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Analysis of Shoulder Rotation Range of Motion and Isometric Strength in Shoulder Pain Badminton Enthusiasts

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Abstract: ***Objective**: To summarize the characteristics of shoulder injuries and shoulder pain in badminton enthusiasts and select subjects by information collection table, preliminary understanding the characteristics of shoulder injuries among badminton enthusiasts. **Methods**: Observation method, analyzing the results of information collection table, Range of motion (ROM) and muscular strength test. **Conclusions**: Shoulder joint injuries are mostly in dominant Side. Visual Analogue Scale (VAS) varies 3 to 6. The external rotation (ER) ROM on the dominant side of the shoulder joint and the ratio of ER/internal rotation (IR) ROM on the non-dominant side of the shoulder joint in women are greater than those in men, and the shoulder rotation muscle strength in men is greater than that in women. The IR ROM on the painful side of badminton enthusiasts with shoulder pain is less than that of badminton enthusiasts without shoulder pain; The ER ROM on the painful side of men is greater than that of men without shoulder pain, but there is no difference in the ER ROM on the painful side of women. Shoulder pain in men may be related to increased ER ROM accompanied by limited IR, while shoulder pain in women is related to limited IR ROM and a larger ER/IR ratio. The ER/IR muscle strength ratio of the painful side in badminton enthusiasts with shoulder pain is smaller than that in badminton enthusiasts without shoulder pain, which may be related to the smaller ER/IR muscle strength ratio.***

Keywords: Badminton enthusiasts, Rotator cuff strength, Rotator cuff ROM, Shoulder pain.

1. Introduction

As the world continues to develop and progress, the media continues to strengthen the promotion of sports, and people's health awareness is gradually improving. Therefore, on the basis of ensuring basic daily life, people are pursuing a higher quality of life. More and more people choose to exercise after work and study to relieve work pressure and strengthen their bodies. People prefer various sports with simple venues and fun. Badminton meets the needs of most people. However, due to the lack of awareness of sports injury prevention and rehabilitation in society, shoulder injuries have also become a problem for badminton enthusiasts.

There are many reasons why badminton enthusiasts suffer shoulder injuries. The anatomical structure of the shoulder joint results in a strong flexibility but lack of stability [1]. Badminton enthusiasts may suffer shoulder injuries due to inadequate warm-up exercises, unreasonable technical movements, excessive exercise intensity, and insufficient relaxation activities [2].

2. The Relationship between Badminton and Shoulder Injuries

The shoulder joint, also known as the glenohumeral joint, is a typical ball-and-socket joint. Its main structures include a thin and loose joint capsule and an articular surface composed of the humeral head and the glenoid cavity of the scapula. Auxiliary structures include the joint lip, ligaments, and synovial capsule. The ball-and-socket joint can perform extensive triaxial motion. The joint surface area difference is large, the joint fossa is shallow, and the restriction on the joint head is small. The joint capsule is thin and loose, the joint cavity is large and wide, and the reinforced ligaments are few and relatively weak. Due to the above anatomical characteristics of the shoulder joint itself, the shoulder joint has strong flexibility, but poor stability. Its stability depends to a large extent on the active contraction of the muscles around the shoulder joint, so strengthening the muscles around the shoulder is very important [1]. However, strength alone cannot reduce the risk of injury. Studies have shown [3, 4] that the balance of the IR and ER muscles of the shoulder joint is one of the important factors in preventing shoulder joint injuries.

