

TEMPORAL STRUCTURE COMPARISON OF THE NEW AND CONVENTIONAL SCORING SYSTEMS FOR MEN'S BADMINTON SINGLES IN TAIWAN

Hsin-Lian Chen, Trevor C. Chen

Department of Physical Education, National Chiayi University, Chiayi County, TAIWAN

The purpose of this study was to test the hypothesis that the temporal structure of the new “rally-point scoring system” for top-level male badminton players in Taiwan would be shorter than that of the conventional scoring system. In order to reflect real badminton conditions, we used high-speed cameras to record all second-round to finals men's singles matches played during one of Taiwan's national series of badminton tournaments in 2005 (the conventional system) and 2006 (the new system). After data collection, the temporal structure during each match was determined from video recordings. The results of this study showed that rally times and the number of shots per rally were significantly greater ($p < 0.05$) under the new scoring system than under the conventional system, while the rest of the measures (e.g. match duration) were significantly shorter ($p < 0.05$) in matches played under the new system than in those played under the conventional system. It was also found that under the new system, most of the measures (e.g. match and exercise durations) during the second and third innings showed greater increases ($p < 0.05$) than during the first inning. Likewise, under the conventional system, the exercise duration and number of serves during the second and third innings showed greater increases ($p < 0.05$) than during the first inning. These results suggest that the temporal structure of the new scoring system is significantly different from that of the conventional system, and may require coaches to modify current on-court training methods to maintain specificity with the demands of the new system.

Keywords: exercise duration, notational analysis, rally point scoring system, rally times

Introduction

Badminton is a sport that requires a balance of physical preparation, patience, and tactical expertise (Pearce 2002; Bloss & Hales 1994). There are five disciplines within the sport of badminton including men's and women's singles, men's and women's doubles, and mixed doubles. Each discipline requires on-court preparation unique to that discipline (Pearce 2002; Bloss & Hales 1994). For instance, singles training drills are

based around patience, control and physical fitness. In a badminton singles match situation, the players generally set up the rally for a winning shot only after using a variety of other shots and placements that allow for an effective smash (Hong & Tong 2000; Bloss & Hales 1994).

Analyzing how one's strengths compare to those of one's opponent is another exercise that can help improve a badminton player's game (Hong & Tong 2000). This can be accomplished by recording matches with a video camera and analyzing the resulting videos after the game (Pearce 2002; Hong & Tong 2000; Blomqvist et al. 1998; Liddle et al. 1996; Hughes et al. 1989). This method is generally referred to as notational analysis. Because notational analysis has been proven to be reliable and effective, it is often used today by researchers and coaches to evaluate performance in badminton



ELSEVIER

Corresponding Author
Trevor C. Chen, Department of Physical Education,
National Chiayi University, 85 Wenlong Village,
Minsyong Township, Chiayi County 62103, TAIWAN.
Tel: (886) 5 226 3411 ext. 3000
Fax: (886) 5 206 3082
E-mail: trevorchen@mail.ncyu.edu.tw

matches, or to promote an understanding of specific game demands and thus assist in the creation of game-specific training schedules (Faude et al. 2007; Pearce 2002; Blomqvist et al. 1998; Liddle et al. 1996; Hughes et al. 1989).

Several previous studies (Faude et al. 2007; Cabello Manrique & Gonzalez-Badillo 2003; Docherty 1982) have already investigated the temporal structure changes in elite men's singles badminton matches. Cabello Manrique and Gonzalez-Badillo (2003) found that in competitions in which two out of three innings won the match, match duration was 28.0 ± 5.2 minutes (not including rest intervals); the average number of shots per rally was 12; and the ratio of exercise duration (rally time, 6.4 ± 1.3 seconds) to rest duration (12.9 ± 2.7 seconds) was approximately 1:2. Similar results were also found in other studies (Faude et al. 2007; Docherty 1982). Moreover, from an analysis of a video of the first round of men's badminton singles matches at the 2004 Olympic Games in Athens (unpublished observation), it was preliminarily found that 11 matches ended with a score of 2 to 0 (average score of 15.0 to 5.6). Of these, each match lasted for an average of 36.3 ± 12.5 minutes. Meanwhile, five matches ended with a score of 2 to 1, of which the average score was 15.1 to 9.1. Each match lasted for 71.6 ± 6.5 minutes; the maximal duration of shots per rally was 58 seconds, and the maximal number of shots per rally was 56. Although the competitions (international-level, Olympic or World Cup competitions) analyzed in the aforementioned studies differed in terms of tournament ranking (finals, semi-finals, quarter-finals, second-round or first-round) and number of innings per match (two or three), all competitions lasted for an average of 30–48 minutes.

