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Waltz combining and step changing gravity center mobility base on biological movement mechanics

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ABSTRACT

The features of Waltz are fine motion, big fluctuating gravity center, strong body inclination, and the coordination of dancer's limits the performance, especially the combining and step changing, which becomes the major purpose. This paper measures the gravity center of body by camera, with the biological movement mechanics methods, analyzes the mechanical principle of gravity center movement of human rigid model. The result indicates the process of the man and woman dancers' gravity center movements, conducts the special analysis on gravity center movements of waltz, explains such principles reasonably, and provides new theoretical supports for improvements and research of waltz athletes and coaches.

KEYWORDS

Coordination method;
Gravity movement;
Waltz;
Mechanics.

INTRODUCTION

Originating in Austria folk dance from 17th century, combining with traditional music in German and Bavaria, waltz was popular in Europe. After series of reforms and regulated by British teachers in 20th century, waltz become one of international standard dances with complex motions and accurate rhythm. Waltz dancers slide finely, with slow velocity about 20-30 sections per minute, but it will be dynamic with powerful music. The basic step is a step per tempo, which are three steps for a section. The high level step can be 4-6 steps per section with varied rotations, which demonstrates strong dynamics.

Currently, there are many researches on standard dances. For example, Jiao Xibian master, from Physical Education Department in China university of Petroleum, according to five technologies of standard dances, summaries in literature and techniques. It is a good paper, but without specific analysis in a motion. Take another example, Lu Chunxia and Dong Weixin, from Institute of Physical Education in Hunan normal College; study the system of dance teaching method, with lots of scientific performances, which analyzes the teaching method and teaching situations specifically, but lack of theoretical basis. The previous researchers planed for future development of dances, but without current significances.

This paper, bases on biological movement's mechanics, analyzes the process of gravity center mobility, and analyzes the gravity center mobility for combining and step changing. The renovation is to explain its prin-

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ciple reasonably and provide new theory for improvements and studies of waltz athletes and coaches.

GRAVITY CENTER MOVEMENTS FOR RIGID MODEL

Coordination selection

In this study, we classify body into 14 sections, shown as Figure 1:

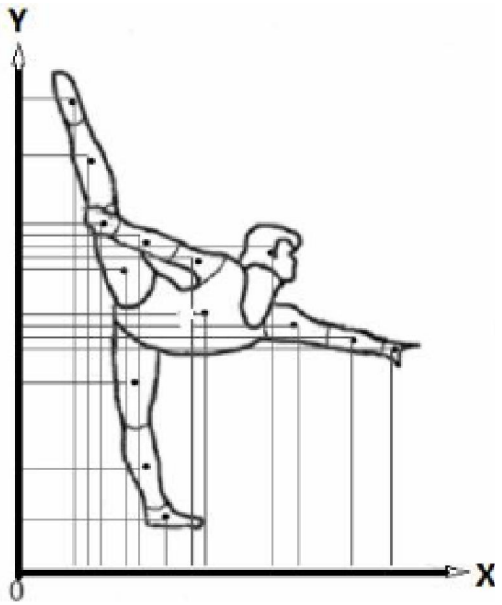

Figure 1: Distribution of rigid structure in coordination

Rigid model classifies body into 14 parts, such as head, arm, leg, foot, etc. After a posture curtained, the gravity center is also curtained, whose position relates to the coordinates of the mass of the various sections. According to point of division for fixed-ratio, solve the relative positions of mass:

$$\begin{cases} x_c = (1-\lambda)x_{over} + \lambda x_{bottom} \\ y_c = (1-\lambda)y_{over} + \lambda y_{bottom} \end{cases} \quad (1)$$

In formula (1): λ is mass position ratio, $(x_{over}, y_{over}), (x_{bottom}, y_{bottom})$ is the coordinates of middle points of up and down sections, (x_c, y_c) is the coordinate of mass center.

The functioning point of gravities of all the sections of body is called as human gravity center. According to the rigid model in formula (1), separate the various sections. While the dancer moving, each posture has a gravity center position, which is solved by torque synthesis principle, shown as formula (2):

$$\begin{cases} X_c = \dfrac{\sum_{i=1}^{14} F_{xi} \times x_{ic}}{\sum_{i=1}^{14} F_{xi}} \\ Y_c = \dfrac{\sum_{i=1}^{14} F_{y_i} \times y_{ic}}{\sum_{i=1}^{14} F_{y_i}} \end{cases} \quad (2)$$

In formula (2): (X_c, Y_c) is gravity center coordinate of dancer, $(x_{ic}, y_{ic})(i = 1,2,3,\cdots,14)$ is mass center of various sections, $\left(\dfrac{F_{x_i}}{\sum_{i=1}^{14} F_{x_i}}, \dfrac{F_{y_i}}{\sum_{i=1}^{14} F_{y_i}}\right)$ is relative mass on the coordination direction. The mass center ratio $\lambda\%$ of Chinese youth is shown as TABLE 1:

