FINAL REPORT - abstract

Project Title	**Development of the shoulder joint screening test criteria to prevent shoulder pain in Japanese Badminton Players.**
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Purpose

This study aims to identify shoulder joint flexibility screening test criteria for preventing and coping with/without shoulder pain in badminton players.

Introduction

In badminton competition, many athletes continue to play with shoulder pain due to the high load placed on the shoulder joint by repeated stroke movements. However, there are few sports medicine studies on the actual physical condition and direct factors of shoulder pain in badminton players, and no countermeasures or preventive measurements for shoulder pain have been established.

Fahlström et al. (2006) conducted a survey of international competition-level athletes regarding shoulder pain and found that approximately 53% of them had pain that affected their daily life, and this pain was a serious problem that interfered with their play. Furthermore, in a survey of 99 recreational-level players, 52% had shoulder pain, with a decreased Constant Score that is an indicator of shoulder joint function, and a decreased abduction range of motion of the shoulder joint (Fahlström et al. 2007). The shoulder joint is the key part to transmit the energy from the lower limb to the upper limb during the stroke, and the disharmony of the motor chain caused by shoulder pain is thought to have a great influence on the performance. In addition, it is suggested that pain is one of the factors that athletes themselves must control in order to improve and maintain their performance. The author investigated the incidence of shoulder pain in approximately 1,000 Japanese junior high school, high school and college badminton players and clarified the actual condition of shoulder pain in badminton players (Warashina et al. 2015). The results showed that about half of the domestic badminton players had a history of shoulder pain, and the rate of shoulder pain differed between junior high school, high school, and college age groups. Further analysis of the data showed that having a history of pain was the single most relevant independent association item at any age (Warashina et al. 2018). This data suggests the importance of preventing the initial onset of shoulder pain in badminton players and alleviating pain in players who suffers with it.

It is thought that many badminton players continue to play with shoulder pain as a result of the high load placed on the shoulder joint by repeated stroke movements. Although many athletes suffer from shoulder pain, the factors related to pain and effective preventive measures against shoulder pain have not been yet developed. Studies of shoulder joint range of motion in non-badminton athletes have often reported a decrease in 2nd internal rotational range of motion as a change in range of motion that has also occurred in overhead sports, including baseball and tennis. It has also been reported that a decrease in total range of motion, a decrease in internal rotation, and an increase in external rotation of the dominant arm occur in overhead sports while the trend is different in baseball and tennis as the same racquet sports.

Shoulder pain is an important issue for all badminton players regardless of age or gender. However, there are few sports medicine studies on the actual condition and direct key risk factors of shoulder pain in badminton players, and no specific countermeasures or preventive measures for shoulder pain have been established. Furthermore, few have reported on changes in range of motion of the shoulder joint and muscle tightness items in badminton players. Therefore, the effect and relationship in the shoulder pain and the range of motion in the shoulder joint have not been clarified.

In this study, the development of criteria for shoulder joint flexibility items for the prevention of shoulder joint pain will be carried out by collecting data from a large number of athletes and clearly presenting the criteria by ROC analysis, and specifically presenting the possibility of preventing the occurrence of pain in the future and reducing the current pain, regardless of whether athletes currently have pain or not. Such occurrence prediction systems and reference values are often used in the field of medicine, not sport, but little analysis has been done based on such data from the sports field.

The main research question in this study is that "Where the cut-off value would be in the shoulder joint flexibility of badminton players with shoulder pain?". Establishing the shoulder joint flexibility cut-off value would be useful to detect and prevent further severe injuries for badminton players.

Methods

Subjects for this study are 20 Japanese badminton players in junior high school.

In the shoulder joint medical screening, the following three items will be investigated and measured.

1. Questionnaire: Age, Gender, Competition history, History of shoulder pain, Current shoulder pain on the dominant arm, and Interference with play

2. Shoulder joint range of motion (all bilateral) by using goniometer: Flexion, Extension, Abduction, 1st position external rotation, 90-degree abduction of the shoulder joint (2nd position) internal and external rotation, 90-degree flexion of the shoulder joint (3rd position) internal and external rotation

3. Shoulder muscle tightness (all bilateral): Combined Abduction Test (CAT), Horizontal Flexion Test (HFT)

The group with current shoulder pain was defined as the painful group, and the group without current shoulder pain was defined as the pain-free group. In addition, the group with a history of shoulder pain was defined as the pain-history group, and the group without pain was defined as the healthy group.

