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Analysis and application of rumba body barycenter shifting based on the mechanics of human motion

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ABSTRACT

The formation of rumba player's body weight and barycenter, and the relationship between the barycenter and shifting are the key technology for rumba technique. There has been some progress on the study of the weight shift technology in transport step forward and backward about rumba, but there are still some practical problems in application. In this paper, we conduct a study on rumba player's barycenter Shifting technique with a method of human motion mechanics. We analysis the position changes when the barycenter shifts and the physical stability in the process of barycenter shifting. The study shows that the grasp of barycenter shifting has an absolute effect on rumba players and helps maintain dance movements fluent and coherent. By analyzing and applying this technology, players can make new breakthrough in training and stand out in the competition, thus has certain practical significance.

KEYWORDS

Barycenter shifting;
Guide techniques;
Mechanics;
Stability.

INTRODUCTION

Sports dance is a comprehensive discipline from an academic point of view; it involves an extremely broad range of disciplines, including Human Morphology, human anatomy, art, aesthetics, humanities, social ethics and human motion mechanics. So in order to accomplish some achievements in the field of sport dance, master multifaceted knowledge and improve accumulation of comprehensive quality are musts. Rumba is a typical item of sport dance, and its learning process is like the construction of a palatial building, where need the concept of art theory, choreography capacity, high-quality players, and technical guidance. Rumba technology is also a comprehensive discipline. Researches on rumba can cover many aspects with thousands of topics, but any kind of topic is a invisible support to the technology. Players should choose the appropriate technical support combining with their own needs.

The mechanics analysis of sports dance has been a focus topic among Research scholars in recent years. Pengping Zhu studied on classical ballet training combined with biodynamic and gave its correlation analysis. Xiling Deng discussed the mechanical problems that impacts aerobics. Liang Xu introduced kinematics to sports dancing skill tests, and focused on the analysis of the body barycenter shifting. But consider the differences between the two professions of Dance Sport and

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mechanics are too many, universal mechanic studies and analyses that widely applied to Dance Sport are not many. In this paper we analysis the scientific principles in rumba movement applying the knowledge of human motion mechanics. We give a detailed description of the relationship between rumba player's barycenter and movement in use of basic mechanical knowledge, and study on the four barycenter shifting techniques with mechanical knowledge, then obtain the body stability when enhance dancing.

RUMBA BARYCENTER SHIFTING TECHNIQUE SYSTEM

Formation of the center of body weight

The pressure that body gives to the ground is called body weight. For a dancer, to analyze and judge the location of the center of body weight by body weight distribution and transformation is a worth studying problem, as well as how to convert body weight to achieve barycenter shift.

The body barycenter is the center vertical line of the body's three-dimensional pressure, as shown in Figure 1:

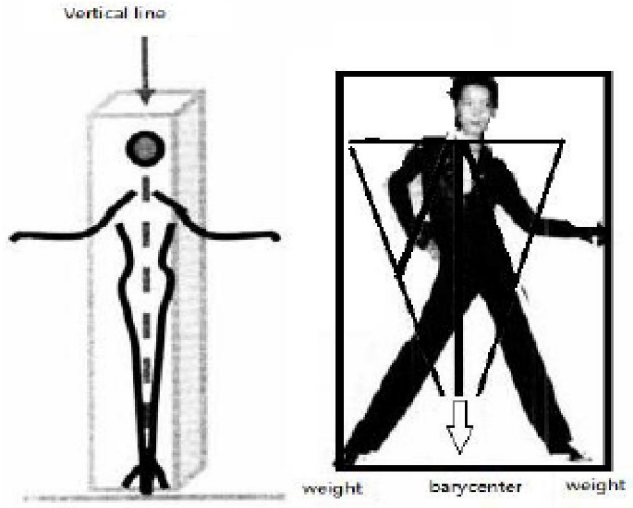

Figure 1 : Schematic diagram of the dancer's body center vertical line

The center of mass and center of gravity (barycenter) are two different concepts, the center of mass related to the distribution of the quality of each particle in the particle system, and has nothing to do with the force on it. In the above figure, human body is divided into various links and the decomposition principle is the position of each link point. They are connected to form a human link diagram with no mass but tangible lines

The total mass of the particle system:

$$M = \sum_{i=1}^{n} m_i \rightarrow x_i = \frac{\sum m_i x_i'}{M}, y_i = \frac{\sum m_i y_i'}{M} \quad (1)$$

In formula (1): M indicates the total mass of the particle system, x_i', y_i' represent the horizontal and vertical coordinates of each micro-element in human body.

