J Shoulder Elbow Surg (2021) ■, 1–12

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

# Rehabilitation for atraumatic shoulder instability in circus arts performers: delivery via telehealth

**Charlotte L. Ganderton, PhD[a,*], Oren Tirosh, PhD[b], David Munro, PhD[c], Denny Meyer, PhD[b], Ross Lenssen, BHSc(Physiotherapy)[d], Simon Balster, BPhty(Hons)[d], Lyn Watson, DProf[d], Sarah Warby, PhD[d]**

[a]*Department of Nursing and Allied Health, Faculty of Health Arts and Design, Swinburne University of Technology, Hawthorn, VIC, Australia*
[b]*Department of Health Sciences and Biostatistics, Faculty of Health Arts and Design, Swinburne University of Technology, Hawthorn, VIC, Australia*
[c]*National Institute of Circus Arts, Prahran, VIC, Australia*
[d]*Melbourne Shoulder Group, Prahran, VIC, Australia*

**Background:** The Watson Instability Program (WIP1) is current best evidence for conservative management of atraumatic shoulder instability, but it is unknown if this program can be effectively delivered via tele-consultation. The purpose of this longitudinal pre-post intervention study was to determine the effects of the WIP1 on patient-reported outcome measures, scapular position, shoulder strength, and handstand stability in student circus performers with atraumatic shoulder instability when delivered via tele-consultation.
**Methods:** Student circus performers aged between 15 and 35 years from the National Institute of Circus Arts were recruited. A 12-week shoulder exercise program was delivered via tele-consultation during the Melbourne, Australia COVID-19 (coronavirus disease 2019) lockdown. The primary outcome measures were the Western Ontario Shoulder Instability Index score and the Melbourne Instability Shoulder Scale score. Secondary outcomes measures included the Orebro Musculoskeletal Pain Questionnaire, the Tampa Scale for Kinesiophobia, and physical assessment measures including strength via handheld dynamometry, scapular position using an inclinometer, and handstand stability via center-of-pressure fluctuation. Patient-reported outcomes were collected at baseline and 6-week, 12-week, 6-month, and 9-month time points, and physical outcomes were measured at baseline and 9-month time points. A repeated-measures mixed model (with effect sizes [ESs] and 95% confidence intervals [CIs]) was used to analyze patient-reported outcomes, handstand data, strength, and scapular measures. Significance was set at $P < .05$.
**Results:** Twenty-three student circus arts performers completed the study. Significant improvements were found in both Western Ontario Shoulder Instability Index scores (effect size [ES], 0.79 [95% CI, 0.31-1.33] at 6 weeks; ES, 1.08 [95% CI, 0.55-1.6] at 12 weeks; ES, 1.17 [95% CI, 0.62-1.78] at 6 months; and ES, 1.31 [95% CI, 0.74-1.95] at 9 months; $P < .001$) and Melbourne Instability Shoulder Scale scores (ES, 0.70 [95% CI, 0.22-1.22] at 6 weeks; ES, 0.83 [95% CI, 0.34-1.37] at 3 months; ES, 0.98 [95% CI, 0.46-1.54] at 6 months; and ES, 0.98 [95% CI, 0.43-1.50] at 9 months; $P < .001$), as well as Orebro Musculoskeletal Pain Questionnaire scores at all follow-up time points. The Tampa Scale for Kinesiophobia scores reached significance at 6 weeks and 12 weeks. Following rehabilitation, we found statistically significant increases in shoulder strength in all positions tested and increased scapular upward rotation measured at end-of-range abduction, as well as during loaded external rotation. The affected arm showed greater instability than the

Ethics approval for this study was granted by Swinburne University of Technology Human Research Ethics Committee (reference no. 20202674-4551). This study was registered with the Australian New Zealand Clinical Trials Registry (ANZCTR; registration no. 12620000335998).

*Reprint requests: Charlotte L. Ganderton, PhD, School of Health Sciences, Swinburne University of Technology, John Street, Hawthorn, 3122 VIC, Australia.
E-mail address: cganderton@swin.edu.au (C.L. Ganderton).


https://doi.org/10.1016/j.jse.2021.10.033

unaffected arm with a significant intervention effect on the affected arm showing a greater consistent anterior-posterior movement pattern.

**Conclusion:** In a group of circus performers with atraumatic shoulder instability, treatment with the WIP1 via telehealth resulted in clinically and statistically significant improvements in shoulder symptoms and function.

**Level of evidence:** Level IV; Case Series Treatment Study



**Keywords:** Shoulder; instability; physical therapy/rehabilitation; telehealth; circus; performing arts

Injuries to the shoulder in circus arts performers are common.[44,46] They account for 27.7% of annual injuries at the University of Arts in the Netherlands[46] and 12% at the National Institute of Circus Arts (NICA) in Australia.[34] This is likely because of the high demand of shoulder stability and strength required in hanging and upper-limb weight-bearing positions. Individuals with shoulder presentations to NICA's performance medicine department include those with atraumatic instability—the presence of symptomatic excessive movement of the humeral head on the glenoid fossa in at least 1 direction (inferior, anterior, or posterior).[5] Atraumatic shoulder instability is commonly associated with poor motor control of the scapula and humeral head, as well as reduced shoulder strength and proprioception.[4,39] The recommendation for management of atraumatic or micro-traumatic nonstructural shoulder instability is rehabilitation.[52] Controlling and strengthening the scapula and associated shoulder muscles can help compensate for the lack of passive control and assist in active stability.[7,18]

The COVID-19 (coronavirus disease 2019) pandemic has resulted in significant changes for athletes and the performing arts industry, with modified or reduced training, and cessation of competitions and performances across the globe.[12] These modifications have occurred in addition to enforced government restrictions, such as city lockdowns, quarantines, and limitations in normal activities of daily living, including education and employment. This has led to negative impacts on physical health, such as immune system functioning, cardiorespiratory fitness, and muscle strength, as well as worsening body composition.[12,37] The mental health impacts have also been significant, with increasing reports of feelings of isolation and uncertainty.[12] It is recommended that managing athletes during this time should focus on resetting their mindsets, implementing health promotive behaviors, monitoring body composition, completing personalized conditioning, and focusing on personal development.[21]

As the pandemic has brought about a period of relative downtime, for injured athletes and performers, this may facilitate more comprehensive rehabilitation and improved conditioning and may optimize the return to performance. Currently, there are only 3 published programs for atraumatic instability with enough detail to replicate in the clinical setting: the Rockwood Instability Program (RIP),[9] the Watson Instability Program (WIP1),[57,58] and the Derby Shoulder Instability Rehabilitation Program.[6] There has only been 1 randomized controlled trial (RCT) comparing the WIP1 and the RIP.[50] The WIP1 focuses on re-establishing motor control of the scapula, then the humeral head, before progressing into strength and functional positions. The RIP is a general rotator cuff and deltoid strengthening program performed at lower ranges of elevation. After a 12-week program, the WIP1 was shown to have significantly greater treatment effects on patient-reported outcome measures (PROMs) and pain at 12 and 24 weeks.[50,54] The most recently published program—the Derby Shoulder Instability Rehabilitation Program—has not been compared with any other program in a clinical trial. Thus, the WIP1 currently provides the highest level of evidence for the conservative management of atraumatic instability.

