Original Article

Associations between wheelchair user’s shoulder pain index and tendinitis in the long head of the biceps tendon among female wheelchair basketball players from the Japanese national team

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Introduction

Participation in wheelchair sports provides numerous health benefits. However, players participating in these sports are at...
some risk for secondary injuries. The shoulder is known to have a higher risk of injury in wheelchair athletes. Among the injuries during the Rio 2016 Summer Paralympic Games, shoulder injury was the most common. In general, sports that involve overhead throwing such as basketball and baseball exert remarkable forces to the shoulder. In particular, wheelchair basketball (WB) requires “hard” shoulder movements, including but not limited to overhead throwing and wheelchair pushing, and shoulder injury in WB players has been a global concern. Although regular medical checkups for the shoulder are desirable in order to prevent serious shoulder injury in WB players, the frequent performance of shoulder assessment by the medical staff is limited by time and cost. An easy and valid assessment tool is required to monitor the shoulder status in wheelchair athletes anytime.

The wheelchair user’s shoulder pain index (WUSPI) was developed to evaluate the intensity of shoulder pain experienced during daily activities and has been used for shoulder assessment in WB players. With respect to the validity of this scale, moderate correlations between higher WUSPI score and lower range of motion (ROM) of shoulder movements (abduction, flexion, and extension) were reported. Nevertheless, whether WUSPI reflects other physical examinations for shoulder injury is unknown. A previous study using ultrason imaging investigated the acute changes in the properties of the long head of the biceps tendon (LHBT) in a game of WB or wheelchair rugby and reported that athletes who played for more than 30 min exhibited a larger increase in tendon diameter. Considering this report, WB players with a higher WUSPI score could have LHBT tendinitis. As the association between WUSPI and assessments of LHBT tendinitis remains unclear, clarifying this association could aid in devising strategies for the prevention of shoulder injury in WB players.

The present study aimed to investigate the association of WUSPI with physical examinations for LHBT tendinitis among female WB players from the Japanese national team.

Materials and methods

Study participants

A total of 21 female WB players (mean age, 32.0 ± 7.9 years) from the Japanese national team participated in this cross-sectional study. Study examinations were conducted from November 2016 to November 2019 as part of an annual medical checkup. When players attended the medical checkup two or more times, the latest data were used for this study. This study was conducted in accordance with the principles outlined in the Declaration of Helsinki, and the Human Ethics Review Committee of Ibaraki Prefectural University of Health Sciences (approval numbers: 485 and 445) approved this study. All participants provided informed consent.

Measurement variables

The WUSPI, which consists of 15 items related to daily activities, was used for shoulder pain assessment. All WUSPI items were assessed using a visual analog scale, with a higher score indicating more severe pain. The total WUSPI score ranged from 0 to 150. For pain assessment, this study used the total score and each item score. For participants who did not perform certain functions or for part-time wheelchair users, performance-corrected WUSPI score was calculated as the total score.

LHBT tendinitis in WB players was examined using three well-known assessments—namely, tenderness in the bicipital groove point (TBGP), speed test, and Yergason test. In LHBT tendinitis assessment, direct palpation over the players’ bicipital groove point was performed to confirm a painful response. In the speed test, the players were instructed to try flexing their shoulder against resistance with their elbow extended and their forearm supinated. The Yergason test required the players to place their arm on the side with their elbow flexed at 90° and supinated against resistance. Both the speed and Yergason tests are considered positive when pain is referred to the bicipital groove. Only one player (4.8%) was positive on the Yergason test; therefore, statistical analysis for the aforementioned result was not conducted.

A previous study reported significant correlations between the WUSPI and ROMs of three shoulder movements (abduction, flexion, and extension). Hence, in the present study, the shoulder ROMs of these three shoulder movements were examined. The ROMs were assessed in the seated position using a goniometer. Normal ROMs were set at 180° for shoulder abduction and flexion and at 60° for shoulder extension based on previous studies. When the players moved a shoulder with normal ROM or over, the data were recorded as “norm” and a detailed degree was not measured. Considering the measurement method employed, shoulder ROM items were treated as categorical data (norm or limited).

