PELVIS-SHOULDER MOVEMENT VARIABILITY AND CUETIP MOTION DURING THE WARM-UP AND FINAL STROKES IN POOL

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The purpose of this study was to investigate the variation and variability of cuetip, shoulder and pelvis on stop shot, push shot and draw shot during warm-up strokes (W3, W2, W1) and final stroke (FS). Eight cameras were used to determine three-dimensional motions of cue, shoulder and pelvis for a pool world cup championships winner. The results showed that the largest variation was presented in the final stroke as well as the greatest consistence through trials. Variation of shoulder and pelvis was supposed an essential factor for a pool shoot. The cuetip, shoulder, and pelvis all demonstrate the similar pattern with greatest variability in first warm stoke and greatest consistence on the final stroke. The variability will converge to from the warm-up strokes to the final stroke.

KEY WORDS: pool, variation, variability, consistence

INTRODUCTION:

For a good performance in pool events, the effectiveness of consistent movement is essential. “Don’t bob head or move anything except your forearm”;”The rest of body should remain motionless and keep it during stroke”. (Byrne, 1998; Gapelle, 1995). Cheng et al, in 2007 study that involved champion winner, evaluate peak velocity body and angular kinematic parameter of both upper and lower limbs. The authors demonstrated a nice stop shot with characteristics of stable lower body and a slight variation of shoulder and pelvis during final stroke. Warm-up strokes would allow you to build muscle memory, to get your stroke on track and get a feel for the length and speed of stroke (Gapelle, 1995). However, it is unclear the probable differences in shoulder and pelvis movement variability between different phases.The aim of this study was to compare the movement variation and variability [CV: Coefficient of Variation = (SD/Mean)%] of cuetip and shoulder and pelvis between each stroke phase on stop shot (SS), push shot (PS) and draw shot (DS).

METHODS:

The participant(age:16 years, trainning:7 years) awarded as the champion in 2005 Men‘s World Pool Championships winner was captured at the same season with 60Hz by the Motion Analysis System with 8 high speed cameras (Motion Analysis Corp., Santa Rosa). In total, 120 data were anlaysed (10 strokes x 1 participant x 3 techniques x 4 phases).Fourty-eight reflective markers (diameter=13mm) totally, 42 markers on the participant, 4 markers on the cue and 2 markers on the cue ball and object ball, were used. The reflective marker on acromioclavicular joint (AC joint) and marker on left anterior superior Iliac spine(ASIS) were used respectively to describe the movement of shoulder and pelvis. The last three warm-up strokes (W1, W2, W3)were determined by cuetip marker starting from the closest point to the cueball ,then farest, and back to the closest point again as well as final stroke, shown in figure 1.

The definition of shot was determined by cueball. After impact, the cueball stop to move was called stop shot (SS), moving forward, backward was called push shot (PS), draw shot (DS) respectively. Deviation angle of objectball was caculated by vector dot product of talbe diagonal and objectball moving direction. The definition of variation was displacement of . Measurements of variation and devaition angle are presented as means$\pm$SD. Variability was defined by SD over mean shown by percentage (CV=SD/mean%). One-way ANOVA and post hoc Scheffe test were used to evaluate differences among variations of the four phases and to compare the deviation angle of objectball. All Statistical testing wes performanced with SPSS software,version 12.0 (SPSS Inc., Chicago, Illinois).

