

Article

# Research on the biomechanics and animation assistance of basketball throwing embroidery ball technique

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**Abstract: Objective:** This study aims to use biomechanical analysis of sports to create animations and innovate projection methods to improve the competitive level of ethnic sports such as throwing embroidered balls in baskets. **Method:** Utilizing methods such as analytical mechanics, animation production, and mathematical statistics, the results of training competitions were statistically analyzed to select scientific techniques for throwing embroidered balls into baskets. The prototypes and trajectories of these techniques were then animated to create visual projection technology for training guidance. Innovative projection technology was developed to improve athletic performance. **Result:** The competitive level of basket throwing embroidered ball is lagging behind, there is a lack of research on projection techniques, and the competition rules are not perfect. Excellent players mainly use short flat ( $\alpha \leq 30^\circ$ ) projection method, with a projection speed between 17.32 m/s and 18.97 m/s. The arc top of the projection trajectory is between 4.75 m and 5.5 m from the ground, and the landing point is within the receiving area, forming an effective receiving area. The receiver can easily judge the reception within the effective area, making it easy to achieve good results. **Conclusion:** The combination of biomechanics and animation production technology can effectively assist in improving the projection technology of basket throwing embroidered balls. Using short flat projection method to control the projection cycle can effectively improve performance, improve and unify the use of balls in competitions, and apply drone aerial photography technology to assist referees in making decisions, thereby improving the competitive level and standardization of embroidered ball throwing.

**Keywords:** embroidery ball; throwing techniques; mechanical analysis; animation production

## 1. Introduction

As an important cultural symbol of the Zhuang ethnic group, the embroidered ball was originally a weapon used for combat and hunting with a history of over two thousand years. Hydrangea originated in Zhuang Township, Guangxi, and is a beloved object and mascot of the Zhuang people. In some parts of Southeast Asia, such as Vietnam, Myanmar, Thailand, and Mexico in South America, people also have the custom of giving Hydrangea as a mascot to friends and family. The development of throwing embroidered balls into a formal ethnic sport began in the early 1980s and was widely spread in Zhuang ethnic areas. It has now become an important part of school sports and competitive sports. The sport of throwing

embroidered balls has developed into two sports: high-pole throwing and backbasket throwing.

The outdated competitive level is a major factor hindering the advancement of embroidery ball throwing to higher levels and wider spaces. Especially the widely spread sport of throwing embroidered balls in baskets is often carried out in the form of school teaching and social entertainment. There is a lack of literature on related technologies and tactical research, especially on the direct study of projection techniques from a biomechanical perspective, which is almost blank. This study is based on the author's years of teaching and training competition experience, selecting outstanding contestants' technical movements, and using information technology to animate the captured action prototypes. By forming visual information and combining it with innovative biomechanical projection techniques to guide training, the competitive level has been effectively improved. To provide a feasible path for promoting the international development and innovative inheritance of ethnic sports such as basket throwing and embroidered ball throwing.

## **2. The origin and development of throwing embroidered balls**

### **2.1. The evolution of embroidered ball culture**

Hydrangea is a cultural symbol of the Zhuang in Guangxi, China, carrying rich ethnic cultural connotations (see **Figure 1**) [1]. The origin of the sport of throwing embroidered balls can be traced back to more than two thousand years ago when the "Feituo" was on the Huashan Rock mural in Ningming, Guangxi. It is a rope tied bronze block used to throw and strike long-range targets (see **Figure 2**) [2]. Later, with the development of society and the progress of civilization, hydrangeas gradually developed into a tool for young men and women of the Zhuang ethnic group to express love and social entertainment, and rose to prominence [3]. In the Song Dynasty's "Ximan Congxiao", it is recorded that during the local festivals, young men and women in the wild divide into two groups, each with five colored bags of beans and millet, and throw them back and forth, named "Feituo" [4]. In the "Lingwai Dai Da", it is recorded that on the Lunar March 3rd, men and women gather in rows and columns, using five colored knots as balls, singing and throwing them, which is called "Feituo"; If the male and female like each other, then the woman will accept the Feituo and their marriage has been arranged [5]. The "Feituo" had evolved from a weapon used for "hunting" and "combat" to a "marriage and love tool" for Zhuang young men and women to entertain and communicate. The power and biomechanical beauty displayed by the ancient weapon "Feituo" is similar to that of the discus thrower in ancient Greece. The handmade embroidered ball prototypes such as "cloth thorns and embroidered cages" showcase the magnificent artistic beauty of the Zhuang people. The folk story of the kind and beautiful Ah Xiu girl sewing embroidered balls to save her beloved brother Ah Di who was imprisoned by a young man, finally ushering in a better life, has made embroidered balls the mascot of the Zhuang ethnic group, expressing the Zhuang people's longing for a better life.