The provision of health services via tele-consultation has increased exponentially in response to the pandemic.[61] However, it is unknown if the WIP1 face-to-face shoulder rehabilitation program is also efficacious when delivered via a tele-consultation platform. Therefore, the aim of this study was to determine the effects of the WIP1 on PROMs, scapular position, shoulder strength, and handstand stability in student circus performers with atraumatic shoulder instability when delivered using a tele-consultation platform.

## Materials and methods

### Design

All participants in this longitudinal pre-post intervention study were provided detailed information for the study, gave written signed consent prior to data collection, and approved the use of deidentified data in research.

### Recruitment and eligibility

Individuals with atraumatic shoulder instability aged between 15 and 35 years willing to complete a 12-week shoulder exercise program (March to June 2020), delivered via tele-consultation, were recruited from a convenience sample at NICA. Two experienced shoulder physiotherapists assessed participants for inclusion into the study. A diagnosis of atraumatic shoulder instability was made if the participant reported apprehension and/or guarding or pain in association with a loss of humeral head control via one or more of the following tests:

1. Sulcus sign for inferior instability[2,31,47]
2. Anterior apprehension[47] and anterior draw test (10°-30° and 80°-120° of abduction)[2,16] for anterior instability
3. Posterior apprehension[31] and posterior draw test[2,16] (10°-30° and 80°-120° of abduction) for posterior instability

The presence of pain or apprehension and/or guarding was used as the criterion for a positive test result because unlike patients with traumatic structural instability, patients with atraumatic translational instability are more likely to report feelings of pain and not necessarily apprehension.[1,3,32] In addition, a participant's shoulder must have been amenable to manual correction of the scapula or humeral head to be included in the study. Manual correction involves the therapist choosing an objective test, noting the patient's faulty scapular and humeral head biomechanics during the test, and then providing manual assistance to the scapula, humeral head, or a combination of both to correct the faulty mechanics, after which the test is reassessed.[58] Active flexion and abduction range of motion was used to test the effect of scapular correction. A patient needed to have a reduction in pain or apprehension and/or guarding, an increase in active range of motion (minimum of 20°), or an increase in strength on an isometric test for the shoulder to be considered amenable to manual correction.[50] An improvement with manual correction indicates that the participant has a component of motor control dysfunction that is appropriate to treat with rehabilitation.[57,58] This set of diagnostic criteria has been used in a previous RCT, and its components have shown acceptable reliability and validity.[50,51] Tests of instability and correction techniques were performed prior to commencement of the COVID-19 lockdown by an independent assessor not involved with delivering the intervention.

Participants were excluded if they had a history of shoulder surgery on the affected shoulder; significant shoulder trauma (eg, a fall or collision leading to glenohumeral dislocation requiring relocation); non-correctable volitional instability; extreme anxiety; neurologic motor deficit (eg, upper motor neuron or lower motor neuron lesion); connective tissue disorder (eg, Ehlers-Danlos syndrome or Marfan syndrome); or shoulder pain from a cervical origin (eg, cervical radiculopathy or thoracic outlet syndrome).

## Context

The study intervention was completed over a 12-week period, during a COVID-19 pandemic lockdown period—a time when citizens in Melbourne, Australia, were only able to leave home for essential activities (eg, medical appointments or grocery shopping) or exercise (limited to a 5-km radius, 1 hour per day). During this time, physical access to the NICA training facilities was forbidden and all education was delivered online.

## Outcome measures

PROMs were collected via an online questionnaire platform at baseline and 6-week, 12-week, 6-month, and 9-month time points. The primary outcome measures included the Western Ontario Shoulder Instability Index (WOSI) score[25] and the Melbourne Instability Shoulder Scale (MISS) score,[56] which are valid and reliable for measuring change in shoulder instability populations.[40] Minimal clinically important differences of 10% for the WOSI score[23] and 5 points for the MISS score[56] were used to determine clinical significance. Secondary outcome PROMs included the Orebro Musculoskeletal Pain Questionnaire,[29] a measure of psychosocial risk factors[28] shown to be valid and reliable for predicting recovery,[30,60] and the Tampa Scale for Kinesiophobia, a reliable measure of pain-related fear.[33] For the Orebro Musculoskeletal Pain Questionnaire, a score $> 50$ points indicates a higher estimated risk of future work disability.[29] For the Tampa Scale for Kinesiophobia, a score $< 37$ points indicates a low level of pain-related fear.[49] The included shoulder of each participant was physically assessed at baseline and 9-month follow-up.

Secondary physical outcome measures included assessment of strength via a dynamometer (Commander Echo Muscle Tester; JTECH Medical, Midvale, UT, USA),[15,51] a valid and reliable tool for measuring shoulder strength,[19] and assessment of scapular position via an inclinometer, a valid and reliable tool for measuring scapular upward rotation.[55] These physical outcome measures were completed by the same 2 assessors who assessed participants for study eligibility. Handstand stability (Fig. 1), a key skill in performing arts and gymnastic performance, was investigated by exploring center-of-pressure (COP) fluctuation using 2 Kistler force plates (600 × 400 mm, type 9281E; Kistler Group, Winterthur, Switzerland) sampled at a rate of 1000 Hz.[36] The force plates were embedded in the floor and positioned 10 mm apart. Handstand stability was assessed by a biomechanist and researcher (O.T.) who was not involved in intervention delivery.

At the conclusion of the study (9-month time point), participants were asked to rate the perceived change in their shoulder injury using an 11-point global rating-of-change score,[22] ranging from "very much worse" (–5) to "completely recovered" (+5), via the following question: "With respect to your shoulder injury, how would you describe yourself now compared with prior to completing the shoulder study?"

## Intervention

Participants progressed through the previously published WIP1[57,58] via tele-consultation with 1 of 4 trained physiotherapists once weekly for 12 weeks. Each physiotherapist had a special interest in the shoulder, had >5 years of experience rehabilitating sporting injuries, and participated in a 2-hour training evening on delivery of the protocol. Each session was 30 minutes in duration. The WIP1 has 6 stages: Stage 1 focuses on regaining scapular motor control using the position found to be most effective on testing of manual correction. Typically, this is achieved through an upward rotation and elevation drill because most individuals with atraumatic shoulder instability present with a scapula that rests in a position of downward rotation and depression and have a lack of upward rotation and elevation throughout shoulder range of motion.[53] Once scapular motor control is established, humeral head control is gained in 0°-45° of elevation. Stage 2 involves developing posterior musculature to control posterior translation of the humeral head. Stage 3 focuses on sagittal-plane (flexion) control between 0° and 45° of elevation. Stage 4 involves developing control of the scapula and humeral


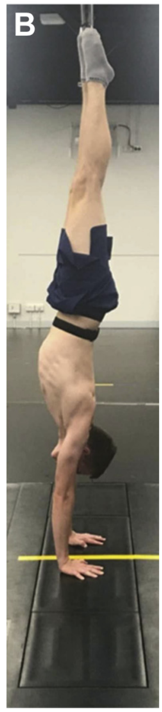

**Figure 1** Handstand stability setup on force plates: sagittal view (**A**) and coronal view (**B**).

head in 90° of elevation. Stage 5 focuses on building additional strength and hypertrophy of the anterior, middle, and posterior deltoid. Finally, stage 6 integrates program principles of gaining motor control, endurance, and then strength in end-of-range shoulder positions, followed by integration of partial practice of sport- and circus-specific skills (eg, hanging position offset by power bands in a local park) to full practice.[57,58] Specific exercises in this stage were individualized based on each participant's circus discipline and the type of equipment (eg, home gym or local park gym equipment) accessible to the participant.

