A QUANTITATIVE ANALYSIS OF SQUASH SHOT ACCURACY

Benjamin Kane Williams[1,2], Pitre Collier Bourdon[1,3], Philip Graham-Smith[1] and Peter J. Sinclair[2]

Sport Science Department, Aspire Academy, Doha, Qatar[1]
Discipline of Exercise and Sport Science, The University of Sydney, Sydney, Australia[2]
School of Health Sciences, University of South Australia, Adelaide, Australia[3]

The purpose of this study was to examine the validity of the Hunt Squash Accuracy Test (HSAT) for predicting within-game performance on specific shot types. A correlation analysis compared the accuracy of specific shots during tournament match-play to the accuracy of the corresponding shot type in the HSAT. The correlation of the overall HSAT score against tournament rank was significantly large (0.95), as were the total % shot accuracy (0.90), total % backhand (BH) accuracy (0.94) and total % forehand (FH) accuracy (0.77) correlations. The only specific HSAT shot types with significantly large correlations to the corresponding match-play shots were; BH straight drive (0.92) and BH straight volley (0.97). The remaining shot types; boast, volley-drop and drops all showed non-significant correlations on both the BH and FH sides.

KEY WORDS: validity, error, performance analysis, technique.

INTRODUCTION: Unlike other racket sports, in squash the ball is propelled around a defined four walled space within which both players interact. It allows for the ball to be hit off any of the four walls, as long as it hits the front wall within the defined region before bouncing. Points can be won by accurately hitting to a strategically advantageous point on the court thereby putting an opponent out of position or ensuring they are unable to return the ball successfully (Lees, 2003). This results in squash being both a very technical and tactical game (Vučković, Perš, James, & Hughes, 2009). However, while there have been numerous studies evaluating the tactical aspects of squash (Hughes & Franks, 1994; Pereira, Wells, & Hughes, 2001; Vučković et al., 2009), there are very few studies evaluating the technical part of squash performance and even fewer validated tests that attempt to assess and track technical squash performance.

Improvements in sport performance can be partly attributed to increased training quality as assessed by sport-specific testing (Müller, Benko, Raschner, & Schwameder, 2000). As such, the development of valid reproducible tests that assess athlete strengths and weaknesses, that could be missed by less specific tests, become a necessity (Wilkinson, Leedale-Brown, & Winter, 2009a). The Hunt Squash Accuracy Test (HSAT) is used by some coaches to assess one of the technical aspects of squash, shot hitting accuracy. It evaluates an athlete's hitting accuracy over 13 different types of squash strokes on both the forehand (FH) and backhand (BH) sides. The HSAT has been previously shown to be a reliable and valid test when compared to both tournament and experienced coach rankings (Williams, Hunt, Graham-Smith, & Bourdon, 2014). However, there has been no evaluation on whether scoring well on a particular shot on the HSAT equates to good performance of the same shot within a match. The aim of this study is to therefore evaluate the link between the scores from the HSAT and the corresponding accuracy of shots played within tournament match-play.

METHODS: <u>Participants:</u> Eight male junior squash players (15.5 ± 1.8 years, height 168.3 ± 10.8 m, body mass 61.9 ± 14.6 kg) from a national sports academy volunteered to participate in the study. Informed consent was obtained for each player and all players were free from injury at the time of testing. All players were familiar with the HSAT, having previously performed the test a minimum of three times (average 8.1 ± 4.4).

Equipment set-up: All the testing took place at an indoor squash training facility on standard glass-back squash courts (ASB SquashCourts, Czech Republic). Players used their own racket for both the HSAT and the tournament. Two video cameras (HDR-XR260VE, Sony Corporation, Japan) were mounted onto tripods 1.4 m from the ground and 7.0 m from the centre of a squash court. They were set-up such that the field of view was perpendicular to the glass back wall. Each camera was zoomed so that the court edges filled the view to maximise the field of view of each court. Each match was filmed at 25 Hz in high-definition.

HSAT: The HSAT consists of 375 shots across 13 different types of squash strokes on both the FH and BH side. These included: drives, volleys, boasts, and drop shots. Each shot had a target area that the ball had to land in to be called successful. The players hit the ball continuously for all drive and volley strokes and accrued a score based on the number of shots landing in the target area (not including the first shot). The boasts and drop-shots were hit off a fed ball from an experienced coach, with 3-5 s between feeds. The players had approximately 30 s between each different stroke test. The total score was expressed as the percentage of successful shots that hit the target area.

