2004;18(2):97-108.
31. Liu M, Wei L, Zhang J. Review of guidelines and literature for handling missing data in longitudinal clinical trials with a case study. *Pharm Stat.* 2006;5(1):7-18.
32. McFarland EG, Kim TK, Park HB, Neira CA, Gutierrez MI. The effect of variation in definition on the diagnosis of multidirectional instability of the shoulder. *J Bone Joint Surg Am.* 2003;85(11):2138-2144.
33. Moher D, Sally H, Kenneth FS, et al. CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials. *Br Med J.* 2010;340:c869.
34. Morden J, Lambert P, Latimer N, Abrams K, Wailoo A. Assessing methods for dealing with treatment switching in randomised controlled trials: a simulation study. *BMC Med Res Methodol.* 2011;11(1):4.
35. Morris AD, Kemp GJ, Frostick SP. Shoulder electromyography in multidirectional instability. *J Shoulder Elbow Surg.* 2004;13(1):24-29.
36. Neer CS, Foster CR. Inferior capsular shift for involuntary inferior and multidirectional instability of the shoulder: a preliminary report. *J Bone Joint Surg Am.* 1980;62(6):897-908.
37. Norman GR, Sloan JA, Wyrwich KW. Interpretation of changes in health-related quality of life: the remarkable universality of half a standard deviation. *Med Care.* 2003;41(5):582-592.
38. Ogston JB, Ludewig PM. Differences in 3-dimensional shoulder kinematics between persons with multidirectional instability and asymptomatic controls. *Am J Sports Med.* 2007;35(8):1361-1370.
39. Pizzari T, Wickham J, Watson L, Zika M, Hill S. Altered muscle activation patterns in multidirectional shoulder instability during dynamic abduction. *J Sci Med Sport.* 2009;12(suppl):S4.
40. Plancher KD, Lipnick SL. Analysis of evidence-based medicine for shoulder instability. *Arthroscopy.* 2009;25(8):897-908.
41. Pleger B, Tegenthoff M, Ragert P, et al. Sensorimotor returning in complex regional pain syndrome parallels pain reduction. *Ann Neurol.* 2005;57(3):425-429.
42. Portney LG, Watkins MP. *Foundations of clinical research.* 3rd ed. Philadelphia, PA: FA Davis Co; 2015.
43. Remple MS, Bruneau RM, VandenBerg PM, Goertzen C, Kleim JA. Sensitivity of cortical movement representations to motor experience: evidence that skill learning but not strength training induces cortical reorganization. *Behav Brain Res.* 2001;123(2):133-141.
44. Roche SJ, Funk L, Sciascia A, Kibler WB. Scapular dyskinesis: the surgeon's perspective. *Shoulder Elbow.* 2015;7(4):289-297.
45. Schulz K, Grimes D. Generation of allocation sequences in randomised trials: chance, not choice. *Lancet.* 2002;359(9305):515-519.
46. Smith C, Grimmer-Somers K. The treatment effect of exercise programmes for chronic low back pain. *J Eval Clin Pract.* 2010;16(3):484-491.

47. Snapinn S, Jiang Q. Responder analyses and the assessment of a clinically relevant treatment effect. *Trials*. 2007;8(1):31.
48. Struyf F, Nijs J, Mollekens S, et al. Scapular-focused treatment in patients with shoulder impingement syndrome: a randomized clinical trial. *Clin Rheumatol*. 2013;32:73-85.
49. Sullivan KJ, Brown DA, Klassen T, et al. Effects of task-specific locomotor and strength training in adults who were ambulatory after stroke: results of the STEPS randomized clinical trial. *Phys Ther*. 2007;87(12):1580-1602.
50. Taubert M, Lohmann G, Margulies DS, Ragert P. Long-term effects of motor training on resting-state networks and underlying brain structure. *Neuroimage*. 2011;57(4):1492-1498.
51. Tsao H, Galea MP, Hodges PW. Driving plasticity in the motor cortex in recurrent low back pain. *Eur J Pain*. 2010;14(8):832-839.
52. Warby SA, Ford JJ, Hahne AJ, et al. The effect of exercise based management on multidirectional instability of the glenohumeral joint: a pilot randomised controlled trial protocol. *BMJ Open*. 2016;6:e013083.
53. Warby SA, Pizzari T, Ford JJ, Hahne AJ, Watson L. The effect of exercise-based management for multidirectional instability of the glenohumeral joint: a systematic review. *J Shoulder Elbow Surg*. 2014;23(1):128-142.
54. Warby SA, Pizzari T, Ford JJ, Hahne AJ, Watson L. Exercise-based management versus surgery for multidirectional instability of the glenohumeral joint: a systematic review. *Br J Sports Med*. 2016;50:1115-1123.
55. Watson L. Measurement of scapula upward rotation: a reliable clinical procedure. *Br J Sports Med*. 2005;39(9):599-603.
56. Watson L, Balster S, Lenssen R, Hoy G, Pizzari T. The effects of a conservative rehabilitation program for multidirectional instability of the shoulder [published online September 22, 2017]. *J Shoulder Elbow Surg*. doi:10.1016/j.jse.2017.07.002.
57. Watson L, Story I, Dalziel R, Hoy G, Shimmin A, Woods D. A new clinical outcome measure of glenohumeral joint instability: the MISS questionnaire. *J Shoulder Elbow Surg*. 2005;14(1):22-30.
58. Watson L, Warby SA, Balster S, Pizzari T, Lenssen R. The treatment of multidirectional instability with an exercise program: part 1. *Shoulder Elbow*. 2016;8(4):271-278.
59. Watson L, Warby SA, Balster S, Pizzari T, Lenssen R. The treatment of multidirectional instability with an exercise program: part 2 [published online June 1, 2016]. *Shoulder Elbow*.
60. Whorowski DC. Multidirectional glenohumeral instability. Available at: <http://emedicine.medscape.com/article/1262368-overview>. Published June 21, 2014. Updated January 15, 2016. Accessed June 8, 2016.