**Figure 1.** Traditional embroidered ball.

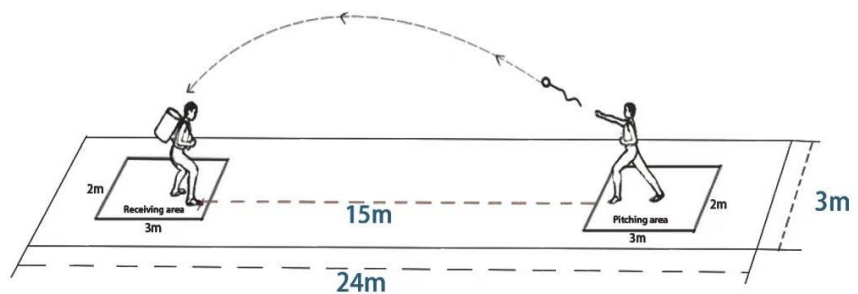


**Figure 2.** The “Feituo” of huashan rock painting.

## 2.2. Rules for the competition of basket throwing embroidered balls

Athletes should throw the ball into the receiver’s basket within the designated time. The team with the most goals thrown wins. If the number of goals is the same, the team with less time used wins.

On a flat rectangular ground of 24 m × 3 m, rectangular pitching and receiving areas of 3 m × 2 m are set at two ends separated by 15 m (as shown in **Figure 3**). Each team has 5 members, 4 pitchers and 1 receiver. The bowler must enter the pitching area in sequence, with each person throwing 6 balls. Only 1 ball can be thrown to the receiver in sequence at a time; The receiver stands with a basket on his back in the receiving area to receive the ball. Four pitchers need to efficiently cooperate to throw 24 balls into the receiver’s basket in the shortest possible time, which is a collective project that tests athletes’ skills, psychology, and teamwork.



**Figure 3.** Rules of throwing backbasket embroidery ball.

### **2.3. The rise of the sport**

In the early 1980s, ethnic sports workers in Guangxi excavated and organized “embroidered balls” and “colored balls” into the sport of “throwing embroidered balls” and promoted it. It has now become one of the sports projects for middle school students in Nanning City [6]. In 1986, Guangxi officially established the event of throwing embroidered balls, which appeared at the 4th National Traditional Minority Sports Games in 1991 [7]. The competition includes two events: high-pole throwing and backbasket throwing. The development of backbasket throwing was relatively lagging, and it was not until the 13th Guangxi Student Games in 2023 that it officially became a university competition event. With the development of sports, the number of participating teams has increased from 42 in the 11th Guangxi Student Games in 2016 to 61 in the 13th Games in 2023, but the level of competition has stagnated. From the perspective of sports performance evaluation attributes, throwing embroidered balls in the back basket is a hit event; According to the dominant factor of competitive ability, throwing embroidered balls in the back basket belongs to the accuracy project dominated by technical and psychological abilities [8].

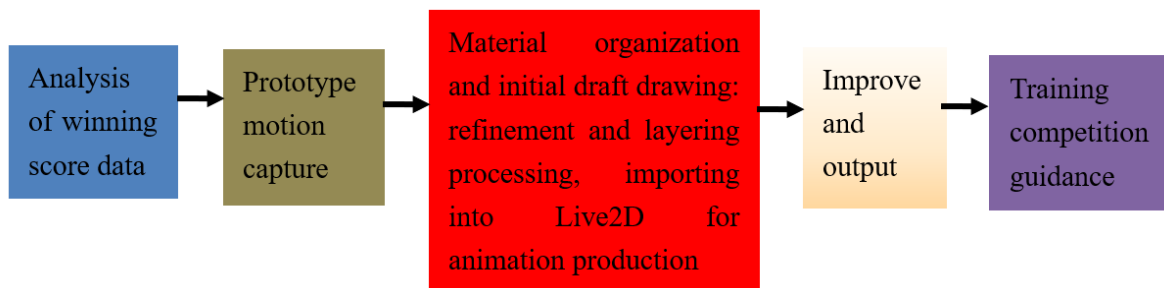
The evolution history of embroidered balls reflects the development process of the social needs of the Zhuang people and expresses traditional ethnic emotions. The changes in the symbolism of embroidered balls have led to the development and inheritance of the profound cultural meanings they carry, constantly adapting to social life. The evolution process of objects such as “Feituo, embroidered balls, and mascots” as objects reveals the Zhuang people’s pursuit of power beauty, artistic beauty, and a better future life in terms of spiritual and cultural aspects. The emerging ethnic sport of throwing embroidered balls showcases the Zhuang people’s pursuit of the beauty of sports in the new era. embroidered ball has developed into an important cultural symbol of the Zhuang ethnic group that combines the beauty of life, art, and sports [9,10]. Therefore, developing the sport of throwing embroidered balls is of great significance for the inheritance of ethnic sports culture.

