CHAPTER III

METHODS

Participants

A total of eight participants were recruited from a group of active-status Thai male sprint hurdles affiliated with two different training locations in order to form two levels of sprint hurdlers groups (n = 4 each). The characteristics of the participants are shown in Table 2. The HI group was recruited from a group of Thai male sprint hurdlers who were selected to be in the national athletic team of Thailand for competing in international events, such as the 1st Asian Indoor Games and the 23rd SEA Games at the Philippines. The records for the HI group ranged from 13.92 to 15.20 seconds. The AM group was recruited from a group of male sprint hurdlers who were representative athletes of the Royal Thai Air Force Academy, and their records were 20.24 to 24.50 seconds. The potential hurdlers were excluded from the study if they had any current or prior injuries to the lower extremities or trunk or current symptoms of pain that might affect their performance. All participants were instructed not to have a meal, alcohol or caffeine beverage approximately 2 hours before testing, and had sleep time not less than 6-8 hours before testing. The study was approved by the research ethics committee of the Faculty of Associated Medical Sciences, Chiang Mai University.

Table 2 The characteristics of the participants.

Variables	HI	AM
Age (yr)	22-27	19-23
Height (m)	1.80-1.90	1.69-1.76
Weight (kg)	70-80	63-66
Leg length (m)	0.87-0.94	0.79-0.84
Experience (yr)	6-7	2-5
Personal best time (s)	13.92 – 15.20	20.24 – 24.50

Equipment

1. Digital video camcorder (Canon MV500i using miniDV tape)
2. Tripod
3. Four standard hurdles (height 1.067 m, width 1 m)
4. Starting block
5. Spherical markers

Experimental setup

Four standard hurdles were placed as in the actual competition. The first hurdle was places at a distance of 13.72 m from the starting line. The three hurdles were placed at a distance of 9.14 m between hurdles. A starting block was set and adjusted by each hurdler to his comfort position. A digital video camcorder (Canon MV500i) was positioned to obtain a sagittal view of the hurdler's whole body, perpendicular to plane of progression of the lead leg and trunk. The camera was

located in line with the 3rd hurdle which the optical axes was approximately 90º to the view of motion, at a distance of 8.0 m from the lane used for running, and at a height of 1.35 m above the ground. The camera's view was adjusted to cover the distance required for at least one complete step of the lead limb during the HS which was 3.0 m before and after the hurdle. A plummet and a spirit level were used to ensure that the camera was not tilting and aligned in parallel with the plane of progression. Marked lines were made at 3.0 m before and after the location of 3rd hurdle to justify the camera view. The 3rd hurdle was marked with black circular-shaped markers to indicate a standard length of 0.9 m in the vertical axis and a standard length of 0.7 m the horizontal axis. There standard lengths were later used for calibration of a 2-D video analysis.

Participant preparation

The participants wore their own running shorts and running shoes. The spherical markers, 1 ½ inch in diameter, were mounted via double-sided adhesives to the side of the body corresponding to each hurdler's leading limb. The markers were placed on the skin overlying anatomical landmarks over the participant's body at the following locations; lateral malleolus, lateral epicondyle, greater trochanter, middle trunk (midaxillary line), acromioclavicular joint, sacrum, and tips of both shoes.

Testing protocols

Prior to testing, each participant were informed the purposes and procedures of the study, signed a consent form, and answered a questionnaire regarding individual data, such as age, height, weight, years of experiences, etc. Each participant was

given enough time to perform their routine warm up (at least 10 min) prior to testing. After the warm-up, each participant was later mounted markers on the anatomical landmarks, and was asked to set at the starting block.

Data collection was administered at an outdoor track during daytime. Practice trials (up to three trials) were allowed before the actual data collection. During data collection, each participant was asked to run at his maximum speed as if he would do in the actual competition. Each participant was instructed to perform three trials of hurdle running with a 5 min inter-trial rest interval. Data from any trial during which the participant's foot contacted the hurdle was considered unsuccessful trial and was not used for further analysis. In such case, an additional trial was performed until three successful trials were accomplished. The three successful trials for each participant were later carried out for data reduction and data analysis.

Independent and dependent variables

Independent variable was the level of performance of the participants (high-level and amateur-level). Dependent variables were average values from three selected trials and were described as the followings.

1. Mean velocity was an average linear velocity during the hurdle step calculated by dividing the CM displacement from the last point of the take off phase to the first point of the landing phase by the time taken for this movement.
2. Takeoff distance was the distance from the point of toe contact during the take off phase to the base of the hurdle.
3. Landing distance was the distance from the base of the hurdle to the point of toe contact during the landing phase.