Over-shoulder sports such as badminton, tennis, table tennis, volleyball, baseball, and swimming are characterized by athletes often moving their forearms over their shoulders during training and competition, and require high strength and coordination of the shoulder joint rotation muscles. During training and competition, athletes of such sports need to quickly and frequently complete repeated movements of an action at the shoulder joint, such as high-flying balls in badminton. Therefore, shoulder injuries have become a cause of concern for athletes and enthusiasts of such sports [5]. Although badminton is less risky than some other sports, Fahlström M et al [6] conducted a survey of 188 world-class badminton players and found that 37% of badminton players had experienced shoulder pain in their dominant arm, and 20% of badminton players were experiencing shoulder pain in their dominant arm, with no significant difference between men and women. In addition, shoulder injuries can affect athletes' training and athletic ability. For amateur badminton players, shoulder injuries are also a factor that cannot be ignored. Shoulder pain affects the lives and sports of badminton enthusiasts, so it is very important to study and solve the shoulder pain problem of badminton enthusiasts [7]. The study by Yung PS et al [8] showed that the incidence of shoulder joint injuries was high among both adult (over 21 years old) and youth (under 21 years old) elite badminton players.

There are many reasons for shoulder injuries, including the age, weight, and awareness of injury prevention of badminton enthusiasts [9-10], unreasonable technical movements, uncoordinated muscle strength, and excessive exercise intensity [11]. Miyake E et al [12] conducted a study on Japanese high school badminton players in adolescence and found that injuries caused by excessive use of the shoulder joint were three times more common than skin injuries. Therefore, ideological education for badminton enthusiasts, standardization of hitting movements, and the combination of strength and relaxation can effectively prevent and reduce the occurrence of injuries.

Studies have shown that insufficient and unbalanced shoulder rotation muscle strength is one of the causes of shoulder pain in competitive swimmers [13]. Robert C. Manske et al [13] conducted shoulder rotation muscle strength training three times a week for 12 weeks in swimmers under the age of 18 with shoulder pain. The experimental group performed extra strengthening exercises on the shoulder joint ER muscles, while the control group only performed underwater swimming training. The results showed that the experimental group was more effective in preventing shoulder injuries than the control group.

During the IR of the shoulder joint, the internal rotator muscles contract concentrically and the external rotator muscles contract eccentrically. The antagonism between the IR and external rotator muscles and the balance of strength play a very important role in maintaining the stability of the shoulder joint and completing high-quality movements [5]. Therefore, the ER muscle strength of the shoulder joint plays a vital role in eccentric contraction and deceleration in shoulder sports. When the ER/IR ratio of the dominant side is smaller than that of the non-dominant side, it means that the ER muscle strength of the dominant side is too weak. It is necessary to strengthen the ER muscle strength of the dominant side to reduce the risk of shoulder joint sports injuries [13].

Since shoulder rotation muscle strength balance is one of the important factors in reducing the risk of shoulder injury, what is the ratio of IR and ER muscle strength balance? Different studies have reached different conclusions. Most studies believe that the ER/IR ratio of shoulder movement should be 60%. Some researchers tested the shoulder muscle strength of college swimmers and found it to be 1:1 [14]. Foreign studies [3] used isokinetic dynamometers to measure healthy and uninjured shoulder joints in most body positions and found that this ratio was approximately between 60% and 70%.

The increase in the ER range of the dominant arm in over-the-shoulder sports allows the prime mover to fully lengthen to increase the contraction force and extend the distance of the final force, thereby extending the duration of action, achieving the purpose of increasing the impulse and increasing the speed and force of the ball. This is the need for high-level technical movements. In badminton, some special movements such as smash and chop require the dominant arm shoulder joint to fully rotate externally to achieve a powerful and fast shot. In addition, backhand transitions and backcourt pulls require a larger ER range of the shoulder joint to get the ball in place. Therefore, a larger ER range of the dominant shoulder joint is required for badminton special techniques. In the measurement of the joint ROM of over-the-shoulder athletes, it was found that the increase in the ER angle of the dominant arm was accompanied by a decrease in the IR angle [5]. Tension of the posterior joint capsule and tension of the posterior rotator cuff tendons are factors that lead to limited IR [14]. Excessive ER ROM and limited IR ROM are one of the causes of shoulder injury. Therefore, it is important to relax and stretch the posterior joint capsule to increase the IR range of the dominant arm and reduce the risk of injury.

