

## THREE DIMENSIONAL KINEMATIC ANALYSIS IN WOMEN'S SHOT PUTT: INFLUENCE OF HEAD MOVEMENT ON TECHNIQUE

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The influence of head motion of shot put during competition was studied in this study. Six female elite shot putter was recruited as subjects in this study. Shots performed by six female elite shot putter were filmed. Three-dimensional analysis was employed to determine the angle of head, trunk, shoulder rotation and height of shot at different throwing phase. Results found that the raising of head position in every phase influenced the movements limb and trunk. Therefore, it is necessary for coach and athletes to pay more attention on the head movement in shot put.

**KEYWORDS:** attitudinal reflex, the angle of head and trunk, the angle of head rotation

**INTRODUCTION:** The influence of head movement in sport has been the focus of considerable research, reflected in a study on the effect on track athletes, related to the crouch start (Li, 1992) and on the effect of neck movement on gymnastic performance (Gu,1996). Other studies have indicated that the head's movement plays an important role on bar clearance technique. However, until now, there have been no quantitative articles on the influence of head movements on shot put techniques. The paper intends to attract both coaches and athletes' attention to attitudinal reflex. By efficient training, the athletes' heads can be in a favorable position in every phase of throwing, allowing them to give full play to their techniques and to achieve the best results.

**METHODS:** The subjects selected for this study were six female shot putters, either state or international athletes who attended the 8th National Games. The essential features of 6 shot putters are shown in Table 1.

**Table 1 The Essential Features of 6 Shot Putters**

Athlete	Order	Best Result (m)	The lowest Result (m)	Height (m)
Xinmei Sui	1	20.25	19.29	1.72
Zhihong Huang	2	20.24	19.35	1.72
Meisu Li	3	19.46	18.94	1.76
Yawen Wang	4	19.22	17.88	1.78
Xin Yu	5	19.16	18.46	1.92
Lihong Zhang	6	18.79	18.46	1.78
Mean		19.52	18.73	1.78
SD		0.60	0.57	0.07

Using three video cameras with electrical shutters, the performance was filmed, with a frequency of 50HZ. Using the close-range dynamic three-dimensional cinematography, photos of the competing process of the 6 elite Chinese women shot putters who attended the 8th National Games, was analyzed. By applying EIMG64PN---1 Sport Video Analytical System, the players' techniques were analyzed by three-dimensional approach.

Several definitions:

Angle of head and trunk. The angle is formed by the straight line from the head top to the seventh cervical vertebra and by the straight line from the seventh cervical vertebra to the perineum. The larger the angle, the greater is the extent the head raises.

Angle of head rotation: The angle is formed by the straight line from one ear to the other and by the perpendicular axis. The positive value means the head turns to the left and the

negative value means to the right. The zero value indicates the head is parallel with the horizontal axis.

Angle of shoulder rotation. The angle is formed by the straight line from one shoulder joint point to the other and to the perpendicular axis. The positive value means the shoulders turn to the left and negative value means to the right. The zero value indicates the shoulders are parallel with the horizontal axis.

Lean angle of the trunk. The angle is formed by the straight line from the seventh cervical vertebra to the perineum and to the vector axis. The smaller the value the greater is the extent the trunk leans backward, opposite to the throwing direction.

**RESULTS:** The technical parameters of each phase are shown in Table 2 and Table 3.

**Table 2 Kinematic Parameter of Each Phase (°)**

		Angle of head and trunk	Angle of head rotation	Angle of Shoulder rotation	Tilt angle of Trunk	Height of shot
Tucked	A	144.8	17.8	7.3	-5	0.7
	B	141.2	12.7	4.3	-0.3	0.69
	D	3.6	5.1	3	-4.7	0.01
R	A	151.2	19.8	9.3	12.7	0.96
	B	145.2	13.3	6.5	10.5	0.93
	D	5.3	6.5	2.8	2.2	0.03
R↓	A	149	19.5	8.7	16.2	1.06
	B	143.7	13.2	5.5	13.2	10.1
	D	6	6.3	3.2	3	0.05
L	A	152.7	52	25.3	37.8	1.18
	B	146.8	43	19.5	34.8	1.12
	D	5.9	9	5.8	3	0.06
O	A	206.5	219.8	198.6	108.8	2.07
	B	214.2	218.7	206.7	110.3	2.04
	d	-7.7	1.1	-8.1	-1.5	0.03

Note: R the right foot leaves the ground  
 R↓ the right foot touches the ground  
 L the left foot touches the ground  
 O the release of the shot  
 A) the mean top result of the six athletes  
 (B) the mean lowest result of the six athletes  
 (D) the difference between top result and lowest result

**Table 3 Technical References of Delivery**

	S (m)	S <sub>H</sub> (m)	S <sub>V</sub> (m)	Time	Angle of release	Height of release	V	V <sub>H</sub> (m)	V <sub>V</sub> (m)
a	1.65	1.31	91.7	0.18	35.2	2.04	13.15	10.63	7.59
b	1.57	1.25	88.7	0.18	36.0	2.07	12.93	10.61	7.44

Note: S the path of shot  
 S<sub>H</sub> the horizontal displacement of shot  
 S<sub>V</sub> the vertical displacement of shot  
 V velocity of release  
 V<sub>H</sub> horizontal velocity of release  
 V<sub>V</sub> vertical velocity of release

