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Information technology assists in the innovative development of throwing embroidered balls

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This study aims to understand the historical and development of throwing embroidered balls, combine information processing and drone technology to innovate throwing techniques, improve the competitive level and competition rules, promote the high-pole throwing embroidered balls to the international sports. Utilizing literature review method to clarify the evolution history of throwing embroidered balls; using mathematical statistics to analyze the results of competition during the 12th and 13th Guangxi Student Games; Using mechanics analysis and animation production methods innovate throwing techniques. The imperfect competition rules, inconsistent specifications of embroidered balls, and outdated throwing techniques have hindered the healthy development of throwing embroidery ball. The optimal throwing angle range for innovative throwing techniques is between $64° < \alpha < 72°$, with the range of throwing speed being between $13.04\ m/s < v < 13.70\ m/s$. When $\alpha < 66°$, $v \approx 13.70 m/s$, the ball passes through the lower edge of the top of the circle; When $\alpha > 64°$, $v \approx 13.04 m/s$, when $\alpha < 72°$, $v \approx 13.17 m/s$, the ball passes through the upper edge of the bottom of the circle. Drone aerial photography technology can assist judges; using animation production techniques to form throwing motion models to guide training can improve competitive skills. Improving competition rules, unifying the use of competition balls, and strengthening the integration of information technology with ethnic sports can effectively enhance the development level of the sport of throwing embroidered balls.

Keywords High-pole throwing embroidered ball, Throwing techniques, Competition rules, Competitive level

The tradition of embroidered ball culture has endured for nearly 2000 years in Zhuang Township, Guangxi[1,2]. Since the establishment of the Guangxi Zhuang Autonomous Region, it has gradually developed into a popular sport of throwing embroidered balls with high competitive value, and has been rapidly promoted. Recently, the sport of throwing embroidered balls has become the main event of the large-scale sports meet in Guangxi, and the number of participating teams has increased annually. Since the first Guangxi Ethnic Minority Traditional Sports Games in 1982, throwing embroidered balls has been the main competition event and has continued to this day[3]. In the 10th Guangxi Traditional Ethnic Sports Games in 2002, basket throwing of embroidered balls was added as a competition event[4]. With the development of specialization and competition in the sport of throwing embroidered balls, although the original diversified throwing technology theories can meet the requirements of teaching and popularization, the lack of scientific and practical guidance for high-level training competitions. Moreover, the imperfect competition rules, and controversial referees have hindered the development of throwing embroidered balls to a higher level. One of the most effective ways for the development of ethnic sports is to improve the level of competition organization and management, as it is a concentrated reflection of the organizational and management capabilities of ethnic sports[5,6]. The continuous integration of advanced tools and information technology into the field of sports management has become a development trend. For example, civilian drones can shoot sports competitions, performances and other activities, providing valuable materials for later review and analysis (Zhao et al., 2023)[7]. The application of technology and algorithms in sports information management systems helps optimize data information management in this field (Li, & Liu, et

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al., 2024)[8]. Using motion capture technology for deep learning of human movements and expressions, achieving simple design of human motion systems (Wei, 2022)[9]. The integration of modern technological information concepts into ethnic organization management is undoubtedly a new engine for promoting its development. At the same time, it enables ancient ethnic sports to demonstrate new vitality in the new era. This provides scientific method and information technology support for resolving disputes over referee hits and improving embroidered ball throwing technology.

The authors innovatively integrates modern information technology into traditional ethnic sports management: for the first time, unmanned aerial vehicle (UAV) aerial photography technology is used to observe and capture the release state of the throwing ball and the state of the ball flying through the circle from different angles. Using animation technology to create throwing motion models to guide training. These innovative practices provide scientific and information technology support for resolving disputes over referee hits and improving embroidered ball throwing technology. The purpose of this study is to combine information processing and drone technology to innovate the throwing technology of embroidered balls. It holds significant theoretical and practical importance in inheriting ethnic sports culture, promoting the standardization and internationalization, and fostering innovative development in excellent ethnic traditional sports.

The development of throwing embroidered ball

Origin and history culture

There are two main theories about the origin of throwing embroidered balls. One is the weapon theory: the term "Feituo" was initially documented on the Huashan mural in Ningming County, Guangxi, with a history of approximately two thousand years[10]. This type of "Feituo' with a rope tied to its tail was a weapon cast in bronze at the time and was mostly used for combat and hunting. The second is the tool for conveying emotions: embroidered balls are made into embroidered cloth bags by Zhuang girls, and they are thrown together for entertainment. He Weidong (2010) mentioned that during the Chinese New Year in the Song Dynasty, men and women in rural areas were divided into two groups and threw colorful bags containing beans and millet at each other, naming the activity "Feituo"[11]. Consequently, throwing embroidered balls gradually evolved into a popular way for Zhuang young men and women to express their love.

Rise of the sports

Since the establishment of the Guangxi Zhuang Autonomous Region in 1958, ethnic sports have continuously integrated into the development of modern sports, and a group of excellent traditional ethnic sports has gradually transitioned from being primarily mass sports to becoming integral components of school and competitive sports. Subsequently, ethnic sports workers excavated and organized the throwing and receiving of "embroidered balls" and "throwing colored balls," later known as "throwing embroidered balls." In the early 1980s, they excavated and organized the "throwing embroidered balls" sports event, establishing developed relevant competition rules and referee methods[12]. At the Fourth National Ethnic Minority Traditional Sports Games in 1991, the Guangxi Embroidered Team presented this traditional Zhuang event for the first time at a national level event. Currently[13], the sport of throwing embroidered balls has spread to all over the country, reaching countries and regions in Southeast Asia. However, it predominantly remains a form of folk performance and entertainment, with competitive events not attaining a high-level prominence.

There are two forms of throwing embroidered balls: high pole throwing embroidered balls[14] and back basket throwing embroidered balls[15]. This article focuses on the study of high pole embroidered balls. Throwing embroidered balls has become a regular competition in the ethnic and student sports games in Guangxi. In the 11th Guangxi Student Games in 2016, there were 42 participating teams, and in the 12th Guangxi Student Games in 2019, this number increased to 52[16]. The teams were categorized into four groups: middle school, vocational college, regular undergraduate, and professional groups. The competition featured four awards for men's singles, women's singles, and men's and women's teams. Comparing 2019 with 2016, there was a significant improvement in individual and group competitive levels.

