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ORIGINAL RESEARCH REPORT

Evaluation of a Shoulder Injury Prevention Program in Wheelchair Basketball

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Context: Previous literature has theorized that alterations in shoulder physical characteristics are present in wheelchair athletes and contribute to shoulder pain and injury. Limited empirical evidence is present that evaluates the effectiveness of a shoulder injury prevention program focusing on improving these altered characteristics. ***Objective:*** To evaluate the effectiveness of a 6-week intervention program at improving characteristics that increases the risk of developing pain or shoulder injury. ***Design:*** Pretest and posttest. ***Setting:*** Home-based and controlled laboratory. ***Participants:*** Seven college wheelchair athletes. ***Interventions:*** Shoulder range of motion (ROM) and scapular muscle strength were assessed, and a 5-minute injury prevention program was taught to participants. Participants completed the intervention 3 times per week for 6 weeks. Following completion of the program, a postintervention screening was performed. ***Main Outcome Measures:*** Internal rotation (IR)/external rotation (ER) ROM, retraction strength, and IR/ER strength. ***Results:*** Participants experienced a significant improvement in dominant limb shoulder IR ROM ($t_6 = 3.56$, $P = .01$) with an average increase of 11.4° of IR ROM and a significant improvement in dominant limb shoulder ER ROM ($t_6 = 2.79$, $P = .03$) with an average increase of 8.0° of ER ROM. There were no significant increases in shoulder IR or ER strength and scapular retraction strength ($P > .05$). ***Conclusions:*** Improvements in ROM have previously been linked to decreases in shoulder pain and injury in other upper-extremity dominant sports by improving scapular kinematics. These results provide evidence that a 6-week strengthening and stretching intervention program may decrease risk factors for shoulder injury in wheelchair basketball athletes.

Keywords: sport, disability, intervention

The shoulder girdle is a complex system that has become a specialty in clinical sports medicine.[1] Athletes who play overhead sports have been described as having an increased risk for developing shoulder problems, such as pain and strength loss.[1–8] Shoulder impingement and rotator cuff tears are common conditions in overhead athletes.[9–12] Shoulder injuries in overhead athletes are frequently attributed to adaptations in physical characteristics, such as range of motion (ROM) and strength imbalances that develop secondary to the repetitive motions of the sport. These adaptations may lead to biomechanical and neuromuscular abnormalities, such as impingement, that affect the motion of the scapula.[13,14] Adaptations and imbalances in the strength of glenohumeral joint muscles can lead to altered scapular kinematic patterns, such as an anteriorly tilted shoulder that lead to injury.[13–18] Pectoralis minor tightness, as measured by a shortened pectoralis minor, and posterior shoulder tightness, as measured by restricted ROM, have previously been associated with altered scapular kinematics that are associated with injury.[14,19]

Wheelchair athletes use their arms overhead frequently when playing wheelchair sports, such as wheelchair basketball. The scientific literature has provided evidence that repetitive motion, over the head reaching from a wheelchair position, poor shoulder mechanics, and overuse are responsible for shoulder problems in wheelchair users.[20–23] Wheelchair users participating in overhead sport activities are twice as likely to develop rotator cuff tears than their nonsports counterpart.[24] In addition to the risk of shoulder injury due to repetitive motions in sport, wheelchair basketball athletes are at an even greater risk of injury due to the demand on the shoulder while propelling the wheelchair on the court and during daily living. In a study of manual wheelchair users, an external rotation (ER) of the glenohumeral joint, as well as an anterior tilt and internal rotation (IR) of the scapula occurred during wheelchair propulsion, increasing risk for impingement.[22] As discussed previously, studies have identified specific variables that may result in altered kinematics that lead to impingement, which can provide valuable information to create an effective intervention program that addresses muscle imbalances and tightness to indirectly improve scapular kinematics, leading to a decrease in pain and injury.

