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THE EFFECT OF STRING TENSION ON SHUTTLECOCK VELOCITY

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Badminton players currently lack of knowledge and understanding about the effect of tension on hitting performance. This study aimed to investigate the effect of string tension on shuttlecock velocity. The experiments were performed by stringing 5 racquets with automatic machine and assigned pull tension at 22, 24, 26, 28 and 30 lbs/ft^2, respectively. The racquets were set up in the system with motor speed adjusted at 450 rpm. Then, each racquet was conducted to hit 10 times and capture with 2 high speed cameras at 2,000 frame/sec. Five screenings were made as to search a perfect hitting to analyze shuttlecock speed. The statistic comparison uses one way-ANOVA and repeated measure. The result shows that shuttlecock velocity depends on string tension, that is, lower tension generates more shuttlecock velocity than high tension (22>24>26>28>30). Therefore, badminton players should be have an understanding and modify their stringing behavior to suit each individual.

KEY WORDS: Tension, String, badminton

INTRODUCTION: Badminton players require a mix of strength, speed and a good body control to send the shuttlecock to the aspired target. In international competitions, players must bear in mind that their performance is not different. Therefore, one thing that important is a sporting device that is used in order to gain a technical advantage for the athletes. Racquet is the most important device for playing badminton. So, athletes must know their racquet's property such as a balance point, swing weight, shaft stiffness and string tension. The tension will result directly to bouncing and landing target of the object (Bower and Cross, 2005). High tension gives players a better control. Meanwhile, if the tension is low, players can generate more power but they also have a chance to make more error. (Baker & Wilson, 1978; Brannigan & Adali, 1980; Bower & Sinclair, 1999 and Brody, 1979).The tension also changes due to several factors. After the stringing process, tension gradually decreases slowly according to time, as a result of the stress relaxation of the racquets frame.

Badminton players still lack of sports knowledge and understanding of the proper string tension. String tension is commonly selected by feeling or following other players. However, feeling or sound senses cannot tell the exact string tension because of limitation of the human nervous system. In addition, frequency and oscillation depend on mass and length of the string which is difficult to recognize and classify for future reference. Therefore, to make a correct understanding about string tension, the purpose of this study was to investigate the effect of the string tension on shuttlecock velocity.

METHOD: Ten badminton racquets were used in this study (5 for the tests, 5 for spare). Racquet specification including weight, shaft stiffness and moment of inertia was examined in order to confirm validity (Fig. 1). Stringing process uses a machine (Dunlop) that passes the calibrating from technicians. The tension was fixed at 22, 24, 26, 28, 30 lbs/ft^2. After stringing, the tensions were confirmed by sound frequency analysis (String Tension Measurement Tester, Gosen: ERT300, Japan and Racquet Tune software).

Figure 1: The validity testing: shaft stiffness and moment of inertia

Four markers were attached on the racquet head: top, bottom, left and right to determine the center of the racquet (Fig.2). Testing was conducted in a system room that is designed for racquet swing test. The order of tension testing was randomized. A racquet was locked on the holder and an adjusted motor speed at 450 rpm for the similarity of hitting speed in badminton playing, with the adjusted timing to drop the shuttlecock to the center of the racquet at 1,800 ms. For each tension, the tests were run for 10 times. Afterwards, the tension was confirmed to remain equal before the next testing. The data were recorded via 2 high speed cameras (3-Motion Analysis System, Dmas, USA) operating at 2,000 Hz. Five screenings were made as to search a perfect hitting to analyze shuttlecock speed at impact point and after impact 1, 2, 3, 4, 5 frame.   All data was digitized and smoothed by using cut of frequency at 200 Hz.
The one-way ANOVA (1x5) designed with repeated measure was applied to examine the possible interaction between each string tension. The level of significance was set at $p \leq 0.05$.

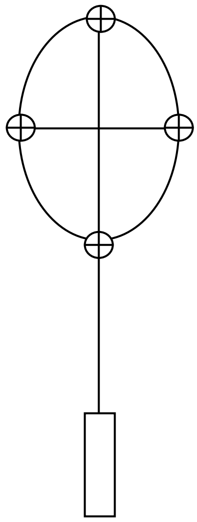

Figure 2: Makers position on badminton racquet

RESULTS: The average velocity slightly decreased when string tension was increased. The ANOVA indicated a significant ($p \leq .05$) interaction effect on shuttlecock velocity at impact point and after impact 1, 2, 3, 4, 5 frames. Post hoc with Scheffe's tests showed a significant between different strings tension that appeared on table 1.

Table 1
Average shuttlecock velocity defined by position and statistical analysis

Frame Position	Average velocity (m/s)					(Sig.) ANOVA
	Tension (lbs) 22	Tension (lbs) 24	Tension (lbs) 26	Tension (lbs) 28	Tension (lbs) 30	
Impact	4.48±0.20 c, d, e	3.92±0.42 c, d, e	2.64±0.50 a, b, e	2.08±0.34 a, b	1.67±0.32 a, b, c	.00*
After 1 F.	11.59±0.47 c, d, e	10.61±0.55 d, e	9.73±0.78 a, d, e	5.94±0.79 a, b, c, e	3.82±0.46 a, b, c, d	.00*
After 2 F.	24.50±1.21 c, d, e	22.31±2.13 d, e	21.01±1.90 a, d, e	15.96±1.46 a, b, c, e	11.26±1.19 a, b, c, d	.00*
After 3 F.	37.14±2.66 d, e	35.94±1.14 d, e	35.54±1.77 d, e	30.69±1.83 a, b, c, e	24.35±2.15 a, b, c, d	.00*
After 4 F.	49.59±1.87 d, e	49.01±1.22 d, e	47.13±2.21 e	44.95±1.39 a, b, e	38.95±2.15 a, b, c, d	.00*
After 5 F.	56.30±1.03 e	55.55±1.11 e	54.34±1.15 e	54.37±0.55 e	50.51±1.65 a, b, c, d	.00*