Throwing technology theory

In 1986, they officially established the high-pole throwing embroidered ball as a competition event in Guangxi and gradually moved toward standardization[12]. The promotion of the competition was not carried out simultaneously among all age groups until the 11th Guangxi Student Games in 2016. The throwing technology is not yet mature enough and is constantly improving, and the level of competition is on the rise. At present, professional research on the analysis of embroidery ball throwing techniques is very limited, and the most prominent theories as as follows. Early professional research has shown (Chen & Shi, 2010) that in pitching, the trajectory of the embroidery ball movement is curved[17]. Through the mechanical analysis of throwing the embroidery ball, the release angle should be between 45 and 50 degrees. The technique of throwing embroidered balls is divided into three parts: holding embroidered balls, swinging embroidered balls, and throwing embroidered balls. It is required to hold the ball with grace, swing the ball coherently and elegantly, and strive to throw the ball into the goal circle. The research lacks in-depth technical analysis and illustrations. The research on systematic analysis of pitching techniques from a physics perspective is very limited. Yu Xiaoying, Li Fansheng, and Wei Guanghui (2013) mentioned that there are three ways for the embroidered ball to pass through the circle (with figure attached), and the optimal position should be at the midpoint of the throwing control line. The optimal throwing angle for the embroidered ball is $\alpha = 65°$, the optimal initial velocity is $V_0 = 16.3$ m/s (with logical calculations and illustrations attached), reaching the highest point in 1.5 s, and crossing the circle's center[18]. Liu Shanshan (2016) mentioned that when the ball is thrown, it is 2 m above the ground, the optimal throwing angle for the embroidered ball is $\alpha = 65°$, the optimal initial velocity is $V_0 = 16.3$ m/s[19]. Yang Qin (2018) discussed that there are three ways for the embroidered ball to pass through the circle, the release point of the ball is 2 m above the

ground, the optimal throwing angle for the embroidered ball is $\alpha = 65°$, the optimal initial velocity is $V_0 = 16.3$ m/s[20]. The commonality of these representative theories: Highlights that optimal throwing angle is $\alpha = 65°$. The recommended initial velocity is $v_0 = 16.3$ m/s. These throwing technology theories have a good guiding effect on where the ball can smoothly cross the circle and have an important promoting effect on the popularization and teaching of throwing embroidered balls. However, they lack significance for high-level sports training and competition guidance. Presently, there is no training theories on the techniques and tactics of high-pole throwing embroidered ball in China.

These existing theories of throwing techniques have demonstrated the optimal values of multiple unilateral factors for hydrangea passing through the circle, but there is insufficient prediction of the highest point that the ball rises to, the landing point of the ball, and the next release situation, considering the lack of coherence. If these individual factors are comprehensively considered, then the flight trajectory and shooting results of hydrangea are difficult to meet the needs of high-level competitions (Fig. 3). According to the performance evaluation rules, the winner of a high shot embroidered ball is the one with the highest number of hits per unit time. According to the classification of the dominant factors of competitive ability, high shot throwing embroidered belongs to the accuracy category of technical and psychological ability. Classified by action structure[21], it belongs to a fixed combination of multiple action structures and has evident cyclical characteristics. According to the competition rules, to win, it is necessary to complete more shots per unit time and improve the hit rate. This is a sports event that tests the coordination of athletes' psychology, skills, and physical fitness.

Competition rules and main controversies

The current competition rules for high pole embroidered balls are relatively complete, but there are still controversies in some details, mainly manifested in the use of balls in the competition (Fig. 1). The ball used in the 2022 and 2019 student sports games is different. In the 2022 competition, the ball is solid, measuring 5–7 cm in diameter and weighing of 150 g. It is crafted from silk cloth wrapped in fine sand, with a 90-cm long rope tied at the center to serve as the tail wing[22]. In 2019, the use of colloidal inner bladder balls, capable of rebounding on the ground, proved advantageous for athletes in enhancing their competitive skills. The competition embroidered balls were provided by the conference. Currently, there are colored cloth-wrapped fine sand, rubber, and tennis balls filled with fine sand and then wrapped in colored cloth in the market. However, the competition uses "rubber balls or tennis balls filled with fine sand and then wrapped in colored cloth embroidered balls." The requirement for delicate movements in the opponent's body is high in throwing embroidered balls, and many uncertain factors in the ball specifications directly affect the athlete's hand feel and technical performance level. The second is that the control line for pitching is unclear. The starting control line on both sides is 7 m away from the centerline. As the playing field is on grass, the repeated running and stepping of athletes gradually blur the white chalk's pitching control line, posing a potential risk of misjudgment. The third is the determination of scores, which is the focus of disputes and complaints in each competition. The pitch circle is 10 m away from the ground, and the embroidered ball flies faster in the air. When the embroidered ball passes close to the circle, relying on the referee's naked eye judgment is more difficult, resulting in significant controversy over the number of hits. This unresolved issue has affected the normal development of the competition.

Methodology

Research subjects

The present study investigates and compared the results of the high-pole embroidered ball throwing competition during the 12th and 13th Guangxi Student Games and explores the athletes' throwing techniques. The focus is on researching athletes' throwing techniques, therefore the top eight contestants with high shooting accuracy and stable performance are selected. The throwing methods, hit rates, and other indicators related to throwing technology have been included in the research scope, excluding the influence of psychological factors in the competition. Psychological factors can cause significant changes in shooting accuracy during competitions and regular training.

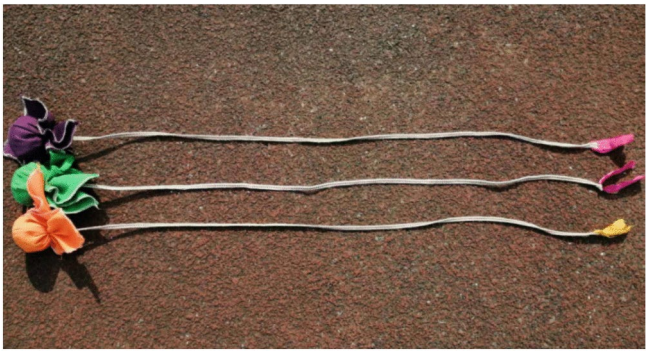

Fig. 1. Embroidered Ball for Competition.

