ISSN : 0974 - 7435 Volume 10 Issue 9

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(9), 2014 [2957-2964]

Biomechanics indicators-based best tennis technological performing strategy research

Changjun Zhang

Institute of Physical Education, Yangtze University, Jingzhou 434000, Hubei, (CHINA)

ABSTRACT

The paper takes tennis and athletes as research objects, applies kinematics relative theories to make force analysis of tennis stroking process front, middle and back parts, gets that proper increasing racket swinging strength and suitable angles are beneficial to arrive at best state of stroking. In addition, it applies biomechanics to study tennis, it carries on systematic analysis of service techniques correlation contents, and finally it gets that except for athletes themselves qualities and it still is related to sweet spot opportunities grasping extent.

KEYWORDS

Tennis event; Kinematics; Physics; Physiological indicator.

INTRODUCTION

Along with the development of time, sports are also constantly moving forward, from which tennis is an indispensible research content, tennis even is a kind of speed, strength opportunity and others comprehensive event, to let tennis players to arrive at higher levels, it should goes deeper researching on tennis event.

For tennis event, formers have already put forward many kinds of theories to improve athletes levels, such as : Wu Song-Wei and others made deepen analysis of tennis from driving and angles, they got that for different spinning tennis, the tennis players stroking process' motions structures were in a kind of dynamics; Ma Yan-Hui made biomechanics analysis of forehand stroking process to make up the field deficiency.

The paper tries to carry on force analysis from tennis kinematics and biomechanics two aspects, and puts forward its opinions, it can effective help tennis players early make up for the deficiency in training process so as to improve their technological levels.

TENNIS MOVEMENT PROCESS KINEMATIC MECHANICAL PERSPECTIVE ANALYSES

If athletes exerted force on racket is a constant force F ,and meanwhile the racket accelerated speed is also fixed, and in speed changing process, time corresponding T_1 instant speed is u_1 , T_2 instant speed is u_2 , time that athletes act on racket is ΔT , mass is M then according to dynamics momentum theorem,it has:

$$F \cdot \Delta T = Mu_2 - Mu_1 \quad \textbf{(1)}$$

But considering practical status, athlete racket swinging process force doesn't remain unchanged, then make integral of above formula, it has:

$$\int_{T_1}^{T_2} F(T)dT = Mu_2 - Mu_1 \quad \textbf{(2)}$$

By above two formulas, we know that racket should have higher impulse if it wants to get larger momentum increment. So it needs to let athlete body to try to surpass his racket height in final stage.

Racket instantaneous contact mechanical analysis model

When tennis contacts with racket, tennis will suffer effects from racket friction f , supports force F_N , and tennis itself gravity. In order to more reasonable state problem, it might as well set when ball contacts with racket, racket is vertical to ground, correspondingly as following Figure 1-2shows.

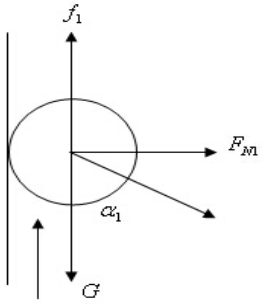

Figure 1 : Topspin stress analysis

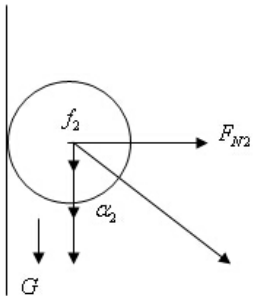

Figure 2 : Backspin stress analysis

Then,it has:

$$F_{N1} = F_{N2} = F_N \quad \textbf{(3)}$$

In above two figures, supporting forces are equal, then every figure suffered resultant force is:

$$F_1 = G - f_1 \quad \textbf{(4)}$$

$$F_2 = G + f_2 \quad \textbf{(5)}$$

According to physics parallelogram corresponding vectors rules, we solve its direction, from which, in Figure 1, tennis rebound angle:

$$\alpha_1 = \arctan \frac{F_N}{G - f_1} \quad \textbf{(6)}$$

Then, corresponding Figure 2 tennis rebound angle:

$$\alpha_2 = \arctan \frac{F_N}{G - f_2} \quad \textbf{(7)}$$

According to mathematical relative knowledge, we know that in the region $(-\overline{2}, \overline{2})$, for $f(x) = \arctan x$, it is an increasing function, and it has $G - f_1 < G + f_2$,then combine with above two angles solution process, we can know the two sizes meet :

$\alpha_1 > \alpha_2$,above formula proves topspin direction's speed is slower than backspin direction speed by comparing, it is the cause of tennis event process's under the neting.

