PARAMETERS OF BALL RELEASE IN WHEELCHAIR BASKETBALL FREE THROW SHOOTING

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The purpose of this study was to identify the relationship between ball release parameters and player classification in wheelchair basketball free throw shooting. Utilizing three-dimensional (3D) video data collected during international competition, parameters of ball release associated with performance of the dean swish were examined. Significant differences were identified between the four player classes. The upper classes (3 & 4) tended to release the ball from a greater height, with less speed and a smaller angle of projection. The lower classes used a technique that demanded greater accuracy, but still managed to achieve free throw shooting percentages similar to the upper classes (3 & 4) who did not appear to utilize their height advantage.

KEY WORDS: wheelchair basketball, free throw, player classification, shooting mechanics

INTRODUCTION: Wheelchair basketball is an exciting, fast paced, high-caliber sport played in over 75 countries around the world. To ensure fair and equitable competition, a player classification system is used, based on the functional limitations caused by physical disability. The current system consists of four classes, with Class 4 players having the greatest degree of functional ability and Class 1 players the least. With championships being won or lost at the free throw line, the critical factor in a close game is the ability of players to make successful free throws. Successful free throws are reported to account for 20-25% of a team's scoring in men's college basketball (Hays and Krause, 1987). With free throws being such an important aspect of basketball any improvement in this particular skill by players on a team could help produce a greater percentage of wins over the season. Whereas free throw shooting percentages in men's college basketball in the USA consistently average near 70% (Krause and Hayes, 1994), scoring averages of wheelchair basketball players from the free throw line typically range between 45-55% (Owen, 1982). Although there are obvious disadvantages to shooting a basketball from a wheelchair (limited impulse from legs, increased distance to basket) as compared to standing up, it does not seem likely that the difference in success rates can be attributed solely to differences in the required shooting mechanics (Owen, 1982).

To date, little if any quantitative research has been completed with respect to the mechanics of wheelchair basketball shooting. Instead, the available literature tends to be qualitative in nature, based on coaches' opinions and subjective analyses. Due to the wide range and complex nature of disabilities, it is apparent that relying on information from stand-up basketball is not an effective method for developing the skill of free throw shooting in wheelchair basketball. If performance is to be optimized, the technique of free throw shooting by wheelchair basketball players in each of the individual classes must be understood. Therefore, in an attempt to determine what factors are associated with successful free throw shooting in wheelchair basketball, an analysis of clean swishes taken at the 6th Gold Cup World Wheelchair Basketball Championship was undertaken. As part of a larger investigation, the purpose of this study was to identify the relationship between parameters of ball release (height, angle and speed of projection) and player classification in successful free throw shooting.

METHOD: Free throws taken at one end of the court during the course of the tournament were recorded using 3D video data collection procedures. Two Panasonic AG450 SVHS video cameras were securely positioned to record the free throws of right handed shooters at a sampling rate of 60 Hz. One camera was set parallel to the free throw line in order to obtain a side view of the player and the other was set obliquely to the front line to obtain a more frontal view. For the process of data reduction, the Ariel Performance Analysis System (APAS) was utilized. For each shot, twenty frames were grabbed from each camera view, starting ten frames before start of the shooting motion until ten frames after the ball left the player's hand. The center of the ball was manually digitized in each frame, and the two camera views were time-matched using a manually triggered LED. Sixteen points surrounding the activity space (150cm x 225cm x 300cm) were recorded prior to filming and later utilized for calibration. The two-dimensional views from each camera were converted into a three-dimensional image sequence using the DLT algorithm implemented on the APAS system, and then smoothed using a quintic spline. Release parameters of the ball (height, angle and speed of projection) were calculated using the three-dimensional displacement data of the center of the ball. In addition, to further describe the trajectory of the basketball, the following variables were calculated for each free throw: angle of entry, margin for error, minimum projection angle, and minimum-speed angle (see Malone,1999) for methods used to calculate each variable]

