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The Effect of Functional Training on the Performance of Female Handball Players' Shooting Skills

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Abstract: A randomized grouping experiment was conducted to study the effect of 8-week functional training on shooting performance of Beijing female handball players. According to the athletes' FMS (functional movement screening) scoring results, they were randomly divided into 2 groups. The experimental group adopted an 8-week functional training, aiming at strengthening their core strength, joint stability, and the power chain of shooting techniques. The control group adopted the traditional strength training mode. ANOVA(analysis of variance) was adopted to analyze the different performance of the athletes from two groups on their FMS scores, distances of throwing, and 7-meter shooting speed before and after the experiment. The results show that: (1) the total FMS scores of the experimental group athletes have been increased more significantly than those of the control group, and the injuries per capita has been significantly reduced; (2) the athletes in the experimental group have more significantly improved performance in handball throwing and 7-meter shooting speed than those in the control group. It shows that 8 weeks of functional training may effectively improve the physical function of Beijing female handball players and their performance in two special skills of handball throwing and shooting speed.

Key words: Effect of functional training, performance, female handball, shooting skills.

1. Introduction

In recent years, the performance of Chinese women's handball in the world competitions has been declining, and it has missed the Olympic finals for three consecutive times. Beijing Women's Handball Team is a traditional strong team in China, with many players being selected out for the training in national team. The performance of this team may basically represent the level of China's women's handball. Literature review shows that there are still several major problems in shooting techniques for female handball players, such as slow approach and jump, few changes, insufficient force, short time in the air, and slow ball speed [1].

The technical statistics of Chinese female handball players participating in a number of world competitions show that the shooting effect is far lower than that of the opponents, which is the main reason for the poor shooting success rate, and exposes the practical problems of insufficient shooting skills and sports performance of Chinese female handball players. The level of special training for women's handball in China has been unable to adapt to the development trend of women's handball in the world [2]. Although the gap between the Chinese women's handball team and the world's top teams is manifold, shooting skills and shooting speed are obviously basic factors. Shooting speed is the ultimate manifestation of athlete's body control and whiplash explosive power, requiring athletes to have good core stability and limb flexibility [3]. Therefore, the study adopts FMS (functional movement screening) to evaluate the physical function of Chinese female handball players, takes the weak points shown in the FMS tests as the starting point [3], and hopes to improve their core strength, shoulder flexibility, and strengthen their training of the shooting power chain, with the aim of improving athletes' body control ability, and a consequently improved shooting speed.

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2. Research Methods

2.1 Test Object

Twenty athletes from Beijing Women's Handball Team are targeted for intervention, including 8 national athletes, 10 first-level athletes, and 2 second-level athletes. As for their offensive positions, there are 7 left and right inner defenders, 5 wingers, 4 bottom liners, and 4 goalkeepers. Altogether 20 athletes were randomly divided into experimental group A and control group B according to their FMS test results, with 10 athletes in each group (Table 1). According to the *T* test of the results of the FMS of both groups, *p* value=0.597, and there was no significant difference between the two groups (table 1).

During the experiment, the experimental group adopted the method of functional training, while the control group adopted conventional strength training. The variable tested before the experiment is defined as "pre-test", and that by the end of the 8-week training is defined as "post-test". The actual effect of functional training can be judged by comparing the performance of shooting skills and physical motor function indexes of athletes in pre- and post-tests.

2.2 Test Indicators

Two types of indicators reflecting the shooting performance of female handball players are selected: (1) indicators reflecting shooting skill performance (ball-shooting speed, handball throwing distance); (2) indicators reflecting body function and sports injury risk based on FMS assessment. The methods used for data collection are interviews and questionnaires of coaches from high-level professional teams nationwide.

2.3 Test Instruments and Equipment

Select women's No.2 handball, handball court, American Stalker handheld radar speedometer Sport 2 tester, etc.

2.4 Experiment Plan

According to the weekly training plan of Beijing Women's Handball Team, the experimental group and the control group train in the Handball Training Hall

Table 1 Random grouping of 20 women handball players in Beijing.