But after tennis contacting with ground, movement state is just opposite to it, that backspin speed is obviously slower than topspin speed, it is because that during tennis and ground contacting process, in horizontal direction, it suffers effects of speed increment Δu,we let speed after contacting with ground is u_1,then corresponding horizontal direction speed is :

$$u_{t\,opspi\,nx} = u_1 \sin\alpha - \Delta u \quad \textbf{(8)}$$

Then corresponding horizontal direction backspin speed is:

$$u_{backspinx} = u_1 \sin\alpha - \Delta u \quad \textbf{(9)}$$

By above two formulas, we can also verify above conclusions that topspin speed is bigger than backspin speed. So the tennis athlete should have higher backspin racket swinging strength in stroking tennis process then can let ball landing instant to suffer higher supporting force effects, so that promote stroking efficiency.

Racket whole contacting process mathematical model

If let racket and tennis collision process forces are successively F_1 and F_2, corresponding masses are respectively M_1 and M_2, the two contacting time is using ΔT to express, opposite directions equal sizes two forces F_1 and F_2,then it will meet relations : $F_1 = F_2 = F$

In the following, if let u_1 and u_2 to respectively represent opposite directions before contacting racket and ball speeds, then it can let after collision is u_3,the two accordingly generated impulse is using $F \cdot \Delta T$ to express, according to physics relative momentum theorem, it has :

$$F \cdot \Delta T = M_2 u_3 + M_2 u_2 \quad \textbf{(10)}$$

Then after tennis racket collides with ball, the two speeds are :

$$u_3 = (F \cdot \Delta T - M_2 u_2) / M_2 \quad \textbf{(11)}$$

But in practical process, people force on racket will also have corresponding effects, then for corresponding resultant force, we assume it as $F_{resultant}$, then corresponding impulse is:

$$F_{resultant} \cdot \Delta T = F \cdot \Delta T + \Delta T \quad \textbf{(12)}$$

By formula (12) we can get tennis and racket contacting time extending as well as athletes use larger strength to stroke, both can let tennis to get higher impulse.

RESEARCH ON TENNIS PLAYER SERVICE PROCESS IN THE PERSPECTIVE OF BIOMECHANICS

Tennis service techniques attract more and more attentions from broad athletes, so in order to research on its causes, the paper takes tennis players (men and women four person each) as research objects, their basic information is as following TABLE 1 shows:

TABLE 1 : Research objects information

	Men			Women		
	Age (years old)	**Height (m)**	**Weight (kg)**	**Age (years old)**	**Height (m)**	**Weight (kg)**
Average value	19.1	1.85	72.54	18.9	1.71	62.10
Standard deviation	2.6	0.06	4.96	2.5	0.06	6.34
Maximum value	24	1.92	80	26	1.80	74
Minimum value	14	1.69	61	14	1.58	55

For competition video, it makes analysis, from which service phase is composed of three parts,it mainly includes swinging racket and stroking, leaning back, tossing and holding racket, and the paper mainly targeted stroking actions, tossing, service and the three coordination,it makes system researches.

Tossing technique problems analysis

Best tossing position is that ball is just on the right above of vertical rotating arc. Tennis players' awareness of taking the net has inseparable relations with tossing forward horizontal direction's distance, comparison between men and women is as following TABLE 2 shows:

TABLE 2 : Tossing features parameters (m)

Statistical magnitude	Tossing point height		Sweet spot and left foot supporting point horizontal distance		Sweet spot height		Sweet spot and tossingpoint horizontal distance		Gap between top point and sweet spot	
Gender	Men	Women	Men	Women	Men	Women	Women	Men	Women	Men
Ratio with weight	0.85	0.90	0.425	0.30	1.56	1.45	0.35	0.44	0.51	0.36
Average value	1.50	1.50	0.780	0.49	2.81	2.40	0.49	0.85	0.81	0.69
Standard deviation	0.20	0.15	0.112	0.14	0.04	0.05	0.26	0.32	0.19	0.25
Maximum value	2.00	1.75	0.914	0.75	2.83	2.50	0.80	1.40	1.21	1.13
Minimum value	1.35	1.30	0.661	0.27	2.73	2.40	0.12	0.43	0.49	0.22

In order to more clearly present men and women differences, it draws horizontal direction tossing distance bar figure, as following Figure 3 shows:

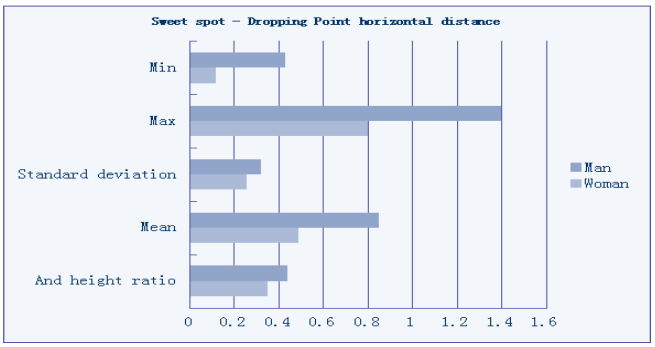

Figure 3 : Sweet spot - Dropping Point horizontal distance

By above Figure 3, we can find men tossing horizontal distance is obvious further than women, due to individual special structure, in-situ takeoff is not as high as forward takeoff, therefore only has larger horizontal direction distance, it will naturally have certain height in vertical direction, Chinese athletes should pay attention to improve distance in horizontal direction.

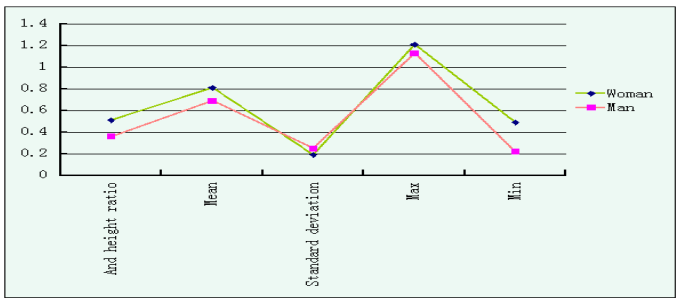

Figure 4 : The highest point - the ball point gap

Tossing gap problems research

By above Table, we can also see tossing gap aspect differences, in order to more clearly present differences, it draws broken line figure, as following Figure 4 shows:

By above Figure 4, we can see even no matter men or women have very big gaps in tossing, men gaps in tossing is obviously lower than women, enlarging gap will leads to movement being postponed, let each articulation overall cooperative ability to reduce.

Sweet spot position research

For high speed hitting process, to get big success rate, it should let sweet spot height to be big enough, research in technical aspect, it is required gravity center after body hanging to arrive at top point, trunk should fully extend, lower limbs to move forward as much as possible, when extend trunk to maximum, both racket holding hand and racket are vertical to ground. In order to study sweet spot position, combine with above table, it draws scattering figure, as following Figure 5 shows:

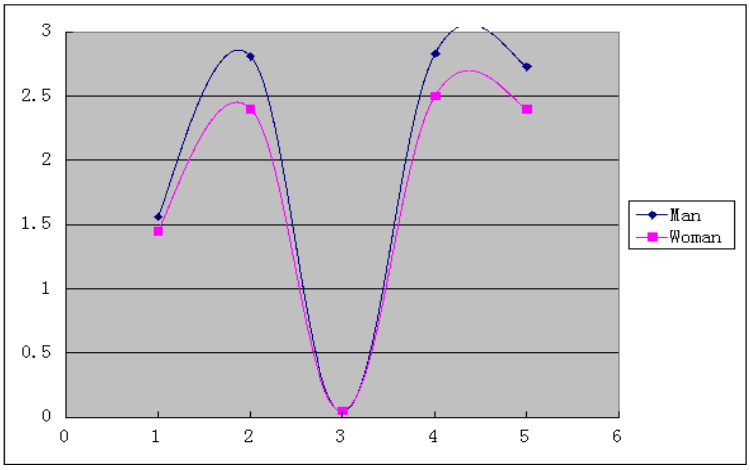

Figure 5 : Sweet spot height

By above Figure 5,and combine with above table,we can get women sweet sport is shorter than men, it mainly because women lack of strength in lower limbs pedaling ground that leads to lower takeoff height, in addition, it also is related to grasping of top point dropping till sweet spot and athlete take-off time.

Figure 6 : Players tee action

Tossing way research

In tossing process, it always should remain ball movement trajectory stability, when tossing arm stretches to tossing point, ball starts to leave from arms, now avoid accelerated tossing, after tossing, don't hurry putting hands back but still keep original postures, then it will helpful for sweet spot position. As following Figure 6 shows:

In order to compare service techniques each parameter stability, it tests on the school four athletes, the result is as following TABLE 3 shows:

TABLE 3: Regarding athletes service techniques stability comparison table

Serial number of athletes	Tossing point height	Sweet spot point height	Gap between top point and sweet spot	Tossing point and Sweet spot horizontal distance
No.1	1.26	2.51	1.15	0.30
	1.27	2.49	0.99	0.36
No.2	1.75	2.47	0.76	0.65
	1.65	2.45	0.84	0.69
No.3	1.57	2.49	0.89	0.74
	1.59	2.49	0.85	0.64
No.4	1.56	2.40	1.12	0.51
	1.49	2.36	1.11	0.46

