INFLUENCE OF SHOT FORCE ON MOTION VARIABILITY OF TOP SNOOKER PLAYERS

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The purpose of this study was to determine the influence of shooting with different force on motion variability of top snooker players. Six professional male players shot with hard force shot (HF) and soft force shot (SF), then coefficient of multiple correlations (CMC) and coefficient of variation (CV) were calculated. In SF, flexion-extension (p=.045) and adduction-abduction (p=.001) of shoulder showed higher CMCs than HF and adduction-abduction (p=.042) of shoulder showed lower CV than HF. In SF, flexion-extension of wrist showed higher CMC (p=.035) and lower CV (p=.030) than HF and adduction-abduction of wrist showed higher CMC (p=.039) and lower CV (p=.036) than HF. There was no difference in CMC and CV of cue. Thus hard force shot might increase motion variability of upper limbs.

KEYWORDS:snooker, motion variability, shot

INTRODUCTION: In order to achieve better performance in the competition, snooker athletes would select different hitting points and control force to control the stop position of cue-ball while shooting (Ma et al, 2009). A research found different shots had different characteristics in kinematics such as hitting velocity (Song et al, 2018). At present, successful pool billiard players are required to have efficient fine motor skills coupled with excellent repeatability in order to handle the different challenges on the table (Kornfeind et al, 2014), what’s more, when top pool billiard players shoot with different tasks, coefficient of variation (CV) of the angle and velocity of their cues show little variability (Kornfeind et al, 2015). However, it is not clear whether shoot force would have influence on variability of upper limbs’ movement of top snooker players. Thus, the purpose of this study was to determine the influence of shot force on variability of upper limbs.

METHODS: Six of the world's top 32 professional male snooker players (body height 1.80 ± 0.10 m, body mass 77.8 ± 16.3 kg), of which two were left-handed, participated in this study during the World Snooker China Open on March in 2018. Subjects were asked to use draw shot which hit the cue-ball under centre and the cue-ball stopped momentarily then drew away from the object-ball towards the player upon contacted with the object-ball. Subjects were requested to shoot in the manner shown in Figure 1. The cue-ball was located in the brown spot. The object-ball was located at the left of the blue spot and bottom pocket, the cue-ball and the object-ball were on the same line. For left-handed players, position of ball and pocket in their manner was symmetrical about the long axis of the table with right-handed players. This study determined the shoot force by controlling the displacement of the cue ball (Kornfeind et al, 2015).

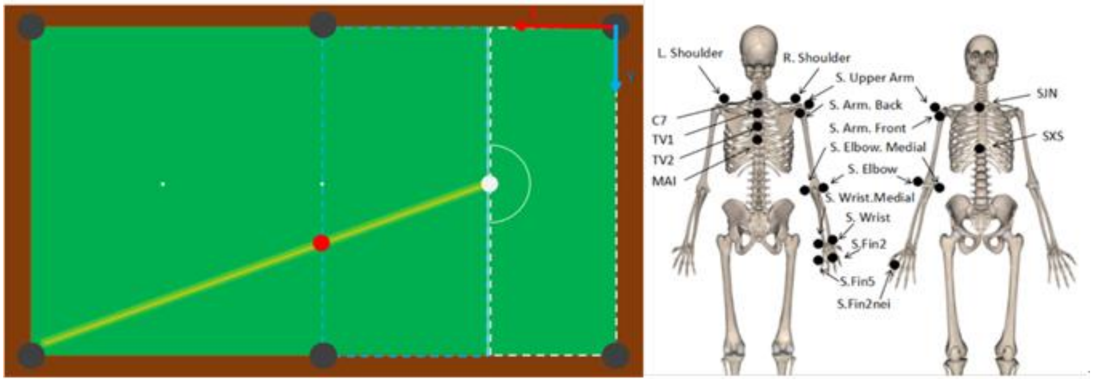

Figure 1: Shooting route of right-handed players and Markers on the body surface

A successful shot was defined as the cue-ball stopped at corresponding area after hitting the object-ball. When cue-ball stopped in the blue area was defined as soft force shot (SF), and when cue-ball stopped in the white area was defined as soft force shot (HF). Each player shot 10 times for each kind of shot and they were encouraged to try their best to make the object-ball fall bottom pocket, then the result of each shot was recorded. All the subjects were asked to use the same snooker cue and affix four reflective markers on the cue. The position of the cue was shown in Figure 2, and cue2-4 were not collinear. Cue 1 and S.Fin2nei were removed after the calibration completed. Then cue-head was built in visual 3D (C-motion, USA), and was a landmark calculated from the cue2-4 on the cue according to the calibration. Eighteen reflective markers were attached to the body on trunk, upper arm, forearm and hand. Before the shot, the subjects performed appropriate warm-up exercises in tight sportswear and began testing after they found the feeling of shooting with the cue.

Figure 2: Cue Marker scheme

All motion acquisitions were performed on a 13-lens infrared high-speed motion capture system (Qualisys oqus 700+ and 210c, Sweden, 200 Hz). The model of the limbs of subject and cue were built in visual3D. All signals were smoothed by using a low-pass filter, the frequency of which was 13.3 Hz. Euler angles were then calculated for the shoulder, elbow and wrist. Shooting stage started from the time point when the furthest distance between the cue and the cue-ball to another time point when the cue-head touching the cue-ball. The displacement, position and velocity of cue were presented by which calculated from cue-head. And the angle of cue was defined as the spatial vector angle formed by cue-head, cue2 and X axis. Data of ten shots during shooting stage was normalized to 300 points to calculate coefficient of multiple correlations (CMC). And data of ten shots at end of shooting stage was to calculate CV. SPSS22.0 (SPSS Inc, Chicago, Illinois) was used for statistical analysis, and the difference between SF and HF of each index was analyzed by using paired T-Test. The level of significance is defined as a Type I error of which rate not greater than 0.05.