## **3. Research design**

Research object: Innovation in projection technology for basket throwing embroidered ball movement. Based on the competition results and the development trend of projection technology, select outstanding athletes from the Liuzhou Institute of Technology embroidered balls team, improve their projection technology through biomechanical analysis and animation production, and use them as prototypes for projection technology movements to guide training competitions.

### **3.1. Analysis of winning score data**

As shown in **Figure 4**, the results of the embroidery ball throwing competition and training were compared, and the athletes with excellent performance were selected from the winning teams. Their projection techniques were comprehensively analyzed and improved as demonstration movements to guide the training competition.



**Figure 4.** Research design diagram.

### **3.2. Prototype motion capture**

Using cameras for continuous shooting and video recording of athletes' projection techniques, and then filtering mature and stable movements for technical decomposition.

### **3.3. Material sorting and initial draft drawing**

Open the Photoshop software, create a new canvas ( $1920 \times 1080$  pixels), and draw static images of athletes and embroidered ball based on the captured photos in the layer.

### **3.4. Improve and output**

Multiple adjustments and optimizations have been made to the animation effects in Live2D to ensure harmonious and unified movements of the embroidered ball and athlete as a whole. Finally, output the completed animation file.

### **3.5. Training competition guidance application**

Transforming the technology of the action prototype into animation files through improvement, guiding the training practice of the women's embroidery ball team at Liuzhou Institute of Technology, comparing the stable training results obtained with the highest record in the competition, and evaluating the effectiveness of this mechanical combined animation assisted training method.

## **4. Result analysis**

### **4.1. Analysis of excellent competition results**

Taking the latest 2024 Guangxi "Chaodong March 3rd Games" series competition as an example, the performance of men's bacbasket throwing embroidered balls. Collect projection time and projection method data from the top two participating teams for analysis. Both teams have a 100% shooting percentage of 24 pitches and a time of less than 50 s, indicating a relatively high overall level of competitiveness (see **Table 1**). Teams with lower competitive levels tend to spend too much time and make mistakes in throwing and receiving.

**Table 1.** Men's team results on Chaodong march 3rd games.

Name (Score)	Guangxi University for Nationalities (45.7 s)				Liuzhou Institute of Technology (47.1 s)			
	1	2	3	4	1	2	3	4
Athlete order	1	2	3	4	1	2	3	4
time	10.2	10.1	10.2	15.2	13.5	12.3	9.5	11.8
Throwing technique	short flat	short flat	short flat	Long high	Long high	Long high	short flat	short flat

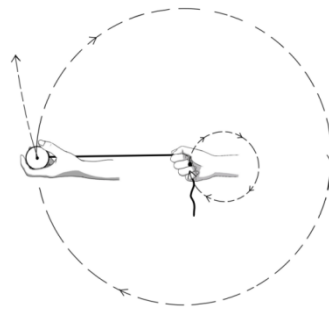
From **Table 1**, it can be seen that under the premise of a 100% hit rate, Guangxi University for Nationalities had 3/4 of the participants using the short flat projection method and won the championship in 45.7 s. Liuzhou Institute of Technology had half of the students using the short plane projection method and finished second with a time of 47.1 s. The tall projection method takes a long time and is not conducive to achieving good results. The shortest duration of the entire competition was the third contestant from Liuzhou Institute of Technology. He is also a key player for the team championship of the 13th Student Games in 2023, with the characteristics of the fastest speed and stable performance. Based on the technical movements of contestant 3, analyze and improve the training guidance (as shown in **Figure 5**).

