Motion Analysis of the International and National Rank Squash Players

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Abstract

In this paper, we present a study on squash player work-rate during the squash matches of two different quality levels. To assess work-rate, the measurement of certain parameters of player motion is needed. The computer vision based software application was used to automatically obtain player motion data from the digitized video recordings of 22 squash matches. The matches were played on two quality levels – international and Slovene national players. We present the results of work-rate comparison between these two groups of players based on game duration and distance covered by the players. We found that the players on the international quality level on average cover significantly larger distances, which is partially caused by longer average game durations.

1. Introduction

The work-rate of the players during the match is the activity of the players on the playing court, expressed in measurable physical quantities. It depends on the conditions of the play, which are defined by spatial and temporal dimensions. From the viewpoint of player preparation, studies of player work-rate are extremely important. This kind of data represents an important foundation for planning and determining the amount of player effort during the trainings, which indirectly affects the efficiency of the training process.

Therefore, numerous studies on this topic have been published. Authors have mainly studied work-rate of the athletes in the team sports. Most often they studied player work-rate in soccer [1, 3, 8], basketball [2, 11], European handball [10] and rugby [7].

2. Work-rate of the squash player

Squash is a sport game with different number of games. Each game is made up of number of rallies and passive phases, which, when summed up, represent the rallies and the passive part of the squash play. The rallies are characterized by constant player motion, and are therefore much more interesting from the viewpoint the work-rate analysis. The motion of the squash players is specific to squash, due to closed and small space in which the game is played and the bouncing of the squash ball from the all four walls of the court. The motion is comprised from different stops and poses, changes of motion direction, turns, jumps, lunges and side-steps.

First studies on work-rate of the squash players have been performed by Hughes et al. [5]. They designed a tracking system to analyze movement in squash. A Power Pad was used to gather positional data along with the time base. A video camera was positioned so that the image of the playing area representation on the Power Pad coincided with the video image of the real court by using a video-mixer.

Using the described setup, various work-rate indicators of players of different quality have been analyzed [6]. Authors have explored the differences between winners and losers in the length of the lateral and longitudinal motions. They used average values of last ten seconds for the each rally in the first three games. They found statistically significant differences between those groups – the losers had longer paths of the longitudinal motion than the winners in all player quality groups.

Differences in motion path length between winners and losers have been observed by Vučkovič et al. [12] as well. Surprisingly, they found out that winners had longer motion path in individual games. Results were attributed to the specifics of the player sample, where the ultimate winner of the competition played on all of the matches and has been also in most cases the winner of the individual games. Therefore, the results could be a consequence of the specific motion pattern of this particular player.

This motivated further research into the differences in motion path length between winners and losers on the larger sample of players and larger sample of games [13]. The results have shown again, that the winners' motion path length exceeds the path length of the losers both when measured for the whole game (922 m > 902 m) or just during the rallies (672 m > 656 m). The longer motion path has been interpreted with the larger number of serves and winning strokes in winning players. After the serve, the player moves to the T area, which adds certain amount of motion to his overall

statistics. Same authors [14] have studied the correlation of various motion intensity indicators and certain properties of the played matches. It has been established that both the motion path length and the duration of the games are highly and statistically significantly correlated with the number of points won by both players.

Eubank and Messenger approached the problem in a slightly different way [4]. Using a sample of 14 club-level players they studied the number and execution of individual steps during the 341 minutes of rallies. Players on average made 2866 steps during the whole match and 580 steps during the game. In 74.4% of the motion the »flying phase« could be detected, which the authors attributed to the dynamic motion. The most frequent type of step was the step forward (70.1%) and the step aside (10.6%).

However, none of the above mentioned studies included the work-rate (expressed as motion path length), measured through all the games played for the players of different quality levels. In this paper we decided to present the study on differences in work-rate (motion path length) for the best squash players in the world and the best players in Slovenia.

3. Methods

3.1. Design

Data was collected on two different competitions. The first set of data was obtained during the Men's World Team Championships (Vienna 2003), and the second set was obtained during the Slovene National Championship (Ljubljana, 2003). 11 matches were videotaped during each of the competitions. The matches were later split to games, and individual games were processed. Since one game represents the enclosed unit of the play and is not related to other games in the match neither by duration or by results, we studied all the variables on the game level, where we have taken into the account both the results of the winning and the losing player. This way, the first competition yielded 42 games, and the second competition 44 games. Variables studied included duration of the game, cumulative duration of the rallies in the game, the motion path distance of both players during the whole game and during the rallies only.

3.2. Participants

Sample of international players included 16 professional players, all of them highly ranked on the international scale in the time of competition. The sample of national players was comprised of 14 best squash players in Slovenia.