Group	Name	BMI index	Sport years	Offensive positions	Level
Experimental Group A	Wang xx	20.99	6	Goalkeeper	National
	Ji x	23.31	9	Left winger	National
	Yang xx	23.67	6	Left inner	National
	Cao xx	23.14	9	Left winger	National
	Hou xx	21.22	7	Right winger	First level
	Huang xx	20.20	5	Right winger	First level
	Wang xx	24.22	5	Bottom liner	First Level
	Liuxx	29.32	6	Goalkeeper	First level
	Wang x	24.28	6	Bottom liner	First level
	Xu xx	19.69	4	Left inner	Second level
Control Group B	Song xx	22.64	7	Right inner	National
	Hao xx	23.96	7	Bottom liner	National
	Chen xx	17.87	5	Central halfback	National
	Tian x	23.89	7	Bottom liner	National
	Tian x	23.74	7	Central halfback	First level
	Hou xx	23.81	6	Right inner	First level
	Chang xx	22.60	5	Left inner	First level
	Jin*	21.60	5	Goalkeeper	First level
	Zhou**	20.34	5	Goalkeeper	First level
	Wang**	21.45	4	Right winger	Second level

Note: BMI index = weight (kg)/height $(m)^2$.

or Physical Training Hall on Monday, Thursday, and Saturday mornings. Each training may last 2 h (table 2). The control group followed the previous training model, mainly using traditional strength training methods, and the training load was maintained at 60%-80% 1RM (Reperition Maximum).

After analyzing the typical characteristics of Chinese women's handball shooting techniques and the functional dysfunction of the subjects, the experimental group followed the basic principles of functional training, and took a 8-week (from December 14, 2020 to February 4, 2021) training plan. (table 3) The training intervention program is divided into three stages: the first stage (2 weeks): functional recovery and movement mode correction (table 4); the second stage (4 weeks): functional improvement and special advancement stage (table 5); and the third stage (2 weeks): functional stability and special promotion stage (table 6).

Table 2 Weekly training plan for training intervention of the experimental group and control group of Beijing Women's Handball Team.

Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	14, Dec.	15, Dec.	16, Dec.	17, Dec.	18, Dec.	19, Dec.
Experimental Group	Functional training	Technique class	Rest	Functional training	Technique class	Functional training
Control Group	Strength training	Technique class	Rest	Strength training	Technique class	Strength training

Table 3 Phase division and tasks of Beijing Women's Handball Team's 8-week training intervention.

Period	2 Weeks	4 Weeks	2Weeks
Training stage	Basic stage	Developmental stage	Advancement stage
Training content	Functional recovery + movement mode (upper limbs, trunk, lower limbs)	Movement mode + special physical fitness (upper limbs + trunk; trunk + lower limbs; upper and lower limbs)	Movement mode + special physical fitness + shooting techniques (body)
Training load	Low	Medium	High

Table 4 Typical training plan for the first phase of training intervention for Beijing Women's Handball Team.

Section	Content	Method	Interval	Ratio
Upper limb movement mode	Stability exercises for the scapulothoracic and glenohumeral joints: standing postures I, Y, T, W	4 sets/10reps	120 s	30%
Pillar strength of the trunk	Stable support glute bridge leg-retraction exercises Stable support side bridge leg-lift exercises Stable support abdominal bridge leg-retraction exercices	60s/4 Sets	90s	30%
Lower limbs movement mode	Bare-handed legs squat jumping and landing exercises Bare-handed single-leg squat jumping and landing exercises	4 sets/10 reps	120s	20%

Table 5 Typical training plan for the second phase of training intervention for Beijing Women's Handball Team.

Section	Content	Method	Interval	Ratio
Upper limb movement mode	Stability exercises for the scapular thoracic and glenohumeral joints: standing postures I, Y, T, W Shooting and throwing ball action with elastic belt swing exercises	4 sets/8 reps	90 s	20%
Pillar and rotation strength of the trunk	TRX glute bridge leg-retraction exercises TRX side bridge leg-lift exercises TRX abdominal bridge leg-retraction exercices	60s/4 reps	60s	40%
	Sit-ups throwing heavy balls (4kg)	4sets/12 reps	90s	
	Tossing heavy balls with separated legs(4kg)	4sets/12 reps	60s	
	Standing torso rotation with the heavy ball over the head(4kg)	4sets/12 reps	60s	
	Romanian kettlebell deadlift (4kg)	4sets/12 reps	90s	

Tbale 5 to be continued

Lower limbs movement mode	Double-leg squat jump and single-leg landing and supporting exercises	3sets/12 reps	60s	25%
	Continuous box jumping exercises	3sets/12 reps	90s	
	Raising the kettlebell on the straight arm with the opposite side (8-10kg) Romanian single leg squat (8-10kg)	4sets/10reps	60s	

Table 6 Typical training plan for the third phase of training intervention for Beijing Women's Handball Team.