The total rotation angle was calculated by adding up the angles of 2nd internal rotation and external rotation, 3rd internal rotation and external rotation, and zero position internal rotation and external rotation. The left-right differences in the range of motion and tightness of each joint in each group were also calculated.

Age, athletic history, range of motion and tightness of each joint, and left-right differences of each group, which are continuous variables and interval measures, were expressed as mean ± standard deviation, and the Kolmogorov-Smirnov test was performed to check for normality.

The mean values of each item were compared between the groups using an unpaired t-test between the two groups for items for which normality was confirmed, and a Mann-Whitney U-test between the two groups for items for which normality was not observed. The effect size (Cohen's d) was calculated from the number of people, mean, and standard deviation, with Cohen's d defined as 0.20 or more as a small effect size (hereafter referred to as "small"). The effect size was defined by Cohen's definition as 0.20 or more for small effect size (hereafter Small - the difference is small but not insignificant), 0.50 or more for medium effect size (hereafter Medium - the difference is recognizable if the researcher looks at the data carefully), and 0.80 or more for large effect size (hereafter Large - there is a clear difference).).

Categorical variables and nominal scales, such as gender of each group and presence or absence of a history of pain (items for comparison between the painful and pain-free groups only), are indicated by the number of people (percentage; %). For comparison of proportions between groups, a $\chi 2$ test of independence was performed, and effect size was calculated using the Phi (φ)

coefficient. 0.1 or more was defined as Small, 0.3 or more as Medium, and 0.5 or more as Large, according to Cohen's definition.

ROC analysis was conducted to examine the cutoff values for the continuous variables and interval scales of age, athletic history, range of motion, and tightness, with the presence or absence of shoulder pain or a history of pain as the dependent variable. Age and athletic history were categorized into 1-year increments, and range of motion and tightness items were categorized into 5-degree increments, with the highest Area Under the Curve (AUC) extracted.

All statistics were performed using SPSS Statistics 25.0 (IBM), and the significance level was set at 5%.

Results

Six players (30%) had current pain. In the painful group, 6 (100%) had a history of pain, and in the pain-free group, 6 (42.9%) had a history of pain. Among the painful group, 4 (66.7%) answered that they had difficulty in playing.

Table1. Questionnaire results

		Paunful *n=6*	Pain-free *n=14*	All *n=20*	*p*	ES
Age		13.3 ± 0.5	13.4 ± 0.7	13.4 ± 0.7	*0.944*	0.03（None）
Competition history		4.3 ± 2.7	4.1 ± 2.0	4.2 ± 2.1	*0.863*	0.09（None）
Gender	男	4（66.7%）	7（50.0%）	11（55.0%）	*0.492*	0.15（Small）
	女	2（33.3%）	7（50.0%）	9（45.0%）		
History of shoulder pain	**(+)**	**6（100%）**	**6（42.9%）**	**12（60.0%）**	***0.017****	**0.54（Large）**
	(-)	**0（0%）**	**8（57.1%）**	**8（40.0%）**		
Difficulty in playing	(+)	4（66.7%）	-	-	-	-
	(-)	2（33.3%）	-	-	-	

A significant difference was observed in the difference of range of motion of 2nd internal rotation between the two groups: -13.3±17.2 degrees in the painful group and 0.7±7.6 degrees in the painless group ($p<0.05$, ES: d=1.26-Large, 1-β =66.3%). There was no significant difference in flexibility in the other items.