3.3. Materials

All the matches have been recorded using PAL color video camera (JBL, UTC – A6000H, Korea), which was fixed to the ceiling construction above the squash court. Using the appropriate wide angle lens (JBL, SCV 2982D, Korea), we were able to capture whole squash court, as shown in Figure 1. The video signal was recorded on S-VHS video tape on the external recorder, and the recordings were then transferred to the digital domain (Motion JPEG – MJPEG video files) using video capture card (Pinnacle miroVideo DC30+, Germany) at resolution of 384x576 pixels and 2 MB/second data rate. The subsequent processing was performed on the video frames with the resolution of 384x288 pixels.

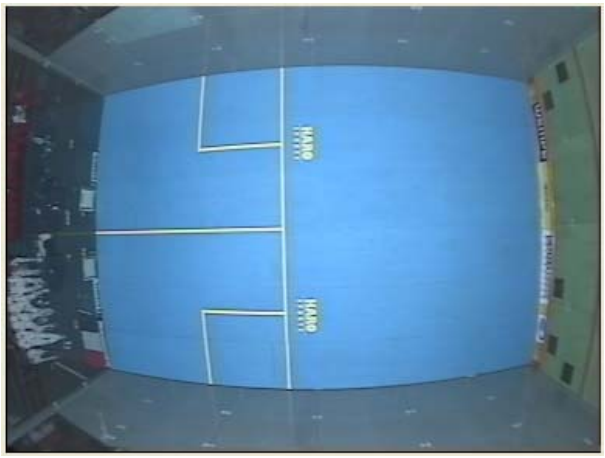

Figure 1: Court surface, captured with our camera setup, using wide-angle lens.

3.4. Procedure

Digitized recordings were processed off-line with the tracking system SAGIT/SQUASH, which is based on computer vision technology (tracking by background image subtraction). The basic technology behind the tracker was described in [9]. Transformation from digitized videos to the quantitative data was performed as follows:

- Calibration of the system, based on squash court markings. This included obtaining parameters for radial distortion correction (removal of the »fish-eye« effect).
- Manual initialization of the tracker by clicking the anatomical point near player's center of gravity – for both players.
- Automatic tracking (15-20 frames per second using modern PC with 2.4 GHz Pentium IV processor) and possible reinitialization of player position if the software lost track of any of the players.
- Smoothing of player positions with the Gaussian smoothing kernel, which reduces measuring errors in path length and player velocity.

Table 1: Basic statistical properties of the variables analyzed: Tg - time of a game, Tap – cumulative time of rallies, DC – distance covered during a game, DCap - distance covered during the rallies.

players	variable	Mean	sd	min	max	K-S	sig
international	Tg (s)	1004,95	400,74	337	1944	1,04	0,23
national	Tg (s)	591,26	284,33	130	1268	0,91	0,38
international	Tap (s)	547,11	214,38	158	995	1,30	0,07
national	Tap (s)	334,53	169,72	60	919	0,97	0,44
international	DC (m)	1118	425	345	2161	0,96	0,31
national	DC (m)	617	307	109	1568	0,78	0,58
international	DCap (m)	795	305	234	1482	1,28	0,07
national	DCap (m)	435	231	68	1289	0,75	0,63

Table 2: Results of variance analysis

variable	players	Mean	sd	df	F	p
Tg (s)	international	1004,95	400,74	171	61,41	0,000
Tg (s)	national	591,26	284,33			
Tap (s)	international	547,11	214,38	171	52,24	0,000
Tap (s)	national	334,53	169,72			
DC (m)	international	1118	425	171	78,87	0,000
DC (m)	national	617	307			
DCap (m)	international	795	305	171	76,15	0,000
DCap (m)	national	435	231			

- Final data processing – calculation of motion path lengths and player velocities for the every processed frame.
- Manual annotations of rallies.
- Export of numerical data and generation of graphical presentations of player data.

Data, collected for each game was processed with selected methods of the descriptive statistics. Differences between both groups of players on the selected set of variables have been determined using the one-way analysis of variance.

4. Results

Table 1 shows the results – the statistics on game durations, cumulative duration of the rallies, distances covered by players during the whole game and during the rallies only, for both player groups.

International players on average finished the game after 1005 seconds, or, approximately 17 minutes. High values of standard deviation show large variation in game durations. The longest game was 32 minutes long, and the duration of the shortest was approximately 5 minutes. Average duration of the games played by national players is approximately 10 minutes and is therefore much lower than the mean duration of games played by international players. The average duration of the rallies is much higher in the group of international players as well. International players covered on average a distance of 1120 meters during the game. The longest distance in individual game was 2160 meters. When rallies alone are observed, the average distance covered during the game was 795 meters. In the group of Slovene national players, the average distance covered was 615 meters for the whole game and 435 meters when only rallies are taken into the account.

Table 2 shows the results of the variance analysis. The results show that there are statistically significant differences in all variables between the two observed groups of players.

