THE AFFECTION OF POSTURE IN SKY TO THE JUMP REACH HEIGHT

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The purpose of this study is to understand in which degree the posture will affect the JRH (Jump Reach Height), and also to look for a posture in which he/she will get the maximum JRH. The jump performances of a male student with height 1.75m after release from the ground were simulated on computer. JRH of the hand were calculated when the subject made fourteen different postures in sky. It was shown that different posture has affection to JRH. The difference between the maximum and the minimum JRH is about 23 cm, which is about 7% of the largest JRH. In the extent of posture affection, the Lower Extremity seems to be much more important than the Upper Extremity.

KEY WORDS: posture in sky, jump reach height, simulation, center of gravity

INTRODUCTION: Because of the importance in sport, up to now the jump ability has been becoming the popular project. Scientists have been studying around how to improve the jump height, and got a large body of literature (Shetty, A.B., & Etnyer, B.R. 1989, Shan X-h, 1997, Zhang Yue, 2000). However, these researches were mainly on jump performances before takeoff, and few researchers were kept an eye on performance in sky. In fact, there are a lot of postures for an athlete in sky after he/she jumps from the ground (taking the upper and lower extremities up and down in volleyball player, for an example), and the posture in sky will affect the JRH (Jump reach height) (Peter McGinnis, 1999, Rolf Wirhed, 1996). Therefore, in this paper, a Chinese Model was used to simulate jump performances of different postures in computer after release from the ground. The purpose of this study is to understand in which degree the posture will affect the JRH, and also to look for a posture in which he/she will get the maximum JRH.

METHODS:

Subject: A student (male, year 22, height 175 cm, weight 78 kg) in Physical Education Department was volunteered to participate in this research. The segment variables of the subject are listed in Table 1.

Table 1 Segment Variables of the Subject.

Segment	Head	Trunk	Arm	Forearm	Hand	Thigh	leg	Foot	total
Length (cm)	37	44	27	25	14.5	45	42	7	175
Height Index*	0.21	0.29	0.16	0.14	0.10	0.27	0.22	0.04	1.00

Note: *means the segment length divided by the body height.

Model of Human Body: A 14 segment Chinese Model (X.Y Zheng, 2002), which included 1 head, 1 trunk, 2 arms, 2 forearms, 2 hands, 2 thighs, 2 legs, 2 feet, was selected in this paper. The Inertial Parameters of Chinese Model are listed in Table 2. In this Table, RW means relative weight, or the segment weight/ Body weight. RPS means relative position of the center Gravity of the segment.

Table 2 Inertial Parameters of the Chinese Model.

Segment	Head	trunk	Arm	Forearm	hand	thigh	leg	foot	Total
RW (%)	9.30	42.6	2.61	1.3	0.64	14.0	4.0	1.5	100
RPS(%)	46.69	50	51.40	58.13	63.21	52.29	59.09	39.51	--

The Function of Simulation: the Center Gravity (CG) of the body could be calculated through equation (1):

$$y = \frac{\sum m_i y_i}{\sum m_i} \qquad (1)$$

In (1), y_i represents the position of CG of Segment i, and m_i means the weight of the segment i. If we use the Relative Weight (RW), and because the RW of whole body is 1, then we have:

$$y = \Sigma RW_i y_i \qquad (2)$$

On the other hand, just like a movement of a point (Peter McGinnis, 1999), the CG movement after takeoff should meet with the following equation:

$$y = v_0 t - \tfrac{1}{2} g t^2 + h_0 \qquad (3)$$

From equation (2) and (3), we can see that if the takeoff velocity V_0 and h_0 was given, then at any time t, we could get the CG position y and JRH of the hand.
Regarding to the velocity, the maximum JRH of the subject during a 10 trials was 3.10 m, and zero reach height (without jump) of hand is 2.02 m. Therefore, the maximum CG jump height is 1.08m, which means the maximum takeoff velocity V_0 ($=\sqrt{2gh}$) is about 4.6 m/s. In order to simulate the practical jump on computer, 4.6 m/s is selected to be the takeoff velocity V_0.
JRH in different posture could be calculated according to the function (3) and the Data of the segment parameter of the subject in Chinese Model.

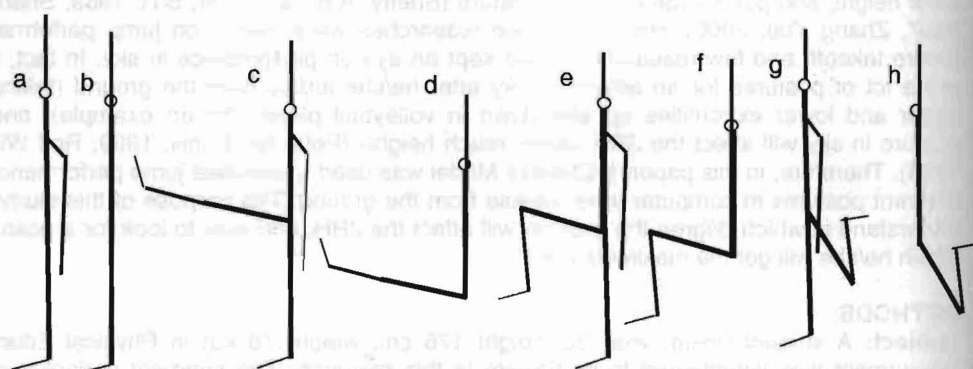

Figure 1 Postures of human body in sky.

