THE INFLUENCE OF COORDINATION BETWEEN UPPER LIMBS' JOINTS ON SPORT LEVEL IN SNOOKER

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This study explored the effect of coordination between upper limb joints on the technical level of shooting in billiards. Eight professional and eight amateur players were asked to shoot according to a specific rounte and vector coding method used to quantify the coordination of the motions of the limbs during the shooting stage.For coordination between the flexion and extension of shoulder and flexion and extension of elbow,the proportion of the anti-phase and elbow-phase coordination in the professional group was higher than the amateur group,and the proportion of the shoulder-phase was lower for professional than amateur group. For coordination of the flexion and extension of shoulder and the the adduction and outreach of wrist,the proportion of the wrist-phase coordination in the professional group was higher than the amateur group,and the proportion of the shoulder-phase was lower for the professional than amateur group.These indicators can be used as diagnostic indicators for snooker player's shooting motion

Key words: Billiards, shot, technical diagnosis, motor control

INTRODUCTION: In the current research on movement techniques, studies on coordination are rare and most of them are simple qualitative analysis (e.g. Lin, 2012). In which research the relationship between the timing of muscle activity. Research from the perspective of action is rare. The vector coding method is often applied to the study and evaluation of motor coordination with its features of simplicity, clarity, and ease of interpretation. Liang (2014) used this method to study the coordination of lower limb joints on discus throwing. Most of the research on billiards is of the collision between balls and the collision between ball and cue with less on snooker's movement skill. Therefore, this study uses vector coding to analyse the coordination between upper limb joints in the shooting motion of snooker. This paper explores the influence of coordination between upper limbs' joints on sport level in snooker and the influence of different modes of coordination among players of different ability level and explores the influence of this coordination on athletic performance.

METHODS: Sixteen players, 8 in the professional group and 8 in the amateur group, all of whom were right-handed players, participated in this experiment. The professional groups were World's top 64 professional snooker players, and the amateur group was a good-natured snooker enthusiast without participating in international competitions. For motion analysis, a total of 22 markers was placed on each subject with at least 3 points on each link. The subjects were allowed to warm up before the experiment. Subjects were requested to hit the ball in the manner shown in Figure 1. The cue-ball was located in the center of the kick-off area. The subject-ball was located at the left of the five-point ball and the shooting motion of the cue was to score the subject-ball. The cue-ball must stop in the shadow area to be successful. Each player shoot 10 times, and finally selected for further analysis one successful shot that he considered most satisfactory.
All motion acquisitions were performed on a 13-lens infrared high-speed motion capture system (Qualisys oqus 700+, Sweden, 200 Hz). A model of the subject was built in visual3D. All signals were smoothed using a low-pass filter, the frequency of which was 13.3 Hz. Euler angles were then calculated for the shoulders, elbows and wrists of the human body. In origin 8.0, all data in the hitting phase is normalized to 101 numbers.

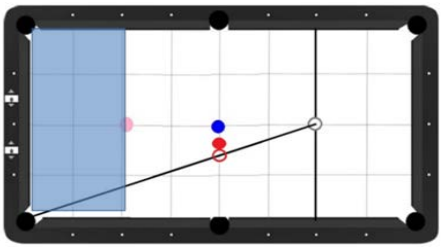

Figure 1: shooting route

Coordination	Range of θvc
Anti-phase	157.5> θvc≥112.5 ; 337.5> θvc≥292.5
In-phase	67.5> θvc≥22.5 ; 247.5> θvc≥202.5
Joint1-phase	22.5> θvc≥0 ; 202.5> θvc≥157.5 ; 360> θvc≥337.5
Joint2-phase	112.5> θvc≥67.5 ; 292.5> θvc≥247.5

Figure 2: definition of coordination

Shooting stage starts from the farthest point of the cue from the target ball to the cue head touching the target ball. In this experiment, vector coding method quantifies relative relationship of change of the angle between the two joints in the striking process.