Following the face-to-face baseline shoulder assessment, all participants were provided with a series of elastic exercise bands (TheraBand, Akron, OH, USA) and an exercise diary to monitor weekly exercise adherence. Following each online consultation, participants received an email with a summary of their prescribed exercises, and between appointments, they were invited to contact their physiotherapist to answer any questions. The allocated therapist for each participant remained consistent throughout the 12-week period. The study intervention was concluded at 12 weeks, no matter what stage of the program was reached. However, participants were encouraged to continue their rehabilitation exercises 3-4 times per week for long-term shoulder health. Participants were invited to contact their physiotherapist if they wished to continue treatment following study conclusion.

## Data processing

Mediolateral (ML) and anteroposterior (AP) COP data from both force plates were calculated from the 10-second handstand trials. Data were processed and calculated using MATLAB (version R2017A; The MathWorks, Natick, MA, USA), with raw COP data filtered using a zero-lag eighth-order Butterworth filter with a low-pass cutoff frequency of 12 Hz.[10] The COP is the point of pressure generated by the hand on the force plate. The point of pressure is described in the Cartesian coordinate system, as made up by the pairs of perpendicular axes, X (AP) and Y (ML). COP is measured in millimeters to allow quantification of movement during a handstand, which indicates the level of stability. Stability measures from the force-plate data included the (1) travel path of the COP (smaller values indicate greater stability), (2) average ML and AP COP travel distance (smaller values indicate greater stability),[43] (3) average ML and AP COP travel velocity (smaller values indicate greater stability),[43] (4) root-mean-square of ML and AP COP travel measures (smaller values indicate greater stability),[43] and (5) ML and AP approximate entropy to quantify the amount of regularity and the unpredictability of fluctuations. Recorded values are between 0, indicating maximum regularity, and 2, indicating maximum irregularity.

## Data analysis

A repeated-measures mixed model (with effect sizes and 95% confidence intervals) using SPSS analysis software (version 27; IBM, Armonk, NY, USA) was used to determine if the intervention had a significant effect on PROMs, strength, and scapular measures and to account for the withdrawal of 1 participant. The Hedges *g* statistic was used to report the size of the effect, where 0.2 to <0.5 was considered a small effect; 0.5 to <0.8, a medium effect; and ≥0.8, a large effect.[11] Suitable transformations were applied for some of these measures to make the model assumption of normality more appropriate and reduce the number of outliers. Separate analyses for handstand stability were conducted for both arms together and then for the affected arm on its own. These multilevel analyses were conducted in HLM7.03 (Scientific Software Int., USA) to allow for tests of moderation regarding age and height.[8] The initial analysis involved both arms tested for significant intervention effects, as well as an affected-arm effect, whereas the analysis for the affected arm was tested only for an intervention effect. For most measures, a square root transformation was applied to make the model assumption of normality more appropriate. The global rating-of-change score was reported with descriptive statistics. An $\alpha$ level of .05 was used to determine statistical significance.

## Results

Thirty-three student performers from NICA reported shoulder symptoms (pain and/or dysfunction) and volunteered to participate in the study. Following telephone screening, 9 were excluded (6 reported a history of traumatic dislocation and 3 had incorrect diagnoses), leaving a total of 24 performers to be physically assessed. All 24 performers (16 female and 8 male performers) were found to have a diagnosis of atraumatic shoulder instability and were included in the study. Baseline demographic characteristics are detailed in Table I. One participant was unable to be contacted following collection of baseline demographic characteristics and strength measures, leaving 23 remaining participants in the study. Only 16 participants were able to complete a handstand for the 10-second duration required to undertake the stability analysis.

**Table I** Baseline demographic characteristics

| Characteristic | Data |
|---|---|
| Total cohort, n | 24 |
| Age, mean (SD), yr | 23.82 (2.88) |
| Height, mean (SD), cm | 166.61 (7.74) |
| Weight, mean (SD), kg | 64.09 (10.26) |
| Positive Beighton score, n (%)* | 14 (58) |
| Experience level, n | |
| Certificate IV (diploma) | 7 |
| First year | 6 |
| Second year | 7 |
| Third year | 4 |
| Dominant arm affected, n | 14 |
| Direction of instability, n (%) | |
| Multidirectional | 13 (54) |
| Posterior | 8 (33) |
| Anterior and posterior | 3 (12.5) |

*SD*, standard deviation.
* A Beighton score $\geq$ 4 points (of 9 points) indicates generalized ligamentous laxity.

### Outcome measures

The results of PROMs are detailed in Table II. There was a significant and clinically important improvement in both the WOSI and MISS total scores at all follow-up time points, except for the WOSI physical subsection. For the Orebro Musculoskeletal Pain Questionnaire, a significant improvement was found at all follow-up time points[29] as scores were below the threshold score (>50) that indicates a higher estimated risk of future work disability. The Tampa Scale for Kinesiophobia showed a low score for pain-related fear (<37)[49] at all follow-up time points, but statistical significance was only reached at the 6-week and 12-week time points. Handheld dynamometry shoulder strength measures significantly improved across all positions tested; however, only scapular upward rotation at end-of-range abduction was significantly increased compared with baseline (Table III).

### Handstand stability

Significant differences in stability were evident only in the AP direction. The multilevel analysis of the handstand data for both arms showed only 1 significant intervention effect of increased movement regularity using the approximate entropy measure in the AP direction. Between the unaffected and affected arms, there was a significant effect for path of the center of pressure trajectory - less overall movement and less AP variability (ie, improved control) in the unaffected arm compared with the affected arm (Supplementary Table S1). Age moderated the effect of the intervention on the affected arm in the case of path (pre-post change, –0.937 + 0.465; $P$ = .027) and average velocity in the AP direction (pre-post change, –0.236 + 0.141, $P$ = .029). For both variables, the effect of the intervention was less beneficial with increasing age (Supplementary Table S2).

### Global rating-of-change score

Nineteen of the 24 participants reported an improvement in their overall shoulder function following study completion. Four participants reported feeling ‘‘unchanged’’ (0 points). No participants reported worsening of their pre-intervention shoulder condition (Supplementary Fig S1).