Posture Designed: The changes of posture were got through moving the upper or lower or both extremities (see in Figure 1). It was supposed that the thigh could move forward to the position in which the thigh and trunk makes a hip angle 120º (Figure 1.c and d). Also the thigh could move backward to the position in which the thigh and the trunk makes a hip angle 150º (Figure 1.e). In any position in Figure 1, the trunk and the leg is always perpendicular to the ground. Fourteen kinds of postures were selected in this study.

GLossary of Terms Relative to the Posture:

1UU ---- one upper extremity up with lower extremities down (Figure. 1. a)
2UU ---- two upper extremities up with lower extremities down (Figure. 1. b)
1UU-1LSU ---- one upper extremity up with one lower extremity straight up and the other down (Figure. 1. c)
1UU-2LSU ---- one upper extremity up with two lower extremities straight up
2UU-1LSU ---- two upper extremities up with one lower extremity straight up and the other down
2UU-2LSU ---- two upper extremities up with two lower extremities straight up(Figure. 1.d)
1UU-1LBU ---- one upper extremity up with one lower extremity bending up and the other down (Figure. 1. e)
1UU-2LBU ---- one upper extremity up with two lower extremities bending up
2UU-1LBU ---- two upper extremities up with one lower extremity bending up and the other down

2UU-2LBU ---- two upper extremities up with two lower extremities bending up(Figure.1.f)
1UU-1LBBU ---- one upper extremity up with one lower extremity bending back up and the other down (Figure. 1. g)
1UU-2LBBU ---- one upper extremity up with two lower extremities bending back up
2UU-1LBBU ---- two upper extremities up with one lower extremity bending back up and the other down
2UU-2LBBU ---- two upper extremities up with two lower extremities bending back up (Figure 1.h)

RESULTS: It was shown that the largest JRH 310.0 cm is in posture of 1UU. The lest reach height 287.02 cm was happened in posture of 2UU-2LSU, which is relative to the posture of two upper extremities up with 2 lower extremities also up in sky (Figure.1.d). The difference between the largest and lest is 22.98 cm, which is 7.4% of the largest JRH 310.0 cm.

Table 3 JRH Relative to the Different Posture.

Posture	1UU	2UU	1UU-1LSU	1UU-2LSU	2UU-1LSU	2UU-2LSU	1UU-1LBU
JRH (cm)	310.0	307.61	299.7	289.41	297.31	287.02	301.79
Diff (cm)	0	-2.39	-10.30	-20.59	-12.69	-22.98	-8.21

Diff—difference between JRH of this posture and that of posture 1UU.

Table 4 JRH Relative to the Different Posture (continuous).

Posture	1UU-2LBU	2UU-1LBU	2UU-2LBU	1UU-1LBBU	1UU-2LBBU	2UU-1LBBU	2UU-2LBBU
JRH (cm)	293.57	299.4	291.18	306.64	303.28	304.25	300.9
Diff (cm)	-16.43	-10.6	-18.82	-3.36	-6.72	-5.75	-9.1

From the extent of affection, there is only 2.39 cm change of JRH when the subject makes one upper extremity up or down. However, 10.30 cm change will get during one lower extremity up or down. This means the lower extremity has about 5 times larger extent of affection to JRH than the upper one.

DISCUSSION: The purpose of this study is to understand in which degree the posture will affect JRH, and also to look for a posture for an athlete in which he/she will get the maximum JRH. The computer simulation result seems to meet with this purpose.
It was shown that the posture in sky would make affection to JRH. This result agrees well with the conception of Peter McGinnis (1999) and Rolf Wirhed (1996). However, to the extent of the affection, the result seems to be lower than that of Rolf Wirhed (1996). The change of JRH in this paper is 2.39 cm when the subject moved the upper extremity from down position to up position while 4cm in Rolf Wirhed's study instead.
The affection of posture may also be relative to other facts in practical jump, such as sex, age, fatigue and flexibility of the athlete. Therefore the further study should be continuous to search for relative factors so that we could understand this problem thoroughly.

CONCLUSION: The affection of posture to the reach height could be found by making Lower and Upper Extremities down and up. The maximum JRH could be achieved when the subject is in the posture of one upper extremity up with two lower extremities down. The lowest will be in the posture of two upper extremities up with two lower extremities also stretching up. The difference between the maximum and the minimum is about 23 cm, which is about 7% of the largest JRH. In the extent of affection, the Lower Extremity seems to be much more important than the Upper Extremity.

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