N	Name	Participants	Interference	Throwing method A	Throwing N	Hits N	Hit rate 100%	Primary hits
1	Lu	1	0	13	33	29	87.88	29
2	Yang	3	0	12	31	29	93.55	29
3	He	4	2	25	32	28	87.50	30
4	Chen	5	1	11	31	26	83.87	27
5	Xiong	2	1	10	32	26	81.25	27
6	Liang	3	1	11	28	25	89.29	26
7	Yang	4	2	19	30	25	83.33	27
8	Meng	4	2	16	31	24	77.42	26

Table 1. Analysis of the Results of the Men's High-Pole Embroidered Individual Competition During the 13th Guangxi Student Games (n = 8).

N	Name	Participants	Interference	Throwing method A	Throwing N	Hits N	Hit rate 100%	Primary hits
1	Chen	4	3	27	35	27	77.14	30
2	Mo	5	2	18	34	27	79.41	29
3	Rong	4	2	12	33	26	78.79	28
4	Wu	5	3	12	32	25	78.13	28
5	Chenpeng	5	2	10	32	24	75.00	26
6	Li	4	2	23	33	24	72.73	26
7	Lu	5	1	14	31	24	77.42	25
8	Bai	5	2	10	30	23	76.67	25

Table 2. Analysis of the Results of the High-Pole Embroidered Men's Individual Tournament During the 12th Guangxi Student Games (n = 8).

Item	Mean value	Interference	Throwing N	Hits N	Hit rate 100%	Primary hits
13th	3.25 ± 1.28	1.13 ± 0.83	31 ± 1.51	26.50 ± 1.93	85.51 ± 5.06	27.63 ± 1.51
12th	4.63 ± 0.52	2.13 ± 0.64	32.5 ± 1.60	25.00 ± 1.51	76.91 ± 2.16	27.13 ± 1.89
Mean Difference	−1.38	−1.00	−1.50	1.50	8.60	0.50
P-value	0.054	0.018	0.075	0.105	0.000586	0.567

Table 3. Comparative Analysis of Competition Results in Two Sports Games (n = 63).

Research methods

Literature review method: Collect and organize the origin and evolution history of embroidered ball culture, as well as the origin and development process of throwing embroidered ball sports, through channels such as CNKI, ancient book library, local chronicles of Ningming County, Guangxi, and interviews with the Sports Bureau. Collect the results of the high-pole embroidered ball throwing competition during the 12th and 13th Guangxi Student Games and examine the athletes' throwing techniques and competition rules.

Mathematical statistics method:

Based on the winning factor structure of the item group theory, SPSS 26.0 software was used to collect data on the number of concurrent participants, interference balls, throwing methods, shots, and hits from the teams of the top 8 individual high pole throwing ball players in two sports games using t-test. The hit rates and recovery hit rates were calculated, as shown in Tables 1 and 2.

SPSS statistical software t-test selects a significance level of 5% (i.e. 0.05) to determine whether the observed effects are significant enough. The mean ± standard deviation of each indicator in the two data sets is compared for mean deviation and significance difference between groups, as shown in Table 3. Analyze the impact of factors such as shooting techniques and tactics on competition results under existing competition rules and referee conditions.

Research process and strategies diagram

Integrating the enterprise management model framework into the practice of ethnic sports management. Based on the requirements of modern development of ethnic sports, in-depth research is conducted on two management (throwing techniques and competition management) objectives from three approaches: existing throwing techniques, innovative throwing techniques, and innovative methods and approaches (see Fig. 2). Analyze the existing problems in throwing technology theory and competition rules, and determine the goals of reform and innovation. Innovate throwing methods through comparative analysis of competition results.

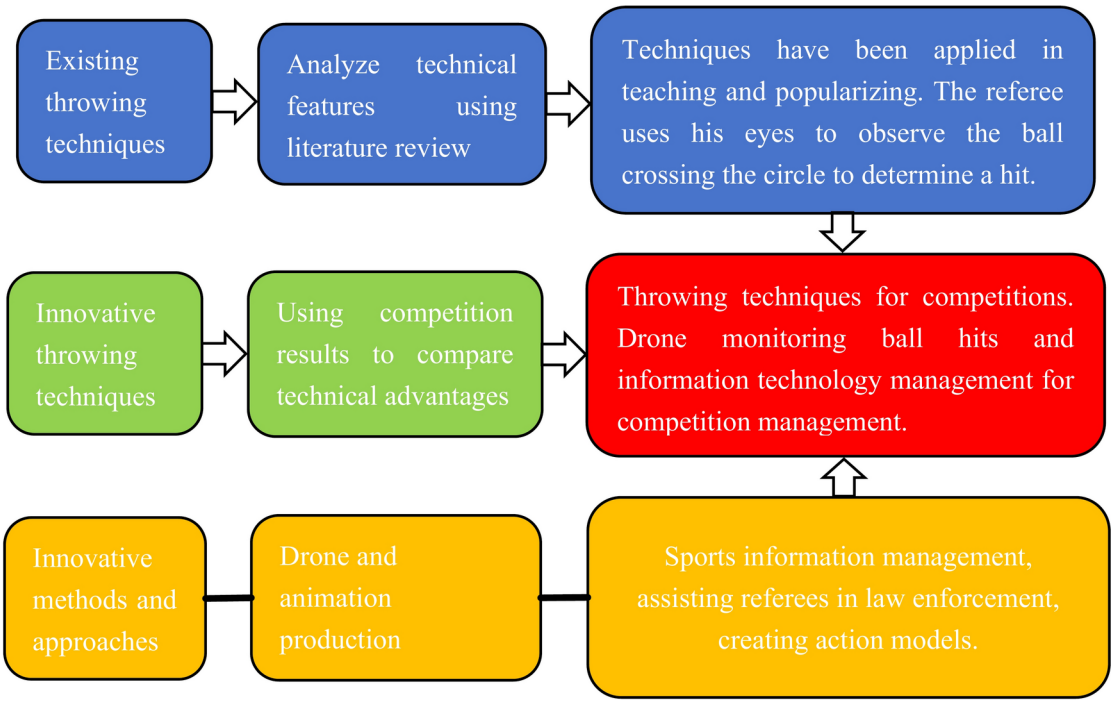

Fig. 2. Research methods and processes: Three pathways and two management objectives.