5. Discussion

Games played by international players are on average 414 seconds longer than the games played on the national level. If only the rally time is taken into the account, the difference between average duration is still large - 213 seconds. Considering the results from [14], where high and statistically significant correlation between duration and distance covered by players has been established, the statistically significant differences in path length are expected. However, differences in distance covered are still unexpectedly large. The difference in distance covered between the two player groups, when the whole game is considered is 500 meters, and 360 meters, when only the rallies are taken into the account. This means that the work-rate of international players surpasses the work-rate of Slovene national players for more than 80% when only rallies are observed. Such huge differences are probably the consequence of better technical and tactical capabilities, skills and knowledge of international players. Their

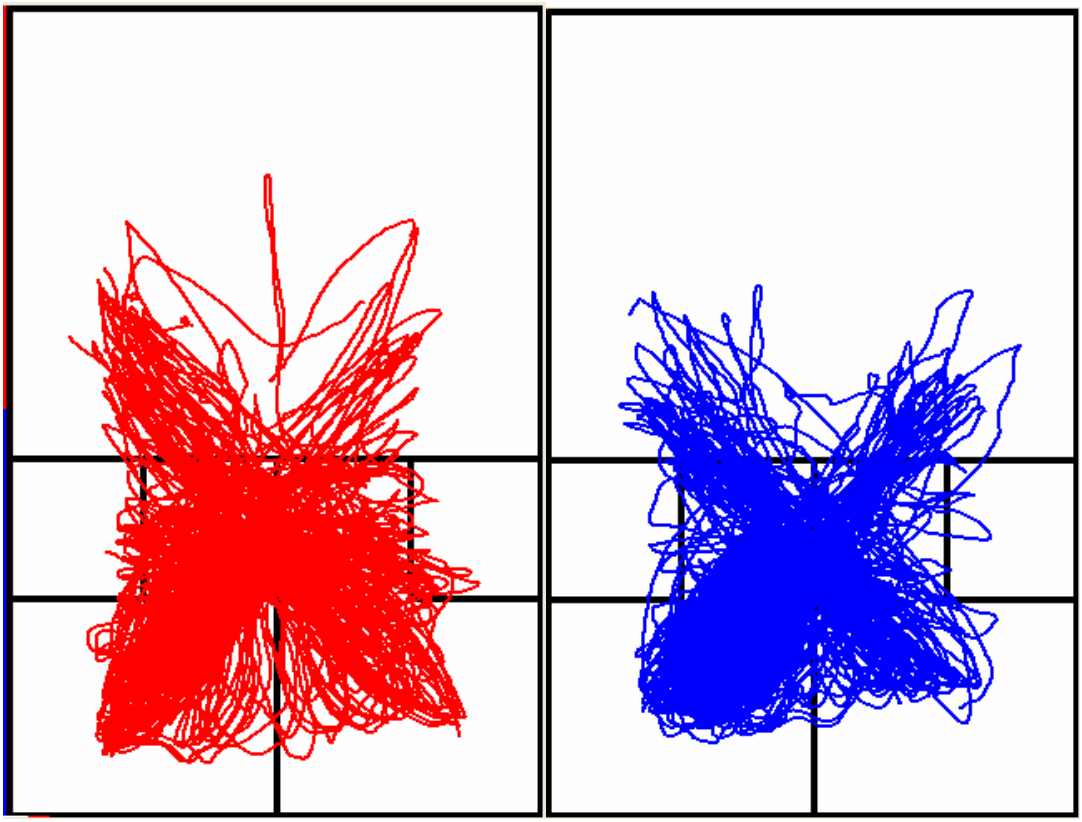

Figure 2: Trajectory (motion path) of the international player during the rallies (left). Trajectory of the slovene national player during the rallies (right).

capabilities, skills and knowledge are reflected in basic and defensive play, not only in better offensive actions (accuracy of the stroke). It is difficult to achieve a point with single stroke in matches at the highest international quality level. The point is won gradually, by achieving high number of strokes (basic play) to gather the advantage, which can be exploited in the attack to achieve a point. All these factors contribute to longer durations of games and higher player work-rate.

Higher distances covered by international players are probably also influenced by their greater accuracy of strokes. With accurate strokes, players are forced to make longer moves from the T area to the stroke area and back, even if with similar playing tactics, as it can be seen in Figure 2.

Both diagrams depict typical X-shaped motion of players during the rallies, which suggest the similar play tactics of players of different quality rank. Despite this, we can observe significantly shorter diagonals in motion trajectory in the diagram which shows the motion of the national player. Shorter diagonals confirm the hypothesis that Slovene national players play with less accuracy, which directly influences the distance covered by players and the work-rate.

6. Conclusion

The aim of this research was to study work-rate (distance covered by players) of squash players of different quality ranks. Results show much higher work-rate of the international players, compared to best Slovene national players. Additionally, results represent starting point for design of objective theory on squash player work-rate, which, based on the presented results, heavily depends on the quality level of the competition. Based on these conclusions, squash coaches and players will be able to design more efficient condition training plans, which will improve the training process and the development of players.

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