Section	Content	Method	Interval	Ratio
Upper Limb Movement Mode	Shooting and throwing ball action with elastic belt swing exercises	3sets/15 reps	60 s	30%
	Shooting and throwing ball action with dumbbell swing exercises (2.5kg)	3sets/15 reps	60s	
	Shooting and throwing ball action with solid ball swing exercises	3sets/15 reps	60s	
Pillar and Rotation Strength of the Trunk	Sit-ups throwing heavy balls (4-6kg)	60s/4 sets	60s	30%
	Separated legs, opposite arm, pushing and raising the kettlebell (10-12kg)	3sets/15 reps	60s	
	Separated legs, whirling the rubber ball on the wall(4-6kg)	3sets/15 reps	60s	
	Separated legs, rotating the body and tossing the heavy ball (4kg)	3sets/15 reps	60s	
	Separated legs, rotating the body and raising the heavy ball over the head (4kg)	3sets/15 reps	60s	
	Pulley weights, rotating quickly downwards Pulley weights, rotating quickly upwards	3sets/15 reps 3sets/15 reps	60s	
Lower Limbs Movement Mode	Exercises of legs holding medicine ball on the standing balance mat	3sets	90s	30%
	Continuous box jumping exercises	3sets/12 reps	90s	
	Upward jumping resistance exercises	3sets/12 reps	60s	
	Resistance training with double-leg/single-leg jumping to hold the medicine ball	3sets/12reps	60s	
	Romanian single leg squat(10-12kg)	3sets/12 reps	60s	

In addition to three fixed training sessions per week, the two groups of athletes also have 4-6 technical and tactical training sessions. The conditions of technical and tactical training, sports diet, and work and rest time remain consistent within 8 weeks of the experiment.

3. Results and Analysis

3.1 Analysis of Beijing Female Handball Players' FMS Test Results and Injury Risk

The total score of the FMS test is 21 points, and 14 points is an important watershed for the evaluation. A score lower than (or equal to) 14 points indicates that the athlete has a high risk of sports injury, and it is necessary to carry out corrective exercise for the functional obstacles that have affected the body to complete the technical movements. A score greater

than (or equal to) 14 points indicates that the athlete has a low risk of sports injury and can carry out the next step of advanced physical training in a normal and orderly manner [4]. Statistics show that 12 athletes of the Beijing Women's Handball Team, accounting for 60% of the team's test population, scored no more than 14 points before the experiment (table 7), indicating that there is a potential risk of sports injury.

The lowest average score among the 20 athletes in the 7 tests was the trunk stability push-up (1.15±0.91). The torso of the human body is responsible for controlling the body posture and transferring energy to the limbs. The average score of the tested athletes is lower than 2 points, which indicates that the tested athletes' torso resistance to flexion is relatively weak (table 8). On the other hand, the FMS test results show the athletes' deep squat scores are also relatively low, reflecting the lack of core strength and core control ability for athletes. Thus, they may have greater risks of injury. At the same time, the FMS test results show that the athlete's shoulder flexibility scores are also lower than 2 points (1.60±0.97). The shoulder flexibility is the key in the power chain of handball shooting technique, which directly determines the completion effect and shooting speed of the whiplashing

Table 7 FMS injury risk for Beijing Women's Handball Team (*n*=20).

	>14points	≤14 points
Number	8	12

Table 8 Statistics of FMS sub-items of the Beijing Women's Handball Team (*n*=20).

Screening items	Average score
Deep squat	1.80 ± 1.17
Hurdle step	2.20 ± 0.68
Inline lunge	2.40 ± 0.92
Shoulder mobility	1.55 ± 1.02
Active straight-leg raise	2.35 ± 0.65
Trunk stability pushup	1.15 ± 0.91
Rotary stability	2.00 ± 0.00

Table 9 Distribution of sports injuries of the Beijing Women's Handball Team (*n*=20).

Parts	Shoulder	Waist	Knee	Wrist	Ankle	Sum up
Man-time	7	3	2	2	1	15
Experimental group	3	2	1	1	1	8
Control group	4	1	1	1	0	7

Table 10 Test data (M±SE) of physical function assessment of experimental group and control group at different time.

Index	Group	Pre-test	Post-test
FMS total scores	Control group	13.10± 3.41	13.20± 2.94
	Experimental group	13.80± 2.30	17.60± 2.07

movement. After a comprehensive analysis of FMS test results, it is not difficult to find that Beijing female handball players obviously lack core stability and shoulder joint flexibility, which will inevitably restrict their speed performance of shooting skills, and they may have greater risks of sports injury.