Previous literature has theorized that alterations in shoulder physical characteristics are present in wheelchair athletes, and these alterations may contribute to the high incidence of shoulder pain and injury in these athletes.[23,24] To date, there is limited empirical evidence that describes these characteristics in wheelchair athletes, as well as identifying an evidence-based effective injury prevention program that focuses on improving these characteristics in order to decrease the risk of injury. Therefore, the purpose of this study was to (1) describe the shoulder physical characteristics observed in wheelchair athletics and (2) evaluate the effectiveness of a 6-week intervention program at improving characteristics that increase the risk of the development of shoulder injury.

Methods

Design

A pre/postintervention design was used. The main outcome variables were IR/ER ROM, retraction strength, and IR/ER strength.

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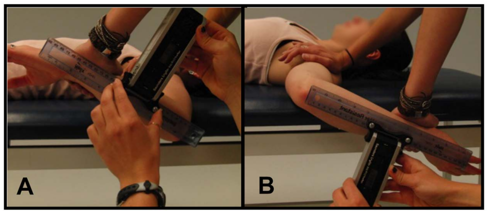

Figure 1 — Rotational range of motion assessments.

Other variables included demographic information—such as age, race/ethnicity, and sex—and a history of shoulder injuries.

Participants

The researchers recruited individuals from an adapted athletics program at a university for this study. Inclusion criteria for this study included (1) having physical disability, such as spinal cord injury, spina bifida, or amputation; (2) actively involved in wheelchair basketball; and (3) between the ages of 18 and 25 years. Exclusion criteria included current shoulder pain or injury or noncompliant with the shoulder injury prevention program, defined as missing 3 or more sessions in a row or missing a total of 6 or more sessions.

Procedures

All participants read and signed the informed consent form approved by the University of Alabama Institutional Review Board. Individuals consenting to participate in the study attended a preassessment, were taught a brief shoulder injury prevention program that they completed over a 6-week period, and returned for a follow-up assessment. The physical characteristic assessment was conducted in an athletic training research laboratory and took approximately 10 minutes to complete. The assessment included humeral ER/ER ROM, strength, and an injury history and participation questionnaire. Shoulder ROM was assessed using a digital inclinometer, and shoulder and scapular muscle strength were assessed using a handheld dynamometer. The questionnaire included questions about the type and level of disability, sports played, years of experience, and shoulder injury history.

Humeral IR ROM and ER ROM were measured passively bilaterally with a digital inclinometer (baseline) based on the recommendations of Norkin and White.[25] Use of a digital inclinometer has been identified as a valid assessment of joint angles.[25] Participants were supine on a portable treatment table with 90° of shoulder abduction and elbow flexion and forearm pronation. Scapular stabilization was provided by the examiner through a posteriorly directed force at the coracoid to isolate motion at the glenohumeral joint. The examiner passively rotated the limb to end range in IR (Figure 1A) and ER (Figure 1B) while a second investigator aligned the digital inclinometer with the forearm and recorded the humeral rotation angles. Each motion was measured 3 times by the dominant and nondominant limbs. The research team has established strong intersession reliability and precision for measuring IR ROM (intraclass correlation coefficient [ICC] = .976, SEM = 1.36°) and ER ROM (ICC = .988, SEM = 1.2°). The same investigator measured stabilized and the same investigator measured for all ROM trials in the project.