3. Study Groups

Amateur badminton enthusiasts of Li Ning Badminton Hall were selected as the research subjects to investigate the shoulder injury characteristics of their shoulder rotation ROM and muscle strength.

70 badminton enthusiasts of Li Ning Badminton Hall were randomly selected as the survey subjects. After distributing the information collection form, the survey subjects who met the conditions were divided into two groups. The 24 badminton enthusiasts in the shoulder pain group and the non-shoulder pain group were aged between 21-45 years old, with a training duration more than 1 year, playing badminton ≥2 days a week, ≥1h each time, without other diseases causing shoulder pain, and without shoulder joint surgery and disease. There were 6 males and 6 females in the shoulder pain group, 12 people in total (shoulder injury within 1 year, VAS ≥3 or only shoulder pain, no injury, VAS ≥3); There were 6 males and 6 females in the non-shoulder pain group, 12 people in total (no shoulder injury and pain).

4. Methodology

Through the information collection of samples, muscle strength and joint ROM tests, we observed whether the shoulder joint IR and ER muscle strength of the survey subjects was an influencing factor of shoulder injury.

According to the research purpose, relevant literature was obtained through China National Knowledge Infrastructure, Google Scholar and other channels, and information collection forms were designed based on this and randomly distributed to badminton enthusiasts in Li Ning Badminton Hall. The basic information of the survey subjects was collected through the collected information collection forms, which served as the basis for grouping the shoulder pain group and the non-shoulder pain group and the basis for analyzing the test results of muscle strength and joint ROM.

Using the joint angle ruler to measure the shoulder joint IR and ER ROM, the error was small when the body position was supine. Due to the limitation of the test site, the test position was selected as the short sitting position, and the shoulder joint was abducted 90° to measure the shoulder joint IR and ER ROM.

The microFET 2 handheld dynamometer produced by Hoggan was used, with a measurement range of 0 to 300 pounds (lbs) and a measurement accuracy of 0.1 pounds (lb). Compared with isokinetic dynamometer, handheld dynamometers are easy to carry and operate, and the measurement results of handheld dynamometers and isokinetic dynamometers have a good correlation [15]. Therefore, handheld dynamometers are selected as more suitable for this study.

According to the measurement site, the standing position is selected for measurement. The upper arm is close to the trunk, the elbow is flexed 90°, the palm faces the inside of the body, and the trunk is perpendicular to the forearm. The handheld dynamometer is fixed on the wall, the distal end of the forearm is close to the dynamometer pole, and the shoulder joint isometric muscle contraction is performed. Before the test, it is emphasized to use the maximum force of the shoulder joint IR and ER, and the test is performed according to the command.

Since the test position is standing, it is necessary to pay attention to the test without using the trunk to compensate for the force, and only use the strength of the shoulder joint rotation muscle group.

5. Results and Discussion

5.1 Information Collection

After the questionnaire survey, a total of 70 questionnaires were distributed, 70 were collected, and 67 were valid.

As shown in the data in Table 1, the number of male badminton enthusiasts is slightly more than that of females, and most players use their right hand as their dominant hand. Most badminton enthusiasts have been playing for a long time and have a moderate exercise intensity. People with a playing age of 3 to 5 years account for 40.3%, and 55.2% of people play for 1 to 2 hours each time. Most players will do warm-up activities, and only 1 person does not do warm-up activities. It can be seen that badminton enthusiasts have a high degree of awareness of the importance of warm-up activities. 27 people choose to relax for 5 to 10 minutes, 10 people relax for 10 to 15 minutes, and as many as 24 people only use less than 5 minutes for relaxation exercises, but there are still 4 people who do not do any relaxation activities. Relaxation activities after exercise are very important, which helps to relieve muscle soreness and tension, eliminate fatigue, and facilitate physical recovery.