RESULTS: Mean values and standard deviations for all indexes are depicted in Table 1 which showed the results of CMC and Table 2 which showed the results of CV .

Table 1: Results of CMC.

	HF	SF	P value
Shoulder flexion-extension*	0.69±0.25	0.81±0.16	0.045
Shoulder adduction-abduction*	0.45±0.14	0.73±0.23	0.001
Elbow flexion-extension	0.84±0.14	0.92±0.11	0.078
Elbow rotation	0.79±0.19	0.72±0.32	0.870
Wrist flexion-extension*	0.53±0.29	0.74±0.16	0.035
Wrist adduction-abduction*	0.75±0.15	0.89±0.05	0.039
Cue displacement x	0.89±0.15	0.97±0.04	0.109
Cue displacement y	0.83±0.28	0.98±0.02	0.231
Cue displacement z	0.85±0.18	0.95±0.09	0.072
Angle of cue	0.60±0.18	0.82±0.17	0.075

***meaning there are significant differences between HF and SF.**

Table 2: Results of CV.

	HF	SF	P value
Shoulder flexion-extension (%)	9.83±8.24	7.69±8.72	0.075
Shoulder adduction-abduction (%)*	4.43±1.40	2.82±1.19	0.042
Elbow flexion-extension (%)	6.01±5.04	4.09±4.37	0.160
Elbow rotation (%)	10.84±11.90	5.83±7.17	0.120
Wrist flexion-extension (%)*	58.20±32.20	41.19±21.35	0.030
Wrist adduction-abduction (%)*	60.21±29.08	19.66±8.12	0.036
Cue position x (%)	4.48±5.24	4.32±4.51	0.811
Cue position y (%)	1.75±1.69	1.01±0.73	0.227
Cue position z (%)	7.87±7.39	8.15±6.62	0.789
Cue velocity x (%)	6.61±5.26	6.00±4.35	0.406
Cue velocity y (%)	7.40±6.43	5.23±4.82	0.060
Cue velocity z (%)	32.12±25.39	14.49±13.37	0.140
Angle of cue (%)	4.83±3.82	3.55±2.01	0.152

***meaning there are significant differences between HF and SF.**

Except for shoulder adduction-abduction in HF, results of CMC were relatively high and showed good repeatability (Table 1). As for the movement of the limbs, CMC of shoulder's flexion-extension (p=.045) and adduction-abduction (p=.001) in SF were higher than HF. The wrist saw that CMC of flexion-extension (p=.035) and adduction-abduction (p=.039) in SF were higher than HF. In terms of CV, all indexes show low variability flexion-extension and adduction-abduction in wrist, except cue velocity z. In SF, adduction-abduction in the shoulder and wrist and flexion-extension in wrist were lower than HF. However, there was no significant difference between HF and SF in CMC and CV for movement of cue.

DISCUSSION: In terms of limb movement, top players showed great repeatability except shoulder adduction-abduction and wrist flexion-extension in HF. The shooting velocity of cue increases in HF and elbow which operates the main movement during shot (Zhang, 2008), could not bring enough effect of stroke to achieve strong shooting velocity. It is possible that the shoulder movement was a compensatory mechanism for improve the shooting velocity of cue. Thus, higher CV and lower CMC of the shoulder may be the result of increased components of the shoulder movement. In respect of the wrist, high CV in both of flexion-extension and adduction-abduction were result of low mean angle and high variation at the end of shooting stage. In some experts' points of view, wrist was used to modify the cue movement and it could improve the accuracy of shot (Zhang, 2008). With regards to the movement of the cue, CMC and CV showed high repeatability and low variability, what's more, there was no difference between HF and SF. This result was consistent with the results found by Kornfeind (2015). Those finding may indicate when top snooker players shoot with different force, they modify the cue movement by changing the movement of wrist and shoulder to achieve great repeatability and this may be the technical characteristics of shot in top players. In addition, the subjects of this study were the top players in the world, and these results could provide reference for similar research in the future.

CONCLUSION: The shoot force will increase motion variability of upper limb, however repeatability of movement of cue is not influenced by it. We suggest top players should select appropriate shot force according to the situation on table.

REFERENCES

Kornfeind, P., Baca A., Kuzdas, D., Gollnhuber ,G., & Neumann,M. (2014). Investigation of Subject Independent Movement Parameters in Professional Pool Billiard, in: A. De Haan, C.J. De Ruiter, E. Tsolakidis (Eds.) , *Book of Abstracts of the 19th Annual Congress of the European College of Sport Science.*

Kornfeind, P., Baca, A., Boindl, T., Kettlgruber, A., & Gollnhuber, G. (2015). Movement Variability of Professional Pool Billiards Players on Selected Tasks. Procedia Engineering, 112, 540-545.

Ma,W.Shi,J. & Wang,C.(2009). Theoretical Mechanics Analysis of Technology of Snooker. Journal of Wuhan Institute of Physical Education, 43(4),48-51.

Song, Y.,Qu,Y., Qu,F.,Zhao,S.,&Zhou,Y.(2018) A Biomechanical Analysis of The Upper Limb on Different Snooker Batting Techniques. ISBS Conference.

Zhang Feng-cheng. (2008). How to Play Billiards. Perth: Beijing Sport University Press.