On January 1, 2006, the International Badminton Federation (IBF) adopted the new "Rally Point Scoring System" (<http://www.internationalbadminton.org/statues.asp>). This system was designed to shorten the length of badminton matches in an effort to make them more exciting to watch, attract more sponsors, expand media exposure, and eventually increase the sport's popularity. Comparing the regulations in 2006 (after the new 3×21 format system had been implemented) with those in 2005 (when the old 3×15 format system was still in place), it is reasonable to assume that under the new system, match duration, exercise duration and rest duration would all be significantly shorter than under the conventional system, making matches faster, more competitive and more intense. Yet, a more recent study by Tu (2007) showed that this

is not always the case. In his study, Tu analyzed the men's singles matches in several international five-star badminton tournaments sponsored by the IBF. Some of these (the 2006 Thomas Cup, Uber Cup, and Chinese Taipei Open) were scored under the new scoring system, while others (the Chinese Taipei Open, Singapore Open, and IBF World Championships from 2000–2005) were scored under the conventional system. Tu's results showed that the average stroke time was indeed significantly shorter under the new system (0.92 ± 0.20 seconds) than under the conventional system (0.98 ± 0.26 seconds). However, the study also found that there were no significant differences between the two systems in average match duration (new system, 1116.4 ± 347.5 seconds; old system, 1229.9 ± 304.6 seconds) and rally time (new system, 8.1 ± 6.3 seconds; old system, 7.4 ± 5.7 seconds).

Although the results of this study may have provided some useful information for badminton coaches and players, the study did not include any further detailed analysis of the temporal structure of badminton matches under the two scoring systems. Specifically, it did not give any information on how the timing of the various variables differed from inning to inning (each badminton match generally has a total of three innings). Similar results were also seen in other studies (Faude et al. 2007; Cabello Manrique & Gonzalez-Badillo 2003; Pearce 2002). Yet, in all of these studies (Faude et al. 2007; Tu 2007; Cabello Manrique & Gonzalez-Badillo 2003; Pearce 2002), the subjects analyzed were international-level, Olympic or World Cup-level athletes, who are much stronger players and enjoy higher rankings than their counterparts in Taiwan. Results from such studies may thus not be very useful for Taiwan's badminton coaches or players in training. To generate results that would be more relevant to local badminton players and coaches, the present study used as subjects second-round to finals male singles badminton players in Taiwan. At the same time, the study explored the changes in temporal structure of the different innings within the same match. Such a design enabled us to more effectively define the actual degree of influence the new scoring system is having on badminton players in Taiwan, and to draw some initial temporal structure comparisons between their games and those played by the international-level players who were analyzed in the aforementioned studies.

Therefore, the purpose of the present study was to test the hypothesis that "using the new (rally-point) scoring system would cause the temporal structure of elite men's singles badminton tournaments to be significantly

shorter than that of tournaments played under the scoring-by-service system”.

Methods

Subjects

In this study, 15 matches played by Taiwan’s top 16 male singles badminton players during each of two national series of badminton tournaments—one in March 2005 (held at the Yong-an Badminton Stadium in Taichung City, when the old scoring system was still in place) and the other in August 2006 (held at the Kaohsiung County Badminton Stadium, after the new system had been implemented)—were recorded and analyzed. In the 2005 series, the final score in 13 of the matches was 2 to 0, while in the other two matches, the final score was 2 to 1 (for an average score of 14.8 to 8.3). In the 2006 series, the final score in nine of the matches was 2 to 0, while in the other six matches, the final score was 2 to 1 (for an average score of 18.6 to 16.3).

Procedure

We used high-speed camcorders (JVC 9800U and GR-DVL9800U, JVC Co., Japan) to record all matches played by the top 16 male singles badminton players in Taiwan (including the second rounds, the quarter-finals, the semi-finals and the finals) during both of the above-mentioned series of tournaments. For each match, camcorders were placed at either the back or the side of the court, depending on the court’s physical layout. After the tournaments, we used Windows Movie Maker software on a standard computer to create videos, and hired two of Taiwan’s top-level badminton players to serve as analysts. Following extensive training in the methods and procedure of this study, analysts were instructed to watch the videos of the badminton matches, and record their observations directly into a table.