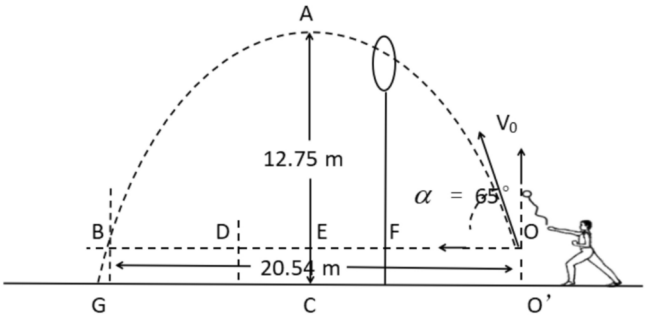

Fig. 3. Optimal Throwing Angle and Velocity Matching of Existing Theories.

The application of drone aerial photography to monitor the hit of the ball improves the referee's level. Using animation to create action models to improve throwing techniques and enhance the overall competitive level of the sport.

Analysis and results

Theoretical analysis of existing throwing techniques

Flight trajectory analysis of existing throwing technologies

(1) The height of the arc at the highest point A of the ball's flight and the distance OB between the starting point O and the symmetry point B:

By substituting the data from the representative theory, such as the optimal throwing angle and initial velocity at a height of 2 m above the ground, into the formula: $h = v_0 \sin 65° \, t - 1/2gt^2 = 16.3 \times \mathrm{Sin}65° \times 1.5 - 1/2g1.5^2 = 10.75$ m, the ball is released from point O at a height of 2 m from the ground. When the ball flies to the highest point A, the distance from OB is AE = 10.75 m, and the distance from the ground is AC of 10.75 + 2 = 12.75 m. The air resistance is ignored, and the upward and downward trajectories of the throwing parabola are symmetrical about the axis AE (Fig. 3). When the ball falls to point B 2 m above the ground, it forms a symmetrical arc trajectory with AE as the central axis with the shooting point O.

$X = v_0 \cos 65° \, 2t = 16.3 \times 0.42 \times 3 = 20.54$ m, which means that with the optimal release angle and speed, the ball passes through the center of the circle and continues to fly until it reaches the arc top A at a distance of 12.75 m

from the ground before falling. The horizontal distance OB between the symmetrical point B at a height of 2 m from the ground and the throwing point is 20.54 m.

(2) The horizontal distance GC between the ball's landing point G and the symmetric midpoint C, as well as the total horizontal displacement length GO' of the ball, can be calculated as follows:

$X = v_0\cos65°t$, t is the time for 12.75 m to fall, $H = 1/2gt^2$, $t = \sqrt{2H/g} = \sqrt{25.5/g} \approx 1.60$ s.

$GC = v_0\cos65°t = 16.3 \times 0.42 \times 1.60 = 10.95$ m. The horizontal distance GO' between the landing point G and the starting point O is the following: GO' = 10.95 + 20.54/2 = 21.22 m.

The theoretical calculation results of this representative shooting technology result in an increase in throwing height, landing time, horizontal displacement, and the entire throwing cycle, which is not conducive to creating excellent results.

Analysis from the perspective of competition rules

Athletes can score by throwing the embroidered ball over the pitching circle within the designated time. After each pitch, they must run to the opposite pitching area to pick up their ball and continue pitching the circle. The center circle earns 1 point at a time. In this way, they can repeatedly throw the ball on the control line of two pitches. Within the designated time, the number of hits determines the outcome of the game. Figure 2 depicts that, when pitching from point O to point G to pick up the ball, the distance from point D, which is 7 m away from the pole, is 21.22−14 = 7.22 m more. For games that win by running back and forth in the shortest possible time, it is necessary to increase the distance of 7.22 m each time to pick up the ball for a turn back run, which prolongs the pitching time and consumes more physical energy.

The main mistake in the above calculations is that they did not consider the maximum height that the ball can reach while passing through the center of the circle and did not analyze the vertical vector $v_0\sin\alpha$ of v_0 and the throw angle α, which are the synergies between these two factors. Take the formula $h = v_0^2/2g$ for the maximum height reached and the minimum release speed as an example. Substitute the minimum release speed $v_0 = 14.3$ m/s[10], and the maximum height of ascent is as follows: $h = v_0^2/2g = (14.3 \times \mathrm{Sin}65°)^2/2g = 8.28$ m. Even if the ball passes through the circle at 7.5 m from the center, it must continue to rise 8.28–7.5 = 0.78 m and then fall, taking longer time and increasing horizontal displacement. The existing representative theories lack practicality in competitions and do not comprehensively consider the arc height of the ball's flight, the distance between the landing point and the pitching point, and the distance between the ball's return and the throwing line after picking it up. Therefore, the results obtained with the optimal angle and speed of the shot are not ideal. In addition, the range of optimal throw angle α, velocity v_0 range, and their matching have not been demonstrated. In the competition, some athletes throw the ball far away from the control line of the opposite pitcher, and their training level must be improved.

Research and practice innovation of high-pole embroidered ball throwing technology

Setting of conditions for throwing embroidered balls

The athlete stands at a centerline 7 m away from the pole, with the longitudinal plane formed by the ball throwing facing the axis of the pole. The air resistance is ignored, and the ball is regarded as a particle, and the circle is regarded as a coil without thickness. The game is won by running back and forth in the shortest possible time to hit the ball. According to the principle of parabolic symmetry, the height h of the ball's flying arc should not be too high, and the flying distance x should not exceed 14 m. An increase in vertical displacement h means more time consuming. The increase in horizontal displacement x means an increase in running distance, which consumes more energy and time. Therefore, the arc top of the optimal projectile trajectory should not exceed circles. Assuming that the highest point A of the pitch is 10 m from the ground, throw the ball from point O at the maximum angle of release to point A at a height of 10 m from the horizontal and pass through the inner lower edge of the circle, which is the combination of the highest angle of release and a certain speed. AB is the safe range for throwing the upper edge (Fig. 4), and the landing point is close to the opposite side of the pole, which is beneficial for saving time and energy. When throwing the ball at the minimum angle of release to the lower edge of the circle at a distance of 9 m from the horizontal, it involves a balance between the minimum speed and the angle of release. This results in the shortest flight time and throwing cycle, which is beneficial for improving performance, albeit at the cost of considerable physical energy expenditure.