Statistical analysis

As appendix information, the chi-squared test was used in this study to examine the associations among five items of physical examinations including assessments of LHBT tendinitis (positive/negative) and shoulder ROMs (limited/norm) based on the number of shoulders (n = 42), and effect size was indicated as φ. The Mann-Whitney U test was used to compare the means of each WUSPI component item and the total WUSPI score of the respective physical examinations because the WUSPI items were non-normally distributed. To confirm the effect size of differences in the U test, z was converted to r. For both φ and r, 0.10, 0.30, and 0.50 or greater indicate a small, medium, and large effect, respectively. Additionally, receiver operating characteristic (ROC) analysis was performed to estimate the optimal cut-points for the total WUSPI score of the respective physical examinations. The best cut-point for balancing sensitivity and specificity was defined using the Youden index (sensitivity + specificity − 1); when the index is maximized, the score is taken to be the optimal cut-point. Because the WUSPI does not assess pain according to whether it occurs in the right or left shoulder, the findings of physical examinations were considered positive (or limited) in the analysis for WUSPI when either the right or left shoulder had positive findings; that is, the number of players (n = 21) was used in the U test and ROC analysis. All statistical analyses were conducted using SPSS version 25.0 (IBM Corp., Armonk, NY, USA), and the level of significance was set at P < 0.05.

Results

Table 1 summarizes the characteristics of participants, including their age, disorders, ability class, and years of experience in WB. The mean age was 32.0 ± 7.9 years. Of the players, 61.9% had spinal cord injury. In physical examinations for LHBT tendinitis, the highest positive rate was observed with TBGP (38.1%), followed by the speed test (23.8%). Limited ROMs of shoulder movements in abduction, flexion, and extension were observed in 19.0%, 23.8%, and 14.3% of players, respectively.

Table 2 shows the association among physical examinations based on data on the number of shoulders. No association between positive findings of TBGP and speed test was noted. Positive findings of TBGP were moderately associated with limited ROM in abduction; however, the speed test was not associated with any ROM assessments. There were strong associations between limited ROMs in abduction, flexion, and extension.
Table 1
Characteristics of participants.

|                               | Mean (SD)/n (%) |
|-------------------------------|-----------------|
| Age (years)                   | 32.0 (7.9)      |
| Disordered conditions, n (%)  | 13 (61.9)       |
| Spinal cord injury            | 8 (38.1)        |
| Skeletal system diseases      | 2.8 (1.2)       |
| 1.0–1.5 points, n (%)         | 5 (23.8)        |
| 2.0–2.5 points, n (%)         | 7 (33.3)        |
| 3.0–3.5 points, n (%)         | 4 (19.0)        |
| 4.0–4.5 points, n (%)         | 5 (23.8)        |
| Years of experience in wheelchair basketball (years) | 11.2 (6.3) |
| Physical examinations for LHBT tendinitis | n (%) of players |
| TBGP (positive), n (%)        | 8 (38.1)        |
| Speed test (positive), n (%)  | 5 (23.8)        |
| Yergason test (positive), n (%) | 1 (4.8)    |
| Limited ROM of shoulder movements | n (%) of players |
| Abduction (limited), n (%)    | 4 (19.0)        |
| Flexion (limited), n (%)      | 5 (23.8)        |
| Extension (limited), n (%)    | 3 (14.3)        |

LHBT, long head of the biceps tendon; ROM, range of motion; SD, standard deviation; TBGP, tenderness in the bicipital groove point.