Dependent variables analyzed included: number of shots per rally (the total number of times the shuttle was hit by both players from the serve until it hit the ground); rally time (time elapsed from the serve until the shuttle hit the ground); stroke time (rally time divided by the number of shots per rally); match duration per inning (in each inning, the time elapsed from the first serve until the shuttle hit the ground for the last time); total number of serves per inning (total number of serves by both players); total exercise duration per inning (in each inning, the total time elapsed from the serve until the shuttle hit the ground); rest time per inning (in each inning, the total time elapsed

from the time the shuttle hit the ground until the racquet hit the shuttle for the following serve); exercise duration to rest time per inning (in each inning, the ratio of total exercise duration to total time elapsed between rallies); match duration (in each match, the time elapsed from the first serve until the shuttle hit the ground for the last time); total number of serves per match (the combined number of serves by both players in each match); total exercise duration per match (in each match, the total time elapsed from each serve until the shuttle hit the ground); total rest time per match (in each match, the total time elapsed from the time the shuttle hit the ground until the racquet hit the shuttle for the following serve); ratio of exercise duration to rest time per match (in each match, the ratio of total exercise duration to total time elapsed between rallies); and total stroke time per match (in each match, the total rally time divided by the total number of shots in all rallies). After the two research analysts obtained raw data on all of the variables, they added the totals and calculated the averages. These served as the final data for analysis in the present study.

It should be noted that the variables listed above are generally recognized to comprise an effective evaluation index for analyzing the temporal structure of badminton matches (Faude et al. 2007; Tu 2007; Cabello Manrique & Gonzalez-Badillo 2003; Docherty 1982). In order to ensure that the analytical results of the two analysts were consistent, the present study also took steps to ensure interrater reliability (Posner et al. 1990; Landis & Koch, 1977). In this study, the reliability coefficient for all variables was ≥ 0.98 , showing that they were consistent and reliable.

Statistical analysis

Temporal structure statistics for games played under the new and conventional scoring systems were analyzed separately using a one-way repeated measures analysis of variance (ANOVA; 1st-3rd innings) and the paired *t* test (average value and total value of the entire game). When ANOVA showed a statistical difference, the Bonferroni *t* procedure was then used for further comparison. To determine whether differences between the new and conventional regulations would have an effect on the temporal structure of men’s singles badminton games, this study used a mixed-design of two-way ANOVA (1st-3rd innings) and the paired *t* test (average value and total value of the entire game) to analyze the data. When a significant interaction (regulation \times inning) effect was observed, a Scheffé’s *post hoc* test was

conducted to specify the innings. Statistical significance was set at $p < 0.05$.

Results

Temporal structure of badminton singles matches played under new and old scoring systems

Comparing the temporal structure of badminton singles matches played under the new and conventional scoring systems using a mixed-design of two-way ANOVA and the paired t test, the present study found that for the variables of match duration, exercise duration, rest time, ratio of exercise duration to rest time, rally time, number of shots per rally, average stroke time and number of serves, there was a group and/or interaction effect ($p < 0.05$) between the two systems (Table 1). When we further analyzed the data using Scheffé's *post hoc* test, we found a significant statistical difference ($p < 0.05$) in the following variables: ratio of exercise duration to rest time (difference noted in the 1st inning); rally time (difference noted in the 2nd and 3rd innings); number of shots (difference noted in the 2nd and 3rd innings, and in the average number of shots per rally throughout the entire match); and stroke time (difference noted in the 1st and 3rd innings and in the average value throughout all three innings). All of the other evaluation indexes showed a significant statistical difference ($p < 0.05$; Table 1) in all three innings. Taking match duration as an example, the duration of the first through to the third innings, the average duration of the entire match, and the total duration of the entire match were all longer under the conventional scoring system than under the new system ($p < 0.05$). Similar results ($p < 0.05$) were observed for exercise duration, rest time and number of serves.

Temporal structure of badminton singles matches played under the old scoring system

A comparison of the temporal structure statistics of each inning in matches played under the conventional scoring system (Table 1) using one-way repeated measures ANOVA revealed some significant differences ($p < 0.05$). When data were further analyzed using the Bonferroni t procedure, it was found that under the conventional scoring system, the total exercise duration during the second inning, as well as the number of serves in the second and third innings, were significantly greater than in the first inning. Comparing the conventional scoring system statistics of the second and third innings, a significant difference ($p < 0.05$) was noted in both exercise duration and rally time. However, no

significant statistical difference ($p > 0.05$) was found between the innings for the variables of match duration, rest time, stroke time and ratio of exercise duration to rest time.

