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The influence of the sports aerobics C477 jump and the "Thomas" right full swivel toward balance

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ABSTRACT

In sports aerobics, jump and swivel restrict a player's perfect performance, of which balance is the guarantee during the whole process. The essay if focus on analyzing the sports aerobics C477 jump and the "Thomas" right full swivel, gaining the scientific index of biomechanics to make contribution of it and provide feasible advice on how to improve the sports aerobics jump and the swivel skill.

KEYWORDS

Sports aerobics;
Index of biomechanics;
Quiet balance;
Intersection angle;
Range;
Theorem.

FOREWORD

Sport aerobics is a sport of great performativity. A great many jumping and swiveling which mainly restrict the beauty and difficulty of sports aerobics are added into it to show the combination of body and physical culture. So we make an analysis of the above two skills for scientific advice of improvement.

The researchers have been working hard on the sports aerobics jump, swivel and the body balance. Liu Hong (2013) make a kinematics analysis on the turn 180°, Figureked jump and then turn 180°to be push-up C477.

Lijianmin (2009) makes an AMIT biomechanics force plate on the quiet balance testing of the good players and searches the index value features of quiet balance for better improvement of balance. With Allier System, Lixulong (2010) make a mechanics analysis on the Thomas flank circle, and then get the sport biomechanics index with which the method of improving skills is put forward.

On the basis of the former research, the essay analyzes the balance ability of sports aerobics, jumping skill and the swivel to explore the features of improving the sports aerobics skill and make a theory for the development of sports aerobics.

ANALYSIS ON THE JUMPING AND SWIVEL OF SPORTS AEROBICS

Sports aerobics mainly includes walk, jump. Swivel and the coordination of the other part of body, of which jump and swivel presents the difficulty most. Balance ability is the basis of ensuring the above skills. The essay shows a method of testing the player's quiet balance ability and analyzes the jumping and swivel of sports aerobics to study a kind of ability and two skills by scientific biomechanics index and theory, with the purpose of providing reasonable advice for the players.

Testing and analyzing the player's quiet balance ability.

In sports aerobics, the balance of a player is the

guarantee of perfectly finishing the skillful movements, so the testing and evaluation of a player's balance ability is a vey important index. To show the balance, the chapter states a method of testing the player's quiet balance ability.

1) The testing index of quiet balance ability is as follows:
2) Length of the gravity core's swing track
3) 95%EA of the size formed by the swing track and the outside oval size average velocity of leg
4) Swing diameter of legÿDx, Dy ÿand the displacement distance(X, Y)
5) The minimum displacement of the two axis (Xmin, Ymin) and the maximum displacement (Xmax, Ymax);
6) The track length of the gravity core on the two axes(DX, DY);
7) The track length of unit aera (Lng/A).

The swing length of gravity core can reflect the whole distance of the body's gravity core within the testing cycle. The high value shows that the gravity core deviate the center more. 95%EA can reflect the walking area when a body's shaking. The large the value, the lower balance ability a player has. Lng/A equals to the gravity core swing divide by envelope size which can show the balance stability and the ability to adjust posture. The larger the value is the stronger ability of adjustment a player has. Avg.v can reflect the balance ability and the adjustability, the lager it is, the lower ability a player has.

Direction expression of the body gravity core's shaking with one foot standing quietly can be presented by the change features of Dx, Dy, Xmin, Ymin, Xmax and Ymax.

Dy, Ymin 和 Ymax shows the displacement of the testing player gravity in direction Y, which can reflect the player deviation on Y axis.

The AMTI biomechanics force plate system is used to test the player's quiet balance ability. Close the eyes and stand with one foot, you can get the discrepancy of the testing index of the above seven quiet balance ability.

We can see from TABLE 1 that the obvious discrepancy only exists in the length among all the quiet balance ability index of the two group players. The first class is absolutely lower than the second class. The radial displacement on axis X and Y of the two groups' players' left leg is large. The index for the balance of the left leg is normal while the Ymax of the right leg under level 0.001 differs a lot. And there is an obvious discrepancy of Xmin0Ymin and Dy under the level of 0.05. So we can see that the displacement on Y axis of the second class players is bigger than that of the first class players, it's also with less balance than the first class players.