Table 2
Associations among physical examinations for LHBT tendinitis and ROMs of shoulder movements.

| n (%) for the Number of Shoulders | TBGP | Effect Size φ | Speed Test | Abduction ROM | Flexion ROM | Extension ROM |
|----------------------------------|------|---------------|------------|---------------|-------------|--------------|
|                                  | Positive | n (%)     | Positive | Limited n (%) | Limited n (%) | Limited n (%) |
| Low                             | 4 (12.1) | 0.12       | 4 (12.1) | 0.3        | 6 (18.2) | 0.15 | 3 (9.1) | 0.28 |
| High                            | 2 (22.2) | (0.443)    | 4 (44.4) | (0.029)      | 3 (33.3) | (0.326) | 3 (33.3) | (0.065) |
| Speed test                      | 7 (19.4) | 0.12       | 6 (16.7) | 0.15        | 7 (19.4) | 0.12 | 4 (11.1) | 0.22 |
| Positive                        | 2 (33.3) | (0.443)    | 2 (33.3) | (0.336)      | 2 (33.3) | (0.443) | 2 (33.3) | (0.150) |
| Abduction ROM                   | 5 (14.3) | (0.029)    | 4 (11.8) | 0.15        | 2 (5.9) | 0.78 | 0 (0.0) | 0.84 |
| Limited                         | 4 (50.0) | (0.029)    | 2 (25.0) | (0.336)      | 7 (87.5) | (<0.001) | 6 (75.0) | (<0.001) |
| Flexion ROM                     | 6 (18.2) | 0.15       | 4 (12.1) | 0.12        | 1 (3.0) | 0.78 | 1 (3.0) | 0.62 |
| Limited                         | 3 (33.3) | (0.326)    | 2 (22.2) | (0.443)      | 7 (77.8) | (<0.001) | 5 (55.6) | (<0.001) |
| Extension ROM                   | 6 (16.7) | 0.28       | 4 (11.1) | 0.22        | 2 (5.6) | 0.84 | 4 (11.1) | 0.62 |
| Limited                         | 3 (50.0) | (0.029)    | 2 (33.3) | (0.150)      | 6 (100.0) | (<0.001) | 5 (83.3) | (<0.001) |

LHBT, long head of the biceps tendon; ROM, range of motion; SD, standard deviation; TBGP, tenderness in the bicipital groove point. P values were calculated by chi-square test.

Table 3
Scores on wheelchair User’s shoulder pain index.

| Activities related to shoulder pain | Mean (SD) | n (%) of N/A | n (%) with Pain |
|------------------------------------|-----------|--------------|----------------|
| 1. Transferring from bed to wheelchair | 0.56 (1.52) | 5 (23.8) | 3/16 (18.8) |
| 2. Transferring from wheelchair to car | 0.31 (0.82) | 3 (14.3) | 4/18 (22.2) |
| 3. Transferring from wheelchair to the tub or shower | 0.64 (1.49) | 3 (14.3) | 4/18 (22.2) |
| 4. Loading your wheelchair into a car | 0.99 (1.81) | 1 (4.8) | 7/20 (35.0) |
| 5. Pushing your chair for 10 min or more | 1.16 (2.17) | 1 (4.8) | 8/20 (40.0) |
| 6. Pushing up ramps or inclines outdoors | 1.73 (2.66) | 2 (9.5) | 9/19 (47.4) |
| 7. Lifting objects down from an overhead shelf | 0.97 (1.82) | 0 (0.0) | 7/21 (33.3) |
| 8. Putting on pants | 0.11 (0.49) | 0 (0.0) | 1/21 (4.8) |
| 9. Putting on a T-shirt or pullover | 0.53 (1.20) | 0 (0.0) | 5/21 (23.8) |
| 10. Putting on a button-down shirt | 0.14 (0.51) | 0 (0.0) | 2/21 (9.5) |
| 11. Washing your back | 0.55 (1.41) | 0 (0.0) | 5/21 (23.8) |
| 12. Performing usual daily activities at work or school | 0.40 (1.22) | 0 (0.0) | 4/21 (19.0) |
| 13. Driving | 0.78 (1.52) | 1 (4.8) | 7/20 (35.0) |
| 14. Performing household chores | 0.21 (0.45) | 0 (0.0) | 5/21 (23.8) |
| 15. Sleeping | 0.46 (1.01) | 0 (0.0) | 4/21 (19.0) |