4. Maximal trunk flexion was the peak trunk flexion angle during clearance phase.
5. Time to maximal trunk flexion was the time from the point of toe contact during the take off phase to the field when trunk reached maximum flexion angle.
6. Maximal hip flexion was the peak hip flexion angle during the clearance phase.
7. Time to maximal hip flexion was the time from the point of toe contact during the take off phase to the field when lead hip reached maximum flexion angle.
8. Maximal knee extension was the peak knee extension angle during clearance phase.
9. Time to maximal knee extension was the time from the point of toe contact during the take off phase to the field when lead knee reached maximum extension angle.
10. CM parabola path was the motion pattern of body CM during clearance phase of hurdle step. Three variables were used to further explain the CM parabola path. The sacrum (S_2) was used as the representative of the CM:
    a. Horizontal displacement of peak of CM parabola path to the hurdle was the horizontal distance of CM to the hurdle at the highest point of CM parabola path during clearance phase.
    b. CM lift was the vertical displacement of the CM from the point of toe contact during the take off phase to the highest point of CM parabola path during clearance phase.

c. Clearance height was the height of CM to the hurdle bar when the CM passes the hurdle.

Data reduction

Video clips of the successful trials were imported to a notebook computer installed with a SiliconCoach 6.0 program (SiliconCoach Ltd., Dunedin, New Zealand). The video clips from the three successful trials of each participant were selected and captured such that they included one complete hurdle step. For each hurdle step, the video clip started at the last three to four fields prior to toe off and ended at the next three to four fields after the foot came in contact with the ground. The SiliconCoach program generated two fields from one frame of video clip. Therefore, video analysis at a rate of 50 fields per second was enabled. All data frames were digitized using a SiliconCoach 6.0 program to obtain 2D coordinates. Smoothing of the 2D coordinates for reduction of digitization noise was done using an algorithm on a PSI-plot program (Poly Software International, New York, USA) at the cutoff frequency of 6 Hz based on the residual analysis (see Appendix C).

Calculation of all variables were performed on Microsoft excel using the following equations;

- Equation for calculation of mean horizontal velocity:

Mean horizontal velocity = $\Delta s/\Delta t$

where Δs = horizontal displacement of the x - coordinate of CM from take off point to landing point

Δt = times taken from take off point to landing point

- Equation for calculation of hip, knee, and trunk angles

$a \bullet b = ab\cos\theta$

where a, b = vector of lever arm; for hip, knee, and trunk angles

θ = joint angle

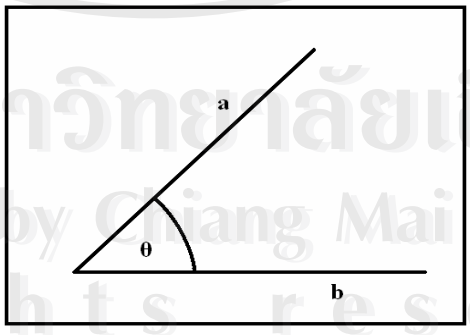

Figure 1 Diagram for calculation of hip, knee, and trunk angles

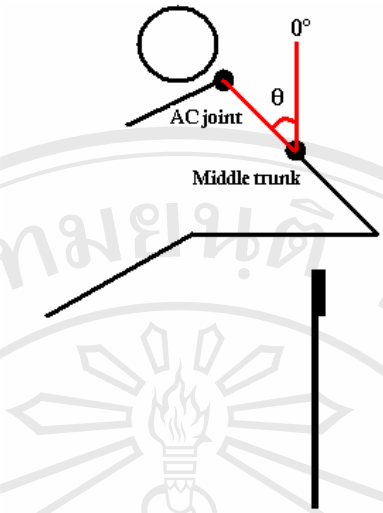

Figure 1.1 Diagram for calculation of trunk angle

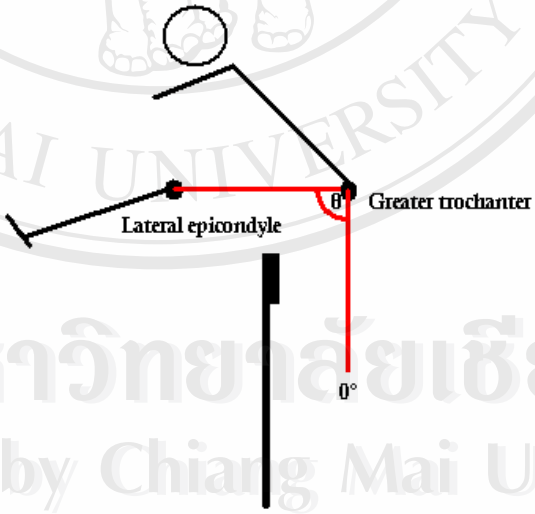

Figure 1.2 Diagram for calculation of hip angle

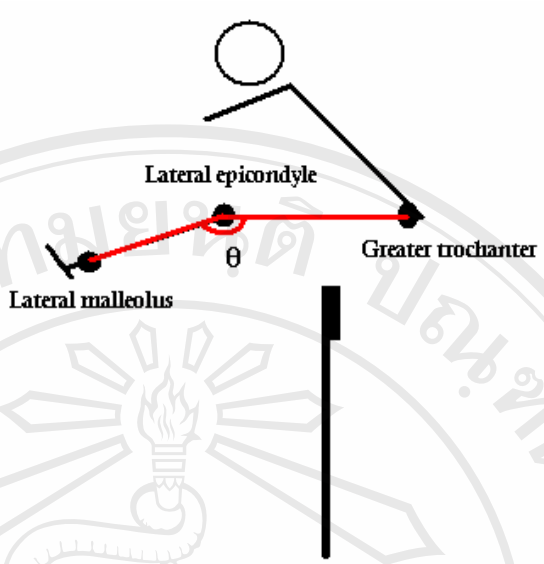

Figure 1.3 Diagram for calculation of knee angle

- Equation for calculation of takeoff and landing distances, and horizontal displacement of peak of CM parabola path to the hurdle:

