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Evaluation of the Validity of Radar for Measuring Throwing Velocities in Water Polo

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Many studies have been published reporting measurements of velocity of balls, implements and corporal segments in sports where those skills are basic for performance. Skill in passing and throwing is vital in Water Polo because accuracy and the ability to produce high velocities are also valuable during the game for shots at goal. The aim of the present study was twofold; firstly to evaluate the validity of the radar gun measurements versus high velocity 2D photogrammetric analysis, in two different situation, and secondly, to establish a valid methodology to asses throwing velocity in Water Polo. The participants carried out 48 throws at maximum intensity from the penalty position (24 throws), and from an oblique position to the goal (θ ~ 20º) in the same penalty line (24 throws) with and without goalkeeper. They executed throws by alternating manner with a 3-min rest between each. The ball maximum velocity was measured with radar gun placed ten meters behind the goal, and aligned with the penalty line. Simultaneously; a 2D photogrammetric study was accomplished. The camera was mounted on a rigid tripod at a height of 1.0 m and placed at a distance of 10 m from the middle of the athlete's lane. The optical axis of the camera was perpendicular to the direction of throwing for each different situation. One trial by each participant for each throw condition was analyzed. Pearson correlation coefficients were used to determine the interrelationship among the maximum velocity obtained by the radar gun and the 2D analysis. For frontal throws without goalkeeper the ICC was 0.96, and with goalkeeper was 0.84. Analyzing throws in oblique situation (θ ~ 20º), the ICC was 0.94 without goalkeeper and 0.96 with goalkeeper. All throws in the frontal situation showed a correlation coefficient of r = 0.91 and in the oblique position the correlation coefficient was r = 0.94 (p ≤ 0.001). In conclusion, the radar gun is a valid method to measure throwing velocity in water polo, both for frontal as well as for oblique throws.

Key words: Validity, Photogrammetric, 2D, radar gun, water polo throwing, water polo

INTRODUCTION

In the last decades, many studies have been published being interested in the measurement of velocity of balls, implements and corporal segments in sports where those skills are basic for performance. (DeRenne, Ho, & Blitzblau, 1990; Gorostiaga, Granados et al, 2005; Granados, Izquierdo et al. 2007; Lachowetz, Evon et al., 1998; McCluskey et al.; Skoufas, Stefanidis et al, 2003; Van den Tillaar & Ettema, 2004, Van den Tillaar & Ettema, 2007).

Skill in passing and throwing is vital in water polo because accuracy and the ability to produce high velocities are also valuable during the game for shots at the goal. Two basic factors are of importance with regard to the efficiency of shots: accuracy and throwing velocity. Naturally, the faster the ball is thrown at the goal, the less time defenders and goalkeeper have to save the shot (Muijtjens, Joris et al, 1991). For these reasons, evaluating throwing velocity is an important issue for coaches in order to assess the training routines.

In order to measure throwing velocity different methodologies like high velocity cinematography have been used (Elliott & Armour, 1988; McCluskey et al.; Van den Tillaar & Ettema, 2004, Van den Tillaar & Ettema, 2007). This technique is knowns to have high sensitivity, validity and reliability (Bartlett, 1997). However, this method is time consuming and is not suitable for use in the playfield. For these reasons, it is an unpractical method in order to provide fast feedback for coaches and athletes. Electronic timing gates is another way to assess throwing velocity (Gorostiaga, Granados et al, 2005; Granados, Izquierdo et al, 2007), but it is unpractical in water polo because of the playing medium (water).

In the last years, several studies have used radar guns as an alternative way to assess throwing velocity in team sports. This equipment has a lot of advantages, because we can assess throwing velocity without interfering in the playfield. Furthermore, velocities are measured instantaneously and in real competitive conditions. However, considering that radar gun calculates the objects velocities through the emission and reception of electromagnetic waves and its operation is based on Doppler's principle, it is necessary validate the standardization protocols in order to avoid or at least to control the error range of the data obtained. For this reason, the protocol used in each study must be rigorous, especially in the radar gun positioning and it must be carefully applied in order to avoid obstacles between the object and the radar gun. The quality of the data is based on the rectilinear trajectories of the object. If the object does not achieve a rectilinear trajectory, it is uncertain to obtain valid data. Therefore, the aim of the present study was twofold; firstly to investigate the validity of the radar versus high velocity 2D photogrammetric analysis, in two different situation: throwing from the penalty position and throwing in oblique position to the goal (θ ~ 20º) in the same penalty line and secondly, to establish a valid methodology to asses throwing velocity in water polo.

METHODS

Two male water polo players were recruited for the study (35 ± 2 years old). The participants carried out 48 throws at maximum intensity from the penalty position (24 throws), and from an oblique position to the goal (θ ~ 20º) in the same penalty line (24 throws) with and without goalkeeper. Before beginning the measurements, the players performed a standardized warm up. They executed throws by alternating manner with a 3-min rest between each. An official water polo ball was used. The study was approved by the Human Subjects Ethics Committee of the San Antonio Catholic University of Murcia, the participants were informed of the protocol and procedures prior to their involvement and written consent to participate was obtained.

The ball maximum velocity was measured through the use of a radar gun (StalkerPro Inc., Plano, USA) with a frequency of 100 Hz and a sensibility of 0.045 $m \cdot s^{-1}$, placed ten meters behind the goal, and aligned with the penalty line.