Tournament: The players competed in a round-robin style tournament, where every player played a best-of-5-game match against every other player. All matches were conducted as per the World Squash Federation international singles rules and were refereed by an experienced coach. Players performed a standard pre-game warm-up before each match. The order of matches was random.

Data analysis: The HSAT scores were converted into percentages using the formula: number of shots landing in the target area / total number of shots. A total overall score was calculated using the average of all the specific shot scores and given as a percentage. A total score was also calculated for all the BH shots and FH shots separately (BH-HSAT and FH-HSAT). A tournament rank (TR) was obtained from the results of the tournament. Every shot from all the squash matches played at the tournament was tagged using the following performance analysis descriptors within Dartfish TeamPro software (Dartfish TeamPro version: 7.0);

- Shot side: FH; BH;
- Shot type: drive; volley; boast; volley-drop; drop; lob; serve
- Shot direction: straight; cross-court;
- Outcome: rally continues; winner; unforced error, forced error.

A winner was defined as a shot that was untouched by the opponent before the second bounce. An unforced error was an error deemed to be the fault of the player on a shot that would normally be returned. A forced error was due to an opponent's shot that lead to a difficult shot to play, which resulted in an error. Each of the different shot types was then converted into a percentage using the formula: total number of shots – unforced errors / total number of shots, to give the % accuracy for each of the specific shot types.

Matching shot types from the HSAT and performance analysis data (10 different shots), as well as the performance analysis data and TR were then analysed using a Pearson product-moment correlation coefficient after checking the normality of distribution for each variable. Significance was set at $p < 0.05$. Correlation effect sizes were considered as small (±0.1 - ±0.29), medium (±0.3 - ±0.49) and large (±0.5 - ±1.0) (Cohen, 1988).

RESULTS: The Pearson's r values for the combined data for all comparable shots from the BH side, FH side and total shots played, as well as the overall ranking from the tournament compared to the corresponding HSAT score are reported in Table 1.

Table 1
Correlations between Total HSAT Score, % Accuracy for Combined Shots and TR

	% Accuracy			TR
	BH	FH	Total	
HSAT: Pearson's r	0.937*	0.767*	0.902*	0.954*

*= $p < 0.05$

The mean number of shots per player (Mean # Shots PP) (± SD) during the entire tournament and Pearson's r values for each of the specific shot type's % accuracy compared to the corresponding score from the HSAT and TR are shown in Table 2.

Table 2
Correlations between % Accuracy for Specific Shot Types, HSAT Shot Scores and TR

% Accuracy	Drive		Boast		Volley		Volley-Drop		Drop	
	BH	FH	BH	FH	BH	FH	BH	FH	BH	FH
Mean # Shots PP	137±30	62±20	30±16	27±10	34±11	14±5	13±5	5±4	35±14	16±9
HSAT: Pearson's r	0.923*	0.641	0.280	0.150	0.972*	0.455	0.367	0.534	0.142	0.624
TR: Pearson's r	0.928*	0.816*	0.564	0.024	0.844*	0.294	0.263	0.570	0.052	0.824*

$* = p < 0.05$

DISCUSSION: The HSAT aims to assess one of the technical elements of the game of squash, the players shot hitting accuracy. The large significant correlation between the total HSAT score and the tournament rank (0.95) confirms a previous validation study where Williams et al. (2014) also found a large significant correlation (0.93). The total HSAT score showed a large significant correlation with total within-game % accuracy (0.90). Both the BH-HSAT and FH-HSAT scores were also found to have large significant correlations with the total % BH accuracy (0.94) and total % FH accuracy (0.77) respectively. These results compare favourably with that of other specific validation studies, such as Wilkinson, Leedale-Brown, and Winter (2009b), who showed that a squash specific change-of-direction speed test significantly correlated (0.77) with squash player rank.

The performance analysis variables used in this study incorporated 'match pressure' and were a direct measure of a player's ability to successfully hit the ball during a competitive game. The specific shots within match-play that showed large significant correlations to HSAT scores were the BH Drive (0.92) and BH Volley (0.97), which also both had large significant correlations to TR (0.93 and 0.84 respectively). The high mean number of shots per person on the BH Drive (on average 23% of all shots) compared to the other shots concurs that this shot is one of the most commonly played shots during a squash match (Vučković et al., 2013). The large correlation to TR (0.93) and high shot count also indicate that the success of this shot has a high influence on the overall performance within a match and tournament.