Body barycenter is a concentrated expression of the various links under gravity. There are many factors that affect the change of body barycenter, including the change of posture. Here is a method to extract body barycenter from a photo:

Principle: moment synthetic principle

$$PX = \sum p_i x_i, \because P = 1, \therefore X = \sum p_i x_i$$
$$PY = \sum p_i y_i, \because P = 1, \therefore Y = \sum p_i y_i \quad (2)$$

In Formula (2): X, Y represent the horizontal and vertical coordinate values of the total body barycenter, p_i stand for the relative weight of a link, x_i, y_i are the vertical and horizontal coordinate values of link's centroid.

In summary, the changes of rumba dancers' body posture, would inevitably lead to centroid changes of the various links, resulting in the movement of the barycenter perpendicular.

The movement of body barycenter

Rumba dancers' moving is essentially the process of body gravity line shifting vertically in the space. Using the center line of the body, we can analyze the completion of barycenter moving through transformation of the body weight, how to keep balance by controlling the center of gravity, and how to maintain graceful dance and to reflect the change at different speeds in the process of moving.

As is shown in Figure 2, the famous Lombardy dancer Slavik firstly concentrated 95% of the body weight on the right foot. The left foot bears only 5% of the body weight. And then he made gravity conversion from right foot to the left. When the line of the body barycenter reached the middle of the feet, each foot bore 50% of the body weight. Then the barycenter line continued moving toward the left until the barycenter

line and the left leg lines coincided, and that showed the weight conversion process from the right foot to the left.

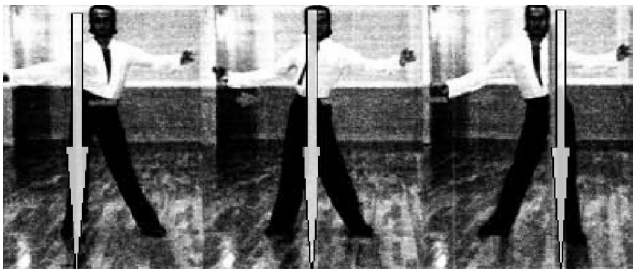

Figure 2 : The three position of Slavik' barycenter line when moving

In conclusion, the weight that both foot bears satisfies the situation shows in figure 3 and match formula (3)

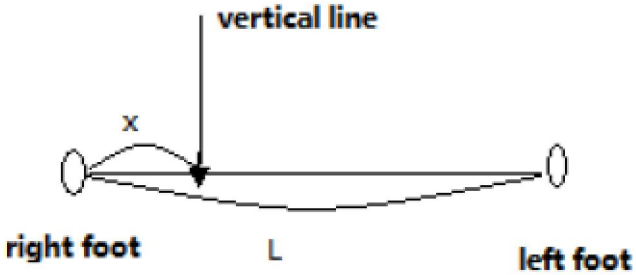

Figure 3 : Simplified schematic diagram of the position of barycenter line

The weight that the right foot bears expressed as F_{right}, and the left expressed as F_{left}. They satisfy formula (3)

$$\begin{cases} F_{right} = G\dfrac{L-x}{L} \\ F_{left} = G\dfrac{x}{L} \end{cases} \rightarrow G = F_{right} + F_{left} \quad (3)$$

The G in formula (3) indicates the total gravity that human body owns.

Stability analysis of the body

The area surrounded by the support points called the support surface. The support surface of rumba dancer is his feet and the area between the feet. A dancer should keep his barycenter line in a reasonable position, when dancing. If the barycenter line is deviated from two feet and the region, it will cause a body deflection. The stability of the body is discussed as follows.

The human balance is divided into four cases according to the degree of stability:

1) Stable equilibrium: When deviated from the balanced position, barycenter rises, and the generated weight moment force the body move to equilibrium position. When back to the equilibrium position, the resultant force is zero, and the resultant moment is zero;
2) Unstable equilibrium: When deviated from the balanced position, barycenter drops, and the generated weight moment force the body continue to deviate. This situation occurs only in the down support balance motion.
3) Limited stable equilibrium: When the deviation from the equilibrium position is within certain limits, the body barycenter rises. The generated weight moment force the body move to equilibrium position until restoring the balance. But if beyond a certain limit of deviation from the equilibrium position, the human barycenter would drop, and the produced weight moment force the bodies continue to deviate.
4) Indifferent equilibrium: When deviated from the original position, the height of barycenter stays unchanged, and will not generate the weight moment that force body moving.

By summing up the four aspects above, we can see that the body stable state is actually an equilibrium state in disguise which is dynamic equilibrium or static balance.