In order to more vividly present mutual relations,it draws broken line figure, as following Figure 7 shows:

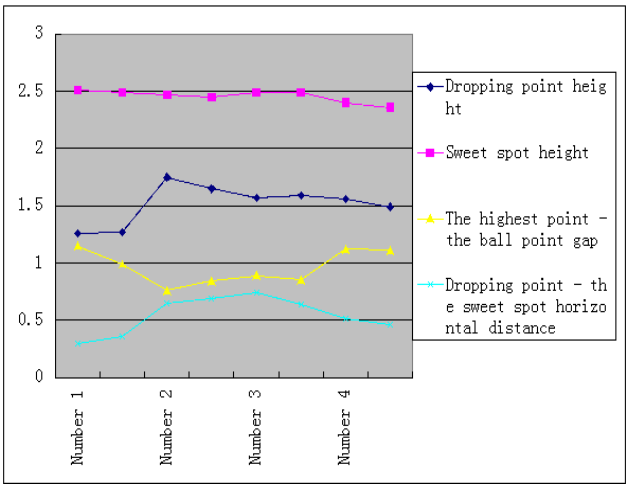

Figure 7 : Stability comparison of serving technology athlete

By above Figure 7,we can get sampled four athletes in service techniques comparison, both distance about tennis dropping distance from top point and horizontal direction distance are bigger, and in tossing point height and sweet spot position,it still is relative stable, because four athletes changing ranges in the directions are not big.

CONCLUSION

(1) The paper goes deeper analysis of tennis stroking process front, medium, and back parts, but due to the process influence factors are quite a lot, the paper selects main factors of them to study, and gets proper increasing racket swinging strength and suitable angles are beneficial to arrive at stroking best state, they should strengthen exercising at ordinary times' training.
(2) By studying sweet spot point positions, we get lower limbs strength gets bigger,takeoff height will be higher and gravity center rising to top point instant,reasonable grasp stroking time, now the sweet spot point is the best.
(3) By stability comparison of athletes service techniques, we can summarize tennis players muscle exertion sensitivity differences are bigger, and stable in movement, there is no differences, and we also know that due to elbow joint doesn't stretch in tossing process,it lets tossing position to be lower, which may be one of exertion aspect stability influence factors.

REFERENCES

[1] Alireza Fadaei Tehrani, Ali Mohammad Doosthosseini, Hamid Reza Moballegh, Peiman Amini, Mohammad Mehdi DaneshPanah; A New Odometry System to Reduce Asymmetric Errors for Omnidirectional Mobile Robots[J]. RoboCup, 600-610 **(2003)**.
[2] R.E.Kalman; A New Approach to Linear Filtering and Prediction Problems [J]. Transaction of the ASME - Journal of Basic Engineering, **82**, 35-45 **(1960)**.
[3] Carlos F.Marques, Pedro U.Lima;A Localization Method for a Soccer Robot Using a Vision- Based Omni-Directional Sensor [J]. RoboCup, 96-107 **(2000)**.
[4] S.Thrun, D.Fox, W.Burgard, F.Dellaert; Robust Monte Carlo localization for mobile robots [J]. Artificial Intelligence Journal, **128**, 99-41 **(2001)**.
[5] Kan Li-ping; Evaluation on Technical data of Free Kick in Impose Fine Region in Football Game[J]. Bulletin of Sport Science & Technology, **19(3)**, 19-20 **(2011)**.
[6] Zheng Wei; On the Training of Football Shooting[J]. Sport Science and Technology, **3**, 23-26, 33 **(2000)**.
[7] Yang Jilin et al.; Research on shooting in the 17th World Cup football semi-finals[J]. Journal of Shandong Physical Education Institute, **18(3)**, 51-53 **(2002)**.
[8] Wang Xin; Analysis on the best region of shoot [J]. Journal of Nanjing Institute of Physical Education, **16(5)**, 96-97 **(2002)**.
[9] Zhang Ji, xiang; A Study on Effect of Application of the Skills of Side-to-middle Court Passing of Chinese Football Team[J]. Journal of Hubei Sports Science, **21(1)**, 74-75,79 **(2002)**.
[10] Li Ning, Zhou Jiandong; Statistical Analysis of Goals at 19th FIFA World Cup [J]. Journal of Jilin Institute of Physical Education, **27(3)**, 45-47 **(2011)**.