## Discussion

Implementation of a shoulder rehabilitation program delivered by tele-consultation resulted in a statistically significant improvement in total scores and the scores of all individual subsections (eg, pain, lifestyle, and sport) of shoulder instability–specific PROMs (MISS and WOSI), at all time points, except for the WOSI physical item. The results were statistically and clinically significant (meaningful) as the average group improvements exceeded the minimal clinically important difference for both the MISS

**Table II** Patient-reported outcome measures

| PROM | *F* test | | Time point | | | | |
|---|---|---|---|---|---|---|---|
| | $F_{(4,83)}$ | *P* value | Baseline | 6 wk | 12 wk | 6 mo | 9 mo |
| Primary | | | | | | | |
| WOSI total (score from 0% to 100%, in which 100% indicates normal shoulder function) | | | | | | | |
| Mean (SD) | 9.61 | <.001 | 69.20 (13.90) | 79.65[*] (11.32) | 84.55[*] (13.59) | 84.07[*] (10.45) | 85.77[*] (10.28) |
| ES (95% CI) | | | | 0.79 (0.31 to 1.33) | 1.08 (0.55 to 1.6) | 1.17 (0.62 to 1.78) | 1.31 (0.74 to 1.95) |
| WOSI physical (score from 0 to 100 points, in which a lower score indicates a lower level of shoulder-related physical disability) | | | | | | | |
| Mean (SD) | 3.72 | .008 | 22.20 (15.08) | 32.31[†] (15.58) | 24.25 (16.57) | 25.11 (14.99) | 22.20 (15.08) |
| ES (95% CI) | | | | 0.64 (0.17 to 1.14) | 0.12 (−0.32 to 0.58) | 0.19 (−0.26 to 0.64) | 0.00 (−0.45 to 0.45) |
| WOSI sport (score from 0 to 40 points, in which a lower score indicates a lower level of shoulder-related sporting disability) | | | | | | | |
| Mean (SD) | 7.68 | <.001 | 14.16 (7.21) | 9.20[*] (5.82) | 7.24[*] (6.43) | 7.44[*] (5.07) | 6.77[*] (5.89) |
| ES (95% CI) | | | | −0.73 (−1.25 to −0.25) | −0.98 (−1.54 to −0.47) | −1.04 (−1.65 to −0.51) | −1.08 (−1.67 to −0.56) |
| WOSI work (score from 0 to 40 points, in which a lower score indicates a lower level of shoulder-related work disability) | | | | | | | |
| Mean (SD) | 5.45 | .001 | 8.30 (7.04) | 5.76[‡] (5.23) | 3.67[*] (5.29) | 4.30[†] (4.34) | 3.22[†] (2.89) |
| ES (95% CI) | | | | −0.40 (−0.87 to 0.06) | −0.72 (−1.24 to −0.23) | −0.66 (−1.18 to −0.17) | −0.91 (−1.50 to −0.37) |
| WOSI lifestyle (score from 0 to 40 points, in which a lower score indicates a lower level of shoulder-related lifestyle disability) | | | | | | | |
| Mean (SD) | 3.06 | .021 | 6.38 (5.49) | 4.43 (3.79) | 3.98[†] (6.39) | 3.31[†] (3.99) | 3.10[†] (2.93) |
| ES (95% CI) | | | | −0.40 (−0.88 to 0.06) | −0.39 (−0.86 to 0.07) | −0.62 (−1.13 to −0.14) | −0.72 (−1.26 to −0.22) |
| WOSI emotion (score from 0 to 30 points, in which a lower score indicates a lower level of shoulder-related emotional disability) | | | | | | | |
| Mean (SD) | 6.62 | <.001 | 11.59 (6.23) | 7.20[*] (5.38) | 5.84[*] (5.50) | 5.85[*] (4.57) | 5.70[*] (5.11) |
| ES (95% CI) | | | | −0.73 (−1.25 to −0.25) | −0.94 (−1.50 to −0.44) | −1.01 (−1.59 to −0.49) | −1.00 (−1.57 to −0.48) |
| MISS total (score from 0% to 100%, in which 100% indicates normal shoulder function) | | | | | | | |
| Mean (SD) | 6.98 | <.001 | 78.40 (11.51) | 85.67[*] (8.23) | 87.61[*] (9.89) | 88.66[*] (8.58) | 88.47[*] (9.12) |
| ES (95% CI) | | | | 0.70 (0.22 to 1.22) | 0.83 (0.34 to 1.37) | 0.98 (0.46 to 1.54) | 0.98 (0.43 to 1.50) |

FLA 5.6.0 DTD ■ YMSE5792_proof ■ 29 January 2022 ■ 12:29 am ■ ce <CE>KO</CE>

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MISS pain (score from 0 to 15 points, in which a higher score indicates a lower level of pain)[§] | | | | | | | |
| Mean (SD) | 4.19 | .004 | 11.61 (2.21) | 12.84[†] (1.60) | 13.09[†] (1.56) | 13.32[*] (1.36) | 13.03[†] (1.62) |
| ES (95% CI) | | | | 0.62 (0.14 to 1.12) | 0.75 (0.26 to 1.28) | 0.90 (0.39 to 1.46) | 0.71 (0.22 to 1.23) |
| MISS instability (score from 0 to 33 points, in which a higher score indicates fewer instability symptoms) | | | | | | | |
| Mean (SD) | 4.72 | .002 | 28.48 (4.10) | 30.09[*] (3.73) | 30.43[†] (3.27) | 31.09[†] (2.97) | 31.26[†] (4.28) |
| ES (95% CI) | | | | 0.40 (−0.06 to 0.87) | 0.51 (0.04 to 1.00) | 0.70 (0.22 to 1.23) | 0.64 (0.17 to 1.15) |
| MISS function (score from 0 to 32 points, in which a higher score indicates a higher level of general function) | | | | | | | |
| Mean (SD) | 7.29 | <.001 | 23.87 (5.91) | 27.22[*] (3.13) | 27.91[*] (3.95) | 27.91[*] (3.78) | 27.91[*] (3.79) |
| ES (95% CI) | | | | 0.68 (0.19 to 1.22) | 0.78 (0.28 to 1.31) | 0.79 (0.29 to 1.33) | 0.79 (0.29 to 1.33) |
| MISS occupational and sporting demands (score from 0 to 20 points, in which a higher score indicates a higher level of sporting and/or occupational function) | | | | | | | |
| Mean (SD) | 2.01 | .089 | 14.44 (3.30) | 15.52 (2.48) | 16.17[‡] (2.90) | 16.35[‡] (2.01) | 16.26[‡] (2.40) |
| ES (95% CI) | | | | 0.36 (−0.10 to 0.83) | 0.54 (0.07 to 1.03) | 0.67 (0.18 to 1.20) | 0.61 (0.13 to 1.12) |
| Secondary | | | | | | | |
| Orebro Musculoskeletal Pain Questionnaire (short form) (10 items scored out of 100, in which a higher score [>50] indicates a higher estimated risk of future work disability) | | | | | | | |
| Mean (SD) | 4.15 | .004 | 38.26 (9.61) | 30.78[†] (11.49) | 29.87[†] (9.87) | 30.44[†] (12.46) | 28.22[†] (11.76) |
| ES (95% CI) | | | | −0.68 (−1.20 to −0.20) | −0.83 (−1.37 to −0.34) | −0.68 (−1.19 to −0.20) | −0.90 (−1.45 to −0.40) |
| Tampa Scale for Kinesiophobia total score (17 items scored from 17 to 68, in which a high score is defined as ≥37) | | | | | | | |
| Mean (SD) | 2.51 | .048 | 33.00 (4.31) | 31.56[‡] (4.62) | 30.65[‡] (4.94) | 32.13 (4.16) | 31.56 (3.87) |
| ES (95% CI) | | | | −0.31 (−0.78 to 0.14) | −0.49 (−0.97 to −0.03) | −0.20 (−0.65 to 0.25) | −0.34 (−0.81 to 0.11) |

*PROM*, patient-reported outcome measure; *WOSI*, Western Ontario Shoulder Instability Index; *SD*, standard deviation; *ES*, Hedges *g* effect size (0.2, small; 0.5, medium; and 0.8, large); *CI*, confidence interval; *MISS*, Melbourne Instability Shoulder Scale.