Analysis of three situations where the ball passes through the circle

When the highest point of the ball passes through point C on the lower edge of the circle at a height of 9 m from the horizontal

$$\text{Horizontal displacement}: \ x = v_0\cos\alpha t \tag{1}$$

∵ The time for vertical displacement h to reach the lower edge of the circle and horizontal displacement 7 m is the same.

$$\because \ H = (9-2) = 1/2gt^2, \ \text{obtain} \ t = \sqrt{14/g}, \tag{2}$$

obtain: $v_0\cos\alpha = 7/\sqrt{14/g}$

$$\text{Vertical displacement}: \ h = v_0\sin\alpha\, t - 1/2gt^2, \ \text{obtain}: \ v_0\sin\alpha = \left(h + 1/2gt^2\right)/t = 14/\sqrt{14/g} \tag{3}$$

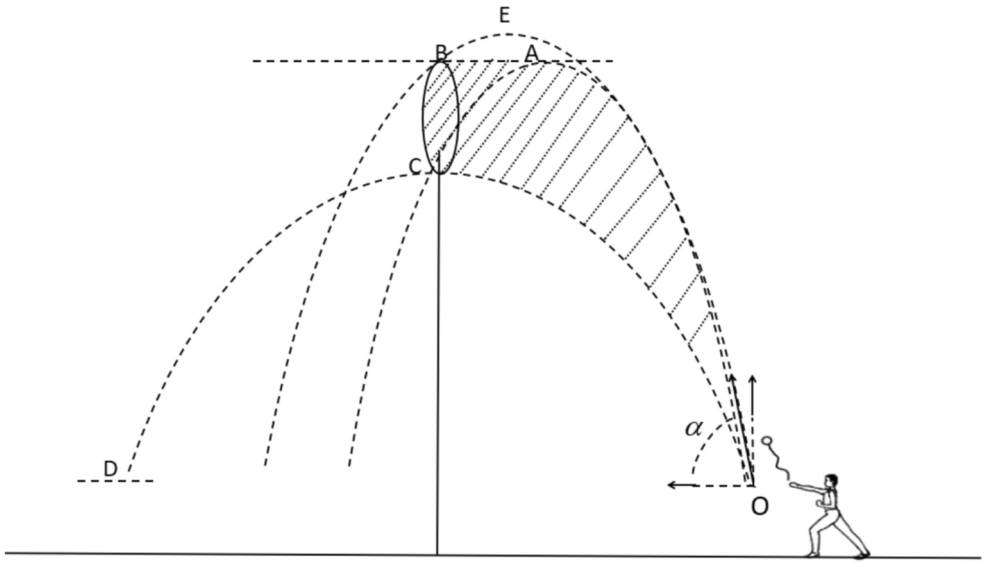

Fig. 4. Matching Diagram of the Best throwing Angle and Speed in Practice.

Equations (1), (2), and (3): $v_0\sin\alpha/v_0\cos\alpha = \tan\alpha = 2$, obtain ≈ 64°,

$V_0\sin\alpha = gt$, obtain $v_0 \approx 13.04$ m/s.

When the highest point of the ball passes through point B on the inner edge of the circle at a height of 10 m from the horizontal

$H = 8$, $t = \sqrt{16/g}$, horizontal displacement remains unchanged, vertical displacement: $v_1\sin\alpha_1 = (h + 1/2gt^2)/t = 16/\sqrt{16/g}$.

Similarly, $v_1\sin\alpha_1/v_1\cos\alpha_1 = \tan\alpha_1 = 16/7$, obtain $\alpha_1 \approx 66°$, $v_1 \approx 13.70$ m/s.

When the ball passes through point A at a height of 10 m from the horizontal and passes through point C on the inner lower edge of the circle

$H = 7$ m, $t_2 = (t + t_3)$ The sum of the time from rising 8 m to point A and falling 1 m to point C, then $t_2 = \left(\sqrt{16/g} + \sqrt{2/g}\right)$

$$\text{Horizontal displacement}: \ 7 = v_2\cos\alpha_2 t_2, \ \text{then } v_2\cos\alpha_2 = 7\Big/\left(\sqrt{16/g} + \sqrt{2/g}\right) \tag{4}$$

Vertical displacement to point A: $8 = v_2\sin\alpha_2 t - 1/2gt^2$, then $v_2\sin\alpha_2 = 8 + 1/2gt^2$,

$$\text{Substituting } t = \sqrt{16/g} \text{ in yields}: \ v_2\sin\alpha_2 = 16/\sqrt{16/g} \tag{5}$$

Equations (4) and (5): $v_2\sin\alpha_2/v_2\cos\alpha_2 = \tan\alpha_2 = \dfrac{16/\sqrt{16/g}}{7/\left(\sqrt{16/g}+\sqrt{2/g}\right)} = 3.09$,

Calculate: $\alpha_2 \approx 72°$, $v_2 \approx 13.17$ m/s, and substitute it into Eq. (4) to calculate the distance $AB = 7\text{-}v_2\cos\alpha_2 t$ from the upper edge B point of the circle when the ball reaches the highest point A, which is obtained from Eq. (5): $v_2 = 16/\sqrt{16/g}\sin\alpha_2$, $AB = 7 - 16\cos\alpha_2/\sin\alpha_2 \approx 1.80$ m.

Analysis of the top eight shooting techniques in competition results

Explanation of table content: Primary Hits = Hits + Interference Balls, reflecting the true competitive level excluding objective influences. Interference ball refers to a ball that is flying close to the circle and has a clear tendency to enter the circle but is hit by another ball and cannot score a goal. The maximum number of players playing at the same time is five, with each player playing accounting for 20%.

Based on the results of preliminary experimental observations, a two sample t-test was used to calculate the sample size formula. The effect size d was set to 0.49, the significance level was set to 0.05, and the test power was set to 0.8. The R language PWR package was used to calculate the sample size for each group, which was 40 cases. In individual matches, any number of players up to 5 can play simultaneously. During the process of collecting data, some athletes may not play due to tactical needs or leave the field before the end of the game, providing a smooth competition environment for other team members to create better results. Therefore, the data on the number of participants is based on the players who have completed the game from start to finish.