Simultaneously, and with the aim of studying the reliability of the radar gun, a 2D photogrammetric study was accomplished. The shots were recorded using a digital mini DV video camera (Sony, HDR, HC9E, Japan) operating at 100 Hz. The camera was mounted on a rigid tripod at a height of 1.0 m and placed at a distance of 10 m from the middle of the athlete's lane. The optical axis of the camera was perpendicular to the direction of throwing for each different situation, and the field of view of the camera was zoomed so that the ball was visible in a 10–m wide region. This field of view ensured that the maximum velocity of the ball would be recorded. The movement space was calibrated with two 2–m high poles that were placed along the midline of the athlete's lane and 5 m apart. For 2D Analysis, The recommendations exposed by Bartlett were followed (Bartlett, 1997).

Kwon3D biomechanical analysis software (Visol, Cheolsan-dong, Korea) was used to analyze the video images of the trials. Two landmarks that defined a model of the ball were digitized in each image. Coordinate data were smoothed using a second-order Butterworth digital filter with a cut-off frequency of 6 Hz, and the velocity of the ball's centre of mass were calculated from the coordinate data using the finite differences method (Winter, 1990).

All digitizing was performed by the same operator in order to maximize the consistency of the dependent variables. The reliability of intra-participant digitizing and inter-participant digitizing was very high. An intraclass correlation coefficient (ICC) value of 0.999 was obtained when three instants of the same video sequence were digitized five times, and an ICC value of 0.998 was obtained when two researchers digitized three instants of the same sequence.

One trial by each participant for each throw condition was analyzed. After the throws were analyzed, Pearson correlation coefficients (SPSS 15.0, SPSS Inc, Chicago, USA) were used to determine the interrelationship among the maximum velocity obtained by the radar gun and the 2D analysis. The alpha level was set to $p \leq 0.05$.

RESULTS

The results obtained are presented in Table 1. Scientific community established that, when a high and statistic significant correlation coefficient between the instruments analyzed exists, we can say that they are valid enough. In the present study we found intraclass correlation coefficients higher (ICC) than 0.80 for all throwing situations and all of them reach statistical significance.

For frontal throws without goalkeeper the ICC was 0.96, and with goalkeeper was 0.84. If we analyze throws in oblique situation (α ~ 20º), the ICC was 0.94 without goalkeeper and 0.96 with goalkeeper.

When we analyzed all throws in frontal situation the Pearson correlation coefficient obtained was 0.91 and in oblique position was 0.94.

Table 1. Pearson correlation coefficient between radar gun and photogrammetry instruments in different situations

Variable	V_{Radar} ($km \cdot h^{-1}$) Mean ± SD	V_{Video} ($km \cdot h^{-1}$) Mean ± SD	ICC (*r*)	*p*
Frontal without goalkeeper (n = 12)	51.3 ± 6.8	51.8 ± 6.7	0.958	0.000
Frontal with goalkeeper (n = 12)	51.3 ± 3.2	50.2 ± 4.2	0.840	0.001
Oblique without goalkeeper (n= 12)	50.8 ± 3.7	49.9 ± 4.7	0.939	0.000
Oblique with goalkeeper (n = 12)	49.3 ± 5.6	49.4 ± 5.7	0.965	0.000
Frontal (n = 24)	51.3 ± 5.1	51.0 ± 5.5	0.911	0.000
Oblique (n = 24)	50.0 ± 4.7	49.7 ± 5.1	0.941	0.000
Total (n=48)	50.6 ± 4.9	50.3 ± 5.2	0.927	0.000

DISCUSSION

The main goal of this study is to validate the radar gun as valid instrument to measure throwing velocities in water polo.

This is a very important issue, because skills in passing and throwing the ball are vital in water polo for reasons of accuracy and ability to produce high velocities, which are valuable during the game. In water polo, the overhead throw is the most effective and frequently used to propel the ball and to score goals (Bloomfield, Blanksby et al, 1990). The overhead throw accounts for up to 90% of all passes and shots during a game. In this pattern, the ball comes from behind the body and is brought up over the head and released in front of the body. The goal of the overhead throw is to achieve high endpoint velocity (Bloomfield, Blanksby et al, 1990). Naturally, the faster the ball is thrown at the goal, the less time defenders and goalkeeper have to save the shot (Muijtjens, Joris et al, 1991).

For this reason measuring throwing velocity during training sessions and during real competition match is an important issue for coaches and athletes. But unfortunately, these measures are really complicated because of the water. The radar gun solves the problems mentioned, because we can obtain the results of the measures immediately, we can assess throwing velocity without getting inside the playfield and we can measure throwing velocity in a real match. Now it is possible to use the radar gun as a valid method for measure throwing velocity even in oblique throw situations in water polo.

CONCLUSION

The results suggest that the measurements obtained with radar are valid, both for frontal throws (r=0.911, p=0.000) as well as for oblique throws (r=0.941, p=0.000) (θ ~ 20º), with and without goalkeeper.
The radar gun is a valid method to measure throwing velocity during a water polo training session and during a water polo match, so for frontal throws as well for oblique throws (r=0.91, p=0.000).

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