We can improve the balance-control ability of the body and extensors muscles of the leg to improve the player's quiet balance ability. And then take more stable

TABLE 1 : Result of the quiet balance ability testing for two different players based on AMTI biomechanics force plate system

Balance ability	$\overline{X} \pm S$			$\overline{X} \pm S$		
	First class (left leg)	Second class (left leg)	*P*	First class (right leg)	Second class (right leg)	*P*
Lng	183.0 ± 18.2	210.8 ± 31.6	0.048	169.1 ± 21.4	218.6 ± 54.1	0.009
Avg.v	9.10 ± 0.88	10.08 ± 0.89	0.061	8.54 ± 1.18	10.40 ± 0.92	0.053
95%EA	4.31 ± 1.51	4.35 ± 1.52	0.954	5.49 ± 1.42	5.66 ± 1.59	0.825
Lng/A	46.2 ± 12.14	50.3 ± 17.3	0.268	32.09 ± 6.07	33.25 ± 2.08	0.622
Xmin	-0.96 ± 0.20	-0.45 ± 0.75	0.099	-0.60 ± 0.68	-1.23 ± 0.12	0.038
Ymin	0.92 ± 0.07	1.22 ± 0.51	0.133	1.62 ± 0.47	1.48 ± 0.43	0.577
Dx	1.87 ± 0.23	1.97 ± 1.20	0.614	2.22 ± 0.72	2.51 ± 0.50	0.401
Ymin	-1.40 ± 0.27	-1.26 ± 0.12	0.203	-1.19 ± 0.32	-1.76 ± 0.32	0.045
Ymax	1.45 ± 0.32	1.58 ± 0.72	0.626	0.99 ± 0.45	1.87 ± 0.55	0.007
Dy	2.86 ± 0.56	2.84 ± 0.74	0.961	2.18 ± 0.75	3.70 ± 0.78	0.028

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training on the X axis of both of the player's feet to unbalance and obvious swing.

Analysis on the jump of sports aerobics

The key points of sports aerobics can be divided into three steps: the Taking off, soaring and landing. Next we will focus on the features of the three steps.

The taking off includes the buffer phase and the stretch phase. The purpose is to make force to the ground by feet through the coordination of the segments of the body, improving the mass center and save power for soaring. The buffer step of taking off means the process a player makes a braking stretch and then bends his knees to the maximum angle. According to theorem momentum of formula (1), the integral of the variable force on time decides the no-momentum of a quality object.

$$\int \mathbf{Fdt} = \Delta \mathbf{mV} \quad (1)$$

We can see from formula (1) that the no-momentum of an object equals to the total of ΔmV and the primary momentum. So if the primary velocity in the buffer step is fast, the integral of variable force towards time is big. When the buffer ends, if the lower muscles are stretched enough, the better it contracts, the fuller the lower muscles are stretched. That's why the player always chooses to make a shot forward before jumping and then lands with two feet to take off. The primary velocity will increase for better taking off. The main factor that influences the taking off during the buffer step is the buffer angle of the hip and knee joint.

When the angle of knee joint in the buffer step of taking off is below 130°, the flexibility of the muscles will reduce by 10% to 20%. Keep a little buffer angle in a certain area can reduce the falling of gravity, save the time; increase the supporting moment force of the drive leg, increase the pressure of landing for better supporting and the vertical velocity of soaring.

Stretch phase starts from the time a player bends knees, buffer the mass of center to the time his feet depart from the ground also named the end of the buffer. At this very moment, the body is not all forward, but with a bias and turning in the rear side. An eccentric force appears with the mass center of the body's backward during the stretching step. It restricts both the horizontal and vertical movement and turning. And we can get the whole vertical displacement according to the mechanic formula of formula (2).

$$\begin{cases} \mathbf{V_f^2 = V_i^2 + 2gs = 0} \\ \mathbf{s = \dfrac{V_i^2}{2gs}} \end{cases} \quad (2)$$

V_i in formula (2) shows the primary vertical component of the maximum velocity when taking off, which is defined as V_{T0} in the following analysis. To gain the vertical component, the working of the stretch before the players depart from the ground meets the mechanic theorem and the functional relationship shown in formula (3) as V_i is zero when the buffer ends and stretch begins.

$$\begin{cases} \mathbf{V_{T0}^2 = \left(\dfrac{2}{m}\right)\int Fds} \\ \mathbf{S = \left(\dfrac{1}{mg}\right)\int (F_z - mg)ds} \end{cases} \quad (3)$$

S in formula (3) means the vertical displacement of roaring, so we can see that it's the integral on the vertical displacement of the mass center toward the upward force that decides the variable of the height of the mass center. So the height is restricted by the height the moment the mass center departs from the ground and the power the muscles have in stretch step.