Temporal structure of badminton singles matches played under the new scoring system

When temporal structure statistics for matches played under the new scoring system were analyzed using one-way repeated measures ANOVA, it was found that all variables showed a significant statistical difference ($p < 0.05$; Table 1). When data were further analyzed using the Bonferroni t procedure, it was found that both stroke time and ratio of exercise duration to rest time during the second and third innings, as well as number of serves in the third inning all showed no significant statistical difference ($p > 0.05$) compared to the first inning. However, match duration, exercise duration, rest time, number of shots per rally and rally time during the second and third innings were all significantly longer ($p < 0.05$) than during the first inning.

Temporal structure of badminton singles matches played in the finals, semi-finals and quarter-finals under the new and conventional scoring systems

In order to give badminton coaches, players and fans a more complete understanding of how differences in scoring systems affect the temporal structure of games played in the finals, semi-finals and quarter-finals, this study also presents related statistical data in Tables 2–4, respectively. Any further discussion of these data, however, is beyond the scope of this study.

Discussion

The main findings of this study showed a significant difference between the new and conventional scoring systems in all criterion measures (Table 1). For example, in games played under the conventional scoring system, the duration of each of the three innings, the average duration of the entire match, and the total match duration were all longer than in games played under the new scoring system (Table 1). Similar results were also seen for exercise duration, rest time and number of serves. These findings support our hypothesis that "changes resulting from the adoption of the new scoring system do indeed have a significant influence on the temporal structure of men's singles badminton matches". These results will be discussed further in the following sections.

Table 1. Changes in temporal structure of badminton singles matches ($N=15$) played under the old and new systems

	Old system	New system	<i>p</i>
Match duration			
1 st inning	1133.7 ± 68.5	644.3 ± 21.0	0.002
2 nd inning	1273.7 ± 69.2	952.8 ± 55.5*	0.04
3 rd inning	1174.0 ± 32.8	940.3 ± 16.6*	0.02
Overall average	1184.7 ± 47.6	803.4 ± 34.7	0.01
Overall	2754.6 ± 178.9	1949.7 ± 147.6	0.01
Exercise duration			
1 st inning	349.2 ± 27.2	239.7 ± 8.7	0.03
2 nd inning	409.7 ± 16.1*	310.5 ± 16.2*	0.04
3 rd inning	344.4 ± 3.7†	311.7 ± 6.9*	0.04
Overall average	368.0 ± 12.6	275.6 ± 11.5	0.01
Overall	860.7 ± 60.0	667.0 ± 50.0	0.05
Rest interval			
1 st inning	784.7 ± 50.0	404.0 ± 15.3	0.001
2 nd inning	864.0 ± 54.0	642.3 ± 55.9*	0.03
3 rd inning	844.4 ± 18.9	628.7 ± 8.9*†	0.02
Overall average	818.0 ± 37.4	527.5 ± 30.9	0.02
Overall	1897.5 ± 123.2	1282.1 ± 106.7	0.04
Exercise duration: Rest time			
1 st inning	1 to 2.44	1 to 1.75	0.02
2 nd inning	1 to 2.06	1 to 2.23	0.37
3 rd inning	1 to 2.46	1 to 2.10	0.13
Overall average	1 to 2.30	1 to 2.01	0.18
Overall	1 to 5.12	1 to 4.76	0.31
No. of shots per rally			
1 st inning	7.4 ± 0.2	7.7 ± 0.2	0.26
2 nd inning	7.6 ± 0.1	8.8 ± 0.3*	0.03
3 rd inning	7.8 ± 0.1	9.6 ± 0.2*†	0.02
Overall average	7.5 ± 0.1	8.4 ± 0.2	0.02
Overall	17.0 ± 0.7	20.1 ± 1.2	0.07
Rally time			
1 st inning	8.0 ± 0.3	7.5 ± 0.2	0.24
2 nd inning	7.9 ± 0.1	8.7 ± 0.3*	0.05
3 rd inning	8.4 ± 0.4†	9.7 ± 0.3*†	0.04
Overall average	7.9 ± 0.2	8.2 ± 0.2	0.19
Overall	17.9 ± 1.1	19.9 ± 1.3	0.19
Stroke time			
1 st inning	1.08 ± 0.03	0.97 ± 0.01	0.04
2 nd inning	1.04 ± 0.01	0.99 ± 0.01	0.08
3 rd inning	1.08 ± 0.02	1.01 ± 0.01	0.17
Overall average	1.05 ± 0.02	0.98 ± 0.01	0.05
Overall	2.38 ± 0.12	2.34 ± 0.11	0.42
No. of serves			
1 st inning	43.0 ± 2.4	31.3 ± 0.7	0.01
2 nd inning	52.2 ± 1.9*	35.2 ± 0.9*	0.002
3 rd inning	53.0 ± 4.0*	32.0 ± 0.3†	0.02
Overall average	47.3 ± 1.5	32.9 ± 0.6	0.001
Overall	108.4 ± 7.6	78.4 ± 3.9	0.002