The specific calculation formula (Miller Rh, 2010) is θvc (i)= $\tan^{-1}\left[\frac{\theta1(i+1)-\theta1(i)}{\theta2(i+1)-\theta2(i)}\right]$ .In the formula, θvc is the vector direction angle, and θ1 and θ2 represent two joint angles respectively. i is the time (1, 2, …, n-1).

The flexion and extension angle of shoulder, the flexion and extension angle of elbow, and the adduction and abduction angle of wrist were selected for analysis as these three angles are the main components of the shooting in snooker. According to the definition of Chang (2008), anti-phase means that the two joints have opposite movement tendency, in-phase means that the joints have the same movement tendency, and joint1-phase means that the joints1 are mainly moving.Independent sample T test was used to test differences between professional and amateur groups. The level of significance is defined as $p < 0.05$. All statistical analyses were performed in SPSS 17.0.

RESULTS: There was a significant difference in the coordination between shoulder and elbow of the two groups, in which the proportion of the anti-phase coordination between shoulder and elbow of professional group was higher than that of amateur (0.39: 0.19), the proportion of shoulder-phase coordination was lower than that of the amateur (0.30: 0.63), and the proportion of elbow-phase coordination was higher than that of amateur (0.24: 0.11), but there was no significant difference in the coordination of in-phase coordination. There was no significant difference in the four coordination modes between the two groups in elbow and wrist .There was a significant difference between the two groups in the coordination between shoulder and wrist, in which the proportion of the shoulder-phase coordination of professional group was lower than that of the amateur (0.33: 0.47). The proportion of wrist -phase coordination is higher than that of the amateur group (0.31: 0.15).

Table 1：Results of coordination between upper limbs' joint of two groups

		Shoulder-Elbow	Elbow –Wrist	Shoulder - Wrist
anti- phase,	professional	0.39±0.14*	0.10±0.06	0.20±0.09
	amateur	0.19±0.14	0.10±0.06	0.19±0.07
in-phase,	professional	0.07±0.04	0.26±0.14	0.16±0.07
	amateur	0.11±0.06	0.22±0.11	0.19±0.07
Joint1- phase	professional	0.30±0.15*	0.33±0.22	0.33±0.18*
	amateur	0.63±0.22	0.24±0.16	0.47±0.13
Joint2- phase	professional	0.24±0.11 *	0.31±0.26	0.31±0.23*
	amateur	0.07±0.04	0.44±0.20	0.15±0.08

***meaning there are significant differences; joint1 – joint2**

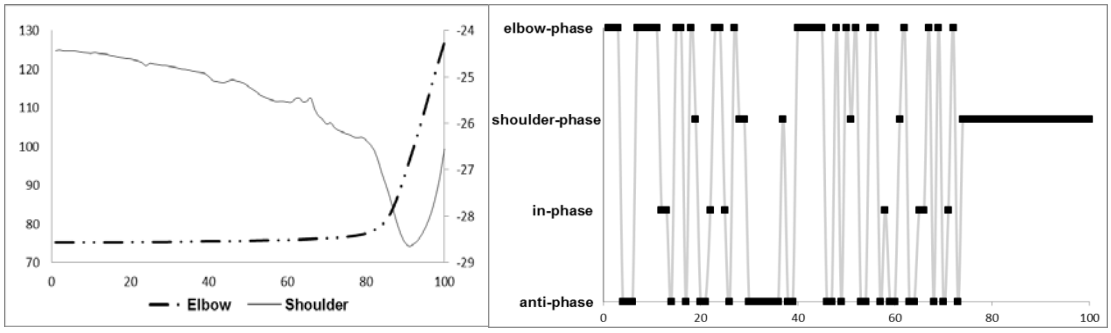

Figure 3: Distribution of coordination of Subject A (P)