Soaring means the time a player departs from the ground to the time he lands down, including turning and vertical soaring. The angular momentum caused by the jumping keeps stable. Any of the muscle force F and the joint moment M caused by F can be seen as inner force. The main feature of the turning is to control his body gesture reasonably, reduce the turning radius of gyration and increase the angular velocity.

When it goes to the final landing step, the player needs to use up his energy by the buffer of all segments of body to ensure a perfect landing. When the player lands down from the roaring location, the maximum gravitational potential energy vanishes and transfers into the kinetic energy, which will be then used up by the minus function of counterforce caused by the ground. When the body touches the ground, no displacement of the force toward the action spot on the ground appears. But the body transfers the force into the inner energy to be used up through the connection of skeleton and muscles.

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Analysis on the swivel of sports aerobics

The swivel of sports aerobics can be analyzed by classic principle feature of rigid body; we can see the vertical inclined angle of the body vertical axis as the angle of rotation. When a perfect swivel happens, the bodies makes uniform motion with a fixed angle of rotation and then spin along opposite direction around the vertical axis to ensure the player's moving forward.

Figure 1 shows the multi-rigid body model of swivel, a three dimensional space right-angle axis ($O-XYZ$) is set with the projection point toward the middle of the two shoulders (O_1, O_2) being the basis.

The model of multi-rigid body model of swivel in Figure 1 can reflect that a player repetitively make turning with the hands being the axis. The swing promotes a angle momentum L for the body, pointing to the right along the momentum axis according to the right-hand principle. The gravity causes a downward resultant momentum $T = MgR$ for the body, which is parallel to the turning axis and perpendicular to the angle of momentum L. The body makes an anticlockwise turning under the combined action of L and T, with a downward accelerated velocity to increase the supporting force F_N on the ground. So after a short fall, the mass center will go up. Judging from the theory, if enough angle momentum can be caused with the arm supporting stably, the swivel movement can be on forever.

The main factor for supporting the swivel is the full use of the two hands' push brace and the drive leg. The push brace can be separated into double-hands forward brace, left-hand brace, double-hands backward brace and the right-hand brace. Double-hands forward brace means the player push hardly with the right hand make the gravity core go left and then stretch the right leg to the upper right. Control the velocity and stretch higher when it comes to the top so that the left leg can bypass under it with the right leg under draught and the right arm preparing to stay on the ground.0Double-hands backward brace means to lift the hips and separate the legs outside with two hands controlling the balance and the left hand preparing to make force to the ground. The right-hand brace means to push the ground powerfully and then move rightward, stretch the left leg to the upper left. Control the velocity and stretch higher when it comes to the top so that the right leg can bypass under it with the left leg under draught and the left arm preparing to stay on the ground.

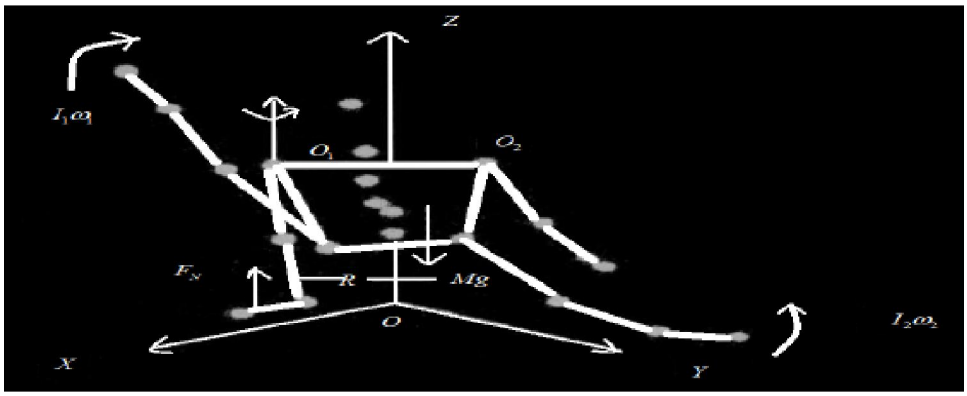

Figure 1 : Drawing for the multi-rigid body model of swivel

THE BIOMECHANICS ANALYSIS ON THE JUMP AND SWIVEL OF SPORTS AEROBICS

The biomechanics index analysis on the jump and swivel of sports aerobics

Collect the biomechanical index of three players' jumps. The essay collects the index of the gravity core mechanical index, lower joint angle of jumping and soaring, the joint angle of landing to figure out the features of jumping in sports aerobics through the three players' real time data and provide evidence for the improvement of sports aerobics. Pls have a look at Table 2, which shows the gravity core mechanical index of C477 difficult jumping.