Table2. Shoulder joint range of motion results

		Painful *n=6*	Pain-free *n=14*	All *n=20*	*p*	ES
Flexion	R	166.7 ± 9.3	166.1 ± 8.8	166.3 ± 8.7	*0.893*	0.07 (None)
	L	168.3 ± 6.8	166.1 ± 8.6	166.8 ± 8.0	*0.576*	0.28 (Small)
	(R-L)	-1.7 ± 5.2	0.0 ± 3.4	-0.5 ± 3.9	*0.602*	0.42 (Small)
Extension	R	63.3 ± 12.1	60.4 ± 7.7	61.3 ± 9.0	*0.239*	0.33 (Small)
	L	64.2 ± 12.4	63.9 ± 6.6	64.0 ± 8.4	*0.444*	0.03 (None)
	(R-L)	-0.8 ± 3.8	-3.6 ± 4.6	-2.8 ± 4.4	*0.312*	**0.63 (Medium)**
Abduction	R	180.0 ± 0.0	179.3 ± 2.7	179.5 ± 2.2	*0.841*	0.31 (Small)
	L	180.0 ± 0.0	180.0 ± 0.0	180.0 ± 0.0	*1*	0.00 (None)
	(R-L)	0.0 ± 0.0	-0.7 ± 2.7	-0.5 ± 2.2	*0.841*	0.31 (Small)
1st position external rotation	R	70.0 ± 13.0	72.9 ± 15.0	72.0 ± 14.2	*0.691*	0.20 (Small)
	L	73.3 ± 12.5	75.0 ± 13.6	74.5 ± 13.0	*0.8*	0.13 (None)
	(R-L)	-3.3 ± 4.1	-2.1 ± 7.8	-2.5 ± 6.8	*0.547*	0.17 (None)
2nd position internal rotation	R	56.7 ± 34.6	58.9 ± 31.8	58.3 ± 31.7	*0.968*	0.07 (None)
	L	70.0 ± 34.6	58.2 ± 30.2	61.8 ± 31.1	*0.109*	0.37 (Small)
	(R-L)	**-13.3 ± 17.2**	**0.7 ± 7.6**	**-3.5 ± 12.7**	***0.041****	**1.26 (Large)**
2nd position external rotation	R	115.8 ± 14.6	116.8 ± 16.8	116.5 ± 15.8	*0.906*	0.06 (None)
	L	112.5 ± 17.0	115.7 ± 14.1	114.8 ± 14.6	*0.665*	0.21 (Small)
	(R-L)	3.3 ± 6.8	1.1 ± 5.3	1.8 ± 5.7	*0.547*	0.39 (Small)
Total range in 2nd position	R	172.5 ± 41.3	175.7 ± 34.7	174.8 ± 35.7	*0.904*	0.09 (None)
	L	182.5 ± 40.8	173.9 ± 33.4	176.5 ± 34.9	*0.397*	0.24 (Small)
	(R-L)	-10.0 ± 18.7	1.8 ± 10.3	-1.8 ± 14.0	*0.239*	**0.86 (Large)**
3rd position internal rotation	R	31.7 ± 18.1	30.0 ± 13.4	30.5 ± 14.5	*0.821*	0.11 (None)
	L	30.0 ± 11.4	30.7 ± 12.7	30.5 ± 12.0	*0.907*	0.06 (None)
	(R-L)	1.7 ± 15.7	-0.7 ± 9.0	0.0 ± 11.0	*0.67*	0.21 (Small)
3rd position external rotation	R	119.2 ± 6.6	115.7 ± 13.3	116.8 ± 11.6	*0.557*	0.29 (Small)
	L	117.5 ± 5.2	117.9 ± 14.2	117.8 ± 12.1	*0.954*	0.03 (None)
	(R-L)	1.7 ± 2.6	-2.1 ± 7.3	-1.0 ± 6.4	*0.207*	**0.6 (Medium)**
Total range in 3rd position	R	150.8 ± 15.9	145.7 ± 17.5	147.3 ± 16.8	*0.547*	0.30 (Small)
	L	147.5 ± 11.7	148.6 ± 18.0	148.3 ± 16.1	*0.896*	0.06 (None)
	(R-L)	3.3 ± 16.6	-2.9 ± 12.7	-1.0 ± 13.8	*0.373*	0.45 (Small)
Zero position internal rotation	R	36.7 ± 11.3	32.5 ± 11.2	33.8 ± 11.1	*0.457*	0.37 (Small)
	L	41.7 ± 13.7	36.8 ± 10.5	38.3 ± 11.4	*0.394*	0.43 (Small)
	(R-L)	-5.0 ± 15.5	-4.3 ± 6.8	-4.5 ± 9.7	*0.779*	0.07 (None)
Zero position external rotation	R	121.7 ± 14.4	122.9 ± 12.2	122.5 ± 12.5	*0.312*	0.09 (None)
	L	121.7 ± 10.3	123.6 ± 13.9	123.0 ± 12.7	*0.602*	0.15 (None)
	(R-L)	0.0 ± 6.3	-0.7 ± 5.5	-0.5 ± 5.6	*0.841*	0.12 (None)
Total range in Zero position	R	158.3 ± 22.7	155.4 ± 17.0	156.3 ± 18.3	*0.749*	0.16 (None)
	L	163.3 ± 16.9	160.4 ± 17.4	161.3 ± 16.8	*0.728*	0.17 (None)
	(R-L)	-5.0 ± 17.9	-5.0 ± 10.0	-5.0 ± 12.4	*0.444*	0.00 (None)

The items with an effect size of Medium (0.5 ≤) or more were: left-right difference in extension range of motion, left-right difference in 2nd total range of motion, left-right difference in 3rd external rotation range of motion, left-right difference in CAT, right-right difference in CAT, right-right difference in HFT, and left-right difference in HFT.

