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Effect of Intervention Based on Sports Rehabilitation Training on Knee Injury After a High-Intensity Confrontation in Soccer

Peng Wang* **and Yi Shi**

Shanxi Technology and Business College, Taiyuan, Shanxi 030036, China

Soccer players often sustain knee injuries during high-intensity confrontations and this can affect training and even life if left untreated. In this paper, the focus is on knee injuries and sports rehabilitation training. Thirty athletes with knee injuries were recruited from the soccer team of Shanxi Technology and Business College and took part in our experiment. They were randomly and equally grouped into a control group and an experimental group. The control group had no intervention, while the experimental group underwent sports rehabilitation training. The two groups of athletes were tested for knee joint muscle strength and function scores before and after the experiments. The results showed that the knee joint muscle strength and function scores of the two groups were not remarkably different before the intervention experiment; after the intervention, the knee joint muscle strength and function scores of the experimental group were not only remarkably greater than those before the intervention, but also remarkably better than those of the control group for which there was no significant change.

Keywords: knee joint injury, sports rehabilitation training, isometric muscle strength test, knee joint function score

1. INTRODUCTION

Because the technical movements in soccer are executed mainly through the lower limbs and soccer athletes also rely on these limbs for movement, these limbs are under great pressure (Prabhakar et al., 2020), especially the knee joint. Even if two players do not collide directly, players will constantly flex, extend, and twist the knee joint in a short time during high-intensity sports (Koseki et al., 2020), which is likely to cause injuries. The accumulation of injuries can lead to a decrease in the strength of the knee muscles, insensitivity to pain, and poor stability of the lower limbs, all of which affect not only the confrontational movement in the game but also, in severe cases, the daily activities of the player. Therefore, players need rest and recovery training after sustaining knee joint injuries (Richardson et al., 2020). Liu (2020) investigated the therapeutic effect of sports rehabilitation training on patients with ligament injuries. The results showed that although knee joint function improved without targeted training, the improvement was not as good as that of the experimental group that had undergone targeted training. Romero-Franco et al. (2016) investigated the validity and reliability of a digital inclinometer to assess knee joint position sense in a closed kinetic chain. The results showed that the inclinometer was more accurate than the isokinetic dynamometer and its readings were very reliable within and between testers. Comfort et al. (2015) compared joint kinetics and kinematics in three commonly-used rehabilitation exercises and pointed out that weight-bearing exercises for the knee and ankle joints during rehabilitation should start with a reverse lunge, followed by a forward lunge and single-leg squat. In this paper, the focus is on knee injuries and sports rehabilitation

*Corresponding address: No. 99, Wucheng Road, Xiaodian District, Taiyuan, Shanxi 030036, China. Email: pen0ub@yeah.net

Table 1 Study subjects.

	Control group	Experimental group	P value
Age/years	20 ± 1.1	20 ± 1.0	0.124
Height/cm	179.3 ± 1.1	179.2 ± 0.9	0.132
Body weight/kg	64.1 ± 1.1	64.2 ± 1.0	0.143

training. For comparison purposes, 30 athletes with knee injuries were recruited from the soccer team of Shanxi Technology and Business College, and experimental results were analyzed.

2. KNEE INJURY AND SPORTS REHABILITATION TRAINING

In actual soccer confrontation, the athlete's knee joint is subjected to a heavy load due to large confrontation movements, resulting in acute knee injury (Mousa et al., 2019). Acute knee injuries can be diagnosed within the first 30 days or so after the event. Not only does a knee injury limit an athlete's athletic ability when it occurs, but it also affects the athlete's daily life and, if left untreated, can greatly increase the risk of arthritis (Curran et al., 2018). While recovering from a knee injury, the athlete will feel weakness in the lower extremity limb during activity and feel displacement and looseness in the knee joint.

Traditionally, acupuncture and medication were used to promote the blood circulation of tissues around the knee joint and accelerate anti-inflammation after knee joint injury (usually for low-severity knee injuries, but in the case of severe structural knee injuries, surgery is required), and recuperation in quiet surroundings was also needed to reduce the burden on the knee joint (Lee and Lee, 2017). However, although traditional therapy can restore the knee injury, it is time-consuming, and the resting process lacks exercise for the lower limb muscles or the muscles around the knee joint that maintain the stability of the knee joint. Without exercise, the muscle strength will decrease (Serpell et al., 2015), which will reduce the stability of the knee joint, especially for soccer players (Ahmad, 2016).