TABLE 1 : mass center ratio $\lambda\%$ of Chinese youth

Young male		Young women	
Hand	50	Hand	50
Forearm	41.87	Forearm	42.72
The upper arm	48.6	The upper arm	46.91
Foot	44	Foot	44
A lower leg	40.91	A lower leg	40.63
Thigh	47.71	Thigh	45.87
Upper torso	53.73	Upper torso	54.26
Lower torso	40.54	Lower torso	47.36
Trunk	44	Trunk	44
Head	50	Head	50

Relative mass of Chinese youth is shown as TABLE

TABLE 2 : Relative mass of Chinese youth

Young male		Young women	
Hand	0.64	Hand	0.49
Forearm	1.30	Forearm	1.18
The upper arm	2.61	The upper arm	2.62
Foot	1.50	Foot	1.38
A lower leg	4.00	A lower leg	4.55
Thigh	14.00	Thigh	14.28
Upper torso	17.00	Upper torso	16.53
Lower torso	25.60	Lower torso	25.87
Trunk	42.70	Trunk	42.70
Head	9.30	Head	8.60

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2:

We can calculate the gravity center of dancer with fixed posture according to formula (1) (2) and TABLE 1 and 2.

Gravity center control status

If a leg or foot takes on the whole gravity of body in the process, it will be in the complete gravity center status; if only a part of gravity, it will be in the non-complete gravity center status; if no gravity for it, it will be in the non-gravity center status.

In the process of dancing, when the gravity center moves from a leg to the other one completely, the transfer is called as gravity center complete transformation. When the gravity center is between two legs, which the gravity center line is between two legs, then the transformation is called as non-complete transformation. For example, in combining and changing step, the first step is the gravity center complete transformation from right foot to left foot, and the second step is the non-complete transformation from left foot to right foot. To keep balance and rhythm harmony, control the gravity center line between two feet, then transform it to right foot slowly.

Keep gravity center stable in dynamic balance. We can classify the balance into 4 categories:

(1) Stable balance: while deviating from balance position, the gravity center increases, and the gravity torque makes it to move towards balance position. After arriving the balance position, the synthesis force is zero and synthesis torque is zero.
(2) Unstable balance: while deviating from balance position, the gravity center decreases, and the torque makes it to incline continuously. Only exist in the down supporting motion.
(3) Limited stable balance: while deviating from balance position to some degree, the gravity center increases, and the torque makes body to move to the balance position, finally reaching balance. But when it exceeds the certain balance position, the gravity center will decrease, and the torque makes it to deviate from balance position continuously.
(4) Neutral balance: while deviating from original position, the height of gravity center does not change, or no torque is generated to make it to move.

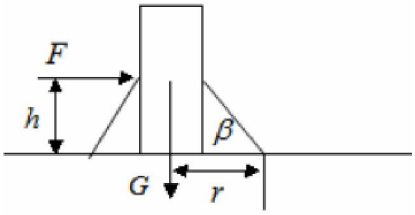

Figure 2 : Stable torque and inclining torque

Figure 2 shows the stable coefficient is:

$$K = \frac{G * r}{F * h} \quad (3)$$

So when $K \geq 1$, the object is stable, otherwise it rotates.

K represents the stable content of static object, also reflects the stability of human. From formula (3), decrease the gravity center, which is to reduce h, or increase the angle between gravity center line and human section, which is to increase β, the stability is increased.

GRAVITY CENTER MOVEMENT FOR THREE STEPS

With the transformation of gravity center line, the gravity center transformation is conducted between two feet. In the process, the step order, rhythm, step method, foot method, position and up and down should be mastered.

Gravity center movement for male three steps

TABLE 3 : male step

Step#	Rhythm	Step	Footwork	Alignment	Rise and Fall
1	1	right foot first strides	Heel-tiptoe	facing skew center	rising on the end
2	2	left foot slightly anterior the other one	tiptoe	facing skew center	go on rising
3	3	right foot combines left one	Tiptoe- Heel	facing skew center	go on rising fall on the end

It is shown as TABLE 3:

Male's preparing posture is two feet on the board, body keeping naturally straight, two knees slightly curving. The gravity on the foot plate. All the body moves gravity center front and exceeds the foot plate. Keep two shoulders relax and horizontal. The breeze should

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not expand. Keep spine vertical. Keep head, should and breast on the same line.

To keep body balance, the gravity center should be in front of two feet. When dancer steps forward or backward, his body will have two balance points, gravity

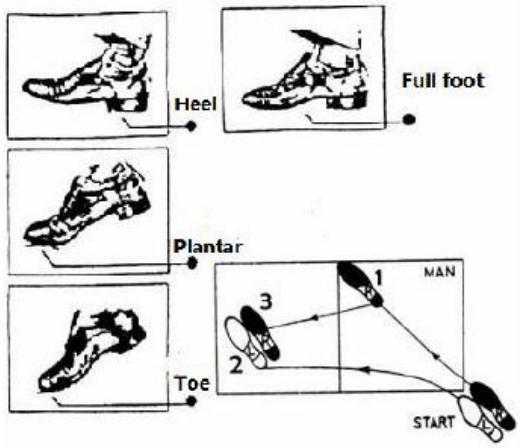

Figure 3 : Male right foot combining and changing step

center is allocated between two feet and forward body.