From the comparison between the results in Tables 1, 2 and 3 it can be seen hat the number of participants in the individual matches of the 13th Student Games has significantly decreased compared with the 12th. The mutual interference between our team members has been greatly reduced, resulting in a significant decrease in

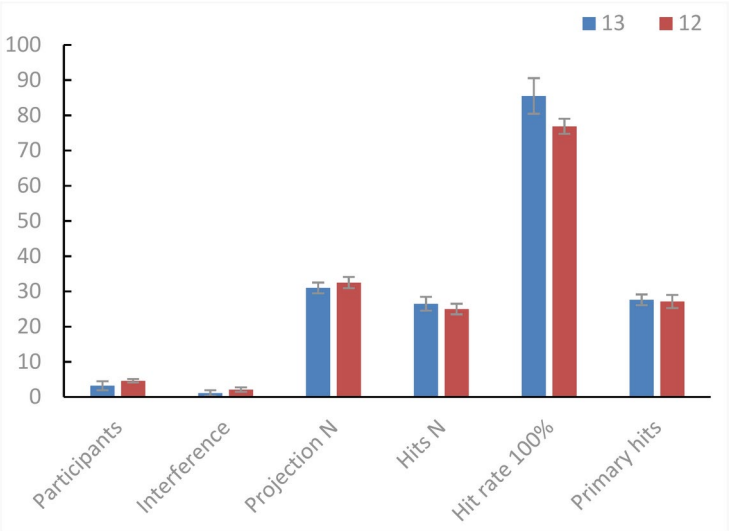

Fig. 5. Comparative Analysis of Competition Results in Two Games.

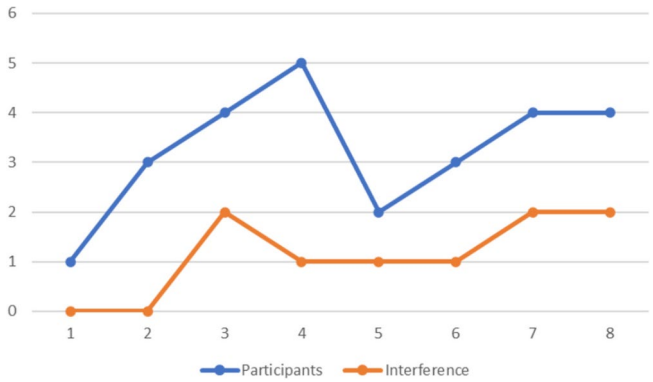

Fig. 6. Relationship Between the Players and the Interfering Balls in the 13th Games.

interference balls compared with the 12th round (Table 3, $P<0.05$). The number of hits has increased, but the number of shots has slightly decreased. The number of athletes in the 13th edition using the Type A throwing method increased, significantly increasing their hit rate compared with the 12th edition (Table 3, $P<0.05$). Judging from the mean ± standard deviation in Table 3, the overall number of players and interfering balls in the 13th edition of the sports team is small and polarized, with a significant differentiation in the number of hits. The overall number of players and interference balls in the 12th edition was large and uniform, resulting in the highest and average overall hit counts being weaker than those in the 13th edition, but the difference in recovery hit counts between the two editions was insignificant. Figure 4 illustrates that the skills of the 12th generation of athletes are not mature, relying on a high number of shots to compensate for interfering balls and mistakes. Although the shooting rate is low, their actual competitive ability is strong. The 13th edition reduced the number of players and shots, improved the shooting percentage, and thus achieved better results.

From a tactical perspective, almost all members of the 12th individual sports team competed for more positions, but the actual results were not ideal due to more mutual interference. There were significant differences in the tactical choices of the 13th sports team (Figs. 5 and 6). The first place only had one player playing, without any interference from the team members, and they achieved the championship by playing their full competitive skills. The second-place team comprises three players, who cooperate well and do not interfere with the ball. However, mutual obstruction objectively exists. The champion with a number of shots of 31 < 33 has a slightly lower competitive potential. Although they both hit 29 in the 3 min, they were defeated by the champion 9/11 in 1-min extra time on 8/10 (taking 10 shots and scoring 8).

Comparative analysis of two shooting techniques

From the scene of the competition, it was observed that the champion played with only one person, without interfering with the ball. His competitive ability was 100% utilized using the B-type throwing method (Fig. 7), and his landing point was far away. Although he ran fast, the distance of the turn back run increased. It was only with strong physical fitness and stable technology that he won the championship 29/33. The third-place player

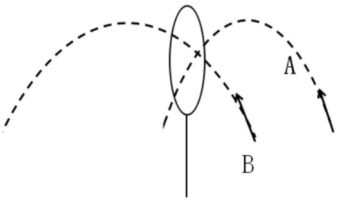

Fig. 7. Two Representative Throwing Methods.

Ranking/casting Method/name/hit/shot	Throwing method A 100%	Participants 100%	Interference	Exercising competitive ability 100%	Hit rate 100%	Primary hits rate 100%
1/B/ Lu/29/33	39.39	20.00	0	100	87.88	87.88
3/A/ He/28/32	78.13	80.00	2	93.75	87.50	93.75

Table 4. Comparison of the Best A and B throwing Methods in the 13th Games (n = 65).

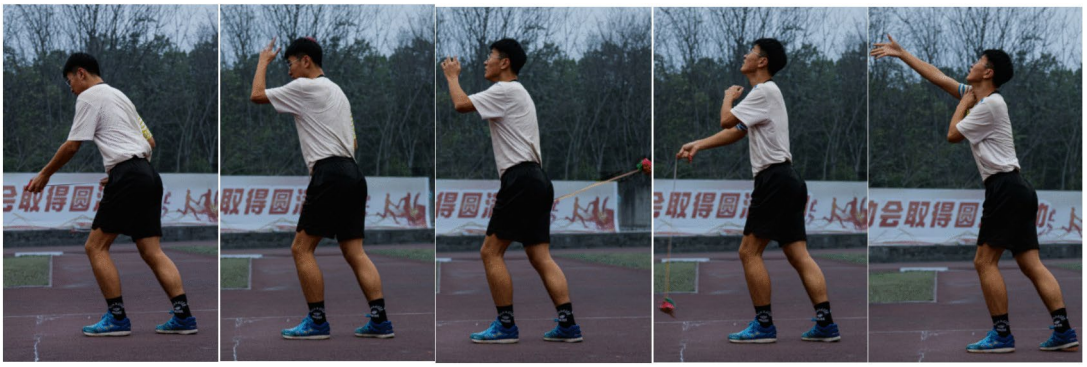

Fig. 8. Prototype capture of throwing technique movements.

adopts the A-type throwing method, with average speed and smooth movements. The ball mostly falls within the throwing control line with a shorter running distance and throwing period compared with the champion. However, their competitive ability is only 93.75%, and their shooting rate is 87.50% < 87.88% compared with the champion, resulting in a 28/32 loss (Table 4). From Table 1, it can be seen that the number of recovery hits and the recovery hit rate are as follows: 30 > 29, 93.75% > 87.88%, respectively, compared with the champions in the third place, reflecting that the true competitive ability of the third place is stronger. The reason is that the third-place player used the Type A throwing method, although it shortened the throwing cycle and reduced the physical energy consumption, made a tactical mistake by arranging four players to play, reducing the number of blocked shots to 32, and interfering with the ball by 2. Consequently, their true competitive ability could not be fully utilized, resulting in a defeat.