We can see from TABLE 2 that the roaring height of player 1 is 0.82m, player1 also has the longest roaring time, while player 2 has the maximum vertical ve-

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TABLE 2 : Gravity core mechanical index of the C477 difficult jumping

Players Classification	Roaring height(m)	Roaring time(s)	Maximum vertical velocity(m/s)
Player 1	0.82 m	0.66 s	3.84 m/s
Player 2	0.81 m	0.60 s	3.95 m/s
Player 3	0.56 m	0.56 s	2.84 m/s

locity. For player 3, the shot roaring time is caused by low roaring height, which is decided by the gesture and maximum vertical velocity of the player in the air. So the better explosive effort and the ability to keep the gesture balance is the guarantee for perfect C477 jumping. The joint angle of the lower joints and the angle of the maximum buffer time decide the player's jumping performance. For the data of the three players, we can refer to TABLE 3:

We can see from TABLE 3, the buffer amplitude of the three players' ankle joint in taking off step is the largest, and then comes to knee joint, the hip joint has the smallest data. So we can say the flexible heat energy saving mainly relies on increasing the primary length of the quadriceps and the triceps. The buffer amplitude of ankle joint for A3 is the smallest of the three players, and is smaller than the other two players in stretch phase; also it's the smallest in the vertical velocity the time they depart from the ground. So it is effective for the players to strengthen the explosive force and the stretch of ankle muscles and the knee-bending. Judging by the movement, the buffer amplitude of the three players' hip joint shows a trend of reduction. The hip joint does not join in the buffer motion from the surface, but actually its buffer style is not the same as that of knee and ankle joint.

TABLE 3 : The joint angle of the lower body in taking off step

A type	Hip joint		Knee joint		Ankle joint		Buffer amplitude		
	N(0)	Nmax	N(0)	Nmax	N(0)	Nmax	Hip joint	Knee joint	Ankle joint
A1	167.4°	160.9°	165.4°	126.6°	137.8°	93.0°	6.5°	38.8°	44.8°
A2	169.3°	174.7°	168.1°	144.1°	153.5°	110.7°	5.4°	24.0°	42.8°
A3	145.1°	149.3°	163.0°	139.7°	103.1°	71.3°	4.2°	23.3°	31.8°

PS: A means the players; N(0) means the time of landing; Nmax means the maximum buffer time

The motion of hip joint is under the coordination of muscular tensor fasciae latae, Sartorius, rectus femurs and gluteus to make braking. Keep the stability and gesture when the player is making stretch, so the buffer amplitude toward hip joint for the taking off step is the minimum.

The movement in the air is the most difficult step, which is decided by the joint angle of the player's lower muscle in roaring step. TABLE 4 shows the index of the angle of the lower joint and body toward the two legs for three years in roaring step.

We can see from TABLE 4, the angle of the body and two legs of the three players all meet the requirement that α should be below 60, all the movements are of high quality. The left and right hip joint angle of player 2 is 170.7°and 173.1, while that for player 2 is 160.9°and 167.5, which means he almost finfish 180°turning by vertical gesture.

The left and right hip joint angle of player 3 is 149.3° and 170.4°, there is a bid discrepancy between the two angles, which is the reason why the player deviates to the left, and also the reason the player turn without the vertical gesture. So in later training, the lumbar muscles training should be focused on. Player 1 has the best

TABLE 4 : Lower joints angle list in roaring step

Player classification	Hip joint		Knee joint		Ankle joint		α
	Left	Right	Left	Right	Left	Right	
Player 1	160.9°	167.5°	167.0°	156.3°	135.2°	128.0°	24.8°
Player 2	170.7°	173.1°	176.0°	171.5°	65.2°	111.0°	47.3°
Player 3	149.3°	170.4°	160.0°	163.2°	111.0°	111.0°	31.9°

PS; left shows the left, right shows the right α means the angle of the body and the two legs

gesture, while the left ankle angle of player 2 is only 65.2°which means he did not flexed his instep and the knee joint angle of player 3 is close to 180°, which means the knee joint keeps vertical when they make a 180°turning.