* $p < 0.05$ compared to data from 1st inning; † $p < 0.05$ compared to data from 2nd inning.

Table 2. Changes in temporal structure of badminton singles matches played in the quarter-finals ($n=4$) under the old and new scoring systems

	Old system	New system
Match duration		
1 st inning	449.3±52.1	652.3±31.0
2 nd inning	718.8±110.6	1002.3±54.3
3 rd inning	–	938.3±13.6
Overall average	584.0±76.9	864.3±29.8
Overall	1168.0±153.9	2592.8±89.4
Exercise duration		
1 st inning	223.0±4.3	261.0±11.2
2 nd inning	363.5±16.3	310.0±17.5
3 rd inning	–	311.8±10.5
Overall average	293.3±8.1	294.3±12.1
Overall	586.5±16.2	882.8±36.3
Rest interval		
1 st inning	452.5±14.3	391.3±22.5
2 nd inning	710.5±58.4	692.3±37.1
3 rd inning	–	629.3±13.5
Overall average	581.5±30.6	550.5±25.9
Overall	1163.0±86.6	1712.8±58.1
Exercise duration:		
Rest time		
1 st inning	1 to 2.05	1 to 1.50
2 nd inning	1 to 1.90	1 to 2.24
3 rd inning	–	1 to 2.08
Overall average	1 to 1.97	1 to 1.94
Overall	1 to 3.95	1 to 5.83
No. of shots per rally		
1 st inning	7.7±0.1	7.9±0.2
2 nd inning	7.6±0.1	8.8±0.3
3 rd inning	–	9.2±0.3
Overall average	7.7±0.1	8.7±0.1
Overall	15.4±0.1	17.1±0.1
Rally time		
1 st inning	7.3±0.1	7.8±0.3
2 nd inning	7.6±0.1	8.8±0.3
3 rd inning	–	9.7±0.3
Overall average	7.4±0.1	8.5±0.3
Overall	14.9±0.1	23.8±1.5
Stroke time		
1 st inning	1.08±0.02	1.00±0.01
2 nd inning	1.05±0.01	1.03±0.01
3 rd inning	–	1.04±0.01
Overall average	1.06±0.01	1.01±0.01
Overall	2.12±0.02	2.81±0.12
No. of serves		
1 st inning	30.3±0.3	32.8±0.3
2 nd inning	47.0±2.7	35.0±0.6
3 rd inning	–	32.0±0.3
Overall average	38.6±1.1	33.3±0.3
Overall	77.3±2.4	99.8±0.9

Table 3. Changes in temporal structure of badminton singles matches played in the semi-finals ($n=2$) under the old and new scoring systems