[*] Significant change from baseline at $P < .001$ level.

[†] Significant change from baseline at $P < .01$ level.

[‡] Significant change from baseline at $P < .05$ level.

[§] Reversal of MISS questionnaire scoring.

**Table III** Strength and scapular measures

| | Mean (SE) | | Change score | | | ES | |
|---|---|---|---|---|---|---|---|
| | Baseline | 9 mo | Mean | SE | *P* value | *g* | 95% CI |
| Strength measures, N | | | | | | | |
| ER at 0° | 96.67 (4.54) | 123.17 (6.52) | 26.51 | 3.28 | <.001* | 4.54 | 3.23-6.15 |
| IR at 0° | 137.75 (9.45) | 173.28 (9.63) | 35.53 | 4.51 | <.001* | 3.58 | 2.54-4.90 |
| ER at 90° | 64.61 (3.65) | 106.41 (4.54) | 41.80 | 2.40 | <.001* | 9.76 | 6.86-13.18 |
| IR at 90° | 98.49 (6.98) | 136.76 (6.27) | 38.26 | 2.98 | <.001* | 5.55 | 3.97-7.50 |
| Shrug | 360.92 (24.43) | 433.01 (29.47) | 72.09 | 13.8 | <.001* | 2.56 | 1.79-3.52 |
| ER at 45° in HF | 63.19 (4.16) | 84.34 (4.19) | 21.15 | 2.13 | <.001* | 4.87 | 3.48-6.60 |
| IR at 45° in HF | 146.42 (12.52) | 172.41 (9.63) | 26.00 | 4.45 | <.001* | 2.24 | 1.55-3.09 |
| Abd at 45° | 130.22 (7.53) | 150.80 (8.26) | 20.59 | 5.15 | .001* | 2.51 | 1.75-3.45 |
| Ext at 90° | 117.13 (7.44) | 157.17 (8.05) | 40.04 | 5.48 | <.001* | 4.97 | 3.55-6.73 |
| Flex at 90° | 149.95 (9.88) | 168.40 (12.24) | 18.45 | 5.83 | .005* | 1.60 | 1.07-2.24 |
| Scapular measures, ° | | | | | | | |
| Resting position | 3.24 (1.92) | 6.33 (1.37) | 3.10 | 2.40 | .213 | 1.78 | 1.01-2.67 |
| Abd at 30° | 9.67 (1.90) | 12.00 (1.51) | 2.33 | 1.86 | .223 | 1.31 | 0.69-2.01 |
| Abd at 90° | 33.95 (1.70) | 35.86 (2.13) | 1.90 | 2.23 | .404 | 0.95 | 0.39-1.58 |
| Abd at EOR | 57.33 (1.16) | 67.76 (1.53) | 10.43 | 1.66 | <.001* | 7.39 | 5.26-10.02 |
| ER at 0° with load | 3.57 (2.02) | 9.19 (1.24) | 5.62 | 1.83 | .006* | 3.23 | 2.19-4.50 |

*SE*, standard error; *ES*, Hedges *g* effect size (0.2, small; 0.5, medium; and 0.8, large); *CI*, confidence interval; *ER*, external rotation; *IR*, internal rotation; *HF*, horizontal flexion; *Abd*, abduction; *Ext*, extension; *Flex*, flexion; *EOR*, end of range.
* Statistically significant ($P < .01$).

and the WOSI. The impact of the intervention resulted in a moderate to large treatment effect at 6 weeks and a large treatment effect at 12 weeks, 6 months, and 9 months for both primary outcome measures.[11] A significant improvement was also seen in the Orebro Musculoskeletal Pain Questionnaire at all time points and in the Tampa Scale for Kinesiophobia at the 6-week and 12-week time points. Given the presence of higher levels of mental health problems in the circus population compared with normative scores,[48] as well as the potential physical and mental burden of a complete city-lockdown environment (eg, limitations on travel, occupation, and social interaction), the results of this telehealth intervention were positive.

The results for the WOSI physical subscale item were surprising, given that the scores of all other subscales (lifestyle, emotion, and sport) improved, as did all subscale scores for the MISS questionnaire. The instability section of the MISS (section B), which corresponds to the physical subscale of the WOSI, showed significant improvements after the intervention ($P < .01$). One explanation for this finding is that the individual items of this subscale differ between the questionnaires. The WOSI physical item questions focus on overhead activity, lack of strength, lack of stamina, and compensation of other muscles (eg, ‘‘How much pain do you experience in your shoulder with overhead activities?’’ and ‘‘How much fatigue or lack of stamina do you experience in your shoulder?’’), whereas the MISS instability subsection asks questions relating to frank instability (eg, ‘‘How often do you feel your shoulder slips or becomes unstable?’’). Although improvements in frank instability may have been easy for patients to perceive on the MISS, the individual items of the WOSI physical subscale may have been difficult for participants to self-evaluate. This may be because of an inability of participants to physically stress their shoulders in the context of their normal circus training regimen. COVID-19 lockdown restrictions meant that participants were largely confined to their homes, with no access to an apparatus that would have tested their high-level functional strength and stamina, such as hanging from a trapeze or corde lisse. Changes in the Tampa Scale of Kinesiophobia at 9-month follow-up were not identified and may reflect the inability of student circus performers to fully assess questionnaire domains (eg, shoulder apprehensive positions when performing specialized circus-specific skills).

Despite patients’ perceived lack of improvement on the physical subscale of the WOSI, physical assessment showed that performers achieved significant improvements in shoulder muscle strength in all positions tested. Scapular dyskinesis is a typical feature of atraumatic shoulder instability, particularly the lack of upward rotation at rest and throughout range of motion.[24,59] The scapular upward rotation range was improved with an upward rotation–elevation motor control drill[57,58] with the arm in 30° of shoulder abduction. In previous publications, this specific drill has been shown to significantly increase the activity of the upward rotators of the scapula on electromyography[38] and improve scapular upward rotation angles (through varying degrees of glenohumeral joint elevation) in a pre-post intervention study.[54] Adequate scapular upward rotation effectively orients the glenoid fossa under the humeral head, enhancing bony congruency as well as providing a base for optimal rotator cuff function.[24] Before the intervention, all of our participants had poor scapular upward rotation and more than half (54%) had generalized ligamentous laxity measured via the Beighton score.[45] Authors have speculated that hypermobility could increase the risk of shoulder injury through decreased stimulation of proprioceptive afferents in the shoulder.[4] Therefore, the need for this active scapular stability may be increased in the case of our circus cohort. Furthermore, improving scapular upward rotation not only assists in improving glenohumeral joint stability but reduces the risk of further shoulder injury.[17] Given the significantly large demands on circus performers' shoulders, improving scapular upward rotation is paramount for reducing their risk of shoulder injury and enhancing sporting participation.

