Evaluation technology and methodology for improving hammer throwing technique using vertical elastic coupling

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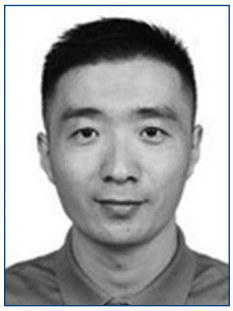

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Abstract

Purpose of the study. To describe the evaluation technology and methodology of improving the hammer throwing technique using vertical elastic coupling.

Methodology and organization of the study. Experimental studies were conducted in China on the basis of the sports team of Shaanxi province. We evaluated a number of kinematic parameters of athletes' movements.

Results of the study and conclusions. The use of aids with vertical elastic links has a positive effect on the technical movements of hammer throwers, which is reflected not only in the improvement of hammer movement parameters, its throwing speed and angular velocity of rotation, but also in the improvement of biomechanical parameters and indicators of physical fitness of athletes.

Keywords: *hammer throwing evaluation technology, hammer throwing technique, improvement methodology, vertical elastic coupling.*

Relevance. Hammer throwing is the most complex of athletics sports with a rotating trajectory and intense action of many different forces. Researcher Pavlovic R. used 28 male hammer throwers who were finalists of World Championships (Berlin, 2009, Daegu, 2011, London, 2017) as a sample. Multiple regression analysis was applied to determine the influence of certain kinematic parameters on throwing performance. The aim was to determine the influence of spatial and temporal biomechanical parameters on hammer throw performance. The results of a study of male finalists confirmed a direct relationship between hammer throw initial velocity, hammer release velocity, hammer first round velocity and performance [3].

Chinese male athletes [2] in hammer throw need to improve their technical level due to poor performance in international competitions. Researchers Jia Chao and Li Chengde used three-dimensional cameras to capture and analyze the technical movements of three top male hammer throw athletes (Wang Shizhu, Guo Kun, and Xiao Feng) at the Chinese Open Championships. The main technical parameters were: quantitative analysis, including pre-swing stage, rotation stage and final tension stage, to find reasonable factors and internal relationships to improve performance. By comparing some technical parameters of outstanding foreign male hammer throwers, we can identify the shortcomings and gaps in the hammer movements of Chinese athletes. Compared with outstanding overseas athletes, the pre-swing time of Chinese male athletes is too long, resulting in lower hammer speed during the pre-swing phase, which puts more stress on the rotation process. Compared with elite athletes in the world, the three hammer throw athletes still have the following deficiencies in the rotation phase: total rotation time is too long, unreasonable distribution of single and double support time - single support time is longer and hammer; throwing velocity increase time

Table 1. Kinematic parameters of hammer throwing technique

Parameters	Description
The speed at which the hammer leaves the hand	The velocity of the hammer as the handle leaves the hand
The angle at which the hammer leaves the arm	The angle between the hammer and the horizontal plane at which the hammer handle leaves the hand.
The time to support one leg.	Time to land on one foot
The time for both feet to rest on the ground.	The time it takes for both feet to stay on the ground.
The angular velocity of rotation of the ball of the mallet	The angular velocity of the line connecting the hammer and handle rotating about a vertical axis
The angular velocity of rotation of the two shoulders	Angular velocity of both arms rotating about a vertical axis
The angular velocity of rotation of the pelvis	Angular velocity of the pelvis rotating about a vertical axis
The angle of the knee joint	Angle between the thigh and the calf
The data of the center of the human body.(velocity, acceleration)	Velocity and acceleration of the center of mass of the human body.

is shorter, which is not conducive to rotational acceleration; poor continuous acceleration ability; insufficient center of gravity drop, different degrees of upper body backward tilt, chest flexion and compensatory actions Chest and elbow flexion are not conducive to maintaining balance and performing subsequent technical movements. The final power stage of the three Chinese athletes is relatively long and should be shortened, especially the time from the lowest point of the hammer throw to its completion. Judging from the speed of hammer throw, the speed in the final force stage has increased significantly, but there is a large gap between the speed of the final throw of Chinese athletes and outstanding foreign athletes [1].

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Results of the study and their discussion. The main method for determining the kinematic parameters of the hammer throwing technique was video analysis using a CASIO camera shooting at 120 frames per minute. Table 1 shows the description of kinematic parameters of hammer throwing technique used in the research work.

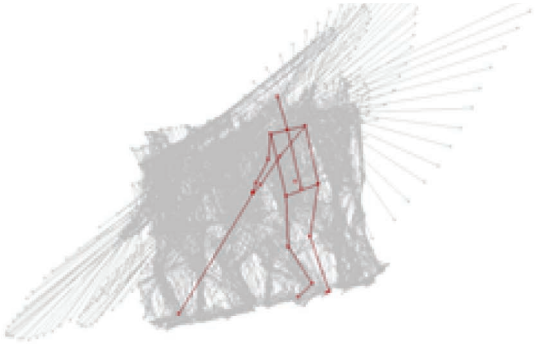

Figure 1 shows the sports video data processed by the APAS software.

Figure 1. Video data of sport competitions processed by APAS software

We have developed a methodology to improve the technique of hammer throwing, the essence of which was that if the body of the hammer thrower to apply a vertical traction force, it is possible to achieve a reduction in the yaw of the axis of rotation and relieve the musculoskeletal apparatus of the thrower from part of the vertical work, redistributing the saved mechanical energy to increase the rotational motion of the body of the thrower (Figure).

