Sports events ornamental research-take table tennis as an example

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Abstract. The effect of bigger table tennis diameter on players' experience quality is defined by means of comparing players' skills and physical consumption in Sydney Olympic Games before reformation with that in the 49th World Table Tennis Championships. First of all, modeling analysis makes it clear that table tennis would increase its mass while decrease its flight speed and rotation speed after turning into bigger diameter. Changes of above three properties directly affect players' skills so that suggests that scoring rate rises in the stalemate phase of competition, resulting in higher requirements on players' skills and more players' physical consumption, that is to say, lower players' experience quality.

1 Introduction

From macroscopic view, after turning a small ball into a big one, both ball self-speed and rotation speed will decrease, requirements on players' strength will be higher, all of these would affect players' skills and their physical endurance during competitions. In this paper, these influence factors would be used as some important indicators of players' experience quality, handling with related data to reflect changes of players' experience quality.

For audience, after turning a small ball into a big one, round number of competitions increases, competitions turns to be more intense, watching focuses in competitions increase so that competitions here are surely more ornamental. In the following, changes of indicators in table tennis competitions in 'Big ball era' are reached and furthermore changes of players' experience quality and audience ornamental are also concluded by analyzing the changes of table tennis diameter in this paper.

2 Property analysis of big ball

2.1 Change of mass after reformation

The original common used $38\,\mathrm{mm}(2R_1)$ table tennis spherical shell thickness is 0.39 mm, inner diameter is $18.61\,\mathrm{mm}(R_2)$, its external radius is $19\,\mathrm{mm}(R_1)$, ball mass is $2.5\mathrm{g}(m_1)$.Set that ball manufacturing material volume is V_1, computational formula is: $V_1 = \frac{4}{3}\pi R_1^3 - \frac{4}{3}\pi R_2^3 = 1.7323(cm^3)$

Set ball manufacturing material density is ρ: $\rho = \frac{m_1}{V_1} = \frac{2.5}{1.732.3} = 1.4432(g/cm^3)$

It is known that big ball diameter is $40\,\mathrm{mm}$, internal radius is $19.61\,\mathrm{mm}(r_2)$, external radius is $20\,\mathrm{mm}(r_1)$, and then big ball manufacturing material mass m_2 and volume V_2 are respectively:

$$V_2 = \frac{4}{3}\pi r_1^3 - \frac{4}{3}\pi r_2^3 = 1.8443(cm^3)$$

;

$$m_2 = V_2\rho = 2.6617(g)$$

Two balls' manufacturing mass difference are respectively Δm : $\Delta m = m_2 - m_1 = 0.1617(g)$, which suggests that mass has increased by 6.47%.

2.2 Changes of rotation speeds after turning a small ball into a big one

If athlete hits two balls of different sizes in the same way and with equal size force, due to big ball and small ball rotational inertias are different, balls' rotation speeds would also have extremely significant changes. Information indicates that spherical shell can be regarded as being composed of n pieces of small circular rings.

Select one circular ring from them to consider, then the circular ring's mass is:

$$dm = \rho dS = \rho \times 2\pi(R\sin\theta) \times Rd\theta$$

Then the mass unit rotational inertia is:

$$dJ = (R\sin\theta)^2 dm = 2\pi\rho R^4 \sin^3\theta d\theta$$

The whole spherical shell's rotational inertia is:

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$$J = \int dJ = \int_0^{\pi} 2\pi\rho R^4 \sin^3\theta d\theta$$
$$= 2\pi\rho R^4 \int_0^{\pi} \sin^3\theta d\theta$$
$$= 2\pi\rho R^4 (\cos 3\theta / 3 - 3\cos\theta) / 4 \Big|_0^{\pi}$$
$$= \frac{2}{3} mR^2$$

So that computational formula for the two balls' rotational inertia is:

$$I_1 = \frac{2}{3} m_1 r_1^2 = 6.017(g \cdot cm^2)$$
$$I_2 = \frac{2}{3} m_2 r_2^2 = 7.098(g \cdot cm^2)$$

Provided that small ball's rotation speed is $50\,\mathrm{r/s}$, according to moment of momentum theorem, it can calculate big ball rotational speed ω_2:

As $I_1\omega_1 = I_2\omega_2$, then $\omega_2 = \frac{I_2\omega_1}{I_2} = 42.39(r/s)$

Two balls angular speed difference is: $\Delta\omega = \omega_2 - \omega_1 = 7.61(r/s)$

By calculation, it is clear when hitting two balls of different sizes in the same way, big ball rotational speed reduces by $7.61(r/s)$ (decrement rate is nearly 15.22%) by comparing to small balls'.

2.3 Changes of flight speeds after turning a small ball into a big one

All objects cannot spread without medium. In objects' motion process, objects and medium will give rise to resistance, the bigger medium resistance would be conductive to prevent objects from moving .Size of effects of factors in medium air on resistance can be expressed by following formula: $f = c\rho S\varphi(v)$.