The ROC analysis showed that the items with significant cut-off values were right 30 degrees of 3rd internal rotation ($p<0.05$, AUC=0.83), right 145 degrees of 3rd total range of motion ($p<0.05$, AUC=0.79).

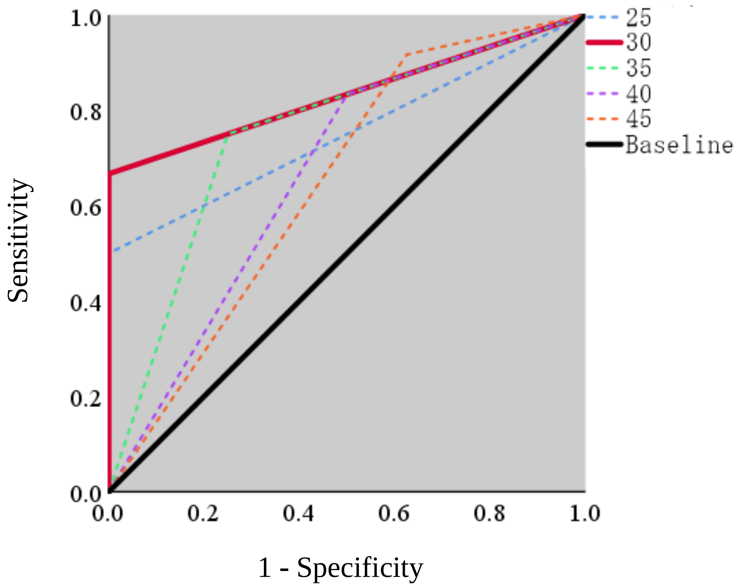

Fig.1 3rd internal rotation

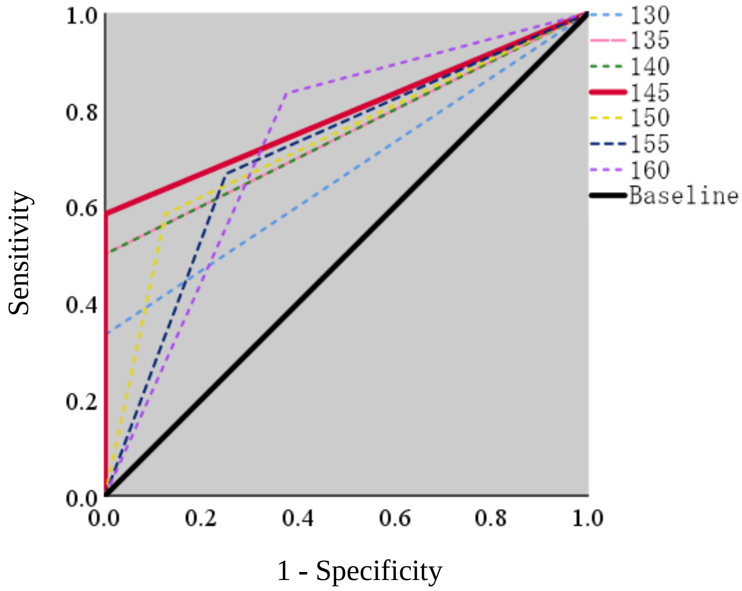

Fig.2 3rd total range of motion

Disucussion

This study once again reveals that many badminton players have a history of shoulder pain. It is assumed that there are many people with pain who have trouble playing, and it will be shown that shoulder pain is an important problem that must be prevented by badminton players when playing and continuously playing badminton.