With knee joint injuries, it is difficult for athletes to recover by means of traditional therapy alone (Xi et al., 2021). In order for athletes to recover from knee injury and improve their overall athletic ability, in addition to traditional therapy, sports rehabilitation training is also applied to speed up recovery. Through sports rehabilitation, the muscles around the knee joint are prevented from becoming inert due to rest (Balci et al., 2021) and can quickly adapt to regular sports training after rehabilitation. Sports rehabilitation can also stimulate the tissues at the knee injury site to accelerate the metabolism and promote the recovery of the tissue structure.

3. EXAMPLE ANALYSIS

3.1 Research Subjects

Research subjects were recruited from the soccer team of Shanxi Technology and Business College. The recruitment criteria are as follows. The subjects only had a history of knee injury diagnosed as tendon injury, which was not severe enough to require rest. The subjects' self-statements about knee injury symptoms included knee giving away and an abnormal motion range of joints. The subjects had not undergone sports rehabilitation training within the last six months. Finally, 30 male soccer players with knee injuries were recruited and randomly and equally divided into two groups, one as the control group and the other as the experimental group. The basic information of the two groups is shown in Table 1, and the differences between them were insignificant. The subjects were informed of the purpose and procedure of the experiment, and signed an informed consent form prior to the commencement of the comparison experiment.

3.2 Training Program

During the test, the control group did not receive sports rehabilitation training and only followed their daily routines but did not engage in high-intensity sports that would aggravate the knee injury. The experimental group underwent an eight-week, three-phase exercise rehabilitation training program, as shown in Table 2. The first phase of exercise rehabilitation training was conducted for one to three weeks, during which the training program included gluteus training, dynamic stretching training, technical movement integration training, and knee stability training. During the second four-to-six-week phase, the training program focused on core strength training. The third phase was conducted for between seven and eight weeks, during which the training program involved joint strength burst training and rapid flexion and extension compound training. The specific training schedule is shown in Table 2.

3.3 Test Items

Both groups of soccer players underwent knee performance-related tests before and after an eight-week training, and the differences were compared to verify the effectiveness of sports rehabilitation training interventions on knee injury recovery (Yang and Lin, 2022).

(1) Isometric muscle strength test

The tested athlete first performed warm-up activities according to the instructions of the isometric muscle strength tester (IsoMed2000, Germany) (Logerstedt et al., 2022); afterward, the tester was turned on to test the muscle strength of the knee joint muscle group at an angular velocity of 60°/s, including total flexion work,

Table 2 Schedule of sports rehabilitation training.

Training phase	Training time period	Training program	Specific content
Phase 1	One to three weeks	Gluteus training	• Two groups of deep squat training (ten times/group) • Two groups of double-leg external rotation (ten times/group) • Two groups of longitudinal walks (10 times/group) • Two groups of lateral walks (ten times/group)
		Dynamic stretching training	• Two groups of anterior thigh muscle stretch during moving (ten times/group) • Two groups of reverse hamstring stretch (ten times /group) • Two groups of lateral lunge movement (ten times/group)
		Technical movement integration training	• Two groups of longitudinal jump on tiptoe (six times /group) • Two groups of arm swing squats (six times/group) • Two groups of crouch jump with single-leg support (six times/group)
		Knee stability training	• Two groups of balance board single-foot stand (three times each for left and right/group) • Two groups of balance board double-feet stand (Three times/group) • Two groups of passing the ball by single-foot stand on a balance board (six times/group)
Phase 2	Four to six weeks	Core strength training	• Two groups of prone bridge with alternating contralateral raises (three times/group) • Two groups of lateral-bridge split (three times/group) • Two groups of prone bridge with a Swiss ball (three times/group)
Phase 3	Seven to eight weeks	Knee joint strength burst training	• Six groups of barbell front squat (five times/group) • Six groups of barbell split squat (five times/group) • Six groups of barbell mixed grip and hard pull (five times/group) • Six groups of single-leg supine split on a Swiss ball (five times/group)

Table 2 Cont.

Rapid flexion and extension compound training	• Two groups of double-feet jump over a jumping box (five times/group) • Two groups of lateral exchange jump (five times/group) • Two groups of double-feet jump over a hurdle (five times/group)

Table 3 Results of the 60°/s isometric muscle strength test for the control and experimental groups before and after training.