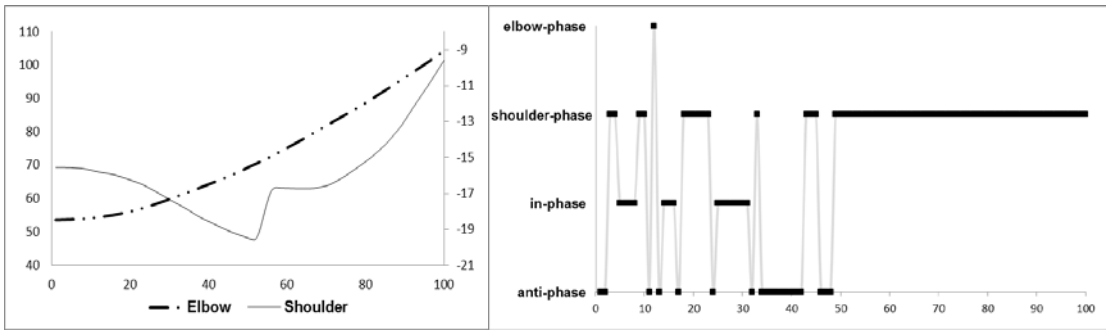

Figure 4: Distribution of coordination of Subject B (A)

DISCUSSION: Considering the coordination of flexion and extension of shoulder and flexion and extension of elbow, from Figures 3 and 4, the professional player used elbow-phase coordination in most of the time, with the proportion of elbow-phase coordination lower in the amateur. This indicates that for most of time, professional players rely on elbow movement while amateur players use the shoulder. For the range of shoulder motion: The range for the professional was lower than the amateur. In addition, the range of elbow motion in the professional was higher than the amateur. Some professional coaches have said elbow movement is mainly used in shooting. Although the range of the elbow movements was not significantly different, elbow-phase coordination was more in professional group. This may be due to the small amplitude of shoulder motion. Some players have said the fixation of the center of the elbow is very important (Ma, 2012), In other words, the range of movement of shoulder should be as small as possible, otherwise, the whole movement of the shooting limbs becomes complicated, resulting in unsatisfactory collision with cue ball. In last part of the motion, for both groups, shoulder-phase coordination was a larger proportion, because the impact that elbow's pendulum movement generated is not enough (Zhang, 2008). Shoulder movement is needed to compensate, resulting in better outcome of shooting; However, if the proportion of shoulder participation is higher, the more complex the limb movement, and the more difficult the cue control is for player. For coordination of flexion and extension of shoulder and the adduction and outreach of wrist: The proportion of wrist-phase in professional group was higher than the amateur, but the proportion of shoulder-phase was less than the amateur. The wrist movements of the professional group were larger, while the shoulder activities of the amateur group were larger. Wrist activities can get a good hit effect in shooting, and this is consistent with the opinions mentioned by some experts in teaching (Zhang, 2008).

There were a huge difference in the distribution of coordination between profession and amateur players studied. Measures of coordination can serve as a reference value in diagnosing player's movement technique and guiding movement technique and can be applied to training and technical diagnosis. The vector coding method, which analyses snooker from a completely new perspective, is more targeted than simple analysis of joint amplitude.

CONCLUSION: In the process of shooting in snooker, different levels of players have significant differences in upper limb coordination which can be used as in evaluation of movement technique.

REFERENCES

Chang R, & R Van Emmerik. (2008). Quantifying rearfoot-forefoot coordination in human walking. *Journal of Biomechanics*. 41(14):3101-3105.

Liang Hai-dan. (2014).The Effect of Inter-Segment Coordination among Lower Limbs in Entry Phase on Skill Level of Discus Throwing. *ZheJiang Sport Science*. 36(04): 106-112

Lin Hui-jie. (2012).Quantitative Methods and Research Status of Motor Coordination in Sport Skills. *China Sport Science,* 32, 81-91.

Ma Zhi-yu. (2012). Mr Ma teaches you play billiards. Perth: Chemical Industry Press.

Miller Rh. (2010).Variability in kinematic coupling assessed by vector coding and continuous relative phase. *Journal of Biomechanics*. 43(13):2554-2560.

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