All patients in the painful group had a history of pain, with two or more recurrent episodes of pain. A history of trauma or disability is an important internal risk factor, and it has been shown in rugby, baseball, and handball that shoulder injury occur when athletes with a history of shoulder injury continue their athletic activities. In recent years, it has also been reported that athletes with a history of pain repeatedly suffer from pain when they continue playing. The results of the present study are similar to those of previous studies in that athletes with a history of pain repeatedly experience pain as they continue their athletic activities, and pain history is considered to be the most important factor. Thus, for athletes with a history of pain, it is thought to be a disincentive to daily practice and performance improvement. On the other hand, for athletes who do not have a history of pain, the disincentive caused by pain can be minimized, and it can be inferred that the time that can be spent on improving performance in the future can be secured.

In addition, differences in range of motion and flexibility screening tests between those with current pain and those without pain are evident, and their relationship to shoulder pain can be clarified.

The left-right difference in the range of motion of 2nd internal rotation was significantly smaller in the painful group than in the pain-free group. The difference between the left and right sides of the 2nd internal rotation range of motion was significantly smaller in the painful group than in the pain-free group. Ellenbeckert et al. found that 26 elite junior tennis players (aged 11-14 years) had a significant decrease in internal rotation range of motion (approximately 10 to 15 degrees) in the glenohumeral joint on the dominant arm side. In a report by Scher et al. on 57 highly competitive professional baseball players, the range of motion of internal rotation was also significantly lower, suggesting that athletes who repeatedly use their shoulders are an important problem for athletes who continue to compete professionally. In addition, in a report on the range of motion of shoulder rotation in 46 professional baseball players and 117 junior elite tennis players, baseball players showed a significant decrease in the internal rotation range of motion on the dominant arm side and a significant increase in the external rotation range of motion, while there was no significant difference in the total rotation range of motion. On the other hand, in the same report, tennis players showed only a significant decrease in the dominant arm internal rotation range of motion and a significant decrease in the total range of motion, with no significant difference in the external rotation range of motion. The difference in the range of motion of 2nd internal rotation between the left and right sides was lower in athletes with a history of shoulder joint injury or shoulder pain, which may be a characteristic of overhead sports, especially racket sports.

The cut-off values for classifying the pain group and the pain-free group were 30 degrees of 3rd internal rotation on the dominant hand side, 145 degrees of 3rd total range of motion on the dominant hand side. Athletes who have had shoulder pain have a range of motion of 3rd internal rotation on the dominant hand below 30 degrees, and a total range of motion of 3rd below 145 degrees on the dominant hand. These AUC was very high. This suggests that players with recurrent shoulder pain may have a decreased range of motion in 3rd internal rotation. It is not clear whether this result is a change caused by pain or not, but it is thought that for players with a range of motion below the above-mentioned cut-off value, taking measures to exceed the cut-off value, such as exercises to improve the range of motion of 3rd internal rotation, may contribute to coping with and preventing repeated pain and pain occurrence. In addition, no significant difference was observed.

The difference between the left and right sides of the CAT and HFT, and the decrease in the range of motion of rotation in each position on the dominant hand side are caused by contracture of the joint capsule, muscle contracture of the rotator cuff, and imbalance between inner and outer muscle function. Harada et al. Harada et al. reported the relationship between shoulder pain and CAT, HFT, and performance scores. The CAT can easily measure the flexibility of only the glenohumeral joint in the shoulder joint, which has a high degree of freedom, and the HFT can measure the degree of contracture of the posterior shoulder joint capsule, which is thought to induce shoulder pain. These results suggest that the items of 2nd and 3rd position range of motion, CAT and HFT may be adopted as specific and useful medical screening items in badminton competitions by examining them with performance-related items in the future.

It is suggested that these items could be adopted as medical screening items specific to badminton by accumulating data by age and competition level and further examining them in the future, and that they could become important indicators for the construction of specific measures to prevent shoulder joint pain in badminton players. Specifically, it serves as a criterion for "how much shoulder joint flexibility should be ensured in warming-up and cooling-down".

This study will be a recommendation that can be given back to everyone who plays badminton. For anyone associated with any form of badminton, this could be an important finding for preventing poor performance and enjoying badminton more safely and for longer.

Conclusion

(1) Sixty percent of the participants had shoulder pain in the past, and 67% of the participants with pain had difficulty in playing.

(2) There were more players with a history of pain in the painful group than in the pain-free group, and the difference between the right and left sides of the 2nd internal rotation range of motion was lower.

(3) The range of motion of 2nd and 3rd position rotation, CAT, and HFT were associated with a history of shoulder pain, indicating the possibility of adopting these items as specific medical screening items in badminton competitions.

References

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