Humeral IR and ER and scapular retraction were measured bilaterally with a Lafayette handheld dynamometer.[26] Evaluation of isometric strength using a handheld dynamometer has been found to be a reliable and valid assessment of muscle strength. This assessment has been a preferred measure of many clinicians and researchers because of the portability of the equipment.[27] For the IR and ER strength assessment, participants were prone on a portable treatment table with 90° of shoulder abduction and elbow flexion and forearm pronation. The examiner stabilized the humerus and then applied an ER force on the distal forearm with the handheld dynamometer while the participant actively internally rotated to assess IR strength (Figure 2A) and applied an IR force on the distal forearm with the handheld dynamometer while the participant actively externally rotated to assess ER strength (Figure 2B). The IR strength assessment primarily evaluated strength of the subscapularis. The ER strength assessment primarily evaluated strength of the infraspinatus and teres minor. Scapular retraction was assessed with the participant prone with 90° of shoulder abduction and 90° of shoulder ER. The examiner placed a stabilizing hand on the opposite scapula to prevent trunk rotation or elevation during the test, while downward force was applied to the humerus to create scapular protraction when the participant actively retracted the scapular to assess retraction strength (Figure 2C). The investigator visually observed that scapular retraction was occurring prior to the assessment. The scapular retraction strength assessment primarily evaluated strength of the middle trapezius. Each motion was measured 3 times on the dominant and nondominant limbs. The research team has established strong intersession reliability and precision for measuring IR strength (ICC = .99, SEM = 0.52), ER strength (ICC = .987, SEM = 0.66), and retraction strength (ICC = .99, SEM = 0.49). The same investigator completed all strength assessments during the project.

Following the preintervention screening, a 5-minute injury prevention program was taught to participants that included strengthening exercises with therapeutic bands and shoulder stretches. The strengthening exercises included scapular retraction,

Figure 2 — Rotational strength assessments.

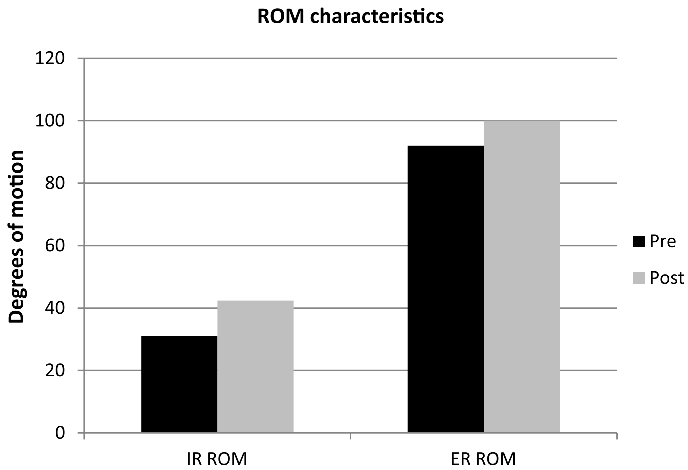

Figure 3 — ROM characteristics for sample of wheelchair athletes (n = 7). ER indicates external rotation; IR, internal rotation; ROM, range of motion.

ER, and shoulder flexion for the lower trapezius with bands, and the stretching exercise was a partner IR stretch. Participants were given at least 2 bands with different levels of resistance based on their current ability to perform the exercises. The participants were asked to complete 3 sets of each exercise for 10 repetitions each for the first week, 15 repetitions for the second week, and 20 repetitions for the third week. It was requested that they then change to the more difficult band they received and to repeat the repetitions scheme for the final 3 weeks of the intervention program. Three repetitions of 20 seconds were performed for the stretching exercise. An activity log was provided to the participants that included the repetition scheme and requested participant information on date and time of exercise completion and the therapeutic band color that was used. An additional sheet was given that included images and descriptions of each exercise to have as a reference. Participants completed the intervention 3 times per week for 6 weeks. This program has previously been found to yield improvements in overhead athletes and those with poor posture/scapular control when done 3 times per week for 6 weeks.[28] Following completion of the program, a postintervention screening was performed, which included the same assessments in the preintervention screening for comparison.

Statistical Analysis

Statistical analyses provided an investigation of the research questions with a priori significance set at $P < .05$. The Statistical Package for the Social Sciences (SPSS, Armonk, NY) version 22.0 (2015) generated descriptive, correlations, and factor analysis. Descriptive information was generated for demographic information, such as age, sex, and disability. Data analysis of physical shoulder characteristics involved paired *t* tests for predata and postdata collected, including IR/ER ROM and strength and retraction strength.

