DIFFERENCES IN TRUNK ANGLES THROUGH DIFFERENT SHOOTING DIRECTIONS IN WATER POLO PENALTY SHOOTING

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The purpose of this study was to investigate three-dimensionally the shooter's trunk motion through 4 different shooting directions. Ten Korean national level water polo players who are right-handed were participated in this study (age, 21.60±3.20 years; weight, 86.30±8.86 kg; height, 1.83±0.05 m). To analyze the shooter's trunk motion among different target, a three-dimensional motion analysis with six video cameras was performed.The analysis events were coking when the trunk was externally rotated maximally and release moment. A one-way ANOVA with repeated measure was performed as main statistical tests and Bonferroni correction was used as a post-hoc test. The results showed that there was statistically significant difference in trunk angle between left and right shooting directions. Especially, the posterior leaning and external rotation angles of trunk in cocking moment were bigger in left shooting direction compared to right one (p<.05). These results suggest that goalkeepers predict shooting direction more precisely by identifying the trunk posture at coking moment.

KEY WORDS: water polo, shot, shooting, direction, trunk

INTRODUCTION: The water polo is a sport event, like other ball games, in which the winner is determined by the score. The shooting skill, an ultimate determinant of scores, therefore, is very important and many studies have focused on the improvement of shooting skill (Abraldes, Ferragut, Rodríguez, Alcaraz, 2011; Feltner & Nelson, 1996). The studies that investigate the defence skill in behalf of goalkeeper, however, were limited. The goalkeeper in water polo is an important position blocking opponent's shooting in final step and the excellent capacity of goalkeeper is an important factor to win a game (Escalante, Yolanda, et al., 2012). The excellent goalkeeper require many conditions including superior physique and fast body reaction time, however the most important one is an ability of predicting ball coming direction. Abraldes et al.(2011) reported that the average speed of ball drawn from 5m shooting line by male players is around 20 m/s, meaning that it takes 0.25 sec for the ball to reach goal line. Considering the response time of human, it is very difficult to judge the direction of coming ball after it is released from shooter's hand, especially in penalty draw situation. This forces goalkeepers to predict the direction of cooming ball in advance to block shooting during penalty draw, and it is necessary to study shooter's posture among different shooting directions for effective prediction. The most of previous studies were, however, biased to quantification of shooter's posture to increase ball speed, ignoring information collection about difference in shooter's posture by different shooting directions. The purpose of this study was, therefore, to investigate three-dimensionally the shooter's trunk motion through different shooting direction and to provide data to assist improvement of predictive ability of goalkeepers by identifying the moment in shooting where the difference occur.

METHODS: Ten Korean national level water polo players who are right-handed were participated in this study (age, 21.60±3.20 years; weight, 86.30±8.86 kg; height, 1.83±0.05 m). After warming-up exercise for 30 minutes each partcipant was asked to shooting to goalpost from penalty draw line. Four shooting targets on goalpost were predefined (4 ends of the coner of goalpost) and shooting trials were run five times from each predefined direction, summing to 20 times in total. The target spots were instructed randomly just before shooting performance to prevent recognition in advance.

To analyze the shooter's trunk motion among different target, a three-dimensional motion analysis with six video cameras was performed. Thirteen self-made markers were attached to participant's upper body and the motion was recorded using six video cameras (HXR-MC2000, Sony, Japan) with 60 Hz of sampling frequency and the focus and illuminance were set manually. The video data obtained from six video cameras were synchronized by whistle sound and were converted to 3D coordinates by DTL technique. The smoothing was performed by using 4th Butterworth low-pass filter and 6Hz of cut-off frequency was set to reduce random noise.
The shooting movements were divided into two events (cocking[event 1], release[event 2]) and the trunk angles of each event were measured. The one-way ANOVA with repeated measure were performed to test difference in kinematic factors among directions and the Bonferroni correction was used as post-hoc test. All statistics were performed by SPSS program and the statistical significance was set as α=.05.

RESULTS: Table 1 shows anteroposterior (A-P) leaning angles of trunk in event 1 and event 2 among directions. In this study, anterior leaning angle and posterior leaning angle were defined as - and +, respectively. Statistically significant differences in A-P leaning angles at both cocking and release were observed between left and right shooting directions (*p*<.05) but not between top and bottom ones.

Table 1
Difference in anteroposterior leaning angle of trunk amoing directions

Direction	Event1(deg.)		Event2(deg.)	
LB	9.33	±7.66	2.63	± 7.18
LT	7.83	±4.55	4.80	± 9.28
RB	-0.87	±6.80	-10.46	± 8.96
RT	2.23	±6.21	-4.02	± 8.95
F(*p*)	8.842	(.002*)	16.481	(.001*)
	LB, LT > RB, RT		LB, LT > RB, RT	

*Statistical differences (*p*<.05) between groups, deg.(degree)
LB(left bottom), LT(left top), RB(right bottom), RT(right top)

Table 2
Difference in left and right leaning angles of trunk amoing directions

Direction	Event1(deg.)		Event2(deg.)	
LB	-13.45	±14.92	-25.03	± 16.10
RB	-22.16	±9.37	-27.52	± 7.23
RB	-18.92	±8.78	-26.93	± 6.65
RT	-17.88	±8.25	-27.54	± 6.44
F(*p*)	.513	(-.686)	.265	(-.763)
	LB, LT, RB, RT		LB, LT, RB, RT	

*Statistical differences (*p*<.05) between groups, deg.(degree)
LB(left bottom), LT(left top), RB(right bottom), RT(right top)

Table 2 shows left (-) and right (+) leaning angles of upper body in event 1 and event 2 among directions. There was no statistically significant difference in right and left leaning angles at both cocking and release.
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Table 3
Difference in internal and external rotation angle of trunk amoing directions

Direction	Event1(deg.)	Event2(deg.)
LB	-71.03 ±13.07	-30.73 ± 11.64
RB	-69.60 ±17.18	-32.87 ± 11.48
RB	-97.10 ±9.89	-2.94 ± 10.13
RT	-92.03 ±13.18	-7.10 ± 15.96
F(*p*)	22.120 (<.001*)	75.329 (<.001*)
	LB, LT > RB, RT	LB, LT < RB, RT

*Statistical differences (*p*<.05) between groups, deg.(degree)
LB(left bottom), LT(left top), RB(right bottom), RT(right top)

Table. 3 shows external (-) and internal (+) rotation angles of trunk in event 1 and event 2 among directions. Statistically significant differences in external and internal rotation angles at both cocking and release were observed between left and right shooting directions (*p*<.05) but not between upper and lower ones.

DISCUSSION: The purpose of this study was to investigate the difference in trunk angle of shooter through different shooting directions at water polo penalty shooting. The results showed that there was difference in trunk posture of shooter among shooting directions, especially significant differences in cocking and release moments between left and right shooting directions. These may indicate that the shooter adjust the shooting direction by changing the posture of trunk.

CONCLUSION: It was reported that the drawing movement like shooting in water polo game is progressed sequentially from proximal to distal directions (Hirashima, Kadota, Sakurai, Kudo, & Ohtsuki, 2002), meaning that the movement of trunk is most influential factor in determining direction in shooting. It is recommended, therefore, for goalkeepers predict shooting direction by identifying the site of trunk where the rotation occurs initially at each shooting direction.

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