Here, ρ is density of medium air, $\varphi(v)$ is physical function of objects' running speed v but its expression form cannot be yet defined. Furthermore, though resistance has connection with objects' volumes and shapes, taking volumes and shapes into consideration, object could only be regarded as a rigid body; situations are even more complicated than what it was. Regard object as a particle here-belongs to the scope of particle mechanics. In detailed discussion, considering that table tennis takes indoors motions, assumed that air is motionless, table tennis size and shape would not change during its flight process, then $c\rho S = k_1$, as for $\varphi(v)$-relative complicated, $\varphi(v)$ is just a function related to speed and $\varphi(v)$ increases as v increases, relative expression is Table 1 as following:

Corresponding expression of table tennis speed by inquiry is: $\varphi(v) = k_2 v^2$

To sum up, table tennis suffered air friction while flight is: $f = k_1 k_2 v^2$

The ratio of air frictions in case two balls move at same speed v_0 is:

$$\frac{f_1}{f_2} = \frac{c\rho S_1 v_0^{\ 2}}{c\rho S_2 v_0^{\ 2}} = \frac{S_1}{S_2} = \frac{\pi r^{\cdot 2}_1}{\pi r_2^{\ 2}} = 0.9025$$

Due to table tennis just suffers the effect from air friction at the direction of motion during flying process, big ball suffered air friction increases by nearly 9.75% by comparing to small ball through calculation -horizontal flight speed after turning a small ball into a big one decreases by 9.75%.

Table 2's data analysis suggests that rotation speed decreases, mass increases and horizontal running speed decreases after turning a small ball into a big one, which leads to fundamental changes in rotation, speed and strength from table tennis winning factors. Just due to speed and rotation are restricted; some players' skills will also be affected.

Zhang Xielin, counselor of China's delegation, thought that skilled players would suffer losses as ball running speed slows down. The weaken ball rotation ability will bring about bad effects on players with good service in varieties of forms, which would directly affect players' performance during competition process and their results in competitions–results in lower players' experience quality.

2.4 The effect of 'Big ball era' on audience enjoyment

Having known the comparison results of scoring rate in phases in Sydney Olympic Games and the 49th World Table Tennis Championships Finals, then it makes statistics and calculation of average stroke number per one point in such two events in the following. Average stroke number of each point in Sydney Olympic Games: 3.7 strokes; while that in the 49th World Table Tennis Championships Finals: 5.0 strokes.

Table 1. Relationship between $\varphi(v)$ and v.

Speed m/s	From 0 to 10	From 10 to 311	Above 311
$\varphi(v)$ expression	$k_2 v^1$	$k_2 v^2$	$k_2 v^n$

Table 2. Corresponding changes of indicators after turning a small ball into a big one.

Indicator	Mass	Rotation speed	Horizontal speed
Change percentage	6.47%	-15.22%	-9.75%

Data results indicate that average stroke number per one point in 'Big ball era' has somewhat increased –number of rallies for player gaining one point has increased. In this way, phenomenon as less rallies, faster

service, victory defined while audience didn't realize in 'Small ball era'players' competing is avoided. Increase rallies even promote the interests of table tennis enthusiasts, together with players' skill improvement required by the competition, the competition would turn to be even more fierce and wonderful.

In addition, considering cases as audiences would not fully enjoy themselves if too little strokes per rally and they suffer visual fatigue if there are too many strokes, best strokes per rally for audiences through inquiry can be expressed higher enjoyment time. Therefore, shifting through video, the paper makes statistics of relationships between intense level of audiences' applauses and strokes per rally as following Table 3:

Table 3. Comparative statistical table of strokes per rally and intense applause level.

Strokes per rally	Intense applause level
1-2 strokes	75
3-4strokes	80
5-6strokes	95
7-8strokes	85
9-15strokes	85
Above 15 strokes	80

From above Table 3, it is clear that the intense audiences' applauses levels will be very high when it comes to 5 to 6 strokes per rally, while such intense level is secondary when it comes to 7 to 15 strokes and the intense level is moderate when it comes to 3 to 4 strokes. In Sydney Olympic Games, the average stroke per one point is 3.7 strokes and that in the 49th World Table Tennis Championships Finals is 5 strokes. By comparing, the intense audiences' applauses levels in 'Big ball era' is higher than that of ' Small ball era'. Therefore, the advent of 'Big ball era' promotes enjoyment quality of audiences.

'Big ball era' would bring into brand new hopes to players with better physical ability, especially European players. In the time of 'Big ball era', many European players encounter to Asians' with more rallies playing and relative close scores. This predicts that the advent of big ball era should weighed European party in the future scale of Europe VS Asia. And European players has opportunities to Challenge previous table tennis champions, which also increase richness of sports events and meanwhile further stimulate players to improve their skills and make sports events more enjoyable. Consequently, theoretical results can be made through summarizing from all aspects that 'Big ball era' is able to promote audiences' ornamental quality to a certain degree.

Since small ball turns into big one, players' experience quality has somewhat lowered but audiences' ornamental quality has improved. Once a best length of table tennis diameter is founded, a balance point will be reached between players' experience quality and audiences' ornamental quality, so that players can give full play of their skills and strength in every competition and audience could focus on the completion and enjoy themselves. In the following, we will make research on best table tennis diameter by mathematical statistics and theoretical analysis.

3 Conclusions

The model is simple and practicable that accurately analyzes the issue of effects of ball diameter changes on players' experience quality and audiences' ornamental quality. With the thought of optimization, firstly it gets optimal value of strokes per rally and best utilization time per game, and finally gets best table tennis diameter. The model offers general models to solve such kind of issues that can be expanded and applied into solution of related issues. In the model, it just goes ahead with preliminary exploration into players' skills. In the future study, it can more detailed present changes of experience quality targeted at the changes of table tennis diameter on different skills. Table tennis diameters has somewhat improves comparing to 'Small ball era'. Through solving problem one, it concludes that requirements on players' physical ability and skills will be higher as table tennis diameter increases. Thus, players' physical ability and skills should be improved by strengthening training of technique of attacking, reinforcing the ability in a stalement, enhancing ability of attack and counterattack as well as lift and counter lift in the middle and back court, and increasing proportion of physical training.

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