One of the factors that affect body stable is the stable angle, the angle of the connection from the barycenter line to the edge of the supporting surface, as is shown in Figure 4:

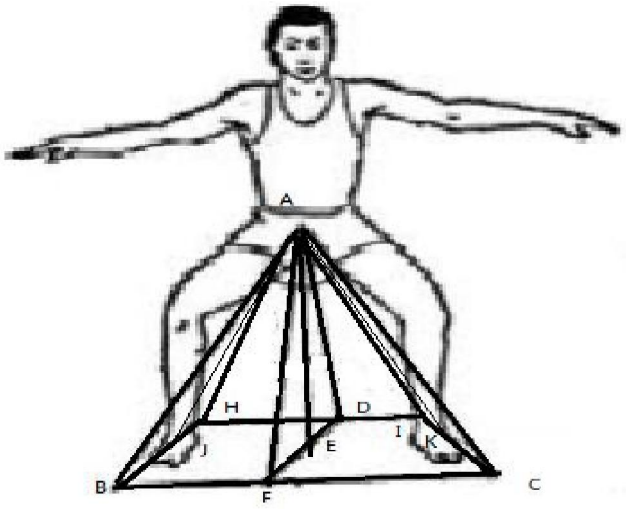

Figure 4 : Schematic diagram of the support surface and the stable angle

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In the above figure $\angle JAE = \angle\alpha_{left}; \angle KAE = \angle\alpha_{right}; \angle FAE = \angle\alpha_{forward}; \angle DAE = \angle\alpha_{back}$ the four angle are four stable angles respectively for the left, right, front and back. The included angle between the barycenter vertical projection line and the connection from the barycenter line to the edge of the supporting surface is the Stable edge of human body in one direction. And the angle of equilibrium is the sum of stable angles in a direction.

The stability factor K is an important indicator when judging the stability. It represents the quotient of the stabilizing moment and overturning moment, as is show in figure 5. The discussion of stability coefficient:

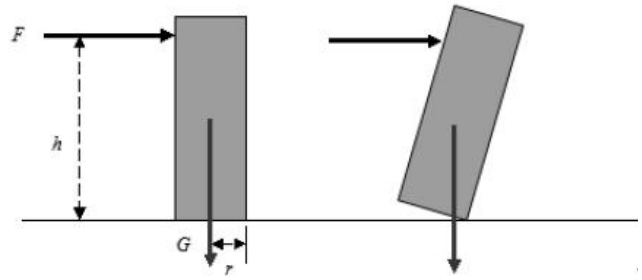

Figure 5 : Schematic diagram of stabilizing moment and overturning moment

The expression of stability coefficient is:

$$K = \frac{G * r}{F * h} \quad (4)$$

In formula (4), $G * r$ indicates stabilizing moment and $F * h$ indicates overturning moment.

So, when $K \geq 1$, the object is to maintain stable, whereas the object will generate inversion.

For a rumba dancer, the stable movement of barycenter when moving can be regarded as dynamic equilibrium stable. When to maintain substantial movement, he should lower the barycenter to increase the stability angle, and reduce the overturned arm to increase its stability, in order to achieve the smooth performance.

THE ANALYSIS OF STEP AND TURN STEP BARYCENTER MOVEMENT

The analysis of barycenter movement when step forward

In Figure 6, "a one-way track" and heel inward rotation are shown. When step forward with the feet front and back, the heels should rotate inward slightly without affect the balanced movement, but not excessive. If the inward rotation excessive and make knees valgus, it would directly restrict the dancer's body movement. So make sure that the knee is always forward, looks like a one-way track.

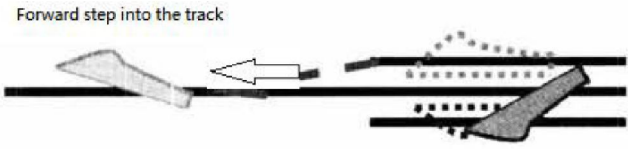

Figure 6 : Schematic diagram of forward step into the track

The first step in the forward stepping is left foot forward. The body barycenter line reach the center between the left and right foot point through the left foot center point in a music beat. The line of spine and leg needs to stretch, and the hip needs to do pressure turn action when body barycenter reach the center of left foot. The second step is the right foot forward, and the technical movements are the same as the first step. The third step is left foot forward, and this step is completed within two music beats. In the beat of & 4, the body barycenter line firstly reached the right foot point, and then move to the intermediate position between the left and right foot during the latter half of 4& and the first half of 1&. Leg line and spine stretching, do hip pressure transfer action when the barycenter line reached the center of left foot.

The technical principles of "pressure turn" in rumba is not a static dance style, but a natural step with Straight knees to pull the buttocks, put the hip and turn separate action. As long as the body barycenter of each step passes the soles force point, buttocks will naturally form a " shape trajectory. Some dancers deliberately pursue the " shape with hip, and in a result, the gravity line missed soles force point, and destruct the fluency of body movement.