**Figure 5.** Decomposition of throwing techniques of winning contestants.

## 4.2. Analysis of throwing techniques

### 4.2.1. Loop technology

Excellent team members generally use the technique of throwing around the ring (as shown in **Figure 6**). In the early stages of training, it is generally recommended to use a medium long rope as a radius loop and a high angle ( $\alpha > 30^\circ$ ) throwing method. This type of throwing method has a slow speed but stable performance, and is referred to as the long high throwing method. With the improvement of training level, in order to achieve excellence, it is necessary to reduce throwing time. Therefore, gradually adopting the short rope as a radius loop, low angle ( $\alpha \leq 30^\circ$ ) throwing techniques, abbreviated as short flat techniques. This throwing techniques is fast, but requires long-term professional training to maintain its stability.



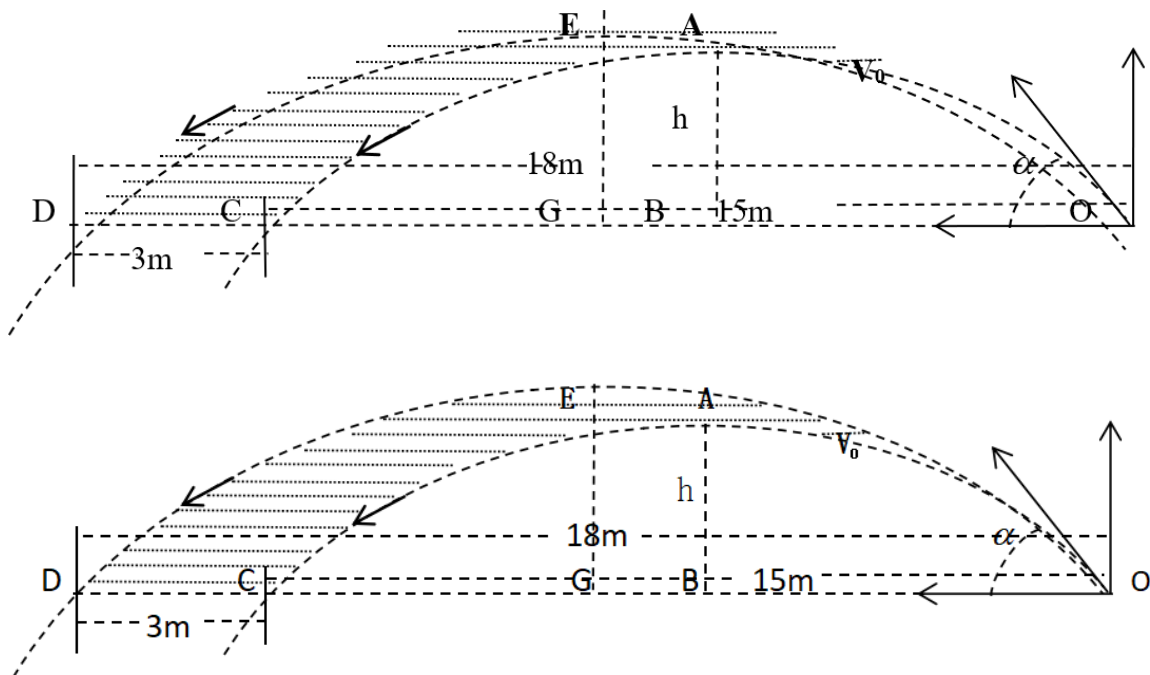
**Figure 6.** Hand throwing technique around the loop.

The practice of throwing embroidered balls from the back basket was initially introduced into school physical education teaching, which mainly focused on leisure and entertainment forms. The development of competitive sports was relatively lagging behind, and there was little research on technical aspects, with almost no analysis of projection techniques from a biomechanical perspective [11]. Therefore, one of the key elements in developing the sport of backbasket throwing embroidered balls is to improve the level of throwing technology.

**4.2.2. Analysis of aerial flight data of the ball**

*When the release angle is  $30^\circ$  and the receiver stands at the front line of the 15 m receiving area*

As shown in **Figure 7**,  $OC = 15$  m, the vertex of the ball's flight arc  $OAC$  is  $A$ . Assuming that the time it takes for the ball to reach the highest point  $A$  after being released is  $t$ , and the horizontal displacement time be the same as the time it takes to throw and drop.