Optimizing strength throughout a large shoulder range of motion is required to execute circus skills. The progression of the WIP1 from motor control to endurance to strength-based exercises is likely to account for the improvements seen in shoulder strength measured via handheld dynamometry. Further improvements in scapular position and shoulder strength may have required access to sport-specific equipment (ie, circus apparatus) to complete ‘‘full practice’’ of circus-specific training (eg, hanging off a trapeze). Unfortunately, full practice was limited because of the COVID-19 lockdown restrictions and the associated circus school closure.

The ability to maintain body balance in an inverted position (handstand) is an essential skill in performing arts and gymnastics,[36] requiring effective use of the nervous, vestibular, and proprioceptive systems.[35,41] This study showed that the affected arm is significantly less able to maintain whole-body sway compared with the unaffected arm in the AP direction prior to shoulder rehabilitation. This finding may indicate that the affected arm relies more on the unaffected arm to stabilize body sway in a direction where the base of support is much narrower compared with the ML direction. The rehabilitation program showed a significant intervention effect on how the affected arm regulated body sway in an inverted position (handstand). Following the intervention, the participants' affected arm was able to control whole-body AP sway in more consistent movement pattern. It could be hypothesized that there was a resultant improvement in the neuromotor control system on postural sway in the AP direction. Surprisingly, as the age of the participants increased, there was less effect by the intervention on controlling body sway. It may be possible that older participants are better able to complete a handstand compared with younger performers. We explored this further among our participants by investigating the number of years of circus arts training (experience level) as a covariate but did not find any effect of expertise. However, as this is a technically challenging task and the participants had an array of circus experience, not all students had the physical capability of performing a handstand for a 10-second duration, so analysis of this task was further limited.

The results of this study are similar to those of 2 previous studies investigating the use of the WIP1 in participants with atraumatic shoulder instability.[50,54] Watson et al,[54] in a pre-post intervention study, and Warby et al,[50] in an RCT intervention study, found statistically and clinically significant improvements in the MISS, the WOSI, strength, and scapular upward rotation after face-to-face delivery of the 12-week WIP1. Despite these similarities, a direct comparison of tele-consultation vs. face-to-face delivery of the WIP1 was beyond the scope of this study. However, an across-study observation of the treatment effect size between our study and the pre-post study by Watson et al shows comparatively large treatment effects at the 12-week time point, indicating a similar therapeutic benefit. The 6- and 9-month outcomes were not measured in the study by Watson et al. A comparison of effect sizes at equivalent 6-week, 12-week, and 6-month follow-up time points with the RCT by Warby et al was inappropriate because of the inherent differences in study design.

Our study revealed that a significant clinical benefit was achieved for participants with atraumatic shoulder instability undergoing a rehabilitation program delivered via telehealth, which is of monumental importance given the context of the current pandemic. The developed world has seen a rise in the uptake of telehealth as routine practice in the context of COVID-19.[14] Evidence-based telehealth shoulder rehabilitation has the ability to transcend geography and may result in more equitable access to health care,[13] particularly for individuals located in rural and remote areas. Patient-perceived directions of shoulder instability correlate well with objective tests[26]; therefore, experienced therapists,[27,42] in most cases, are able to make an accurate diagnosis from the subjective examination. However, limitations to online assessment of the shoulder remain, including the inability to perform therapist-assisted manual correction of the scapula and humeral head, palpate the humeral head for pathologic translation, and assess shoulder strength via a handheld dynamometer. In this study, physical assessment of the shoulder was performed face-to-face at baseline and the 9-month time point, before and after the Melbourne, Australia COVID-19 lockdown, but the entire intervention was delivered online. Given the aforementioned limitations, as well as the inability to perform manual therapy, some individuals may still prefer face-to face physiotherapy consultations, despite known positive outcomes with online alternatives.

Although the condition of interest was atraumatic shoulder instability, the results of this study could be generalized to the physiotherapy-directed treatment of other musculoskeletal conditions via telehealth, given the principles of a thorough subjective examination, observation, and exercise prescription. To truly compare the efficacy of shoulder rehabilitation delivered via teleconsultation against face-to-face delivery, future studies should consider a randomized controlled study design.

## Limitations

An extension of the initial Melbourne, Australia COVID-19 lockdown, as well as a secondary COVID-19 lockdown in the latter stages of data collection, meant that physical data collection of strength, range-of-movement, and handstand-stability measures was delayed from the planned 12-week follow-up to 9-month follow-up. Consequently, we were unable to ascertain the short-term benefits of strength training immediately following WIP1 conclusion. Despite reported improvements, it is unknown whether the strength measures may have been found significant at an earlier time point.

Another limitation of the study is that it was a pre-post intervention study only, with no control group. The inclusion of a control group of circus performers with atraumatic shoulder instability receiving no treatment was not ethically appropriate or feasible at the time this study was conducted. One inherent bias of observational data is the effect of time on the treatment effect.[20] However, given that participants had symptoms for an average of 3 years 6 months (range, 4 months to 11 years) at the time of study commencement, it is unlikely that the effect of time alone would have resulted in any large and significant treatment effects. Although we acknowledge that time and reduced activity (owing to the lockdown) may have influenced participants' pain, it is unlikely that the significant improvements in instability-related symptoms and in sporting and occupation function were the result of rest alone. In addition, objective measures of scapular upward rotation and strength significantly improved after the intervention period. Thus, improvement in outcome measures is likely a result of intervention effects.

## Conclusion

In a group of circus performers with atraumatic shoulder instability, treatment with the WIP1 via telehealth resulted in clinically and statistically significant improvements in shoulder symptoms and physical function (strength and scapular position).

## Acknowledgments

We acknowledge treating physiotherapists for their contribution to the study, the National Institute of Circus Arts for providing access to its circus students and approving their participation in this study.

## Disclaimers:

Funding: Funding was provided by the Department of Nursing and Allied Health at Swinburne University of Technology in the form of a gift of $3253.35 to the research team to support delivery of the physiotherapy intervention to National Institute of Circus Arts student performers.

Conflicts of interest: Some of the authors (L.W., S.B., R.L., and S.W.) developed the intervention exercise program that was tested in this study. Any potential biases have been managed by adhering to previously published intervention protocols, as well as the study protocol, and ensuring data transparency and access among all authors. The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

## Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jse.2021.10.033.