WUSPI, wheelchair user’s shoulder pain index.

a Number of players who were not applicable for a scene.

b Percentages were calculated for players applicable for a scene.

t presents the WUSPI items and scores. The mean total WUSPI score was 9.55 ± 13.35 points. The players were more likely to experience shoulder pain during activities related to wheelchair pushing (i.e., the items “Pushing your chair for 10 min or more” and “Pushing up ramps or inclines outdoors”) and object lifting (i.e., the items “Loading your wheelchair into a car” and “Lifting objects down from an overhead shelf”).

Table 4 shows a comparison of WUSPI scores according to the findings (positive/negative or limited/no limited) of physical examinations. Players with TBGP had significantly greater shoulder pain in terms of the total WUSPI score and on 12 out of 15 items. With respect to effect size, very large effect sizes were observed for the items “Loading your wheelchair into a car” (r = 0.85) and “Lifting objects down from an overhead shelf” (r = 0.86). Similarly, significant differences between positive/negative findings in the speed test were observed for the item “Pushing up ramps or inclines outdoors” and the total WUSPI score. In shoulder ROM assessments, limited ROMs in shoulder abduction and flexion were moderately associated the total WUSPI score. The limited ROMs of the three shoulder movements (abduction, flexion, and extension)
were associated with pain while driving. Furthermore, limited ROM in shoulder extension was associated with pain while performing usual daily activities at work or school.

Table 5 summarizes the ROC analysis results. The total WUSPI score had a significant area under the curve (AUC) for positive findings of TBGP (AUC = 0.98), speed test (AUC = 0.83), and limited ROM in shoulder abduction (AUC = 0.84). When optimal cut-points were set by the Youden index, total WUSPI scores of 4.1 points (sensitivity = 1.00, specificity = 0.92), 11.3 points (sensitivity = 0.80, specificity = 0.81), and 3.3 points (sensitivity = 1.00, specificity = 0.65) were recommended for screening positive findings of TBGP, speed test, and limited ROM in abduction, respectively.

Discussion

This study investigated the association of WUSPI with physical examinations for LHBT tendinitis and ROM of the shoulder movements among female WB players. Among the physical examinations, TBGP was the most strongly associated with each WUSPI component item and the total WUSPI score. This result supports the finding of a previous study that used ultrasound imaging, which reported acute damage to the LHBT after a game of WB or rugby. Positive findings of TBGP were observed in 38.1% of WB players.
which was the highest positive rate for physical examinations of the shoulder including ROM limitations. Considering that TBGP is known to be the most common isolated clinical finding in LHBT tendinitis, LHBT tendinitis could be a major reason for shoulder pain among WB players. When looking at WUSPI component items, individuals who reported pain when loading their wheelchairs into a car and lifting objects down from an overhead shelf were more likely to have positive findings in this test. Because the LHBT is associated with shoulder abduction and flexion, the predictable result was that players experienced pain during activities related to object lifting.

This study also assessed the speed and Yergason tests. Compared to TBGP, few players had positive findings in the speed test, whereas only one player had positive findings in the Yergason test. Additionally, the association between WUSPI and speed test was lower than that observed between WUSPI and TBGP. Although TBGP is an isolated clinical finding in LHBT tendinitis, pain in the speed and Yergason tests could reflect the presence of not only LHBT tendinitis but also impingement and concomitant rotator cuff lesions. In this study, no significant association between positive findings of TBGP and speed test reflected the characteristic difference in the two physical examinations. The speed test assesses pain with the arm in forward flexion against resistance, and the burden of this test relates to the movements of pushing a wheelchair and picking up the ball in WB. Therefore, despite the lower association of WUSPI with the speed test than with TBGP, the positive findings in the speed test should not be taken lightly. Actually, the present study confirmed the strong association between positive findings in the speed test and the WUSPI item “Pushing up ramps or inclines outdoors.” In this study, 23.8% of players had positive findings in the speed test, and this rate cannot be disregarded. As these players could have shoulder impingement syndrome and/or concomitant rotator cuff lesions, further medical examinations of the shoulder with magnetic resonance imaging, which can examine the shoulder status precisely and in more detail, are required.