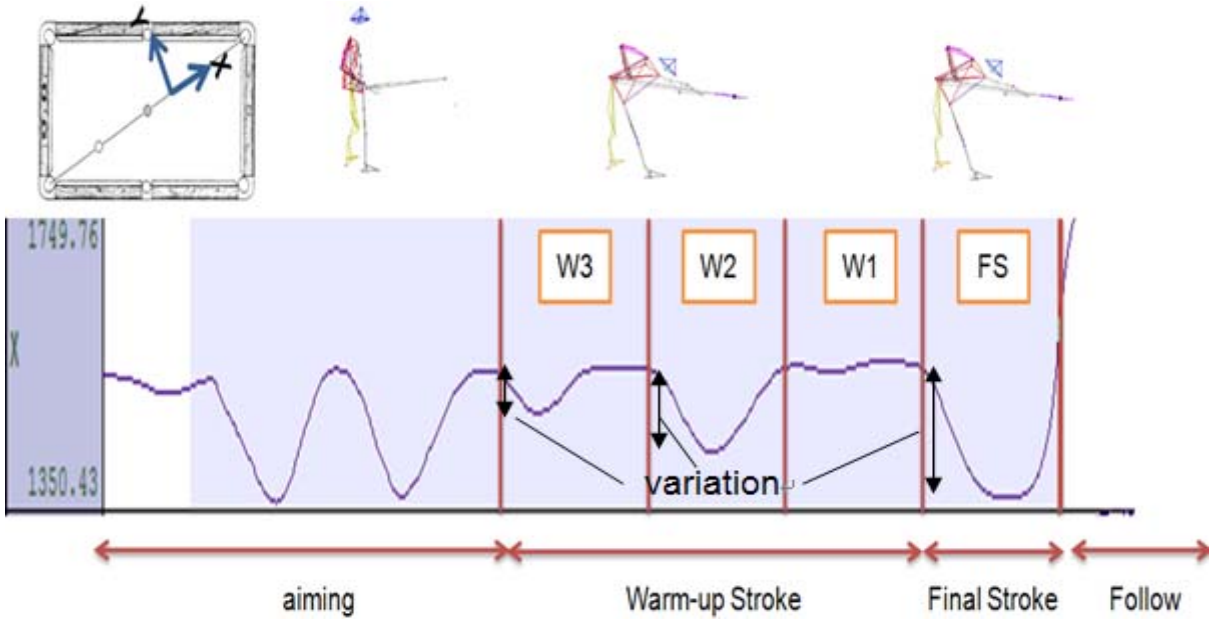

Figure 1: The divsion of a complete pool shot and equipment setup. (X axis: from table center to coner, gray:object ball; white:cue ball;).

RESULTS:
The deviation angle and inpocket percentage of object ball in stop shot(SS), push shot(PS) and draw shot(DS). There was no significant difference between those three shots, shown in Table 1.

Table 1 The deviation angle and inpocket percentage of object ball in pocket on stop shot, push shot and draw shot.

	SS	PS	DS
Deviation angle (θ)	0.512±0.303	0.778±0.764	1.017±0.546
Percentage of inpocket (%)	100%	90%	80%

n=10, p<.05

Variation values for cuetip, shoulder and pelvis are presented in Table 2. Comparisons of all phases, expect W3 versus W2 phases, showed significant differences on all three techniques in cue tip and on DS in shoulder. There were significant differences between each phase, besides W1 versus W2 and W1 versus, on SS in shoulder and on DS, SS in pelvis. None of each phase on PS in shoulder and pelvis showed significant differences.
Variability values for cuetip, shoulder and pelvis are presented in Table 3. CV values decreased from the warm-up strokes to the final stroke.

DISCUSSION:
Variation: Larger Max variation of cuetip in final stroke than in warm-up strokes was expectable. Retaining a distance from cueball to cuetip in warm-up was necessary, otherwise the cuetip would touch the cueball actually. The result also showed the character of top pool player in Warm-up stroke. The warm-up strokes allow you 1) “to build muscle memory and to get your stroke on track”, 2) “to get a feel for the length and speed of stroke” (Gapelle,1995). Therefore, it showed the player get the sense to shoot in W3, W2 and simulating stroke in W1 to approach final stroke, it was agreed with the importance of warm-up strokes mentioned by Gapelle (1995).

Table 2 Variation in cuetip, shoulder and pelvis on three shots during different phases.