*P≤.05, Post hoc with Scheffe's tests - **a**: sig. when compare with 22 lbs tension, **b**: sig. when compare with 24 lbs tension, **c**: sig. when compare with 26 lbs tension, **d**: sig. when compare with 28 lbs tension, **e**: sig. when compare with 30 lbs tension

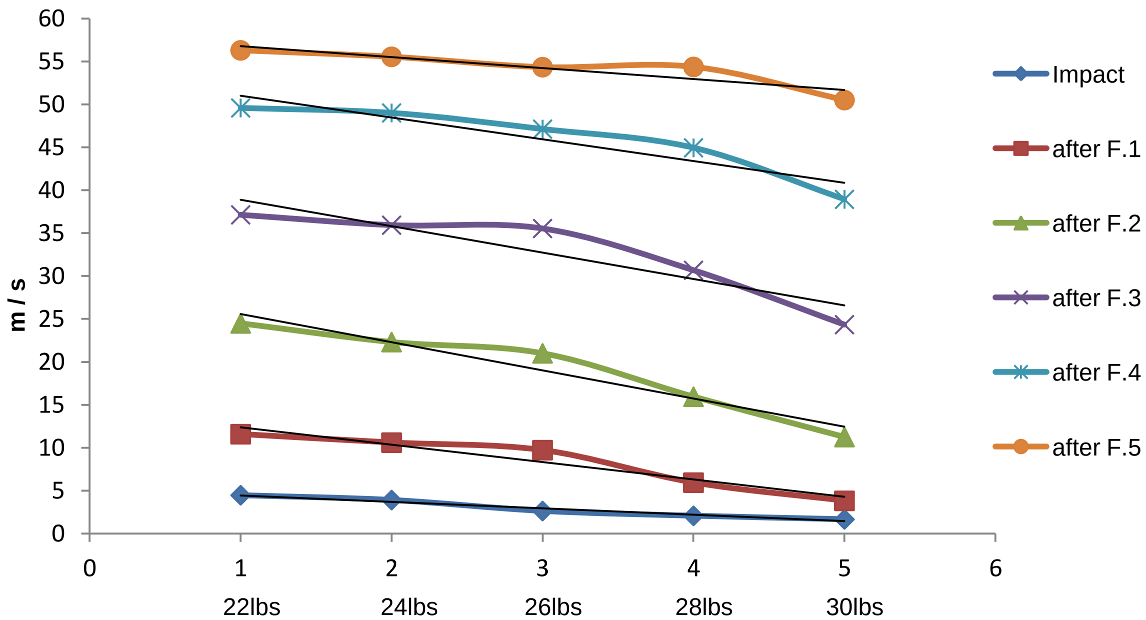

Figure 3: Average shuttlecock velocity with line graph

DISCUSSION: At present, there is a little research related to badminton. Thus, most references are based on study in tennis which is considered to be similar in overall features. To our knowledge, this is the first study that reports string tension effect in badminton.

The main findings of this study are that string tension effect on shuttlecock velocity. Changing velocity of the shuttlecock was effected by tensions that pulled on a racquet. In this study, when string tension increased from 22 lbs until 30 lbs results in shuttlecock velocity decreased respectively. This effect is agreeable with Bower & Cross (2005) that reported effect of high string tension (280N) gives a rebound speed in tennis ball lower than low string tension (180N). Furthermore, it is generally accepted that within the range of commonly used string tensions, low tension provides greater rebound velocity (Baker& Wilson, 1978; Brannigan & Adali, 1980; Bower &Sinclair, 1999; Brody, 1979) and high tensions aid control.

The velocity changes do not cause from string tension only, various string tensions can change a racquet's flexibility, thus affecting velocity and other factors associated with impact (Groppel et al., 1987). Most players choose string tension by follow other players' recommendation or their feeling. According to the previous experiment, only 27% of athlete scan distinguish string tension different at 11lbs/ft^2 (about 5 kilograms)when wearing ear muffs and only 37% can distinguish string tension different at 22 lbs/ft^2 (about 10 kilograms) (Bower &Cross, 2003). For example, this study results showed that a little change in string tension (2 lbs/ft^2) have an effect on average shuttlecock velocity such as at impact point - performed tension 22 lb/ft for an average speed of 4.48 ±. 0.20 m/s. compared with 24 lbs/ft^2 for an average speed of 3.92 ± 0.42 m/s. It has been showed from this study that athletes' feeling or sense cannot distinguish string tension different. Thus, this study has confirmed that the knowledge about string tension is important.

CONCLUSION: A little change in string tension can make a shuttlecock velocity increase or decrease. Increasing the string tension, decreased average velocity of the shuttlecock when hit it out. During a competition, this factor may have effects on achievement or make an advantage to the athlete. This experiment was tested by machine that can generate the same power to hit shuttlecock the same plane every time which the motion may not be exactly the same as natural human performance. Nevertheless, the data from this study may modify a conception about stringing behavior. It should be noted, however, that these results do not take into account the adjustments that players may make over time as they become accustomed to the same racket type and string tension.

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