In the past year, 24 people had shoulder injuries, and as many as 20 people had injuries on the dominant hand side. This is closely related to the sports they often do. Badminton, as an over-shoulder sport, has a greater impact on shoulder joint injuries. 31 people had shoulder pain on the dominant hand side, and most of them had pain between 3 and 6 points. This shows that dozens of people have shoulder pain without any injury, which may be related to the imbalance of IR and ER muscle strength of the shoulder joint. In addition to sports injuries, 3 people had shoulder diseases such as shoulder surgery. 95.5% of the players did not have shoulder diseases, which provided conditions for the screening of experimental subjects and ruled out the relationship between shoulder pain and such shoulder diseases.

In addition to shoulder joint injuries, knee joint injuries account for a large proportion, followed by ankle joints. In the face of the rotation and rapid movement requirements of the trunk in badminton, the knee joints are under great pressure, which causes knee joint injuries over time. If the ankle joint does not have good stability and neuromuscular control ability during rapid movement, it is easy to sprain the ankle. If the rehabilitation after spraining the ankle is not sufficient, the ankle joint is also prone to discomfort in subsequent sports. The waist is also a common site for injury. The rotation of the trunk during the game should use the hip joint instead of the waist, but some enthusiasts are not aware of this and thus suffer from waist injuries. Elbow and wrist joints are also sites where injuries are more frequent. The intensity, type, "age", standardization of technical movements, warm-up and relaxation methods and time are all factors that affect injuries, and these factors will affect a person's injury.

5.2 Shoulder Rotation ROM in Different Genders

Table 1: Shoulder rotaion ROM(°) and ratio(M±SD)

Rotaion	Side	Male	Female
IR	Dominant side	43.33±10.08	41.67±12.12
	Non-dominant side	45.42±7.53	42.50±7.54
ER	Dominant side	74.67±7.23	83.17±4.41**
	Non-dominant side	72.08±8.10	78.75±8.56
ER/IR	Dominant side	1.82±0.53	2.20±0.83
	Non-dominant side	1.62±0.27	1.89±0.28*

*Indicates statistical significance (P<0.05)
**Indicates statistical significance (P<0.01)

There was a significant difference in the dominant side ER ROM between different genders (P<0.01), and females had greater ROM than males; there was a significant difference in the non-dominant side ER/IR ROM ratio between different genders, and females also had greater ROM than males; while there was no significant difference in bilateral IR ROM, non-dominant side ER ROM, and dominant side ER/IR ROM ratio between different genders.

Since the subjects selected for the experiment were not of the same gender, the gender differences were analyzed before the analysis of the shoulder pain group and the non-shoulder pain group. As shown in Table 1, there was no significant difference in the joint ROM between men and women in bilateral IR, non-dominant side ER, and dominant side ER/IR ratio. However, there was a significant difference in the ER ROM on the dominant side between different genders, and the dominant side ER ROM of women was greater than that of men, indicating that the dominant side ER ROM of women was greater. The reason may be that most women have greater flexibility and joint flexibility than men, and are more adaptable to badminton. The influence of hormones on physiological structure between different genders cannot be ignored. In daily life, the other sports that different genders like are also different, and other sports habits have also become factors affecting the ROM of shoulder joints of different genders. There is a significant difference in the ER ROM on the dominant side for women, but no significant difference in the IR ROM. According to the proportional relationship, there should be a significant difference in the ER/IR ratio, but the data show that there is no significant difference in the ER/IR ratio. However, it can be seen from Table 1 that the ER/IR ratio of women is slightly larger than that of men. The reason may be that the sample size of this experiment is small and the test may have errors.

There are significant differences in the ratio of ER/IR ROM on the non-dominant side between different genders, and this ratio is greater in women than in men. As shown in Table 1, although there is no significant difference in the ROM of ER and IR between men and women on the non-dominant side, the ROM of ER on the non-dominant side of women is greater than that of men, while the ROM of IR on the non-dominant side is almost the same, so the ratio of ER/IR ROM on the non-dominant side of women is greater than that of men. The women in the survey may often participate in other sports (such as swimming), which may affect the ROM of ER of the shoulder joint of the non-dominant arm; or because women have better flexibility, their ROM of ER is slightly greater than that of men. The reason why there is no significant difference in the ER of the non-dominant side may be that the sample size is insufficient, and the research results are biased.