At the same time that free throws were being recorded on video, the shots were visually observed from a point parallel to the free throw line. Schematic diagrams depicting ball movement patterns at the basket were recorded for all shots. Ball pattern at the basket was tracked in a numerical sequence and later encoded for descriptive purposes. According to pattern of ball movement at the basket, free throws were then grouped into 5 categories or types of shots, namely: 1) clean swish, 2) long success, 3) short success, 4) long miss, and 5) short miss. For the purposes of this study, clean swishes with acceptable video data (i.e. both camera views clear) were then compiled for kinematic analysis. The total number of clean swishes identified in each class and further analyzed was as follows: Class 1 (n = 7), Class 2 (n = 16), Class 3 (n = 18). Class 4 (n = 26).

To determine if differences existed between the four player classes on the ball trajectory variables, ANOVA tests (a = .05) were conducted followed by Tukey HSD post hoc tests where needed. In addition, to examine the magnitude of differences between the groups and meaningfulness of the findings, effect size was calculated for each variable using the eta-squared index (η^2) as recommended by several authors (Keppel, 1982; Ottenbacher, 1992, Sutlive and Ulrich, 1998; Thomas, Salazar & Landers, 1991).

RESULTS: Results of the ANOVA tests ($p < 0.05$) revealed statistically significant differences between the classes on parameters of ball release (height, angle and speed), and are supported by the large calculated effect sizes for each variable. Mean and standard deviation values for the three ball variables, together with effect sizes, are shown in Table 1.

Table 1 Ball Parameters at Release

	Class 1 (n = 7)		Class 2 (n = 16)		Class 3 (n = 18)		Class 4 (n = 26)		
Variable	M	SD	M	SD	M	SD	M	SD	η^2
Release Height'' (cm)	162	4	160	6	179	13	184	17	40%
Projection Angle[a] (deg)	59	2	58	2	55	3	55	3	30%
Speed at Release[b] (cmls)	743	22	719	32	707	30	699	21	22%

[a]significant difference ($p < 0.05$) between the upper (3 & 4) and lower (1 & 2) classes
[b]significant difference ($p < 0.05$) between Class 1 and the upper (3 & 4) classes

Significant differences were seen in release height of the ball between the classes. The release heights of Classes 1 and 2 were both significantly lower than the release heights of Classes 3 and 4. In labeling the Classes 1 and 2 as the lower classes, and 3 and 4 as the upper classes, it can be said that there was a significant difference between the upper and lower classes, with the upper classes releasing the ball from a greater height. Significant differences were also seen in release angle between the classes. The release angles of Classes 1 and 2 were both significantly different from the release angles of Classes 3 and 4.

The upper classes were found to use a smaller angle of release as compared to the lower classes. In terms of speed of the ball at release, significant differences were found between Class 1 and the upper classes. In general, the release speed tended to decrease with an increase in class.

In Table 2, descriptive statistics (M and SD) for the additional trajectory variables are shown for the four classes. On average the free throws approached the basket with an angle of entry of 43° for the lower classes and 40° for the upper classes. The lower classes tended to have a higher angle of entry, and therefore slightly greater margin for error, as a result of the larger projection angles. The average minimum trajectory angle required for the lower classes was calculated as 53°, while that for the upper classes was determined to be 50°. On average players used a projection angle that was 5° greater than the minimum required. The minimum-speed angle was determined to be 55° for the lower classes and 53° for the upper classes. A comparison of Tables 1 and 2 reveals that on average, players in the upper classes used a projection angle closer to their minimum-speed angle.