	Test index	Control group	Experimental group	Difference between groups (P value)
Before training	Total work flexion/J	786.4 ± 73.6	787.6 ± 90.2	0.125
	Total extension work/J	1313.6 ± 103.9	1373.9 ± 185.3	0.214
	Peak flexion torque/NM	53.5 ± 4.7	54.8 ± 6.4	0.124
	Peak extension torque/NM	93.6 ± 7.8	96.8 ± 13.2	0.133
After training	Total work flexion/J	784.6 ± 83.0	1062.5 ± 77.4	0.004
	Total extension work/J	1315.5 ± 72.5	1674.9 ± 143.4	0.002
	Peak flexion torque/NM	55.6 ± 4.6	78.9 ± 8.3	0.001
	Peak extension torque/NM	96.5 ± 5.6	116.5 ± 10.8	0.002
The intragroup difference before and after training (P value)	Total work flexion/J	0.124	0.002	/
	Total extension work/J	0.143	0.003	/
	Peak flexion torque/NM	0.156	0.001	/
	Peak extension torque/NM	0.132	0.001	/

total extension work, peak flexion torque, peak extension torque, and the ratio of the peak flexion torque to the peak extension torque.

(2) Knee joint function score

The Lysholm knee joint function scoring (Mangone et al., 2017) was used to measure the activity level of knee joints.

3.4 Mathematical Statistics

The collected data were statistically processed using SPSS software and Excel software, and the processing results of the values were presented using the form of $x \pm d$. The t-test was performed on the data before and after training within the same group and the data of different groups (Wohl et al., 2021). When the p value was less than 0.05, it indicated a significant difference.

3.5 Test Results

As shown in Table 3, firstly, before the training, there was no significant difference in the total work of flexion and extension and the peak torque of flexion and extension between the two groups; after the training, the strength of the knee joint muscle groups in the experimental group that received the sports rehabilitation training intervention was remarkably better than that of the control group. A longitudinal comparison of knee muscle strength before and after training in the same group found no significant change in the knee joint muscle strength in the control group before and after training, but the knee joint muscle strength in the experimental group increased significantly after the sports rehabilitation training intervention, indicating that sports rehabilitation training could improve knee joint muscle strength.

In addition to testing the muscle strength of the knee joint, the Lysholm scale was also used to evaluate the knee joint function of the athletes. Table 4 shows the knee joint function evaluation results of the control and experimental groups before and after training. First, the comparison of the knee joint function scores between the control and experimental groups before training found that the differences between the two groups in all the test items and the final total score were not significant, i.e., the knee joint function of the athletes in the two groups was nearly the same before the sports rehabilitation training intervention. The comparison of the knee function score between the control and experimental groups after training demonstrated that the differences between the two groups in all the test items and the final total score were significant. A longitudinal comparison of the knee joint function score of the same group before and after training revealed that the control group without the sports rehabilitation training intervention did not show significant changes in the knee joint function score before and after training, but the experimental group that received the sports rehabilitation training intervention showed a significant increase in the knee joint function score after training.

Table 4 Results of knee joint function evaluation for the control and experimental groups before and after training.

Test item	Time	Control group	Experimental group	P value for the difference between groups
Knee joint pain	Before training	12.5 ± 0.5	12.0 ± 1.0	0.135
	After training	13.5 ± 1.0	24.8 ± 0.6	0.002
	P value for the intragroup difference	0.112	0.001	/
Knee joint locking	Before training	6.2 ± 1.2	6.4 ± 0.8	0.231
	After training	7.5 ± 0.5	14.5 ± 0.5	0.001
	P value for the intragroup difference	0.211	0.002	/
Knee joint swelling	Before training	4.8 ± 0.6	5.0 ± 1.0	0.214
	After training	5.3 ± 0.6	9.5 ± 0.5	0.001
	P value for the intragroup difference	0.136	0.001	/
Requiring standing support	Before training	2.3 ± 0.8	2.4 ± 1.0	0.125
	After training	3.4 ± 0.4	4.8 ± 0.2	0.001
	P value for the intragroup difference	0.139	0.002	/
Degree of Claudication	Before training	3.2 ± 1.1	3.0 ± 1.2	0.212
	After training	4.2 ± 0.2	4.8 ± 0.1	0.002
	P value for the intragroup difference	0.111	0.001	/
Feeling of instability in the knee joint	Before training	10.5 ± 1.0	10.0 ± 1.5	0.213
	After training	11.5 ± 1.0	24.5 ± 0.5	0.003
	P value for the intragroup difference	0.128	0.001	/
Difficulty in climbing stairs	Before training	2.4 ± 0.2	2.2 ± 0.4	0.322
	After training	3.3 ± 0.6	8.5 ± 1.0	0.001
	P value for the intragroup difference	0.216	0.003	/
Difficulty in squatting	Before training	2.6 ± 0.4	2.4 ± 0.6	0.215
	After training	3.4 ± 0.8	4.5 ± 0.5	0.001
	P value for the intragroup difference	0.222	0.001	/
Total score	Before training	44.2 ± 1.2	43.4 ± 1.4	0.222
	After training	52.1 ± 1.6	95.9 ± 2.5	0.001
	P value for the intragroup difference	0.232	0.001	/