Using animation to create a throwing action model

Using Flash software for 2D animation production, perfectly expressing the laws of ethnic sports with Chinese style and showcasing the charm of ethnic sports[23]. This study utilizes animation to showcase the functionality of throwing actions, optimizing and processing the correct throwing action prototypes to guide training in shaping throwing actions and improving competitive skills. The first step is motion capture. Screen throwing techniques with high success rates and use cameras to capture the correct throwing action prototypes as drawing materials (As shown in Fig. 8). Step two, refinement and hierarchical processing. Decompose the throwing action prototype technically, open Photoshop software, create a new canvas (1920 × 1080 pixels), and draw static images of athletes, tall poles, and embroidered balls in layers for layering processing. The third step is to improve and output. Import Live2D software, combine keyframes of athlete movements, and achieve dynamic effects of athlete movements through bone binding. Adjust and optimize the animation effects to ensure the harmony and unity of the embroidery ball flight trajectory and athlete movements, and output the completed animation file (As shown in Fig. 9).

Research on competition rules and approaches

Ethnic sports contain rich ethnic cultural genes from the field, and sound competition and judgment rules are the foundation and important guarantee for the competitive development of ethnic sports. They are of great

Fig. 9. Screenshots created using Live2D animation.

significance for the popularization range and survival and development space of sports projects, as well as the improvement of competitive and event promotion levels. They are an important component of the cultural power strategy.

Standardize venue equipment

Drawing inspiration from international sports such as basketball and football, uniform specifications and standards are implemented for venue equipment. Replacing the grassland with a hardened surface and marking fixed lines help prevent misjudgment and are also conducive to regular indoor play on rainy days. Unified ball specifications and standards for competition are related to the improvement of competitive levels. From the use of balls in the two student sports games, it can be seen that the highest and average number of shots of the 12th generation athletes is significantly higher than that of the 13th generation athletes (Tables 1 and 2). The 12th generation athletes can catch the rebound of the colloidal ball while running, making the competition more technical and enjoyable, which is conducive to the development of their competitive abilities. The 13th generation athletes use solid sandbags, and the ball does not rebound and deforms when it lands. Every time they need to squat on the ground to pick up the ball, it is easy to damage their knees, disrupt the continuity of running, and not conducive to improving their athletic level.

Technological innovation enhances the level of competition judges

Integrating technological innovation and information technology elements into the management practice of competition referees addresses the issue of disputes over hit count determination that has hindered the healthy development of competitions for many years. While economically and efficiently resolving grassroots competition disputes, promoting competition promotion, and improving the level of grassroots competition management, it provides feasible references for promoting the development of competitions to a higher level.

On the one hand, during the process of throwing hydrangea, the trajectory formed by the flight of the hydrangea in visual space belongs to a longitudinal plane movement for athletes, and it is difficult to form intuitive judgments on the core elements of throwing, such as the angle, height, and speed of the shot. Leveraging drone aerial photography technology allows for the observation of the release status of throwing embroidered balls from different perspectives, including side and top views. The use of drone aerial photography technology to capture the state of moving objects, transmit and store information, provides strong support for later information resource management, and plays an important role in promoting the high-level development of ethnic sports[24]. This technology also captures the flight trajectory of embroidered balls in the air and the running trajectory of athletes, facilitating the ongoing refinement of technical movements and the enhancement of competitive levels.

With the help of applying information technology management concepts, innovate information management methods. Real time transmission of drone aerial photography information to the backend computer for observation, encoding and storing the order and time of file names. The on-site referee will announce the number of hits after the game, and those who have objections will immediately retrieve the game video information file for verification.

Meanwhile, drone aerial photography technology is used to clearly record the situation of the embroidered ball passing through the circle, solving the dispute that judges rely on the naked eye to determine whether the ball has hit. At the same time, video data is transmitted to designated competition platforms through the Internet to form information sharing and storage, providing scientific and technological information support for the standardized development of the embroidered ball sport.

One minute before the competition, the drone hovered in the air at a height of 10 m, forming a 45° angle with the circle plane for aerial photography (Fig. 10). When the athlete is preparing to hold the ball, they take a photo of the athlete as a background (Fig. 11), then switch to the circle, and start the game. Record a video of the embroidered ball passing through the circle (Fig. 12) to ensure that individuals responsible for the position and the ball's passage through the circle remain consistent. After the game is over, the number is saved, and the Internet can be used to assist the referee in accurately determining the number of hits. These videos are stored in the school competition archives and can be replayed and reviewed in case of disputes, effectively resolving

Fig. 10. Drone Aerial Photography Assisted Judgment.

Fig. 11. Athlete Position.

hitting disputes in grassroots competitions (Fig. 13). The application of information technology management efficiently processes and saves competition video information, quickly communicates information between the backend and on-site, and saves time and resources. This plays an important role in promoting the healthy development and promotion of ethnic sports events.

Discussion

The existing representative throwing methods focus on the optimal throwing point, theoretically obtaining the optimal throwing angle and throwing speed. The innovative throwing method emphasizes an effective projection range, greatly improving the hit rate in practical applications. To achieve excellent results, the principle is to use the A-type throwing method. The ball passes through the circle during its descent from the highest point. According to the principle of parabolic symmetry, the landing point of the ball should not exceed the opposite throwing line and should be within 14 m. Athletes can catch the ball by running a shorter distance after pitching, giving them ample time to judge the drop and saving physical energy, which is beneficial for maintaining smooth and stable movement.