**Figure 7.** Data analysis of throwing.

∴During the flight of the ball, the time required for vertical displacement and horizontal displacement is the same, and  $OB = 15/2 = 7.5$  m.

$$\therefore OB = v_0 t = v_0 \cos \alpha t, \text{ then } t = OB/v_0 \cos \alpha = 7.5/v_0 \cos \alpha, \text{ then } v_0 \cos \alpha = 7.5/t \quad (1)$$

$$\text{vertical displacement: } h = v_0 \sin \alpha t - 1/2 g t^2, \text{ get: } v_0 \sin \alpha = (h + 1/2 g t^2)/t \quad (2)$$

$$\therefore h = 1/2 g t^2, \text{ get: } t = \sqrt{2h/g} \quad (3)$$

$$\therefore \text{Combining (1), (2), and (3): } v_0 \sin \alpha / v_0 \cos \alpha = \tan \alpha = g t^2 / 7.5$$

$$\text{When } \alpha \text{ is } 30^\circ, \text{ get: } t = \sqrt{7.5 \tan 30^\circ / g} \approx 0.66 \text{ s} \quad (4)$$

Combining (3) and (4):  $\sqrt{7.5 \tan 30^\circ / g} = \sqrt{2h/g}$ , get height BA:  $h = 7.5 \tan 30^\circ / 2 = 2.17$  m. If the height of the ball release is 1.0m, the highest point is  $2.17 + 1.0 = 3.17$  m above the ground.

$$\therefore \text{Vertical speed: } v_0 \sin \alpha = g t, v_0 = g t / \sin \alpha = 2 g t = \sqrt{8 h g} \approx 17.3 \text{ m/s} \quad (5)$$

From (5)  $v_0 \sin \alpha = g t = \sqrt{2 h g}$ , When the time  $t$  is fixed, the height  $h$  is also fixed,  $t = v_0 \sin \alpha / g$ , then the relationship between  $v_0$  and  $\alpha$  is inversely proportional, the faster the throwing speed, the lower the required angle of release. At this time, the short flat projection method is used, which has a low angle and fast speed, which is beneficial for shortening the projection cycle time and creating good results, but it is not conducive to the receiver's judgment and is prone to throwing errors. Most members of the winning team need to undergo long-term training to master this difficult short flat shooting technique. When the distance is fixed at 15 m, then  $7.5 = v_0 \cos \alpha t$ ,  $v_0$  is proportional to  $\alpha$ . This situation usually uses the long height projection method, the larger the throwing angle, the faster the release speed is required, and the longer the projection period, which is not conducive to achieving good results but is conducive to stable performance.

*When the release angle is  $30^\circ$  and the receiver stands at the end line of the 18 m receiving area*

$OD = 18$  m, the vertex of the ball's flight arc OED is E. Similarly, the displacement time for GE and OG is the same, then  $OG = 18/2 = 9$  m, and  $CD = 3$  m is the length of the receiving area. From  $t \approx 0.66$  s in (4) above, the required time for vertical displacement GE is  $t_1 \approx 0.72$  s. At this moment, the height GE = 2.60 m, and height of the ball flying to point E at the top of the arc from the ground is:  $2.60 + 1.0 = 3.60$  m. From the above  $v_0 = g t / \sin \alpha = 2 g t = \sqrt{8 h g} \approx 17.32$  m/s, it can be concluded that the velocity of the shot at this time  $v_1 = 18.97$  m/s.

In practical practice, it is relatively easy to control the throwing speed while first controlling the throwing angle. Applying the short flat throwing techniques, controlling the throwing angle first and then controlling the speed, can effectively control the flight height of the ball, thereby controlling throwing cycle to achieve better results in a shorter time. From this, it can be seen that when the angle of the hand is  $30^\circ$ , the projection speed is between 17.32 m/s and 18.97 m/s. The highest point of the projected arc trajectory is between 3.17 m and 3.60 m from the ground, and the landing point is within the receiving area,  $CD = 3$  m. The receiver can easily determine the receiving in the shaded area of the effective projection area ODC (see **Figure 7**).