## References

1. Ayekoloye C, Nwangwu O. Multidirectional instability of the shoulder (MDI)—focus on non-operative management. Eur J Physiother 2019; 21:197-203. https://doi.org/10.1080/21679169.2018.1514651
2. Bahk M, Keyurapan E, Tasaki A, Sauers EL, McFarland EG. Laxity testing of the shoulder: a review. Am J Sports Med 2007;35:131-44. https://doi.org/10.1177/0363546506294570
3. Bahu MJ, Trentacosta N, Vorys GC, Covey AS, Ahmad CS. Multidirectional instability: evaluation and treatment options. Clin Sports Med 2008;27:671-89. https://doi.org/10.1016/j.csm.2008.07.002
4. Barden JM, Balyk R, Raso VJ, Moreau M, Bagnall K. Atypical shoulder muscle activation in multidirectional instability. Neurophysiol Clin 2005;116:1846-57. https://doi.org/10.1016/j.clinph.2005.04.019
5. Bateman M, Jaiswal A, Tambe AA. Diagnosis and management of atraumatic shoulder instability. J Arthrosc Jt Surg 2018;5:79-85. https://doi.org/10.1016/j.jajs.2018.05.009
6. Bateman M, Osborne SE, Smith BE. Physiotherapy treatment for atraumatic recurrent shoulder instability: updated results of the Derby Shoulder Instability Rehabilitation Programme. J Arthrosc Jt Surg 2019;6:35-41. https://doi.org/10.1016/j.jajs.2019.01.002
7. Beasley L, Faryniarz DA, Hannafin JA. Multidirectional instability of the shoulder in the female athlete. Clin Sports Med 2000;19:331-49.
8. Bryk AS, Raudenbush SW. Hierarchical linear models: applications and data analysis methods. Thousand Oaks, CA: Sage; 1992.
9. Burkhead W, Rockwood C. Treatment of instability of shoulder with an exercise program. J Bone Joint Surg Br 1992;74:890-6.
10. Clark RA, Bryant AL, Pua Y, McCrory P, Bennell K, Hunt M. Validity and reliability of the Nintendo Wii Balance Board for assessment of standing balance. Gait Posture 2010;31:307-10. https://doi.org/10.1016/j.gaitpost.2009.11.012

11. Cohen J. Statistical power analysis for the behavioral sciences. Hillsdale, NJ: Lawrence Erlbaum; 1988.
12. Côrte ACR, Camargo-Junior F, Chalhub T, Moraes Filho JM, Santos R, Feitosa F, et al. COVID-19 and its effects on Olympic sport: the importance of studying social isolation and the harm it causes, in order to minimise it. Rev Bras Med Esporte 2020;26:371-7. https://doi.org/10.1590/1517-869220202605237107
13. Cottrell MA, Hill AJ, O'Leary SP, Raymer ME, Russell TG. Service provider perceptions of telerehabilitation as an additional service delivery option within an Australian neurosurgical and orthopaedic physiotherapy screening clinic: a qualitative study. Musculoskelet Sci Pract 2017;32:7-16. https://doi.org/10.1016/j.msksp.2017.07.008
14. Fisk M, Livingstone A, Pit SW. Telehealth in the context of COVID-19: changing perspectives in Australia, the United Kingdom, and the United States. J Med Internet Res 2020;22:e19264. https://doi.org/10.2196/19264
15. Ganderton C, Kerr B, King M, Lenssen R, Warby S, Munro D, et al. The intra-rater and inter-rater reliability of hand-held dynamometry for shoulder strength assessment in circus arts students. Med Probl Perform Art 2021;36:88-102. https://doi.org/10.21091/mppa.2021.2014
16. Gerber C, Ganz R. Clinical assessment of instability of the shoulder. With special reference to anterior and posterior drawer tests. J Bone Joint Surg Br 1984;66:551-6.
17. Green RA, Taylor NF, Watson L, Ardern C. Altered scapula position in elite young cricketers with shoulder problems. J Sci Med Sport 2013;16:22-7. https://doi.org/10.1016/j.jsams.2012.05.017
18. Guerrero P, Busconi B, Deangelis N, Powers G. Congenital instability of the shoulder joint: assessment and treatment options. J Orthop Sports Phys Ther 2009;39:124-34. https://doi.org/10.2519/jospt.2009.2860
19. Hayes K, Walton JR, Szomor ZL, Murrell GA. Reliability of 3 methods for assessing shoulder strength. J Shoulder Elbow Surg 2002;11:33-9. https://doi.org/10.1067/mse.2002.119852
20. Higgins JP, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al. Cochrane handbook for systematic reviews of interventions. Chichester, UK: John Wiley & Sons; 2019.
21. Jukic I, Calleja-González J, Cos F, Cuzzolin F, Olmo J, Terrados N, et al. Strategies and solutions for team sports athletes in isolation due to COVID-19. Sports (Basel) 2020;8:56. https://doi.org/10.3390/sports8040056
22. Kamper SJ, Maher CG, Mackay G. Global rating of change scales: a review of strengths and weaknesses and considerations for design. J Man Manip Ther 2009;17:163-70. https://doi.org/10.1179/jmt.2009.17.3.163
23. Kemp KA, Sheps DM, Beaupre LA, Styles-Tripp F, Luciak-Corea C, Balyk R. An evaluation of the responsiveness and discriminant validity of shoulder questionnaires among patients receiving surgical correction of shoulder instability. ScientificWorldJournal 2012;2012:410125. https://doi.org/10.1100/2012/410125
24. Kibler B, Sciascia A. Disorders of the scapula and their role in shoulder injury: a clinical guide to evaluation and management. Cham, Switzerland: Springer International; 2017.
25. 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 Shoulder Instability Index (WOSI). Am J Sports Med 1998;26:764-72.
26. Kuhn JE. A new classification system for shoulder instability. Br J Sports Med 2010;44:341-6. https://doi.org/10.1136/bjsm.2009.071183
27. Kuhn JE, Helmer TT, Dunn WR, Throckmorton VT. Development and reliability testing of the frequency, etiology, direction, and severity (FEDS) system for classifying glenohumeral instability. J Shoulder Elbow Surg 2011;20:548-56. https://doi.org/10.1016/j.jse.2010.10.027
28. Linton SJ, Boersma K. Early identification of patients at risk of developing a persistent back problem: the predictive validity of the Orebro Musculoskeletal Pain Questionnaire. Clin J Pain 2003;19:80-6. https://doi.org/10.1097/00002508-200303000-00002
29. Linton SJ, Nicholas M, MacDonald S. Development of a short form of the Orebro Musculoskeletal Pain Screening Questionnaire. Spine 2011;36:1891-5. https://doi.org/10.1097/BRS.0b013e3181f8f775
30. Maher CG, Grotle M. Evaluation of the predictive validity of the Orebro Musculoskeletal Pain Screening Questionnaire. Clin J Pain 2009;25:666-70. https://doi.org/10.1097/AJP.0b013e3181a08732
31. McFarland EG. Instability and laxity. New York, NY: Thieme; 2006.
32. Merolla G, Cerciello S, Chillemi C, Paladini P, De Santis E, Porcellini G. Multidirectional instability of the shoulder: biomechanics, clinical presentation, and treatment strategies. Eur J Orthop Surg Traumatol 2015;25:975-85. https://doi.org/10.1007/s00590-015-1606-5
33. Miller RP, Kori SH, Todd DD. The Tampa scale: a measure of kinisophobia. Clin J Pain 1991;7:51.
34. Munro D. Injury patterns and rates amongst students at the National Institute of Circus Arts: an observational study. Med Probl Perform Art 2014;29:235-40. https://doi.org/10.21091/mppa.2014.4046
35. Olchowik G, Tomaszewski M, Olejarz P, Warchoł J, Różańska-Boczula M, Maciejewski R. The human balance system and gender. Acta Bioeng Biomech 2015;17:69-74. https://doi.org/10.5277/ABB-00002-2014-05
36. Omorczyk J, Bujas P, Puszczałowska-Lizis E, Biskup L. Balance in handstand and postural stability in standing position in athletes practicing gymnastics. Acta Bioeng Biomech 2018;20:139-47.
37. Pillay L, Janse van Rensburg DCC, Jansen van Rensburg A, Ramagole DA, Holtzhausen L, Dijkstra HP, et al. Nowhere to hide: the significant impact of coronavirus disease 2019 (COVID-19) measures on elite and semi-elite South African athletes. J Sci Med Sport 2020;23:670-9. https://doi.org/10.1016/j.jsams.2020.05.016
38. Pizzari T, Wickham J, Balster S, Ganderton C, Watson L. Modifying a shrug exercise can facilitate the upward rotator muscles of the scapula. Clin Biomech 2014;29:205. https://doi.org/10.1016/j.clinbiomech.2013.11.011
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:S4. https://doi.org/10.1016/j.jsams.2008.12.011
40. Plancher KD, Lipnick SL. Analysis of evidence-based medicine for shoulder instability. Arthroscopy 2009;25:897-908. https://doi.org/10.1016/j.arthro.2009.03.017
41. Puszczałowska-Lizis E, Bujas P, Omorczyk J. Postural stability in women in the eighth and ninth decades of life. Acta Bioeng Biomech 2016;18:115-21.
42. Russell T, Truter P, Blumke R, Richardson B. The diagnostic accuracy of telerehabilitation for nonarticular lower-limb musculoskeletal disorders. Telemed J E Health 2010;16:585-94. https://doi.org/10.1089/tmj.2009.0163
43. Schilling RJ, Bollt EM, Fulk GD, Skufca JD, Al-Ajlouni AF, Robinson CJ. A quiet standing index for testing the postural sway of healthy and diabetic adults across a range of ages. IEEE Trans Biomed Eng 2009;56:292-302. https://doi.org/10.1109/tbme.2008.2003270
44. Shrier I, Meeuwisse WH, Matheson GO, Wingfield K, Steele RJ, Prince F, et al. Injury patterns and injury rates in the circus arts: an analysis of 5 years of data from Cirque du Soleil. Am J Sports Med 2009;37:1143-9. https://doi.org/10.1177/0363546508331138
45. Singh H, McKay M, Baldwin J, Nicholson L, Chan C, Burns J, et al. Beighton scores and cut-offs across the lifespan: cross-sectional study of an Australian population. Rheumatology 2017;56:1857-64. https://doi.org/10.1093/rheumatology/kex043
46. Stubbe JH, Richardson A, van Rijn RM. Prospective cohort study on injuries and health problems among circus arts students. BMJ Open Sport Exerc Med 2018;4:e000327. https://doi.org/10.1136/bmjsem-2017-000327
47. Tzannes A, Paxinos A, Callanan M, Murrell GAC. An assessment of the interexaminer reliability of tests for shoulder instability. J Shoulder Elbow Surg 2004;13:18-23. https://doi.org/10.1016/j.jse.2003.09.002