Statistics show that 13 members of the Beijing Women's Handball Team have 15 injuries of varying degrees, with an injury rate of 65% and an average injury rate of 75% per capita. The main injuries and diseases are in the shoulder joints, waist, knee joints, ankle joints, and wrist joints (table 9).

3.2 Analysis of the Effect of Training Intervention

3.2.1 Impact on Body Movement Function

The result of the spherical test shows that the total score of the FMS conforms to the hypothesis of homogeneity of variance and meets the conditions of multivariate analysis of variance. A two-factor repeated measurement analysis of variance was used to test whether there is a difference in the FMS results between the control group and the experimental group in the two measurements (table 10). The results show that the time effect of the intervention is significant, $F(1,18)=10.029$, $p=0.005$, partial η^2 = 0.358; After 8 weeks, the FMS test results of the experimental group athletes are significantly higher than those of the control group (Figs.1). In addition, there are also significant differences in the interaction effects between time and groups, ($F(1,18)=9.026$, $p=0.008$, partial η^2 = 0.334), indicating that the experimental group athletes have a significant improvement in physical function after the test, which is better than that of the control group (table 11).

Injury statistics shows that after 8 weeks of functional training intervention, the injuries of the 10 athletes in the experimental group are reduced from 8 to 1, and the injury rate is reduced by 87%. In the control group, except for the improvement of the ankle and wrist injuries, the three major joints of the

shoulder, waist, and knee are not improved (table 12). It shows that functional training based on core area, power chain training and joint stability training is effective in relieving athletes' injuries.

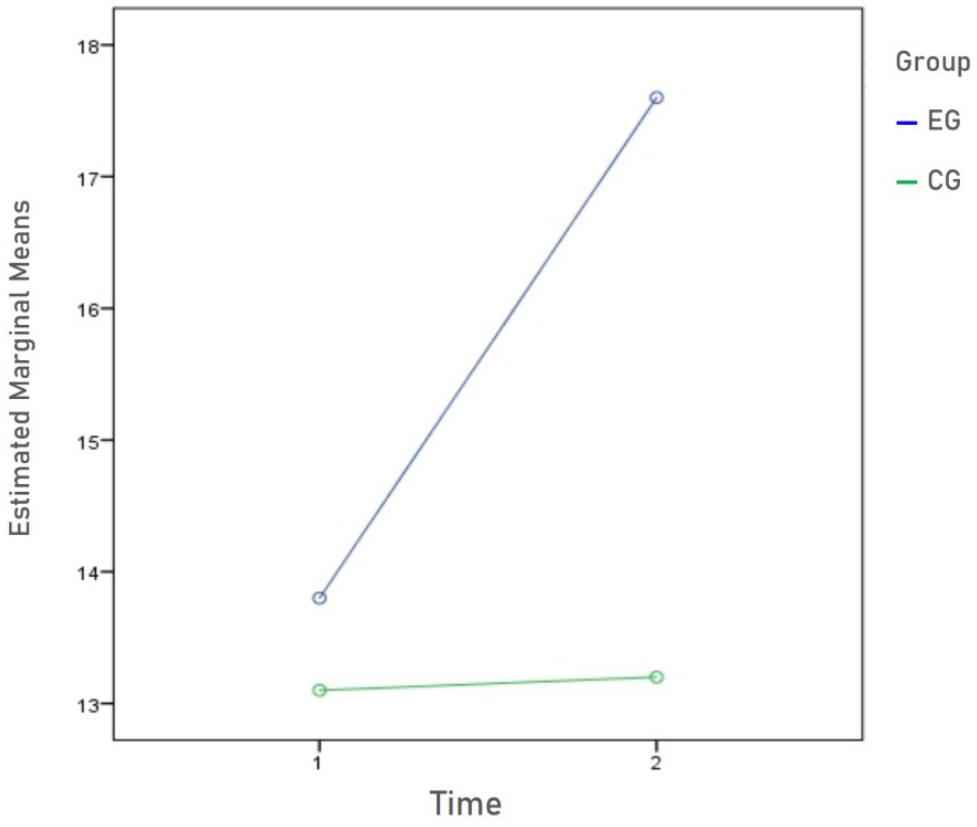
3.2.2 Impact on Shooting Skills

Before and after the training intervention, two shooting skill tests are carried out on athletes of both groups. The distance of handball throwing and the average score of three speed tests with the speed gun are used to evaluate the performance level and training of the handball players' shooting skills and the changes before and after the intervention. Statistical analysis of variance is used to compare the difference between the experimental group and the control group in the special skill performance variable according to their post-test scores (table13), as well as the time effect of training intervention, that is, under the intervention of functional training, the change in the performance of specific skills compared with the baseline level difference (Figs.2).