Position	Phase	SS		PS		DS	
Cue Tip	W3	77.02	± 22.35 [b,c,d]	108.54	± 36.98 [b,c,d]	86.12	± 35.11 [b,c,d]
	W2	91.81	± 12.46 [e,f]	95.90	± 30.99 [e,f]	108.96	± 10.77 [e,f]
	W1	18.41	± 12.15	22.23	± 16.85	30.94	± 17.24
	FS	172.41	± 12.51	168.72	± 12.45	208.30	± 18.14
Shoulder	W3	7.21	± 6.42 [b,c]	25.98	± 37.71	7.03	± 2.29 [b,c,d]
	W2	3.72	± 0.74 [e,f]	3.60	± 1.76	4.99	± 1.18 [e,f]
	W1	1.86	± 0.64	1.96	± 1.02	2.39	± 1.28
	FS	30.57	± 2.00	16.29	± 2.12	35.94	± 3.22
Pelvis	W3	2.36	± 0.91 [b,c]	6.08	± 8.38	2.22	± 1.43 [b,c,]
	W2	1.57	± 0.71 [e,f]	2.10	± 0.73	1.46	± 0.48 [e,f]
	W1	1.05	± 0.47	1.28	± 0.59	0.79	± 0.21
	FS	4.39	± 0.98	2.53	± 0.91	3.35	± 0.69

Data are mean ± SD; All comparisons significance at $P < .05$; ns: no significance; [a] W3 versus W2; [b] W3 versus W1; [c] W3 versus FS; [d] W2 versus W1; [e] W2 versus FS; [f] W1 versus FS.

Table 3 Variability(CV) in cuetip, shoulder and on three shots during different phases.

		CV		
Position	Phase	SS	PS	DS
Cue Tip	W3	29%	34%	41%
	W2	14%	32%	10%
	W1	66%	76%	56%
	FS	7%	7%	9%
Shoulder	W3	89%	145%	32%
	W2	20%	49%	24%
	W1	34%	52%	54%
	FS	7%	13%	9%
Pelvis	W3	39%	138%	64%
	W2	45%	35%	33%
	W1	44%	46%	27%
	FS	22%	36%	20%

CV= (SD/Mean)%

The results of amplitude of shoulder and pelvis in PS and DS agreed with Cheng, Li & Tang (2007) in SS. Byrne (1998) described that the elbow should be motionless during the stroking motion, dropping only at the end of a long follow-through. The arm swings forward, the elbow should drop and the cue should travel on a straight line for preventing from *dipping* the cuetip into the cueball, especially on DS (Gapelle, 1995). The reason of cuetip variation with larger on DS (208mm) than on SS and PS (36,168mm) was that player would use more strength to hit the cue to make it backspin on draw shot.

The SD of cuetip decreased from warm-up to stroke,but slightly increased in shouler and pelvis lightly increase in final stroke (FS). It may suggest that excuting a precise hitting may rely on not only wrist and elbow to adjust and to suit for the cue, but also do the shoulder and pelvis. If the degree of freedom on shoulder rotation *frozen* in the final stroke phase may cause more wrist variation to make cue on a straight line for compensation. Therefore, the pool player may adapt little rotation of shoulder and movement of trunk to avoid extra adduction of wrist joint or flexion of elbow in order to move cue straight to the target.

Variability: The most interesting thing in our study was that the variation was the largest during whole stroke phase, but the variability of all position were the lowest during whole stroke phase(<10%). This could be due to the top player's consistency in final stroke and the CV value should be a good indicator for checking the variability of pool player on cuetip, shoulder. Besides, the CV value of pelvis was higher in FS than others; it should be condsidered with lower variation values.

CONCLUSION:

In the study, the variation and variability pattern were very similar on the three fundamental techniques. It may related to that the rhythm of warm-up was often stressed on pool textbook in order to perform a consistent stroke motion and that may be a key to be a top pool player. Variation of shoulder and pelvis was supposed an essential factor for executing accurate shot. Besides, the lower variability on shoulder was more important for a precise shoot shown in present study.

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Acknowledgement

All authors thank for the equipment support from Chinese Taipei Billiards Association of pool equipments and the participation of the World Pool championships winner.