### **4.3. Animation production guidance training**

#### **4.3.1. Animation production of throwing techniques**

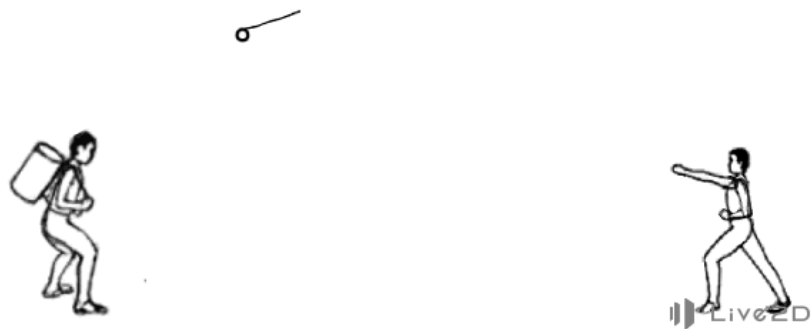
The emerging sport of throwing embroidered balls is a traditional ethnic sports event with a lagging development in competitive level. Among them, the lack of technological information elements to assist is a factor that cannot be ignored. With the assistance of information techniques resources, the development experience of some highly competitive sports projects provides a good reference for a deeper understanding of ethnic sports technology. The use of motion capture technology has captured students' shooting movements, and through corresponding exercises, students' shooting skills can be improved. [12]. Using Flash software for 2D animation production, integrating Chinese style ethnic sports laws with animation production, showcasing the rich artistic charm of Chinese style [13]. The courseware production of aerobic exercise animation model was completed by combining Flash and PowerPoint (PPT) courseware production software with Dynamics software, and the biomechanical analysis of exercise movements was carried out [14]. By using Banner animation software, dynamic elements can be created and rhythm controlled, providing a method reference for the production process of motion animation [15]. In order to meet the practical needs of the healthy development of ethnic sports in grassroots teaching and training, this study fully draws on the successful experience of existing research, adopts animation production techniques, and conducts detailed and in-depth research on the projection technology of throwing embroidered balls from baskets.

Use the projection technique of athlete 3 as a prototype for animation production. Firstly, collect suitable image information and perform refinement and layering processing. According to the decomposed actions, the joints of the athlete image are disassembled and drawn on separate layers for easy animation production in the future. Secondly, import Live2D software to create animations. Import the completed layered materials into Live2D for animation production. By observing the actual trajectory of the embroidered ball in the photo, adjust its motion curve to make it more realistic. At the same time, based on the keyframes of the athlete's movements, the dynamic effect of the athlete's movements is achieved through bone binding, ensuring that the athlete's movements are coherent and natural, and the path of the embroidered ball conforms to the parabolic law. This is a key step in innovatively using animation production technology to explain the principle of throwing embroidered balls and distinguish it from other existing theories. Thirdly, organize the materials and create a preliminary draft. Open the Photoshop software, create a new canvas (1920 × 1080 pixels), and draw static images of athletes, tall poles, and embroidered balls based on the captured photos in the layer. Fourth, refine the actions and animation effects and output the final animation file. Multiple adjustments and optimizations are made to the animation effects in Live2D to ensure harmonious and unified movements of the ball, athlete, and tall pole, and to output the completed animation file.

#### **4.3.2. Training guidance for animation production of throwing techniques**

The projection action of throwing embroidered balls is fast, and it is difficult to form effective action concepts from vertical vision, which is the difficulty of

technical action training. The angle of release, flight trajectory, and landing point of the pitch are the core of animation production and training guidance, determining how the receiver judges and receives the ball. Based on the technical movements of excellent athletes, motion capture technology can accurately capture real-time human movements and embroidery ball flight trajectory data. Through animation production, the technical movements can be decomposed and presented intuitively, which greatly helps to shape the projected movements and form stable release angles (see **Figure 8**). By using a combination of mechanical analysis and animation decomposition, the Liuzhou Institute of Technology Hydrangea Team Women’s Team (consisting of 4 bowlers) was assisted in training. After a period of practice using the short flat projection method to form a dynamic pattern, 30 scores were randomly selected and compared with outstanding players. The training effect of the innovative method was tested by using independent sample t-test (see **Table 2**).



**Figure 8.** Screenshot of Live2D animation production effect.

**Table 2.** Comparative analysis of women’s team performance and athlete No. 3’s performance.

Item	mean value	Fastest (s)	Slowest (s)	t-values	P-values
Athlete No. 3	8.65	7.88	9.23	-8.44	0.000*
women ‘s team	9.46	8.89	10.25		

\*  $p < 0.05$  \*\*  $p < 0.01$ .