Venue and equipment:

-over the cage, over the throwing circle from one edge to the other, a steel non-deformable rod is stretched and attached to the walls of the cage,

-to this rod is attached a rubber cord (vertical elastic connection) with a diameter of at least 1 centimeter. The other end of the cord will be attached to a belt around the thrower's waist (Figure 2).

Figure 2 Schematic diagram of the vertical elastic coupling equipment

On the example of the experimental group, each experimental session was divided into three parts: preparatory, main and final part.

Preparatory part: The main tasks are to warm up and activate the body.

Basic part: includes technical exercises, quick low-load strength exercises, as well as stretching and relaxation. The specific content is as follows:

1) Hammer throwing exercise under vertical elastic linkage;

2) High leg raise exercise with a barbell;

3) Weighted barbell pulling exercises;

4) Grasp the barbell and simulate a rotational motion as in a hammer throw;

5) Stretch and relax.

Final: The main objectives are to get organized and relax.

There is only one vertical elastic connection. While one athlete performs the throwing exercises, other athletes perform other exercises. The main part of the exercises is based on the circuit training method. Each of the five athletes performed the above five exercises that made up one cycle, totaling 10 cycles, with a 3-minute rest between each cycle.

The difference between the experimental and control groups: the experimental group performed hammer throwing exercises under vertical elastic ties, whereas the control group performed hammer throwing exercises in the natural state. The rest of the training content was exactly the same. We developed the

Table 2. Micro-cycle of training on the example of the team of Shaanxi Province in China

Day of the week Content	Day of the week Content	Day of the week Content	Day of the week Content
Monday	1. 800 meter run, warm-up exercise 2. teaching experiment, throwing the ball 30 times 3. Stretching, relaxation exercises	1. 800 meter run, warm-up exercise 2. technical exercises, throws 35 times 3. Stretching, relaxation exercises	Medium intensity with emphasis on technical movements
Tuesday	1. 800 meter run, warm-up exercises 2. technical exercises, throwing 35 times 3. stretching, relaxation exercises	Physical preparation	Focus on technical movements and muscle coordination of the upper and lower extremities.
Wednesday	1. Running 800 meters and warm-up exercises. 2. Teaching experiment: throw the ball 40 times. 3. Stretching and relaxation exercises	Watch the technical video, rest	Physical recovery
Thursday	1. Running 800 meters and warm-up. 2. Technical practice, serve 40 times 3. Stretching and relaxation exercises	Physical preparation	Focus on technical movements and maintain fitness level.
Friday	1. Running 800 meters and warm-up. 2. Teaching experiment: throw the ball 40 times. 3. Stretching and relaxation exercises	1. Run 800 meters and warm up. 2. Technical practice, 45 throws 3. Stretching and relaxation exercises	Focus on developing neuromuscular coordination
Saturday	1. Run 800 meters and warm-up. 2. Technical practice, 45 throws 3. Stretching and relaxation exercises	Jogging 3000 meters	Focus on technical movements and do aerobic training
Sunday	vacation		

Table 3: Physical training plan for hammer throwers

Part	Content	Scope and intensity
Warm-up	Jogging 800 meters Whole body muscle activation	Heart rate 120-140 beats/minute
Special preparatory exercises	Running with small steps, jumping with steps, imitation of exercises from hand, rotation of a bar weighing 40 kg	Heart rate 130-150 beats/minute
Strength training	Squat 150 kg, 160 kg, 170 kg, 180 kg, 190 kg	4 times each * 4 approaches 70-90%
	Small lunge squat jump 140, 150, 160 kg	Alternating left and right leg 3 times each * 4 approaches 70-90%
	Bench press 160, 170, 180, 190 kg	4 times each * 4 approaches 70-90%
	Jerk 80, 90, 100 kg	4 times each * 4 approaches 70-90%
	Bench press 140, 150, 160 kg 4 times each * 4 approaches 70-90%	
Recovery	Relax and run 800 meters. Muscle stretching	

content of the training microcycle considering two training sessions per day (Table 2).

We developed a physical training plan for hammer throwers, including the content of different logical structures: warm-up, special preparatory exercises, strength part, and recovery (Table 3).

Conclusion. To summarize the above, it can be concluded that in order to determine the kinematic parameters of movements it is necessary to use a special camera and a 3D video motion analysis system APAS (Ariel Performance Analysis System) for video analysis and processing. Vertical elasticity allows the hammer thrower to engage additional contractions of the FR motor units because the S motor units contract faster during training. Training with vertical elastic links can effectively improve hammer throwers' biomechanical test scores and help improve competition performance. The training helps hammer throwers achieve directional changes in speed and speed-force performance, and the speed index is significantly increased. Hammer throwers should incorporate explosive strength exercises such as weighted squat jumps and multi-level jumps into their training. After training, hammer throwing velocity and rotational angular velocity increased significantly, while throwing angle remained stable.

Thus, as a result of this study, it can be concluded that the use of aids with vertical elastic links has a positive effect on the technical movements of hammer throwers, which is reflected not only in the improvement of hammer motion parameters, throwing speed and angular velocity of rotation, but also in the improvement of biomechanical parameters and indicators of physical fitness of athletes.

References

1. Bai Caixiang, Hongmin Liu, Yin Han. Analysis of factors affecting the performance of hammer throw[J]. Sports science research, 2006(06):81-83.
2. Chong Jia , Changdong Li , Shengyi Ma ,etc. Studies on the kinematics of chinese elite man hammer athlete throwing technology[J].Applied Mechanics and Materials,2014,568:1930-1933.
3. Ratko Pavlovic Biomechanical Analysis Hammer Throw: The Influence of Kinematic Parameters on the Results of Finalists World Championships[J]. American Journal of Sports Science and Medicine,2020,8(2):36-46.