Landing is the final step of jumping, which influences the final score of the movement, besides; it's easy for a player to hurt his lower segments. TABLE 5 shows the status of the joint angle of the up and lower joint in landing buffer; also it shows that the player mainly relies on the buffer of elbow joint and the shoulder joint in landing buffer step.

The elbow joint has the largest buffer amplitude, and then comes to the shoulder joint, wrist joint has the smallest one. When a player lands with his two hands pushing to the ground from a higher place, the knee joint gets the smallest buffer amplitude. And the buffer of feet mainly replies on the stretch of ankle joint to be more stable.

The data in TABLE 5 shows that player1's buffer amplitude of ankle joint is 39.4°, player 2 is 29.2°. Both of them are landing with their feet hooking. While that of player 3 is the smallest. He did not make full preparation and increase the push force to the ground from ankle joint. So in the C477 jumping, the player should have a reasonable stretch angle to be more stable.

Analysis on the biomechanics of the swivel in sports aerobics

The essay takes the right full swivel of Thomas in sports aerobics for example, chooses the world champion Zhanzhuo and other famous players: Limeng and Zhangyifeng to be the object of study. And then selects the perfect right full swivel of Zhangzhuo and Limeng as well as the mistake of Zhangyifeng. Also the essay collect the five indexes: time, maximum mass center height, maximum mass center velocity, maximum shoulder angle and the maximum straddle angle of the four steps: double-hands forward brace, left-hand brace, double-hands backward brace and the right-hand brace to search the biomechanical feature of the swivel in sports aerobics by analyzing the data discrepancy in the same index and step of the three players.

Table shows the five index of the right full swivel of Zhangzhuo, Limeng and Zhangyifeng in the four steps.

For the average elapsed time in the four stages, double-hands forward brace takes the 3 athletics 0.30s; left-hand brace 0.46s; double-hands backward brace 0.12s and right-hand brace 0.40s. The percentage rate of the elapsed time of each stage in the total elapsed

TABLE 5 : The angle of the upper and lower body for jumping in landing step

A classification	direction	Shoulder joint		Elbow joint		Wrist joint		Buffer amplitude		
		Primary time	Final time	Primary time	Final time	Primary time	Final time	shoulder	elbow	wrist
A1	Left	158.8°	146.7°	162.4°	101.5°	173.6°	161.1°	10.1°	60.9°	12.5°
	Right	132.8°	106.1°	156.8°	104.7°	158.0°	150.5°	26.7°	42.1°	7.5°
A2	Left	134.5°	115.0°	153.5°	142.8°	128.0°	117.4°	19.5°	10.7°	10.6°
	Right	125.6°	138.0°	150.1°	137.8°	111.4°	104.1°	12.4°	12.3°	7.3°
A3	Left	135.2°	148.9°	10.0°	115.6°	135.8°	129.8°	13.7°	24.4°	6.0°
	Right	132.7°	122.5°	136.0°	115.9°	105.8°	88.9°	10.2°	20.1°	16.9°

A classification	direction	Shoulder joint		Elbow joint		Wrist joint		Buffer amplitude		
		Primary time	Final time	Primary time	Final time			Primary time	Final time	Primary time
A1	Left	151.3°	142.9°	159.8°	154.4°	84.3°	44.9°	8.4°	5.4°	39.4°
	Right	151.1°	136.0°	149.1°	142.0°	102.0°	98.4°	15.1°	7.1°	3.6°
A2	Left	175.4°	172.3°	176.7°	176.6°	71.2°	54.1°	3.1°	0.1°	17.1°
	Right	173.5°	173.2°	167.6°	170.2°	107.8°	109.7°	0.3°	2.6°	1.9°
A3	Left	157.6°	167.0°	162.0°	166.0°	93.3°	64.1°	9.4°	4.0°	29.2°
	Right	170.0°	175.0°	163.4°	164.4°	120.1°	127.1°	5.0°	1.0°	7.0°

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TABLE 6 : Five index of the right full swivel of the three players in the four steps