The Most perfect movement is consistent with the beat of the music, so as to complete the move with the music smoothly. Many dancers cannot make the barycenter line pass the soles force point at the right time. If the dancer moves the barycenter a little early or late, there is a possibility for the barycenter to be unsteady and lose balance, and could not step forward. In this case, the dancer can slightly slow down the control of barycenter shifting and does a relatively

static buttocks pressure turn, to avoid the loss of balance.

Rumba keeps pursuing the beauty of flowing and fluency. When body rhythm is out of the music, the dancer should use proper method to save himself.

The analysis of barycenter shifting when step backward

In Figure 7, "a one-way track" and heel inward rotation are shown. When step backward with the feet front and back, the heels should rotate inward slightly without affect the balanced movement, but not excessive. If the inward rotation excessive and make knees valgus, it would directly restrict the dancer's body movement. So make sure that the knee is always forward, looks like a one-way track.

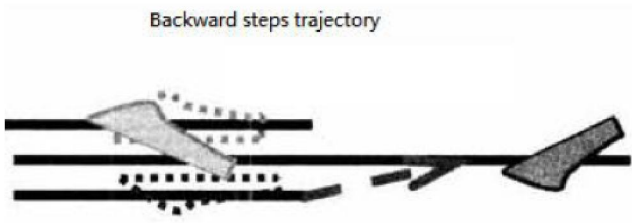

Figure 7 : Schematic diagram of backward steps trajectory

We have had a detailed analysis of the technique of barycenter shifting when step forward above. The technique of barycenter shifting when stepping back is not completely the same with the former, because what in front of the dancer heel is the soles and toes, while noting in the back. So there are differences between forward and backward on barycenter shifting technique. Figure 8 showing the contrast of the right and wrong foot point when stepping back.

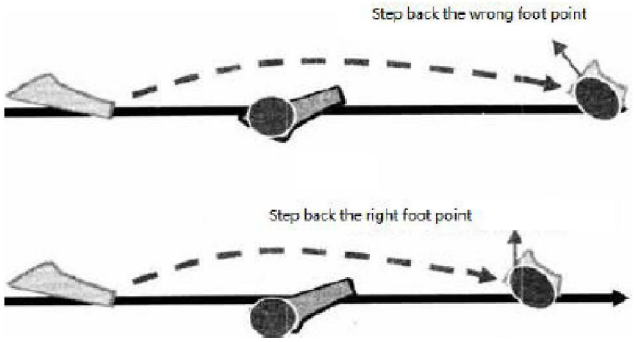

Figure 8 : Schematic diagram of the right and wrong foot point when step backward

The move mode of forward step is to promote the barycenter go over the sole with main force foot, and then the swinging foot step. While in case of backward steps, the swinging foot firstly moves to the back without the barycenter, then the barycenter line move to the proper place with it.

In the case of the forward step, after forcing the tailbone pointing to the ground, there is no need to control the calf to lean inward. While in the backward case, in order to control the pace size, after forcing the tailbone pointing to the ground, both knees should lean inward to each other.

When step forward, tiptoe, soles and heels touchdown successively. The pace get smaller when retrieve the barycenter. While turn to backward step, the tiptoe cannot touch the ground, but with the feet. Since the barycenter would move out when step backward, the range of pace should be decreased.

Stepping backward with tiptoe touchdown uncer-emoniously causes separation of the supporting foot and swinging foot and cannot complete the body barycenter shifting. In this case, the dancer forces the barycenter move to the back foot, which completely destroyed the perfect body shape and lost the sense of melody.

So in the process of step backward, make sure to control the magnitude of space and the location of the barycenter well.

CONCLUSION

In the training process, the rumba players should focus on the learning of theoretical knowledge. When thinking about technological improvement and action improvement, they not only need consider the aesthetics and art forms, but also should seek confirms from the scientific principles, so as to improve their technique faster; In this article, considering the sport of rumba, we use the knowledge of the mechanics of human motion, confirm the stabilizing factors in the process of barycenter line shifting which are increasing the Stable Angle and lower the position of barycenter. Human motion mechanics have a good known effect on rumba.

For rumba players, the move modes of barycenter are not completely the same when step forward and afterward. In this paper, we analyzed the contrast between two kinds of step mode, and draw the corresponding conclusions. From this article, we concluded

that rumba dancers do not have to force hips to draw " shape trajectory deliberately. They should master the location of the barycenter line well through the position of the soles. Mastering rhythm well, and noticing the movement of the barycenter line, dancers can have a complete and beautiful body shape; We analyzed the wrong way of barycenter shifting when step backwardand pointed out that the phenomenon of moving outward will appear to the barycenter line when sole touch the ground. So dancers should control the amplitude and lower the barycenter. The study on rumba in this paper authentically reconstructed and analyzed this kind of sport. And we also provided some analyses and explanations for some unreasonable actions and details that easy to overlook, which provide theoretical material for the sport of rumba.

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