	Old system	New system
Match duration		
1 st inning	1305.0±17.8	641.5±11.7
2 nd inning	1632.5±30.1	1013.0±93.9
3 rd inning	–	–
Overall average	1468.8±27.0	827.3±52.8
Overall	2937.5±47.9	1654.5±105.6
Exercise duration		
1 st inning	389.5±6.1	240.5±13.7
2 nd inning	528.5±30.1	245.0±4.5
3 rd inning	–	–
Overall average	459.0±18.1	224.8±4.6
Overall	918.0±36.2	449.5±9.2
Rest interval		
1 st inning	813.0±17.3	437.0±9.9
2 nd inning	1058.0±65.1	768.0±98.4
3 rd inning	–	–
Overall average	935.5±15.1	602.5±48.2
Overall	2269.9±82.5	1205.0±96.4
Exercise duration:		
Rest time		
1 st inning	1 to 2.10	1 to 2.27
2 nd inning	1 to 2.10	1 to 3.24
3 rd inning	–	–
Overall average	1 to 2.10	1 to 2.76
Overall	1 to 4.21	1 to 5.51
No. of shots per rally		
1 st inning	7.4±0.1	7.6±0.1
2 nd inning	7.5±0.1	9.1±0.3
3 rd inning	–	–
Overall average	7.4±0.1	8.3±0.1
Overall	7.5±0.1	16.6±0.2
Rally time		
1 st inning	8.2±0.1	6.8±0.1
2 nd inning	7.9±0.1	8.8±0.3
3 rd inning	–	–
Overall average	8.0±0.1	7.8±0.2
Overall	16.1±0.1	15.6±0.3
Stroke time		
1 st inning	1.24±0.05	0.99±0.03
2 nd inning	1.15±0.01	0.97±0.01
3 rd inning	–	–
Overall average	1.20±0.03	0.98±0.02
Overall	2.39±0.12	1.97±0.04
No. of serves		
1 st inning	48.5±1.0	28.0±1.4
2 nd inning	55.5±0.4	38.5±1.3
3 rd inning	–	–
Overall average	52.0±0.5	33.3±1.0
Overall	104.0±1.4	66.5±2.7

Table 4. Changes in temporal structure of badminton singles matches played in the finals ($n=1$) under the old and new scoring systems

	Old system	New system
Match duration		
1 st inning	1238	609.0
2 nd inning	1330	673.0
3 rd inning	–	–
Overall average	1284.0	641.0
Overall	2568.0	1282.0
Exercise duration		
1 st inning	203	222
2 nd inning	459	427
3 rd inning	–	–
Overall average	331.0	324.5
Overall	662.0	649.0
Rest interval		
1 st inning	1035	387.0
2 nd inning	871	246.0
3 rd inning	–	–
Overall average	953.0	316.5
Overall	1906.0	633.0
Exercise duration: Rest time		
1 st inning	1 to 5.10	1 to 1.74
2 nd inning	1 to 1.90	1 to 0.58
3 rd inning	–	–
Overall average	1 to 3.50	1 to 1.16
Overall	1 to 7.00	1 to 2.32
No. of shots per rally		
1 st inning	5.1	7.8
2 nd inning	8.7	8.0
3 rd inning	–	–
Overall average	6.9	7.9
Overall	13.8	15.8
Rally time		
1 st inning	5.3	7.9
2 nd inning	8.8	8.2
3 rd inning	–	–
Overall average	7.1	8.1
Overall	14.2	16.1
Stroke time		
1 st inning	1.08	1.10
2 nd inning	1.00	1.11
3 rd inning	–	–
Overall average	1.04	1.10
Overall	2.09	2.21
No. of serves		
1 st inning	38.0	32.0
2 nd inning	52.0	28.0
3 rd inning	–	–
Overall average	45.0	30.0
Overall	90.0	60.0

Match duration

It has been reported that under the conventional scoring system, the duration of elite men's singles badminton matches was about 28–48 minutes (not including rest intervals; Cabello Manrique & Gonzalez-Badillo 2003; unpublished observation). As shown in Table 1, in men's singles matches played under the new scoring system (e.g. average duration per inning, 13.4 ± 0.6 minutes; total match duration, 32.5 ± 2.5 minutes), match duration was significantly shorter than under the conventional system (e.g. average duration per inning, 19.7 ± 0.8 minutes; total match duration, 45.9 ± 3.0 minutes). As mentioned previously, this finding preliminarily supports the notion of the IBF that changes to the regulations that resulted from the adoption of the new (rally-point) scoring system did indeed significantly shorten match duration. However, these results differ from those of a more recent study conducted by Tu (2007), who found that the type of scoring system used did not cause any significant difference in average match duration (new system, 18.6 ± 5.8 minutes; old system, 20.5 ± 5.1 minutes). One possible reason that the results of the present study differ from those of Tu may be that subjects used in the two studies were of different physical fitness, skill and technique levels. In his 2007 study, Tu looked at several international five-star or elite men's singles badminton finals (i.e. World Badminton Championships, the Thomas and Uber Cups, Chinese Taipei and Singapore Opens) that were sponsored by the IBF. While subjects in the present study were all top-level players in Taiwan, it is very likely that they were of lower physical fitness, skill and technique levels than those competing in IBF-sponsored competitions.