5.3 Isometric Strength of Shoulder Rotation in Different Genders

Table 2: Isometric strength of shoulder rotation (lb) and ratio (M±SD)

Rotation	Side	Male	Female
IR	Dominant side	126.03±12.71**	69.60±4.50
	Non-dominant side	115.79±11.11**	62.02±7.95
ER	Dominant side	108.36±7.23**	59.78±4.41
	Non-dominant side	96.40±16.03**	52.94±8.49
ER/IR	Dominant side	0.86±0.11	0.86±0.11
	Non-dominant side	0.83±0.13	0.86±0.11

**Indicates statistical significance (P<0.01)

There were significant differences in the strength of the IR and ER muscles on the dominant and non-dominant sides of different genders ($p < 0.01$); however, there was no significant difference in the ratio of ER to IR muscle strength between different genders.

In the ICC analysis of the three muscle strength tests conducted previously, the data reliability was greater than 0.9, so the mean value could be used for calculation. As shown in Table 2, there were significant differences in the strength of the IR and ER muscles between different genders, with males being significantly greater than females, and the vast majority of males having greater muscle strength than females. However, there was no significant difference in the ratio of ER to IR muscle strength between different genders.

5.4 Shoulder Rotation ROM and Ratio in the Shoulder Pain Group and the Non-shoulder Pain Group

Table 3: Shoulder rotation ROM (°) and ratio (M±SD)

Rotation	Side	Shoulder pain	Non-shoulder pain
IR	Dominant side	37.50±11.38	47.50±8.12*
	Non-dominant side	42.50±8.92	45.42±5.82
ER	Non-dominant side	74.58±17.53	76.25±10.25
ER/IR	Dominant side	2.40±0.81**	1.62±0.25

*Indicates statistical significance (P<0.05)
**Indicates statistical significance (P<0.01)

Compared with the ROM groups of the shoulder pain group and the non-shoulder pain group, the ROM of the dominant side IR was significantly different, and the ROM of the non-shoulder pain group was greater than that of the shoulder pain group; the difference between the ER/IR ROM ratio of the shoulder pain group and the non-shoulder pain group was extremely significant ($p<0.01$), and the ratio of the shoulder pain group was greater than that of the non-shoulder pain group.

There was no significant difference in the bilateral rotation ROM and ER/IR ROM ratio between the shoulder pain group and the non-shoulder pain group.

Table 4: Rotation ROM(°) and ratio (M±SD) in Male

Rotation	Side	Shoulder pain	Non-shoulder pain
ER	Dominant side	79.33±3.56*	70.00±7.07
ER/IR	Non-dominant side	1.61±0.32	1.63±0.25

*Indicates statistical significance (P <0.05)

There was a significant difference in the ER ROM of the dominant side between the male shoulder pain group and the non-shoulder pain group, and the ROM in the shoulder pain group was greater than that in the non-shoulder pain group; there was no significant difference in the bilateral rotation ROM and the ER/IR ROM ratio between the male shoulder pain group and the non-shoulder pain group.

Table 5: Rotation ROM(°) and ratio (M±SD) in Female

Rotation	Side	Shoulder pain	Non-shoulder pain
ER	Dominant side	84.67±4.55	81.67±4.08
ER/IR	Non-dominant side	2.02±0.30	1.76±0.21

There was no significant difference between the female shoulder pain group and the non-shoulder pain group; there was no significant difference in the bilateral rotation ROM and ER/IR ROM ratio between the female shoulder pain group and the non-shoulder pain group.

Because there were significant differences in the ROM between different genders in the ER of the dominant side and the ER/IR of the non-dominant side, the analysis involving these two aspects was analyzed separately by gender.