5.1 When the highest point of the ball passes through the lower edge of the circle, the release angle is the lowest, at 64°, and the release speed is also the lowest, $v \approx 13.04$ m/s. Therefore, the release angle should be higher rather than lower, as it is impossible to score below 64°, and a higher angle can also enter the circle during the descent process. This combination of projection angle and speed has the shortest exercise cycle but has the highest exercise intensity and maximum physical exertion.

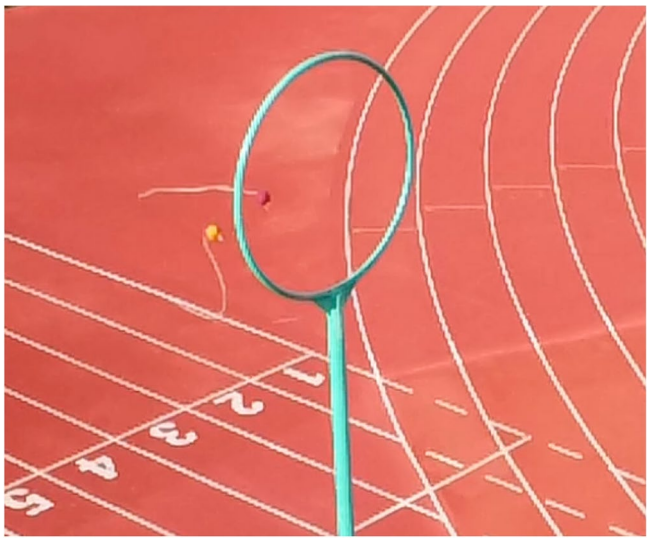

Fig. 12. Drone aerial photography hits.

Fig. 13. UAV Assistance for School Games.

5.2 When the arc top of the ball is 10 m and falls through the inner lower edge of the circle, the arc top is 1.80 m away from the top of the circle, and the maximum angle of release is 72°. When the speed is constant, the ball cannot enter the circle beyond this angle. The release speed is 13.17 m/s, below which the ball cannot pass through the circle. When the shooting angle is 66°, the maximum value of v ≈ 13.70 m/s is taken as the boundary, when reaching 64°, the projection speed v gradually decreases to 13.04 m/s. Up to 72°, the projection velocity v gradually decreases to 13.17 m/s. Therefore, at the maximum release angle, the release speed should be large rather than small, and at the maximum release speed, the release angle should be small rather than large.

Conclusion

Inheriting ethnic sports culture

By comparing competition results, analyzing previous theories of throwing techniques, innovating the theory of throwing embroidered balls, and providing theoretical support for promoting the high-level development of this sport. Applying modern science and information technology management theories to ethnic sports practice, in order to improve the level of competition referee management, and thus improve the organizational management theory of ethnic sports competitions. Developing ethnic sports and inheriting ethnic sports culture. Ethnic sports originate from the social life accumulated in history, evolving into social activities that hold not only physical exercise value but also carry the essence and significance of a cultural identity. They serve as a means to strengthen ethnic identity, enhance ethnic confidence, and inherit ethnic cultural spirit. By tapping into the wealth of ethnic cultural elements, there is an opportunity to expand the ideological and political education path of family, country, and national sentiment and integrate it into the cultural power strategy. Relying on the

teaching and research resources of universities, promoting the popularization and improvement of ethnic sports, building ethnic sports cultural bases, and providing new impetus for the inheritance of ethnic sports culture[25].

Improve athletic level

The research has improved the competitive level of high pole throwing embroidered balls through technological innovation and development. Individual matches require no more than three players to play simultaneously. This will organically combine positional competition, reduce interference, fully utilize each other's competitive abilities, and improve the tactical level of this sport. The A-type throwing method is better for shooting. The range of release angle is between $64° < \alpha < 72°$, and the range of release speed is between $13.04\ m/s < V_0 < 13.70\ m/s$. When the highest point of the ball passes through the lower edge of the circle, the release angle is the lowest, at 64°, and the release speed is also the lowest, $v \approx 13.04$ m/s. The ball's flight trajectory is within the safe area of the shaded area formed by OABC (Fig. 4) greatly increasing the hit range, and improving the training competition ability. The innovative application of drone aerial photography technology and information technology management in competitions. It solves the dispute over referee accuracy, saves manpower and time resources, greatly improves the efficiency of ethnic sports competition management, and promotes the high-level development and large-scale promotion of this ethnic sports sport[26].

Unified equipment and standardized development

High pole throwing embroidered ball is an emerging ethnic sports project, and there is limited research on throwing technology, which hinders the high-level development of this sport. Innovative throwing techniques and theories still need to be constantly tested through teaching and competition. There is not much practice in improving the level of ethnic sports management through modern information technology. Disputes over competition rules and referees have not been effectively resolved, making it difficult to develop on the international sports stage. Improve the quality of competition venues and standardize competition venue equipment. Unifying the standards and procurement sources for the balls used in the competition. Preserve ethnic cultural genetic elements, and get rid of the rural flavor. For example, abandoning the deformed sandbag and returning to the ball shaped embroidered ball wrapped in silk fabric. Improve competition rules; introduce drone Internet information and information technology project management to assist referees in improving accuracy of hit and penalty decisions; improve the level of referees' law enforcement to reduce disputes; maintain fairness and impartiality of the competition; promote high pole embroidered competitions to go beyond ethnic regions; develop to higher levels and levels; take a standardized and international path; and create conditions for the innovation and inheritance of excellent ethnic sports.

Data availability

The datasets generated and/or analysed during the current study are not publicly available due [https://pan.baidu.com/s/1zDPdYDppVHZPTeHms2eTkQ?pwd=tpi5] but are available from the corresponding author on reasonable request. All data generated or analysed during this study are included in this published article.

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Author contributions
This study is an original work. Shijun Xu: Original manuscript; Yu Wei: Treatment plan design and investigation; Qingbin Sun: Survey and result analysis; Yu Wei and Cong Zeng: Collect data and conduct investigations; Ling Li and Cong Zeng: Checks and verifies; Fanhui Xu: Animation model design.

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Declarations

Competing interest
The authors declare no competing interests.

Ethical approval
All methods were carried out in accordance with relevant guidelines and regulations. All experimental protocols were approved by Licensing Committee of Liuzhou Institute of Technology.

Informed consent
Informed consent was obtained from all subjects and/or their legal guardian(s). All subjects and/or their legal guardians give informed consent to the publication of identification information/images in online open access publications.

Consent for publication
This study has obtained publication consent from all authors.

Additional information
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