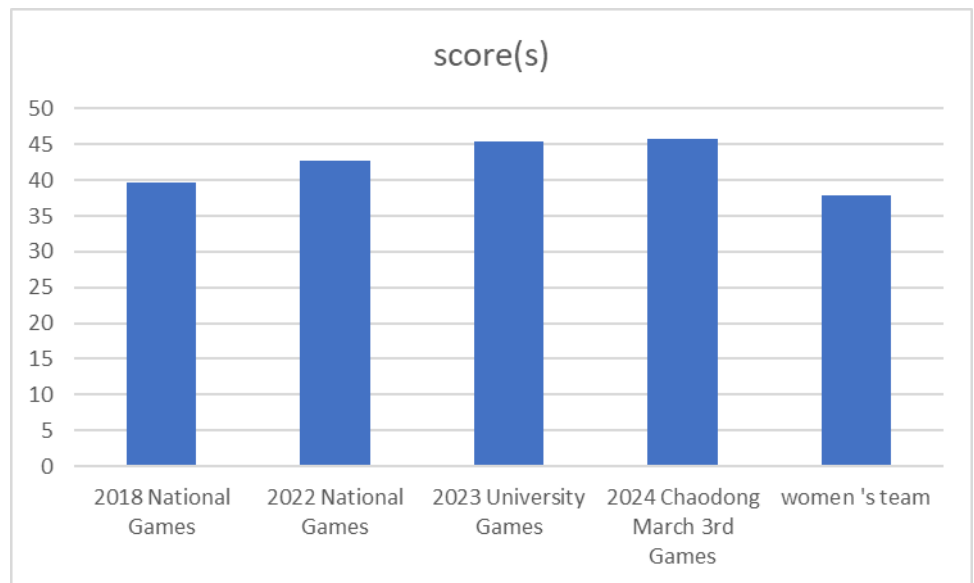
As shown in **Table 2**, presenting significant differences ( $p < 0.05$ ) in the average performance of Player 3 and the women’s team during training. From the average data, the average game time for the women’s team is 9.46 s, with the fastest time reaching 8.89 s and the slowest time being 10.25 s; The average competition time for contestant 3 is 8.65 s. The  $t$ -value ( $t = -8.44$ ) further indicates that there is a significant difference in the competition time data between the women’s team and player 3. Specifically, the average of the women’s team is slightly higher than that of the third player, which means that in terms of average projection time, the women’s team is slightly slower compared to the third player in terms of speed. At the same time, the fastest and slowest time data also indirectly reflect the differences in the stability and maximum level of the women’s team’s competition time compared to the third player to varying degrees. In summary, it can be concluded that the women’s team showed significant differences in their performance during the game compared to the third player after using the short flat projection method for training.

### 4.3.3. Vertical comparison of performance

Comparing the training results of the women’s team with the highest performance in recent years (see **Table 3**), the performance of Guangxi’s basket throwing embroidered ball has been continuously declining in recent years (see **Figure 9**). The highest record has gradually declined from 39.67 s at the 14th Guangxi Minority Games in 2018, 42.78 s at the 15th Guangxi Minority Games in 2022, 45.39 s at the 13th Guangxi Student Games in 2023, and 45.70 s at the “Tide March 3 Ethnic Sports Show” series of competitions in Guangxi in 2024. Although there is a gap between the trained women’s team and the third player, their performance has far exceeded the highest record, testing the effectiveness of this innovative method of combining mechanical analysis with animation production to assist training. However, competition results are influenced by internal and external factors such as environment and psychology, and athletes usually reduce their speed in order to maintain stable performance, resulting in a decline.

**Table 3.** Comparative analysis of women’s team performance and highest score (s).

Item	2018 National Games	2022 National Games	2023 University Games	2024 Chaodong March 3rd Games	women ‘s team
score	39.67	42.78	45.39	45.70	37.84



**Figure 9.** Comparative of women’s team performance and highest score.

### 4.3.4. Theoretical analysis of reasons for lagging competitive level

The continuous improvement of competitive level is an indispensable condition for promoting the sustainable and healthy development of a sports activity. As an emerging ethnic sport, throwing embroidered balls can promote its rapid popularization and gradually expand beyond its origin to the outside world by improving its competitive level, and even step onto a higher level of international sports stage. The factors that affect the development of competitive level, in addition to technical deficiencies, mainly include the use of balls and referees that directly affect competition results. The balls used in the 2018 Chinese People’s Games were in compliance with the initial rules and regulations (see **Figure 10**). The

embroidered ball is made of silk cloth with a diameter of 5–6 cm, filled with fine sand, weighing 150 g. Five 5 cm long and 0.5 cm wide cloth strips are sewn on the top of the ball as the ball spikes, and a 90 cm long rope is tied to the tail. Three 4 cm long and 0.5 cm wide cloth strips are tied to the end of the rope [16]. In order to enhance the feel and ball sense, the embroidered ball is filled with fine sand in the rubber ball bladder, making it the best embroidered ball in competition production technology and the closest match ball to traditional embroidered balls. Especially the fabric strip of the tail system plays a role in fixing the direction of the tail wing, providing a prerequisite for creating excellent results. The 2022 ball (**Figure 11**) and 2023 ball (**Figure 12**) both use sandbags wrapped in fine sand, and even the tail wing is omitted. This type of embroidered ball is simple to make and cannot guarantee the shape of the ball. The excess part of the outer cloth block will increase the resistance of the ball during the process of circling and flying in the air, becoming one of the important reasons for the decline in performance.