The dominant side IR range of the shoulder pain group was less than that of the non-shoulder pain group, and almost all the subjects had the dominant side of shoulder pain, indicating that the limited ROM of IR may be related to shoulder pain, while the dominant side ER range of the male shoulder pain group was greater than that of the male non-shoulder pain group, indicating that the increase in ER ROM was accompanied by limited IR ROM, which may be a related factor for male shoulder pain. The ER/IR ratio of the dominant side ROM in the shoulder pain group was greater than that in the non-shoulder pain group, and the dominant side IR ROM in the non-shoulder pain group was greater than that in the shoulder pain group. There was no significant difference in ER ROM between the female shoulder pain group and the non-shoulder pain group, so the reduced IR ROM and the larger ER/IR ratio may be related factors for female shoulder pain. Compared with the non-dominant side shoulder pain group and the non-shoulder pain group, there was no significant difference in the various indicators. Male shoulder pain may be related to increased ER ROM accompanied by limited IR, while female shoulder pain is related to limited IR ROM and a larger ER/IR ratio.

5.5 Isometric strength ratio of shoulder rotation in shoulder/non-shoulder pain groups

Table 6: Isometric strength ratio of shoulder rotation(M±SD)

Rotation	Side	Shoulder pain	Non-shoulder pain
ER/IR	Dominant side	0.81±0.11	0.91±0.07*
	Non-dominant side	0.81±0.12	0.88±0.10

*Indicates statistical significance (P <0.05)

There was a significant difference in the ER/IR ratio of the dominant side between the shoulder pain group and the non-shoulder pain group, and the shoulder pain group was smaller than the non-shoulder pain group; there was no significant difference in the ER/IR muscle strength ratio between the non-shoulder pain group and the shoulder pain group.

Table 7: Isometric strength of shoulder rotation in male (M±SD)

Rotation	Side	Shoulder pain (lb)	Non-shoulder pain (lb)
IR	Dominant side	135.50±8.95**##	116.57±7.76
	Non-dominant side	120.08±14.33	111.50±4.67
ER	Dominant side	110.35±22.84#	106.35±5.84
	Non-dominant side	96.45±25.31	96.35±15.48

**Indicates statistical significance in different groups (P<0.01)
##Indicates statistical significance in shoulder pain group (IR isometric strength Dominant side and Non-dominant side, P<0.01)
#Indicates statistical significance in shoulder pain group (ER isometric strength Dominant side and Non-dominant side, P<0.05)

The difference between the dominant side IR muscle strength of the male shoulder pain group and the non-shoulder pain group was extremely significant ($p < 0.01$), and the muscle strength of the shoulder pain group was greater than that of the non-shoulder pain group; at the same time, there was no significant difference between the dominant side ER, non-dominant side IR, and non-dominant side ER groups.

The difference between the male shoulder pain group and the IR muscle strength was extremely significant ($p < 0.01$), with the dominant side muscle strength being greater than the non-dominant side; while the male shoulder pain group had a significant difference in the ER ($P < 0.05$); there was no significant difference in the bilateral IR and ER muscle strength of the male non-shoulder pain group.

Table 8: Isometric strength of shoulder rotation in female (M±SD)

Rotation	Side	Shoulder pain (lb)	Non-shoulder pain (lb)
IR	Dominant side	68.50±6.10##	70.70±2.13
	Non-dominant side	57.37±6.84	66.67±6.37*
ER	Dominant side	55.05±9.06	64.52±4.77&#
	Non-dominant side	46.10±2.48	59.78±4.36**

*Indicates statistical significance in different groups (P<0.05)
&Indicates statistical significance in different groups (P<0.01)
##Indicates statistical significance in shoulder pain group (IR isometric strength Dominant side and Non-dominant side, P<0.01)
#Indicates statistical significance in shoulder pain group (ER isometric strength Dominant side and Non-dominant side, P<0.05)

Comparison of bilateral IR and ER muscle strength between females in the shoulder pain group and non-shoulder pain group: there was a significant difference in the ER of the dominant side, a significant difference in the IR of the non-dominant side, and a very significant difference in the ER of the non-dominant side ($P < 0.01$), and the muscle strength of the non-shoulder pain group was greater than that of the shoulder pain group; there was no significant difference in the IR muscle strength of the dominant side between the shoulder pain group and the non-shoulder pain group.