48. van Rens FECA, Heritage B. Mental health of circus artists: psychological resilience, circus factors, and demographics predict depression, anxiety, stress, and flourishing. Psychol Sport Exerc 2021;53:101850. https://doi.org/10.1016/j.psychsport.2020.101850
49. Vlaeyen JWS, Kole-Snijders AMJ, Boeren RGB, van Eek H. Fear of movement/(re)injury in chronic low back pain and its relation to behavioral performance. Pain 1995;62:363-72.
50. Warby SA, Ford JJ, Hahne AJ, Watson L, Balster S, Lenssen R, et al. Comparison of 2 exercise rehabilitation programs for multidirectional instability of the glenohumeral joint: a randomized controlled trial. Am J Sports Med 2018;46:87-97. https://doi.org/10.1177/0363546517734508
51. Warby SA, Ford JJ, Hahne AJ, Watson L, Balster S, Lenssen R, et al. Effect of exercise-based management on multidirectional instability of the glenohumeral joint: a pilot randomised controlled trial protocol. BMJ Open 2016;6:e013083. https://doi.org/10.1136/bmjopen-2016-013083
52. 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; 23:128-42. https://doi.org/10.1016/j.jse.2013.08.006
53. Warby SA, Watson L, Ford JJ, Hahne AJ, Pizzari T. Multidirectional instability of the glenohumeral joint: etiology, classification, assessment, and management. J Hand Ther 2017;30:175-81. https://doi.org/10.1016/j.jht.2017.03.005
54. Watson L, Balster S, Lenssen R, Hoy G, Pizzari T. The effects of a conservative rehabilitation program for multidirectional instability of the shoulder. J Shoulder Elbow Surg 2018;27:104-11. https://doi.org/10.1016/j.jse.2017.07.002
55. Watson L, Balster SM, Finch C, Dalziel R. Measurement of scapula upward rotation: a reliable clinical procedure. Br J Sports Med 2005; 39:599-603. https://doi.org/10.1136/bjsm.2004.013243
56. 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;14:22-30. https://doi.org/10.1016/j.jse.2004.05.002
57. Watson L, Warby S, Balster S, Lenssen R, Pizzari T. The treatment of multidirectional instability of the shoulder with a rehabilitation programme: part 2. Shoulder Elbow 2017;9:46-53. https://doi.org/10.1177/1758573216652087
58. Watson L, Warby S, Balster S, Lenssen R, Pizzari T. The treatment of multidirectional instability of the shoulder with a rehabilitation program: part 1. Shoulder Elbow 2016;8:271-8. https://doi.org/10.1177/1758573216652086
59. Watson LA, Pizzari T, Balster S. Thoracic outlet syndrome part 1: clinical manifestations, differentiation and treatment pathways. Man Ther 2009;14:586-95. https://doi.org/10.1016/j.math.2009.08.007
60. Westman A, Linton SJ, Ohrvik J, Wahlén P, Leppert J. Do psychosocial factors predict disability and health at a 3-year follow-up for patients with non-acute musculoskeletal pain? A validation of the Orebro Musculoskeletal Pain Screening Questionnaire. Eur J Pain 2008;12:641-9. https://doi.org/10.1016/j.ejpain.2007.10.007
61. Wosik J, Fudim M, Cameron B, Gellad ZF, Cho A, Phinney D, et al. Telehealth transformation: COVID-19 and the rise of virtual care. J Am Med Inform Assoc 2020;27:957-62. https://doi.org/10.1093/jamia/ocaa067