Furthermore, we can also see from the results presented in Table 1 that only under the new scoring system was match duration in the second and third innings longer than in the first inning. Under the conventional system, no significant difference was found. Although Tu (2007) did not explore the temporal structure of different innings within the same match, we can see that his figure for overall average match duration under the new scoring system (18.6 ± 5.8 minutes) is significantly longer than that of the present study (13.4 minutes). This, again, may reflect the fact that the physical fitness, skill and technique levels, as well as the strategy and tactics of Taiwanese badminton players are not as advanced as those of the international-level players who were the subjects of Tu's study, leading to an increase in match duration in the second and third innings for the Taiwanese players. Yet, is this really the case? Finding a definite answer to this question, it seems, will have to wait for further study.

Number of shots per rally, rally time, and stroke time

The results of the present study showed that only in the second and third innings, and in the overall average, was there a significant statistical difference between the new and conventional scoring systems in terms of number of shots per rally (Table 1). In the first inning and in the overall number of shots per rally, by contrast, there was no statistical difference (Table 1). Similar results were noted for rally time (Table 1). Stroke time was found to be significantly shorter under the new scoring system than under the conventional system for the first inning (new system, 0.97 ± 0.01 seconds; old system, 1.08 ± 0.03 seconds), third inning (new system, 1.01 ± 0.01 seconds; old system, 1.08 ± 0.02 seconds), and overall average (new system, 0.98 ± 0.01 seconds; old system, 1.05 ± 0.02 seconds; Table 1). No statistical difference was found in stroke time among the rallies in either the new or conventional scoring systems.

Although Tu (2007) found that average stroke time under the new scoring system seemed to be slightly faster than that reported in the present study, overall average stroke time in the present study followed the same trend as that reported by Tu (2007; new system, 0.92 ± 0.20 seconds; old system, 0.98 ± 0.26 seconds). These data all support the theory that when competing under the new scoring system, which serves to make games shorter, players' average stroke time is significantly shorter than under the conventional system. This shortened stroke time, combined with the increased number of shots per rally, seem to make games played under the new scoring system more competitive than those played under the conventional system. This might be partly due to the fact that players play a more aggressive game under the new system than under the old, adopting different skills and tactics that are more suited to the new regulations, under which a point is scored with every rally (Tu 2007; Pearce 2002). In addition, it could also be partly related to improved racquet technology, improvement in the physical and mental health of players, and improved training methods (Tu 2007).

Exercise duration, rest time, ratio of exercise duration to rest time, and number of serves

The exercise duration of a men's singles badminton match was also shorter under the new scoring system than under the conventional system (Table 1). That is, the first inning (new system, 239.7 ± 8.7 seconds; old system, 349.2 ± 27.2 seconds), second inning (new system, 310.5 ± 16.2 seconds; old system, 409.7 ± 16.1 seconds), overall average exercise duration (new system, 275.6 ± 11.5 seconds; old system, 368.0 ± 12.6 seconds),

and overall exercise duration (new system, 667.0 ± 50.0 seconds; old system, 860.7 ± 60.0 seconds) were all significantly shorter under the new scoring system than under the old system. Similar results were observed for rest time, ratio of exercise duration to rest time, match duration and number of serves (Table 1). Although the present study did not determine why these five variables showed similar trends under both scoring systems, it could be that differences between the two scoring systems make different physical demands on the players (Pearce 2002; Bloss & Hales 1994). It has been reported that under the conventional scoring system, the duration of one men's singles badminton match was approximately 28 minutes (Cabello Manrique & Gonzalez-Badillo 2003), of which about 60–70% of energy was contributed by the aerobic system, and the other 30–40% by the anaerobic system (Liddle et al. 1996). The present study was limited by the fact that subjects were competing in formal competition, and thus could not be required to wear lightweight ambulatory metabolic devices (i.e. Cosmed K4b2 portable instruments) or heart rate (HR) monitors to record oxygen consumption ($\dot{V}O_2$) or HR levels during the game. Yet, in a recent study by Faude et al. (2007), in which 12 male and female players competed for 30 minutes (two 15-minute innings) under the new scoring system, it was found that in the men's singles matches, overall average $\dot{V}O_2$ was 46.0 ± 4.5 mL/min/kg (75% of $\dot{V}O_{2peak}$), while HR averaged 166.0 ± 6.0 beats/min (83% of HR_{peak}). These findings suggest the importance of anaerobic alactacid and aerobic energy production in competitive badminton, or the need for competitive badminton players to have a high aerobic capacity.