**Figure 10.** 2018 national games.



**Figure 11.** 2018 national games.



**Figure 12.** 2018 national games.

The impact of referee decisions on performance is one of the decisive factors. The women's team of Liuzhou Institute of Technology scored 24 goals in 42.43 s. After watching a video replay on their mobile phone, they were found to have committed a foul by stepping on the line without evidence and were ordered to replay the game against another team, losing and finishing in second place. The other team slowed down their shooting speed without pressure, achieving their lowest championship record in history with a time of 56.75 s. The improvement of refereeing and law enforcement, as well as the support of technology and information technology for competitions, are worth pondering.

## **5. Discussion**

### **5.1. Standardize the use of balls in competitions**

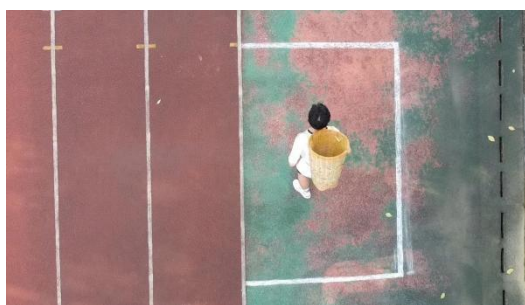
The use of balls in competitions often changes, seriously affecting the continuity of training and competition among teams. Throwing embroidered balls requires high precision in hand movements, and athletes need to have good hand feel. Therefore, in order to adapt to the healthy and sustainable development of the basket throwing embroidered ball competition, it is necessary to constantly summarize experience during the training and competition process, and choose suitable embroidered balls: wrapped in colored cloth, filled with fine sand in the inner rubber bladder, and with a tail fin at the end of the tail rope. From the perspective of sports competitions, using a ball in such games can maintain its shape and help control the direction of flight. The embroidered ball is one of the most important symbols of the Zhuang, carrying cultural connotations such as customs, emotions, and beliefs of the Zhuang ethnic group [17]. From a socio-cultural perspective, this type of embroidered ball production is closer to a scaled down version of traditional embroidered balls, which can maximize the preservation of ethnic cultural elements and contribute to the inheritance of ethnic sports culture.

### **5.2. Information technology assists in referee management**

The referee's decision on whether the receiver stepped on the line has sparked a lot of controversy, affecting the normal progress of the competition. The lack of evidence in manual judgment, the assistance of technological information resources

in judging decisions, and the retention of on-site video and image evidence provide conditions for maintaining judicial fairness.

In the case where flat shooting cannot accurately capture whether the moving target has crossed the boundary, overhead shooting is worth learning from. The application of 3D image reconstruction technology for outdoor scene reconstruction provides good inspiration for drone aerial photography [18]. Compared with traditional shooting methods, drone aerial hovering can observe targets from different angles and save human resources [19]. As shown in **Figure 13**, the real-time recording of the receiving area information is carried out using a drone aerial survey, and the background computer-assisted referee's judgment is synchronously transmitted. Video recording of the movements of the receiving hands and feet, and archiving and storing the information to provide evidence for resolving post match disputes, and promote the standardization and informatization development of competitions [20]. Two line judges are needed to stand diagonally in the receiving area, forming a “L” shape with the receiving area to ensure that they can monitor the two right angled edges. If there is a red card raised by stepping on the line, it is sufficient to check the drone video surveillance for any disputes. Drone aerial photography and information technology applications have effectively reduced the workload of referees and improved their efficiency.



**Figure 13.** Drone overlooking receiving area.

The excellent technique of throwing embroidered balls from the back basket is developing towards the direction of short flat method, but due to the backwardness of technical research, the standards for embroidered balls cannot be unified, and there are disputes in referee enforcement, which hinders the improvement of competitive level. Unifying the use of balls in competitions is conducive to the rapid popularization and promotion of emerging ethnic sports. For traditional ethnic sports that are difficult to master motor skills and form a holistic concept of movement, using mechanical analysis and animation techniques to guide training can significantly improve training results. The use of drone aerial photography can assist in improving referee skills, reducing disputes, promoting the standardized development of ethnic sports, gradually stepping onto the international stage, and innovating and inheriting ethnic sports culture.

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