**DISCUSSION:** The movement of head and neck has great impact the whole technique of shot putting: Table 2 shows that the angle of head and trunk of 6 women putters are  $144.8\pm 16.8^\circ$ ,  $151.2\pm 13.9^\circ$ ,  $149.0\pm 12.0^\circ$  and  $152.7\pm 11.2^\circ$  at the moments of their body tucking, right foot leaving ground, right foot landing and left foot landing. When the putters get  $18.73\pm 0.57\text{m}$ , their angles of head and trunk are  $141.2\pm 19.7^\circ$ ,  $145.2\pm 12.2^\circ$ ,  $143.7\pm 8.7^\circ$  and  $146.8\pm 10.9^\circ$  at each moment above when their result reaches  $19.52\pm 0.60\text{m}$ . Their angles are  $3.6^\circ$ ,  $5.3^\circ$ ,  $6.0^\circ$  and  $5.9^\circ$  increased respectively. Comparing the angle of head and trunk of the former with the latter, it was discovered the former is  $3.0^\circ$ ,  $5.3^\circ$ ,  $6.0^\circ$ , and  $5.9^\circ$  larger than the latter. Their angle of head rotation are  $17.8\pm 11.3^\circ$ ,  $19.8\pm 7.7^\circ$ ,  $19.5\pm 6.3^\circ$ , and  $52.0\pm 23.0^\circ$  at the moments of their body tucking, right foot leaving ground, right foot landing and left foot landing when the putters get  $18.73\pm 0.57\text{m}$ . These angle are  $12.7\pm 9.2^\circ$ ,  $13.3\pm 12.1^\circ$ ,  $13.2\pm 5.7^\circ$ , and  $43.0\pm 21.0^\circ$  at the above moments when their result reaches  $19.52\pm 0.60\text{m}$ . It was found that the references of the former are  $5.1^\circ$ ,  $6.5^\circ$ ,  $6.3^\circ$ , and  $9.0^\circ$  larger than the latter. These parameters have proved that they raise and rotate their head leftward on their own initiative when the women putters get  $18.73\pm 0.57\text{m}$ . Because of raising and rotating their head leftward, as a result of attitudinal reflex, their shoulders are opened more. The angle of their shoulders rotation are  $7.3\pm 4.0^\circ$ ,  $9.3\pm 4.8^\circ$ ,  $8.7\pm 4.5^\circ$ , and  $25.3\pm 6.9^\circ$  at the moments mentioned above when the putters get  $18.73\pm 0.57\text{m}$ . These angles are  $2.1^\circ$ ,  $2.8^\circ$ ,  $3.0^\circ$ , and  $5.8^\circ$  which is larger than the above moment when their result reached  $19.52\pm 0.60\text{m}$ . The lean angles of their trunk are  $5.0\pm 2.7^\circ$ ,  $12.7\pm 8.9^\circ$ ,  $16.2\pm 7.8^\circ$ , and  $37.8\pm 5.2^\circ$  at the moments of their body tucking, right foot leaving ground, right foot landing and left foot landing when the putters get  $18.73\pm 0.57\text{m}$ . These angle are  $5.3^\circ$ ,  $2.2^\circ$ ,  $3.0^\circ$ , and  $3.0^\circ$  larger than these their lean angles of trunk at the above moment when their result reaches  $19.52\pm 0.60\text{m}$ . For this reason, their trunks and shots are raised higher. As their results get  $18.73\pm 0.57\text{m}$ , their heights of shot are  $0.71\pm 0.08\text{m}$ ,  $0.91\pm 0.09\text{m}$ ,  $1.06\pm 0.08\text{m}$  and  $1.18\pm 0.08\text{m}$  at each moment above. These heights are  $0.02\text{m}$ ,  $0.03\text{m}$ ,  $0.05\text{m}$  and  $0.06\text{m}$  higher than the putters get  $19.53\pm 0.60\text{m}$ . Above references have proved that the women putters have emphasized the raising of their trunk and shot's height. Therefore the path of their shot is decreased at the delivery when the women putters get  $18.73\pm 0.57\text{m}$ . The path of their shot of the delivery is  $1.57\pm 0.15\text{m}$  when putters get  $18.73\pm 0.57\text{m}$ ; the path of their shot of is  $1.65\text{m}$  when they get  $19.53\pm 0.60\text{m}$ . Their times of both deliveries are  $0.18\text{sec}$ . The differences between the velocities of shot are respectively  $12.93\pm 0.21\text{m/s}$  and  $13.15\pm 0.23\text{m/s}$ . Their performances are respectively  $18.73\pm 0.57\text{m}$  and  $19.53\pm 0.60\text{m}$ .

**CONCLUSION:** Through comparison of the relative kinematics parameters for the best results and poor results of 6 women shot putters, it can be determined that, as a result of attitudinal reflex, the raising of head's position in every phase, may all bring about certain influences on the movements of limbs, trunk and in the practice of putter's techniques. Therefore, coaches and athletes should pay greater attention to attitudinal reflex, in order to achieve the best possible result.

#### REFERENCES:

- Liu, J., & Li, Y., et al. (1999). The three dimensional kinematic analysis of the influence which the left side technique of our elite shot putters have on their whole technique. *Journal of China Sport Science And Technology*, **35**, 10-2.
- Li, D. (1992). The head's movements have influence on the technique of crouch start. *Journal of China Research on Sport*, **20**, 2-6.
- Gu, S. (1996). A study on neck's movement affecting the performances of gymnastics. *Journal of China Shan Xi Sport Science and Technology*, **35**, 2-10.