4. DISCUSSION

Soccer is a sport that requires frequent lower limb movements. In daily training or games, strenuous movements can burden the lower limbs, especially the knee joints. The knee joint is the largest and most complex joint in the human body, connecting the thigh and lower leg and enabling the flexion and extension of the lower limbs. Once the knee joint is injured, it will directly affect the movement of the lower limbs, not only affecting the performance of a soccer player, but in serious cases also having adverse impacts on daily life. Therefore, it is very essential for soccer players to receive timely and appropriate treatment for knee injuries.

Resting quietly to recuperate is generally the method used to recover the knee joint, during which high-intensity loads should be avoided. However, for soccer players, although resting can recover the knee joint, it takes a long time. Moreover, the lack of exercise for a long time will lead to muscle inertia, and the conditioned reflexes of various soccer techniques established during training will also gradually diminish. Therefore, it is difficult to resume normal training immediately even after the knee has recovered from injury. Therefore, in addition to recuperation, interventions are made through sports rehabilitation to speed up the recovery and maintain player fitness.

In order to verify the intervention effect of sports rehabilitation training on the recovery of knee injuries, 30 athletes with knee injuries were recruited from the soccer team of Shanxi Technology and Business College and were randomly divided into a control group and an experimental group. The control group served as a blank control. Subjects in the control group were not interfered with by sports rehabilitation training but rested quietly to recuperate. Subjects in the experimental group underwent sports rehabilitation training intervention. The isometric muscle strength and knee joint function score tests were conducted for both groups before and after the intervention, the final results of which are shown above. Firstly, the results of the isometric muscle strength test showed that there was no significant difference in the knee joint muscle strength between the two groups before the intervention, but after the intervention, the knee joint muscle strength of the experimental group was not only remarkably greater than that before the intervention but also remarkably better than that of the control group. The knee joint muscle strength of the control group had no significant change after the intervention, as did the knee joint function score.

The results of the isometric muscle strength and the knee function score tests showed that sports rehabilitation interventions were effective in improving knee joint muscle strength, accelerated knee joint injury recovery, and improved knee joint performance. This is because sports rehabilitation constantly stimulated the muscle group around the knee joint to keep the muscles active and took advantage of the excessive recovery characteristic of the muscles to improve muscle strength. The increased strength of the muscles around the knee joint maintained the stability of the knee joint, and the exercise stimulation of the muscles promoted blood circulation around the knee joint, thus obtaining more nutrition and speeding up the recovery of the knee joint tissue.

5. CONCLUSION

In this this paper, we briefly introduced knee joint injury and sports rehabilitation training and analyzed 30 athletes with knee joint injuries from the soccer team of Shanxi Technology and Business College. The 30 athletes were randomly and equally divided into a control group and an experimental group. The experimental group received sports rehabilitation training intervention, while the control group did not. The isometric muscle strength and the knee joint function score tests were performed on the two groups before and after the intervention. The results are as follows. After the sports rehabilitation training, the knee joint muscle strength of the experimental group was not only remarkably greater than that before the training, but also significantly better than that of the control group. After sports rehabilitation, the knee joint function of the experimental group was significantly stronger than that before training and that of the control group.