Right foot combining and changing step is basic one, whose gravity center moves at the time of two feet combining. It is basic technology for right transformation step. It is also the basic step for some ends. Correspondingly, left foot combining and changing step is same as that.

According to figure 3 and TABLE 3, the gravity center moving of male right foot combining and changing step is explained:

First step: right foot strides, with gravity center moving, the heel touches floor firstly and then the toe, which is the gravity center line changing. The posture faces skrew center and the gravity center increases from the beginning of rhythm.

Second step: left step is slightly anterior than the other one. But the gravity center should on the center position of right foot before the left foot touching the floor. The left tiptoe slides to 2 positions along the step line. When tiptoe touches the floor, the gravity center line moves to the middle of two feet. It ends until the left feet touching the floor. Keep gravity center increasing in the process.

Third step: right foot combines left foot. Right foot away from floor refers to right heel keeps away first, then slowly combines with left one as the rhythm. Then moves gravity center line to the left foot. When the right foot exceeds the second step, the gravity center should decrease. When the right foot reaches 3, the gravity center completely transforms to left foot. Meanwhile, the right tiptoe touches the floor first, and takes on some part of gravity, until the gravity is balanced on two feet.

Gravity center movement for female three steps

TABLE 4 : female step

Step#	Rhythm	Step	Footwork	Alignment	Rise and Fall
1	1	right foot backstep	Toe- heel	backward skew center	rising on the end
2	2	right foot slightly backwards the other one	Toe	backward skew center	go on rising
3	3	left foot combines right one	Toe- heel	backward skew center	go on rising fall on the end

It is shown as Table 4:

Female's preparing posture is same as males, but the section up the waist can be towards left and expand backwards slightly.

The center line of body should be between two feet and anterior section. Two balance points exist to keep body statically stable.

Left foot combining and changing step is basic one, whose gravity center moves at the time of two feet combining. It is basic technology for left transformation step. It is also the basic step for some ends.

According to figure 4 and TABLE 4, the gravity center moving of female left foot combining and changing step is explained:

First step: left foot backstops, and the body gravity center line is through right foot. Until the left toe touching the floor, it moves between two feet. The heel touches the floor first, which is the gravity center line falling on the left foot center position. The body posture backwards skrew center. The gravity center increases at the beginning of rhythm.

Second step: right step backwards the other one. But the gravity center should on the center position of right foot before the right foot touching the floor. The right toe slides to 2 positions along the step line. When toe touches the floor, the gravity center line moves to the middle of two feet. It ends until the right feet touching the floor. Keep gravity center increasing in the pro-

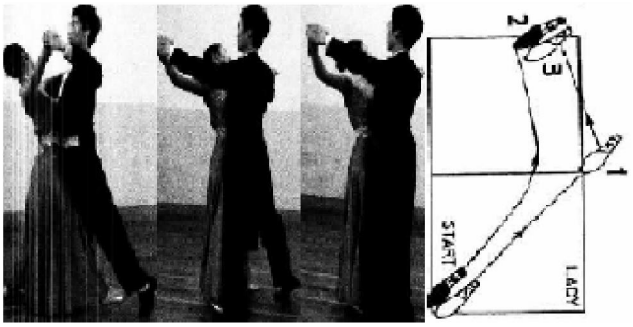

Figure 4 : Relative real object and distance for female left foot combining and changing step

cess.

Third step: left foot combines right foot. Left foot away from floor refers to left heel keeps away first, then slowly combines with right one as the rhythm. Then moves gravity center line to the right foot. When the left foot exceeds the second step, the gravity center should decrease. When the right foot reaches 3, the gravity center completely transforms to left foot. Meanwhile, the right toe touches the floor first, and takes on some part of gravity, until the gravity is balanced on two feet.

CONCLUSION

This paper, according to biological movement mechanics, analyzes the force changing process of gravity movement. Conduct some special analysis on gravity movements of waltz combining and changing step. It explans the principle reasonably. Waltz is a dance for two people, requiring two people matching. This paper analyzes the gravity center transformation between two people. Its symmetric quality should be consistent with rhythm. Select human gravity coordination's in look-up table, which reduces calculation contents and increases the analysis velocity. To keep the gravity center up and downs coordinately, the gravity center should be pressed in the preparation, besides, the velocity for decreasing and increasing gravity center should be controlled. The gravity center will change suddenly in such process; the overturn torque will be generated. To reduce overturn torque and increase the stability of body, the velocity and distance of gravity center changing should be controlled.

We advise: in the process, keep the rhythm of up and downs of body. Regulate gravity center position ahead of time, which is curving the knee and inclining forward (male) or slightly backward (female). Decrease position ahead of time. Rising gravity center slowly with the rhythm. Keep the body in dynamic balance, which is in the moving process with one foot as support, the gravity should be in the forcing status. Keep the expansion. The gravity center falls on the proper position at once while combining. At that time, the body is easy to be unstable. The moving distance should be controlled small, to reduce torque, so as to meet K<1; while training on some dancer, select the gravity center in camera, and studies the fine shortages.

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