Results

A total of 9 participants were prescreened. Two participants were excluded from the final analysis due to noncompliance. The final sample consisted of 7 college wheelchair basketball athletes (n = 7), who were currently not experiencing shoulder pain and who completed the preintervention and postintervention screening. There were 5 males and 2 females in the intervention. Age of participants ranged from 19 to 25 with a mean of 21.86 years. Disabilities among participants included paraplegia from spinal cord injury (4), spina bifida (1), and cerebral palsy (1), and single-leg amputation (1). The mean classification of participants was a 2.5 (1.5). Participants had been competing on wheelchair basketball teams for 5.8 (2.4) years. Three participants also competed in track and 2 participants competed in swimming.

Table 1 Descriptive Statistics for Independent Variables

	Pre	Post
IR ROM, deg	31.00 (3.76)	42.43 (7.02)
ER ROM, deg	92.02 (11.59)	100.00 (10.20)
IR strength, lbs	27.08 (11.07)	46.05 (39.68)
ER strength, lbs	24.29 (10.24)	22.92 (8.61)
Retraction strength, lbs	18.40 (7.14)	17.80 (7.14)

Abbreviations: ER, external rotation; IR, internal rotation; ROM, range of motion. Note: Data are presented as mean (SD).

Descriptive statistics for all independent variables are reported in Table 1. As depicted in Figure 3, participants experienced a significant improvement in dominant limb shoulder IR ROM ($t_6 = 3.56$, $P = .01$) with an average increase of 11.4° of IR ROM. Participants also experienced a significant improvement in dominant limb shoulder ER ROM ($t_6 = 2.79$, $P = .03$) with an average increase of 8.0° of ER ROM. There were no significant ($P > .05$) increases in shoulder IR or ER strength and scapular retraction strength (see Figure 4).

Discussion

The wheelchair basketball athletes in this study presented with similar patterns of alterations in glenohumeral rotational ROM and muscle strength as traditional overhead athletes. The wheelchair basketball athletes presented with limited rotational ROM and weakness in scapular stabilizing muscles. Because of previous literature identifying these as risk factors for the development of overuse shoulder injury, these characteristics are important to address. The goal of the 6-week shoulder program was to improve shoulder ROM and strengthen these muscles. Following a 6-week intervention program, there was significant improvement in IR and ER ROM in wheelchair athletics. There were no significant changes in glenohumeral or scapular muscle strength during 6-week intervention program.

Participants in this study had significant improvement in glenohumeral IR and ER ROM. The increases of 11° in IR ROM and 8° in ER ROM are also considered clinically significant improvements in ROM as they are increases of greater than 5°.[29] The stretch included in this program primarily focused on stretching the pectoralis major and the external rotators which is most likely responsible for the increase in ER ROM. In addition, the IR and ER strengthening exercises that were included also provided a dynamic stretch to both the internal and external rotators, as they were completed to end ROM. The combination of the included stretches and strengthening exercises resulted in an improvement in glenohumeral rotational ROM in the wheelchair basketball athletes included in our study. The intervention program utilized in this

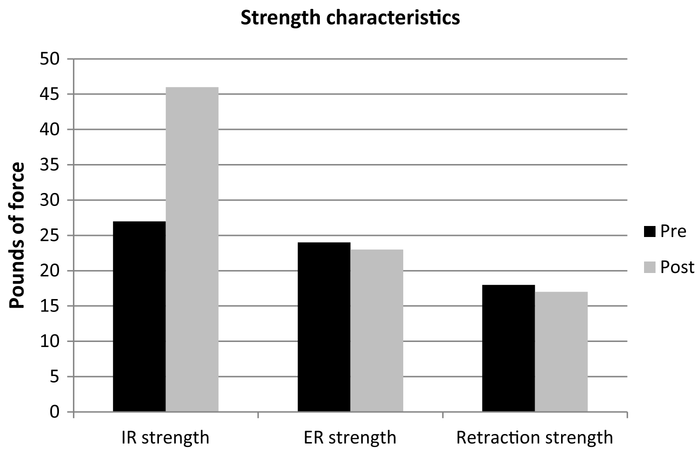

Figure 4 — Strength characteristics for sample of wheelchair athletes (n = 7). ER indicates external rotation; IR, internal rotation.