Table 11 Repeated measures analysis of variance of functional action screening.

Index	Variation source	df	MS	*F*
FMS total scores	Between groups			
	Group	1	65.025	5.845*
	Errors	18	11.125	
	Within group			
	Time	1	38.025	10.029**
	Time×group	1	34.225	9.026**
	Errors	18	3.792	

Note: * $p<0.05$ ** $p<0.01$



Figs. 1 Comparison and change of FMS total score 8 weeks before and after the experiment.

Table 12 Distribution of sports injuries of the Beijing Women's Handball Team (n=20).

Parts	Shoulder	Waist	Knee	Wrist	Ankle	Sum up
Man-time	7	3	2	2	1	15
Experimental Group	0	1	0	0	0	0
Control Group	3	2	1	0	0	6

Table 13 Test data of specific skills of the experimental group and the control group at different time points (m).

Index	Group	Pre-test	Post-test
Distance of handball throwing (m)	Control group	34.56± 3.43	36.41± 3.47
	Experimental group	31.40± 3.36	37.35± 3.16
Three shooting speed tests with the speed gun (mps)	Control group	16.82± 1.22	18.83± 0.94
	Experimental group	16.94± 1.82	23.58± 6.43

Statistics show that the pre- and post-test scores of the two variables, the distance of handball throwing and the average scores of three speed tests have been improved to varying degrees in both groups (Figs.3). The analysis results shows that there is a significant difference between the experimental group and the control group in the special skill performance post-test scores (p<0.01), and the interaction effect between group and time is also significantly different (p<0.01) (table14). It shows that functional training has significantly improved the athletes' shooting special skills performance, and the improvement of the experimental group's special skills performance before and after the intervention is significantly greater than that of the control group.

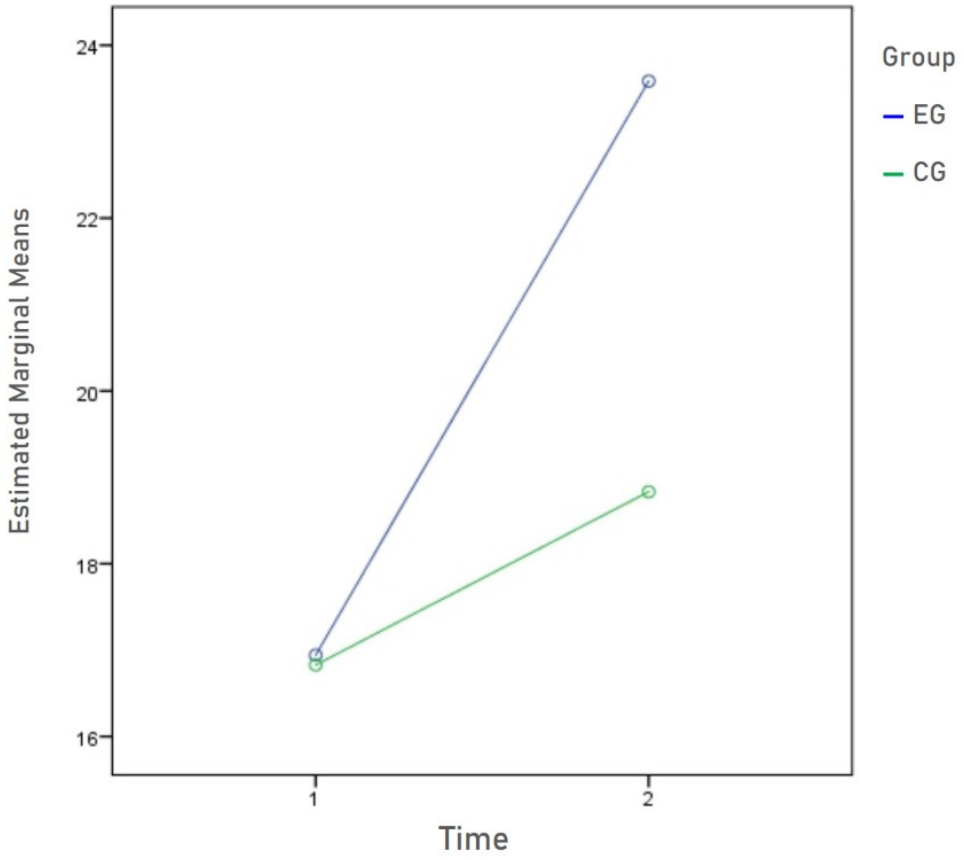


Fig. 2 Comparison and change of handball throw 8 weeks before and after the experiment (group×time, p<0.01).