REFERENCES

1. Ahmad, A.N. (2016). Ideal Rehabilitation Programme after Anterior Cruciate Ligament Injury: Review of Evidence. *International Journal of Science Culture and Sport*, *4*(1), 56–67.
2. Balci, A., Nüvar, E., Akınoğlu, B., Kocahan, T. & Hasanoğlu, A. (2021). Investigation of knee flexor and extensor muscle strength in athletes with and without trunk muscle strength asymmetry. *Advances in Rehabilitation*, *35*(1), 1–8.
3. Comfort, P., Jones, P.A., Smith, L.C. & Herrington, L. (2015). Joint kinetics and kinematics during common lower limb rehabilitation exercises. *Journal of Athletic Training*, *50*(10), 1011–1018.
4. Curran, M., Lepley, L. & Palmieri-Smith, R. (2018). Continued Improvements in Quadriceps Strength and Biomechanical Symmetry of the Knee After Postoperative Anterior Cruciate Ligament Reconstruction Rehabilitation: Is It Time to Reconsider the 6-Month Return-to-Activity Criteria? *Journal of Athletic Training*, *53*(6), 535–544.
5. Koseki, K., Mutsuzaki, H., Yoshikawa, K., Endo, Y., Kanazawa, A., Nakazawa, R., Fukaya, T., Aoyama, T. & Kohno, Y. (2020). Gait Training Using a Hip-Wearable Robotic Exoskeleton After Total Knee Arthroplasty: A Case Report. *Geriatric Orthopaedic Surgery & Rehabilitation*, *11*(2), 1–6.
6. Lee, J.M. & Lee, J.H. (2017). Benefits of using transcranial magnetic stimulation as a tool to facilitate the chronic knee injury rehabilitation. *Journal of Physical Therapy Science*, *29*(4), 733–736.
7. Liu, X. (2020). Effect of nano-ligament combined with sports rehabilitation training on the treatment effect of ligament injury patients. *International Journal of Nanotechnology*, *17*(2/3/4/5/6), 274–290.
8. Logerstedt, D.S., Ebert, J.R., MacLeod, T.D., Heiderscheit, B.C., Gabbett, T.J. & Eckenrode, B.J. (2022). Effects of and Response to Mechanical Loading on the Knee. *Sports Medicine*, *52*(2), 201–235.
9. Mangone, M., Bernetti, A., Paoloni, M., Canonico, R., Tognolo, L., Attanasi, C., Cruciani, A., Alviti, F., Santilli, V. & De Nicola, A. (2017). Motor imagery and rehabilitation of a professional soccer player after anterior cruciate ligament injury: A case report. *Medicina Dello Sport; Rivista di Fisiopatologia Dello Sport*, *70*(1), 109–115.
10. Mousa, H.J., Hadi, A.K. & Kadhim, M. (2019). Effectiveness of the Ultrasonic Device with Therapeutic Exercises in the Rehabilitation of Knee Joint Injury in Football Players. *Indian Journal of Forensic Medicine & Toxicology*, *13*(4), 308.
11. Prabhakar, A.J., Joshua, A.M., Prabhu, S. & Kamat, Y. (2020). Effectiveness of proprioceptive training versus conventional exercises on postural sway in patients with early knee osteoarthritis - A randomized controlled trial protocol. *International Journal of Surgery Protocols*, *24*(5), 6–11.
12. Richardson, M.C., Wilkinson, A., Chesterton, P. & Evans, W. (2020). Effect of Sand on Landing Knee Valgus During Single-Leg Land and Drop Jump Tasks: Possible Implications for ACL Injury Prevention and Rehabilitation. *Journal of Sport Rehabilitation*, *30*(1), 1–8.
13. Romero-Franco, N., Montaño-Munuera, J.A., Fernández-Domínguez, J.C. & Jiménez-Reyes, P. (2016). Validity and Reliability of a Digital Inclinometer to Assess Knee Joint Position Sense in a Closed Kinetic Chain. *Journal of Sport Rehabilitation*, 1–22.
14. Serpell, B.G., Scarvell, J.M., Pickering, M.R., Ball, N.B., Newman, P., Perriman, D., Warmenhoven, J. & Smith, P.N. (2015). Medial and lateral hamstrings and quadriceps co-activation affects knee joint kinematics and ACL elongation: a pilot study. *BMC Musculoskeletal Disorders*, *16*(1), 1–11.
15. Wohl, T.R., Criss, C.R. & Grooms, D.R. (2021). Visual Perturbation to Enhance Return to Sport Rehabilitation after Anterior Cruciate Ligament Injury: A Clinical Commentary. *International Journal of Sports Physical Therapy*, *16*(2), 552–564.
16. Xi, Y., Yang, S., Wang, P. & Feng, Y. (2021). Human Motion System Model Based on Real-Time Image Acquisition and Data Simulation. *Engineering Intelligent Systems*, *29*(3), 175–181.
17. Yang, H. & Lin, X. (2022). Machine Learning Intelligent Medical Algorithm Based on Computer Vision and Parallel Optimization of Biomedical Information System. *Engineering Intelligent Systems*, *30*(5), 387–398.