study was previously used to evaluate improvements in posture in college swimmers.[28] Significant improvements in posture were reported following the completion of the intervention program. The authors hypothesized that improvements in flexibility of hypertrophied anterior musculature were primarily responsible for improvements in posture. Previous work has identified improvements in glenohumeral rotational ROM due to improvements in posture.[30] In the current study, we did not evaluate posture due to limitations with assessment of posture in our population of interest; however, improvements in rounded shoulder posture may have also resulted due to the intervention program resulting in improvements in rotational ROM. These results provide evidence that a 6-week strengthening and stretching intervention program may decrease risk factors for shoulder injury in wheelchair athletics. Decreasing shoulder pain and injury in wheelchair athletes allows them to remain physically active. Physical activity is a possible predictor of decreased shoulder pain and injury among wheelchair users.[24]

There were no significant improvements in muscle strength in the wheelchair basketball athletes following 6 weeks of the tubing program. The included strengthening exercises have previously been found to be effective in activating the target muscle groups.[31,32] Previous research evaluating the effect of a 6-week tubing program on college swimmers did not result in significant improvements in muscle strength.[33] The authors of this study hypothesized that the demands of the sport and weight training that was being completed by the team resulted in the strengthening program not being robust enough to create improvements in strength. This same hypothesis also applies to the wheelchair basketball athletes included in our study. These athletes participated in weight training, team practice, and also pushed themselves around campus as part of their daily lives. The addition of the tubing program may not have provided enough resistance to result in strength improvements. Although strength improvements were not identified, the strengthening exercises provided a dynamic stretch to rotational ROM and may have contributed to improvements in ROM seen in this population.

This study could have implications for all individual wheelchair users, and future research could evaluate a shoulder injury prevention program in nonathlete population as this group also deals with shoulder issues.[34] Musculoskeletal pain is a common occurrence in everyday wheelchair use.[35,36] This is a major barrier to exercise for wheelchair users, and 50% of people with physical disabilities are not physically active.[37,38] Eliminating shoulder pain in wheelchair users would remove this barrier and possibly increase the needed physical activity among this population and improving quality of life.[39,40]

Maintaining sport participation is important as physical activity has many benefits for wheelchair users. Wheelchair users who participated in leisure-time physical activity increased lean mass and decreased fat mass, as well as improved obesity management.[40,41] In addition to reducing body fat, participating in leisure-time physical activity increases total energy expenditure.[42,43] Developing wheelchair skills such as wheeling around, transferring, and popping wheelies increases mobility, and individuals who participate in exercise programs involving strength-, mobility- and aerobic training are more efficient at completing various wheelchair skills.[44] Physical activity interventions have decreased both musculoskeletal pain and neurogenic pain in people with spinal cord injury.[45,46]

There are several limitations that must be acknowledged. The results of this study were collected from a small sample size of wheelchair athletes and may not be representative of all wheelchair athletes. The low sample size may have contributed to some of the nonsignificant results and the generalizability of the findings. Participants were recruited from a university-based adapted sports program; however, small team size and inclusion/exclusion criteria did limit the number of eligible participants. Future multisite trials with a control group are needed. There was no monitoring of the intervention to ensure intervention fidelity among participants other than the self-report log. Self-report relies on the honesty and accuracy of the participant. In evaluation, there is always a chance of measurement error. To minimize measurement error, the same researchers completed both the preassessment and postassessment with each of the participants. In addition, multiple measures were recorded for each physical shoulder assessment to improve accuracy.

Conclusions

This study identified alterations in physical characteristics in wheelchair athletes' shoulders. A 6-week shoulder injury prevention program used with overhead athletes provided some significant positive results. Future research should develop a shoulder injury prevention program aimed at correcting these alterations and testing the effectiveness through the use of a randomized control in wheelchair athletes and nonathletes.

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