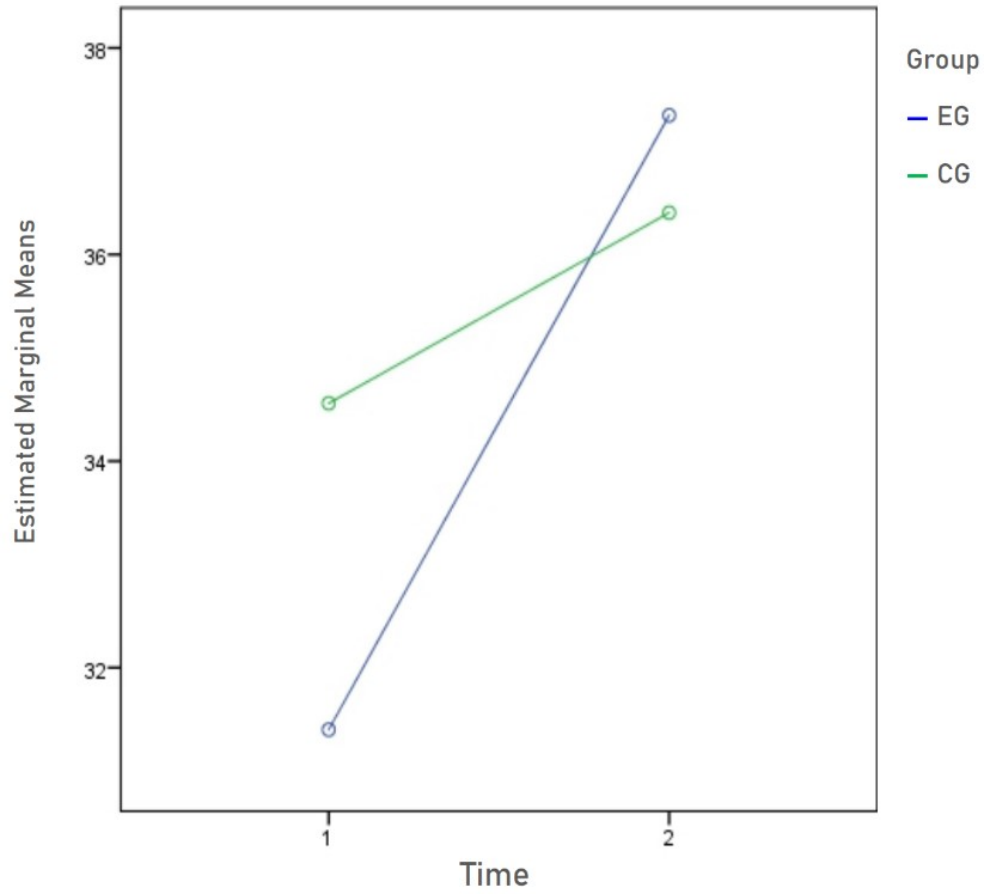


Fig. 3 Comparison and change of the average value of the three speed tests with the speed gun 8 weeks before and after the experiment (group×time, p<0.01).

Table 14 Repeated measures analysis of variance in the specific skill indicators of the experimental group and the control group.

	Variation source	df	MS	*F*
Distance of handball throwing	Between groups			
	Training methods/group	1	12.287	0.637
	Errors	18	19.295	
	Within group			
	Time	1	151.829	46.193**
	Time×group	1	42.088	12.805**
	Errors	18	3.287	
Speed tests with the speed gun	Between groups			
	Training methods/group	1	59.21	4.956*
	Errors	18	11.947	
	Within group			
	Time	1	186.914	16.071**
	Time×group	1	53.785	4.625*
	Errors	18	11.630	

Note: * p<0.05 **p<0.01

4. Conclusion

The experimental results show that after 8 weeks of functional training intervention, the FMS score of the experimental group has been increased significantly than that of the control group. The average number of injuries in the experimental group is lower than that of the control group, too. Thus, sports injuries can be effectively controlled and alleviated. At the same time, repeated measures multivariate analysis of variance reveals the differences in the pre- and post-test within the experimental and control group, reflecting that the performance of the two skills of Beijing female handball players, shooting speed and throwing distances, has been improved greatly after the intervention of 8-week's functional training.

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