Horizontal distance = x_1-coordinate – x_2-coordinate

where x_1 = x-coordinate of the marker on the hurdle

x_2 = x-coordinate of take off or landing point and of CM at the highest point of CM parabola path

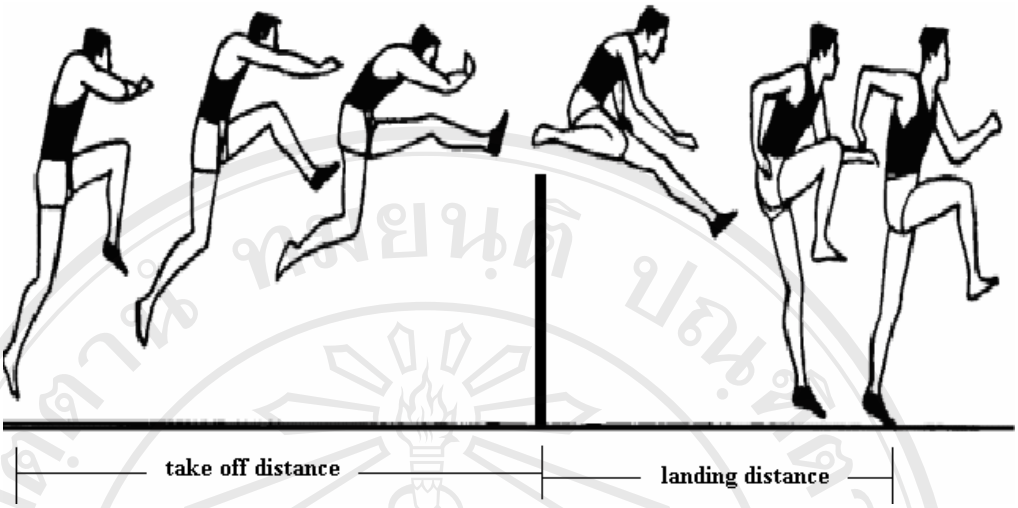

Figure 2 Takeoff distance and landing distance of hurdle step (modified from ref.12)

- Equation for calculation of CM lift and clearance height:

Vertical distance = y_1-coordinate – y_2-coordinate

where y_1 = y-coordinate of the highest point of CM in the CM parabola path and of CM when the CM pass the hurdle bar

y_2 = y-coordinate of CM at take off point and of the hurdle bar

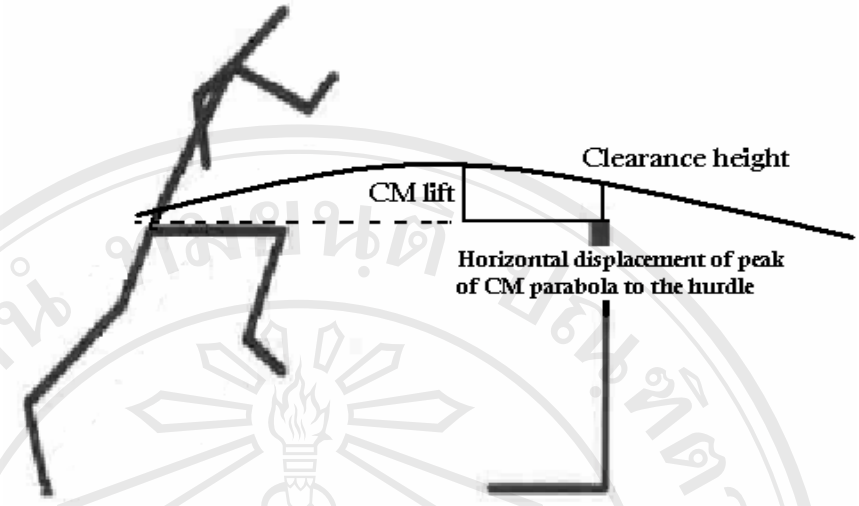

Figure 3 CM lift, horizontal displacement of peak of CM parabola path to the hurdle, and clearance height during hurdle step

Data analysis

Due to the small sample size, nonparametric statistics (a Mann-Whitney U test) was used to compare the differences between the dependent variables between male sprint hurdlers with high-level and amateur-level. SPSS (version 11.5) was used to calculate the statistics. An alpha level of 0.05 was used for all tests of significance.