The ROMs in shoulder abduction and flexion were moderately associated with the total WUSPI score. Furthermore, shoulder extension indicated a moderate effect size, although its association with the total WUSPI score was not significant. Similarly, Curtis et al. reported moderate correlations between these shoulder ROMs and the total WUSPI score. Because of the effect size, they surmised that the WUSPI score is determined not only by the shoulder ROMs but also by other multiple factors. The present study added the finding that WUSPI strongly reflected the presence of LHBT tendinitis, as assessed by TBGP, and also confirmed the moderate association between TBGP and limited ROM in shoulder abduction. It is known that the LHBT functions as an anterior stabilizer of the shoulder joint in abduction. The result of this study suggests that LHBT tendinitis could reduce the ROM in shoulder abduction among WB players. As shoulder abduction is necessary for WB players’ performance, preventive strategies against LHBT tendinitis and ROM limitations in shoulder abduction are important to maintain the performance and physical health of these players.

The ROC analysis showed that the total WUSPI score significantly reflected positive findings of TBGP and speed test, as well as limited ROM in abduction. While the physical examinations conducted by the medical staff are an excellent way to screen shoulder injury, the regular performance of these examinations is limited by time and cost. Because WUSPI is a brief self-report questionnaire, the significant associations with physical examinations are useful for monitoring the shoulder status of WB players. When looking at cut-points, different scores were recommended among the physical examinations. For instance, the WUSPI indicated the largest AUC for positive findings of TBGP with a recommended cut-point of 4.1 points; in comparison, the recommended cut-point for the speed test was 11.3 points. This study did not answer what was the best cut-point of WUSPI for screening shoulder complaints. However, because TBGP is a major finding of LHBT tendinitis, a score of 4.1 points can serve as the target for the prevention of severe shoulder injury. Although this cut-point seems to be slightly lower, further detailed examination is required for players with cut-point or more points, considering the possibility that these players already have LHBT tendinitis. This study did not have an adequate sample size to obtain sound results for the ROC analysis. Hence, further studies with a large sample size will be required in the future to clarify the best cut-point of WUSPI for screening shoulder complaints.

The present study yielded important findings, such as the strong association between WUSPI and TBGP, which could contribute to shoulder status monitoring in WB players. Nevertheless, this study has some limitations. First, it was a cross-sectional study, and the causal relationship is unclear. Although the ROC analysis in the present study revealed the concurrent validity of WUSPI for shoulder complaints assessed by physical examinations, the predictive validity of this scale for future incident risk of shoulder injury is unclear. Second, the shoulders were assessed only by physical examinations, which cannot establish a definite diagnosis of LHBT tendinitis and assess important causes of shoulder pain, including impingement syndrome and rotator cuff lesions. To obtain objective and detailed shoulder data, assessments based on magnetic resonance imaging are needed.

As the study data were only collected from top-level athletes, their generalizability to other players of other levels is uncertain. Considering the population size, findings from amateur players would be desirable.

In conclusion, this study investigated whether WUSPI is associated with physical examinations for LHBT tendinitis (TBGP and speed test) and ROMs of shoulder movements (abduction, flexion, and extension) among female WB players from the Japanese national team. Among physical examinations, TBGP, which is a major finding of LHBT tendinitis, was strongly associated with the total WUSPI score and each WUSPI component item. Hence, pain assessed by WUSPI could reflect the presence of LHBT tendinitis. The WUSPI is a superior tool for monitoring the shoulder status of WB players.

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Declaration of competing interest

The authors declare no conflicts of interest.

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