The comparison of the IR muscle strength of females in the shoulder pain group was very significant ($P < 0.01$), and the muscle strength of the dominant side was greater than that of the non-dominant side; but there was no significant difference in their bilateral ER; the comparison of the ER muscle strength of females in the non-shoulder pain group was significant, and the muscle strength of the dominant side was greater than that of the non-dominant side; there was no significant difference in the IR muscle strength of females in the non-shoulder pain group.

As shown in Table 6-8, the comparison of bilateral IR and ER muscle strength between males in the shoulder pain group and the non-shoulder pain group showed that only the IR of the dominant side had a significant difference, and the shoulder pain group was greater than the non-shoulder pain group. Comparison of the bilateral IR and ER muscle strength of women in the shoulder pain group and the non-shoulder pain group showed that only the dominant side IR had no significant difference, while the other muscle strengths were greater in the non-shoulder pain group than in the shoulder pain group.

There was no significant difference in the bilateral IR and ER muscle strength of men in the non-shoulder pain group; there was a significant difference in the ER strength of women in the non-shoulder pain group. There was a significant difference in the bilateral IR and ER muscle strength of men in the shoulder pain group, while there was only a difference in IR, not ER.

The dominant side IR muscle strength of men in the shoulder pain group was greater than that of the non-shoulder pain group, and greater than their own non-dominant side, and the ER muscle strength was greater than their own non-dominant side, but similar to the non-shoulder pain group, and the shoulder pain side of the subjects was the dominant side, indicating that excessive IR muscle strength may be related to shoulder pain. The shoulder joint rotation muscle strength of the females in the shoulder pain group was lower than that of the non-shoulder pain group, and the shoulder pain side of the subjects was the dominant side. Although there was no significant difference in the IR of the dominant side, it can be seen from Table 8 that the shoulder pain group was also lower than the non-shoulder pain group. This result may be due to insufficient sample size, fatigue after exercise, and posture compensation during testing. In addition, the dominant side of the females in the shoulder pain group was greater than the non-dominant side, and there was no significant difference in the ratio of IR and ER, indicating that the cause of female shoulder pain may be related to the lack of ER muscle strength of the dominant arm.

The ER/IR muscle strength ratio of the dominant side in the shoulder pain group was lower than that in the non-shoulder pain group, indicating that the shoulder pain of badminton enthusiasts may be related to the ER/IR muscle strength ratio. There was no significant difference in the IR and ER muscle strength ratio between the shoulder pain group and the non-shoulder pain group, and it was approximately between 80%-90%. However, some studies have shown that the optimal IR and ER muscle strength balance ratio of the shoulder joint is 60%-70%. In this experiment, the ER/IR ratio of the non-shoulder pain side of both the non-shoulder pain group and the shoulder pain group was greater than this ratio. The reason may be the measurement error, or the cause of the shoulder pain of the subjects was not the imbalance of IR and ER muscle strength.

6. Conclusion

The ER ROM on the dominant side of the shoulder joint and the ratio of ER/IR ROM on the non-dominant side of the shoulder joint in women are greater than those in men, and the shoulder rotation muscle strength in men is greater than that in women.

The IR ROM on the painful side of badminton enthusiasts with shoulder pain is less than that of badminton enthusiasts without shoulder pain; male shoulder pain may be related to increased ER ROM accompanied by limited IR, while female shoulder pain is related to limited IR ROM and a larger ER/IR ratio. Badminton enthusiasts may be related to a smaller ER/IR muscle strength ratio.

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