Motion step	player	Time (s)	Hmax	Vmax	α	β
double-hands forward brace	Zhangzhuo	0-0.30	0.317 m	1.376 m/s	67.448°	89.158°
	Limeng	0-0.38	0.280 m	1.450 m/s	66.437°	98.235°
	Zhangyifeng	0-0.22	0.248 m	1.554 m/s	65.476°	80.786°
left-hand brace	Zhangzhuo	0.30-0.70	0.520 m	1.732 m/s	44.423°	122.687°
	Limeng	0.38-0.78	0.446 m	1.311 m/s	54.943°	116.091°
	Zhangyifeng	0.22-0.80	0.596 m	1.177 m/s	66.335°	127.759°
double-hands backward brace	Zhangzhuo	0.70-0.82	0.522 m	0.602 m/s	47.104°	110.413°
	Limeng	0.78-0.90	0.438 m	0.462 m/s	55.350°	123.608°
	Zhangyifeng	0.80-0.92	0.614 m	1.206 m/s	65.510°	126.498°
right-hand brace	Zhangzhuo	0.82-1.18	0.488 m	2.084 m/s	75.398°	97.208°
	Limeng	0.90-1.40	0.227 m	1.177 m/s	97.307°	109.968°
	Zhangyifeng	0.92-1.26	0.706 m	1.289 m/s	63.215°	122.310°

PS; Hmax means the maximum height of mass center; Vmax means the maximum velocity of mass center; α means the maximum angle of left shoulder. β means the maximum straddle angle

time is 23.4%, 35.94%, 9.375% and 31.25% respectively. The most time consuming is he left-hand brace; right-hand brace takes the second place and the least time consuming is double-hands backward brace.

In right full swivel, the mass center in the Double-hands forward brace and the double backward steps, the player push hardly with the right hand make the gravity core go left and then stretch the right leg to the upper right. Control the velocity and stretch higher when it comes to the top so that the left leg can bypass under it with the right leg under draught and the right arm preparing to stay on the ground.0it can be explained as that the player quickly lift his leg and then brakes to get a upper velocity and then change the location of the mass center. Zhangyifeng's mistake is he has higher location of the mass center, appearing with bending knees, which reduces the resistance momentum of turning the radius and the muscles.

The right-hand brace means to push the ground powerfully and then move rightward, stretch the left leg to the upper left. Control the velocity and stretch higher when it comes to the top so that the right leg can bypass under it with the left leg under draught and the left arm preparing to stay on the ground.

Zhangzhuo raises the location of his mass center by powerful right-hand brace and upper lifting of hips, which increases the kinetic energy in the process of falling. That's why he can keep the velocity of 2.084m/s in the later time of right hand brace.

In order to have a high initial speed, the player normally will step forward of his leftleg to have the maximal angle between the two legs as possible before doing the right circle. The function of this angle is that it not only can fully extend the leg muscle, but also make a powerful swing. The maximum straddle angle is 110.413°, 123.608°, and 126.498 which fully expresses the requirement of the right full swivel toward the two legs.

Limeng keeps big straddle angle in the double-hands brace and left hand brace. But due to the obvious up and down in the forward brace step of straddle angle which was caused by the motion that Limeng has a motion of swinging his left leg forward. So the angle of the two legs can be reduced, and the upper lifting of the right leg makes the angle larger.

When the player makes motions in the double-hands brace, the more the shoulder angle is the lager the turning radius is. The player can get a faster velocity by powerful brace of the arms and the stretch of legs. When it comes to the double backward brace, the shoulder angle is small as well as the location of the center. Only increasing the velocity of the mass center can the player void being touching the ground on the hips. But for the left hand brace, the player needs to extend the shoulder angle for large-amplitude motion. So to ensure the standard movement, the player should try his best to ex-

tend the shoulder angle for better right full swivel.

CONCLUSION

By analyzing the quiet balance ability and the jumping / swivel in sports aerobics, the essay finds out the method of improving balance ability and analyzes the points of jumping and swivel through biomechanical theorem to provide theory for biomechanical index.

And then the essay is focused on the three steps of C477 jumping of the three players: gravity core index roaring height, roaring time and the maximum vertical velocity, angle value of the moment of the hip/knee and ankle joint's landing and the angle value of maximum momentum in the step of taking off; the data of the angle of lower body, the body and the two legs in roaring step, the data of the upper body in buffer step of landing, angle of lower body in three steps and the buffer amplitude of all the joints.

Besides, the essay make an analysis on the data of the three steps, and then get the training advice to improve the player's jumping skill. Also figure out the suggestion of improving the swivel skill according to the five indexes: the maximum height of mass center; the maximum velocity of mass center; the maximum angle of left shoulder. The maximum straddle angle of Zhangzhuo, Limeng and Zhangyifeng in the four steps of Thomas right full swivel.

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