Although match duration, exercise duration, rest time, ratio of exercise duration to rest time and number of serves were shorter under the new scoring system than under the conventional system in this study, the number of shots per rally and rally time were greater under the new system (Table 1). These findings might indicate that to have a chance at winning under the new scoring system—a system that shortens match duration—badminton players must move more rapidly and/or strike the shuttle more frequently than under the old system. Such aggressive and/or competitive playing might force players to simultaneously use both the anaerobic alactacid and aerobic systems as sources of energy throughout the game. This seems to support the results of a study by Faude et al. (2007), which found that under the new scoring system, badminton singles matches require both high aerobic capacity and high anaerobic alactacid capacity. This suggests that badminton players should make room in their normal training schedules for some

intermittent lactic acid tolerance and endurance training. Such information might prove useful for badminton coaches to consider when training players.

We can also see from Table 1 that only in the first inning was the ratio of exercise duration to rest time significantly shorter under the new system (1 to 1.8) than under the conventional system (1 to 2.4). When comparing the innings played under each scoring system amongst themselves, no statistical difference was found for ratio of exercise duration to rest time under either system. The overall average ratio of exercise duration to rest time was 1 to 2.0 under the new system and 1 to 2.3 under the old system—also representing no significant statistical difference. The overall average ratio of exercise duration to rest time in matches scored under the new system was found to be smaller in the present study (1 to 2.0) than in the 2007 study of Tu (1 to 2.7). Yet in matches scored under the conventional system, the overall average ratio (1 to 2.3) was very similar to those reported by Tu (2007; 1 to 2.2), Cabello Manrique & Gonzalez-Badillo (2003; 1 to 2), and Majumdar et al. (1997; 1 to 2). One possible explanation for this finding might be that when playing in matches scored under the new scoring system, top-level male singles badminton players in Taiwan play an especially aggressive game during the first inning. This would lead to a significant decrease in both the exercise duration (Table 1) and energy of the players. By the second and third innings, however, players may start to feel tired, and their physical fitness levels might thus be unable to completely recover to levels seen during the first inning. At this point, players might prefer to keep the shots straight and play a more conservative game, rather than risk a cross-court shot (Pearce 2002; Hong & Tong 2000; Breen & Paup 1983). In this case, the aforementioned research results (Tu 2007) and inferences (Pearce 2002; Hong & Tong 2000; Breen & Paup 1983) might explain why the ratio of exercise duration to rest time in the first inning was significantly shorter under the new scoring system than under the conventional system, and yet in the second and third innings, no significant difference was seen in this ratio between the new and conventional systems.

There were significantly fewer serves in games scored under the new system (e.g. overall average, 32.9 ± 0.6 serves; overall total, 78.4 ± 3.9 serves) than in those scored under the conventional system (e.g. overall average, 47.3 ± 1.5 serves; overall total, 108.4 ± 7.6 serves) in this study (Table 1). These results are similar to those reported by Tu (2007), who found that the overall average number of serves per match was approximately 29 and 43 for the new and old scoring systems, respectively.

From the results of the present study and those of Tu (2007), we can see that changes in regulations that resulted from the adoption of the new rally-point scoring system did indeed significantly reduce the number of serves in badminton matches. This might be due to the fact that under the conventional system, players had to first obtain the right to serve in order to have the opportunity to score a point (Pearce 2002; Liddle et al. 1996; Bloss & Hales 1994). Therefore, in games played under the conventional scoring system, players are often competing intensely for the right to serve (Pearce 2002; Liddle et al. 1996; Bloss & Hales 1994). But under the new scoring system, service has no bearing on the opportunity to score a point, and thus there is no need for players to compete for the right to serve.

In conclusion, the results of this study show that the new scoring system resulted in a significant decrease in average overall match duration, exercise duration, rest time and number of serves, and a significant increase in the average number of shots per rally compared to the conventional system. Furthermore, under the new scoring system, match duration, exercise duration, rest time, number of shots per rally, rally time, and number of serves in the second and third innings were all significantly higher than during the first inning. Under the conventional system, by contrast, only exercise duration and number of serves were found to be significantly higher during the second and third innings than during the first inning. These results suggest that changes resulting from the adoption of the new scoring system may cause players to be more competitive and/or to play more aggressively than they did under the conventional system. Therefore, for the badminton coach, this information may mean that alterations are required in training methods both on and off the court, in order to prepare athletes more specifically for playing under the new scoring system.

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