Table 2 Additional Ball Trajectory Variables

	Class 1		Class 2		Class 3		Class 4	
	(n = 7)		(n = 16)		(n = 18)		(n = 26)	
Variable	M	SD	M	SD	M	SD	M	SD
Angle of entry (deg)	44	3	42	4	40	4	40	5
Margin for error (cm)	3.5	0.9	2.9	1.1	2.5	1.1	2.5	1.4
Min projection angle (deg)	52	0.4	53	1.0	51	2.0	50	2.0
Min-speed angle (deg)	54	0.2	55	0.4	53	0.8	53	1.0

DISCUSSION: Results of this study revealed significant differences between wheelchair basketball classes in the free throw shooting mechanics required for a clean swish. It appears that different techniques, as demonstrated by several aspects of the ball trajectory, are used by the upper (3 & 4) and lower classes (1 & 2). The lower classes tended to release the ball from a lower height, using greater speed and angle of projection. The technique of the lower classes in using a higher angle of release, although providing a larger margin for error, demanded greater accuracy due to the seriousness of errors as the release angle is increased (Hay, 1993). As indicated by the Gold Cup tournament statistics, however, it appears that players in the lower classes managed to develop the required accuracy and achieve similar free throw shooting percentages (Class 1 - 52%, Class 2 - 53%) as players in the upper classes (Class 3 - 49%, Class 4 - 54%) (Malone, 1999).

In addition to the demands for increased accuracy with a high angle of release, is a requirement for a higher projection speed and increased impulse generation. This may pose a problem for some players in the lower classes who have functional limitations affecting their strength (Owen, 1982). If the necessary projection speeds are not attained, and the margin for error is exceeded, the shots will tend to fall short. In order to reduce the force requirements of a shot, and reduce the number of short misses that tend to occur, it may be advantageous for players to shoot with an angle closer to the minimum-speed angle as recommended by Brancazio (1981). Caution must be taken however, as such a strategy would reduce the margin for error, by lowering the angle of entry.

As noted, players in the upper classes used a higher point of release than did players in the lower classes. As indicated by Brancazio (1981), the higher the point of release, the more likely it is that a shot will be successful. The upper classes, therefore, had an advantage over the lower classes in shooting free throws by virtue of having a higher release point. Not only might players in the upper classes tend to be taller, but they also have the ability to lean the trunk forward and reach the arms upward while shooting without loss of stability. Based on the similarity in free throw percentages between the classes, it appears that the upper classes did not fully utilize the advantage of a higher release point. As the height of release is increased, margins for error in both speed and angle become larger, and the necessary force and speed of projection becomes smaller (Brancazio, 1981). With such advantages, it would be expected that the free throw shooting percentages of the upper classes would be greater. In addition to making sure that players in the upper classes utilize any height advantage they have, the combination of speed and angle used for clean swishes can perhaps serve as a guideline in efforts to improve overall free throw shooting performance.

In agreement with Higger (1984), it appears that Owen's (1982) suggestion of a minimum projection angle of 45° may be too small for wheelchair basketball players. Based on the minimum projection angles calculated in this study (see Table 2), it appears that a more reasonable suggestion would be a minimum of 50°. As indicated by Brancazio (1981), a shooter has very little leeway in projection speed for a successful shot. For a given projection angle the difference in speed between a shot that passes through the center of the basket and one that just clears the rim is generally less than 1% (Brancazio, 1981). Therefore, instead of using high angles of release, Brancazio (1981) indicated that successful shooters learn to shoot at or near the minimum-speed angle. A comparison of Tables 1 and 2 revealed that on average, players in the upper classes used a projection angle closer to their minimum-speed angle. In addition to providing the greatest margin for error in angle, a shot projected with the minimum-speed angle requires the smallest projection force (Brancazio, 1981). This is important to consider in wheelchair basketball where force requirements are increased due to increased distance from the basket as compared to stand-up players, whereas force-producing capabilities are reduced due to lack of available power from the legs. Furthermore, as release height increases, the minimum-speed angle decreases. Although a person's height is fixed, efforts can be made to increase release height using strategies such as increasing shoulder flexion and elbow extension. Caution must be taken however, so that changes in technique do not have an adverse effect on impulse generation, which may in turn affect accuracy.

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