Although not significant, the FH Drive, FH Volley-Drop and FH Drop all showed large correlations (0.64, 0.53 and 0.62 respectively) between match-play and HSAT scores. Perhaps with a larger sample size significance may have been achieved. It is possible that the weaker correlations for the other HSAT shot results compared to the % accuracy is caused by the players favouring their more accurate shot types, in order to maintain a rally. They may only play certain less accurate shots when either forced to (due to positioning on the court) or when it is advantageous to do so (trying to hit a "winner"). It is also possible that certain players take more risks than others, thereby trying to hit more "winners" and perhaps chancing less accurate shots earlier in the rally, rather than playing a more accurate, less difficult shot. This would increase the chance of more unforced errors and decrease their % accuracy compared to the non-competitive HSAT score.

Certain limitations of the HSAT became apparent during this study. Most noticeable is that there are no cross-court shots incorporated in the test. Of the 10 shot types analysed in this study, 36% of the match-play shots could not be compared to the HSAT scores as they were cross-court shots (e.g. BH cross-court drives). All serves and lob shots also had to be removed from the analysis as those shots are not part of the HSAT and therefor non-comparable for the purpose of this study.

The HSAT evaluates a technical aspect of squash, the shot hitting accuracy, however it doesn't take into account the potential differences in the mechanics of the shot strokes or racket parameters, which can be of paramount importance in squash (Elliott, Marshall, & Noffal, 1996). The HSAT is performed in a relatively controlled environment, with the majority of shots being hit continuously and the remainder being fed by a coach, where the player knows where the ball will be and therefore has enough time to set themselves to perform the designated stroke without much pressure. The ball velocity and direction, body position and swing kinematics could all potentially change for the same shot type under match pressure when interacting with another player and trying to win a point. It is therefore recommended that a more in-depth investigation that includes a kinematic analysis be undertaken during the performance of the HSAT and during a match to compare the biomechanics of accurate and inaccurate shots. This could further assist in determining the reasons for any differences between shot accuracy and also assist in the development of shot technique and skill.

CONCLUSION: The results of this study, specifically the large significant correlation between the total HSAT score and both the total % accuracy and TR reconfirms the HSAT as a highly valid method of assessing the accuracy and performance of junior squash players when compared to overall performance at a tournament. The high mean shot count and large significant correlations between % accuracy and HSAT score to TR of the BH drive also demonstrate the importance of being able to play that shot accurately and consistently. While the only other HSAT shot to show a significant correlation to the % accuracy of match shots was the BH Volley (which also had a large significant correlation to TR), there were possible trends for a number of other shots. These suggest that future investigations using larger subject numbers may further validate the HSAT.

REFERENCES:
Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Hillsdale, NJ: L. Erlbaum Associates.
Elliott, B., Marshall, R., & Noffal, G. (1996). The role of upper limb segment rotations in the development of racket-head speed in the squash forehand. *Journal of sports sciences, 14*(2), 159-165.
Hughes, M., & Franks, I. M. (1994). Dynamic patterns of movement of squash players of different standards in winning and losing rallies. *Ergonomics, 37*(1), 23-29.
Lees, A. (2003). Science and the major racket sports: a review. *Journal of sports sciences, 21*(9), 707-732.
Müller, E., Benko, U., Raschner, C., & Schwameder, H. (2000). Specific fitness training and testing in competitive sports. *Medicine and science in sports and exercise, 32*(1), 216-220.
Pereira, A., Wells, J., & Hughes, M. (2001). Notational analysis of elite women's movement patterns in squash. In M. Hughes & I. M. Franks (Eds.), *pass.com* (pp. 223-237). Cardiff: CPA, University of Wales Institue, Cardiff.
Vučković, G., James, N., Hughes, M., Murray, S., Sporiš, G., & Perš, J. (2013). The effect of court location and available time on the tactical shot selection of elite squash players. *Journal of Sports Science and Medicine, 12*(1), 66-73.
Vučković, G., Perš, J., James, N., & Hughes, M. (2009). Tactical use of the T area in squash by players of differing standard. *Journal of sports sciences, 27*(8), 863-871.
Wilkinson, M., Leedale-Brown, D., & Winter, E. M. (2009a). Reproducibility of physiological and performance measures from a squash-specific fitness test. *International Journal of Sports Physiology & Performance, 4*(1).
Wilkinson, M., Leedale-Brown, D., & Winter, E. M. (2009b). Validity of a squash-specific test of change-of-direction speed. *International Journal of Sports Physiology & Performance, 4*(2).
Williams, B. K., Hunt, G. B., Graham-Smith, P., & Bourdon, P. C. (2014, July 12 – 16). *Measuring squash hitting accuracy using the 'Hunt Squash Accuracy Test'.* Paper presented at the 32nd Conference of the International Society of Biomechanics in Sports, Johnson City, TN, United States of America.