CHAPTER III

METHODS

1. Participants

Junior badminton players age 14 to 18 years old from several local badminton clubs in Chiang Mai province were recruited to participate in this study. Eligible badminton players were screened according to inclusion/exclusion criteria. Data from a previous study (38) comparing female and male knee joint kinematics for side jumping task was used to estimate the sample size by G*Power Software (55). To achieve 80% statistical power with an alpha level of 0.05, a minimum of 7 subjects per group was required.

Inclusion criteria

Junior badminton players were included in the study if:

1. They had been a member of the badminton clubs and played badminton for more than one year.
2. They were right-handed players (using a right hand stroke)

Exclusion criteria

Junior badminton players were excluded from the study if:

1. They had been diagnosed with significant injury to the lower extremity, such as ligament rupture, meniscus tears, tendon rupture, patella fracture, or had an abnormal knee extensor mechanism that might affect their performance.
2. They experienced cardiovascular or respiratory disease during the previous week.

2. Equipment

1. A three-dimensional motion-capture system (Motion Analysis Corporation, Santa Rosa, CA, USA)
3. Eva Real-Time software version 5.0 (Motion Analysis Corporation, Santa Rosa, CA, USA)
4. ConTrex MJ isokinetic dynamometer (CMV AG, Dubendorf, Switzerland)
5. Reflective markers
6. String and posts
7. Racquet and shuttle cock
8. Marking tape
9. Tape measure
10. Goniometer
11. Balance scale
12. PSI-plot program
13. Microsoft Excel 2003 program

3. Outcome measures

1. The knee joint angles in 3 directions (Flexion/Extension, Valgus/Varus, and External/Internal rotation) during the selected tasks
    a. Angle at foot contact and maximum angle of the jump smash task
    b. Angle at foot contact and maximum angle of the net lift task
2. Knee muscle strength
    a. Quadriceps concentric peak torque at angular velocities of 60º/sec and 180º/sec

b. Hamstrings concentric peak torque at angular velocities of 60º/sec and 180º/sec

c. Hamstrings/Quadriceps ratio of 60º/sec and 180º/sec

4. Data collection procedures

Two testing sessions were administered on separate days, in random order. One session is for 3D kinematics data collection of the knee joint. The other session is for collection of the knee muscle strength (hamstrings and quadriceps) data collected from an isokinetic dynamometer. The study's protocol was approved by the Research Ethics Committee of the Faculty of Associated Medical Sciences, Chiang Mai University. Diagram of data collection procedure is shown in Figure 3.

4.1 The 3D kinematics measurement

<u>Participants preparation</u>

The participants were informed the purpose of the study and the procedures of this session by examiner. Next, they read and signed an inform consent. Then, demographics data, such as gender, age, body weight, height, injury history, practice data, playing experience, thigh circumference, and Q-angle were collected in this session. Participants wore the provided tight-fitting shorts and their regular sport shoes. A regular warm-up including stretching the lower limb muscles for 10 minutes was performed before testing. The examiner placed spherical shaped reflective markers on the participants' skin or clothing on the anatomical landmark of both lower limbs and shoes. Thirty-three reflective markers were attached bilaterally on the anterior superior iliac spine, greater trochanter, middle thigh, lateral femoral condyle, medial femoral condyle, upper shank, middle shank, lower shank, lateral malleolus, medial malleolus, middle foot, fifth metatarsal, heel, head of humerus, lateral humeral condyle, ulna styloid process, and sacrum (see Appendix B).

Experimental setup

Dark-colored marking tape was attached on the floor for set up of a one-half badminton court. A badminton net was made of dark-colored string. Figure 2 illustrates a badminton half-court that was setup in a motion analysis laboratory.

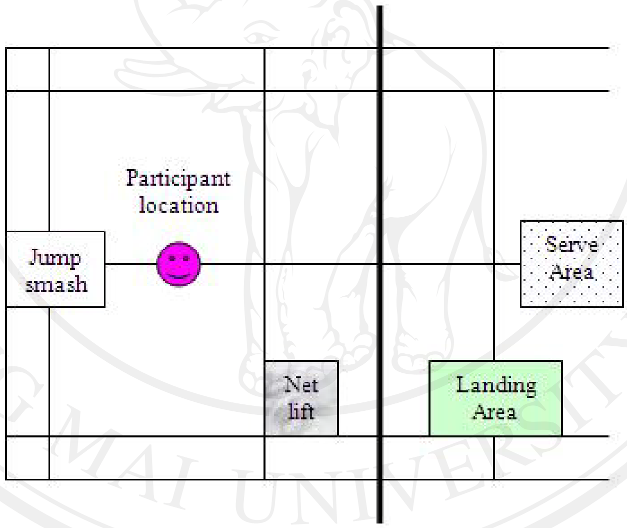

Figure 2. A badminton half court setup

A participant stand in the middle of the court (preparation area) and was asked to get ready to perform the testing movements. For the net lift task, all participants had to return the shuttle served to them from the same test administrator. The test administrator who serves the shuttle to the participants was an experienced badminton player who provided a badminton serve in a consistent manner in terms of direction of force and target location. For the jump smash task, because of limited area and equipment safely in the motion analysis laboratory, the test administrator could not serve a shuttle cock high enough for the participant to initiate a jump smash. Thus, all participants were asked to perform jump smash as they would perform in the competition without hitting the shuttle cock. Each participant was asked to move backward from the preparation area to the jump area and jump as high as she/he can and perform a smash stroke as fast as she/he can. Then, they immediately performed rapid run to the net lift area as immediately to return the dropped shuttle cock after landing from a jump.

Data collection

Before capture the motion, the L-frame calibration square and calibration wand were used to calibrate the markers position in the capture volume. After that, participants performed 3 – 5 practices trials for each net lift and jump smash to familiarize themselves with the experimental setup. Each participant performed three trials of the net lift followed by three trials of the jump smash (45). Fourteen high-speed Eagle-4 cameras (operating at 120 Hz) (56) were used to capture the coordinates of all reflective markers during the participants perform the net lift and jump smash. The EVa Real-time software version 5.0 (Motion Analysis Corporation, Santa Rosa, CA, USA) was used to track the three-dimensional position-time data. The velocity of the sacrum marker was analyzed 10 frames prior to foot contact, to determine an approach speed to the net.

Data reduction

For the jump smash, the left knee joint which is the landing leg was analyzed. For the net lift shot, the knee joint of the right leg that is placed in a lunge position was analyzed. A fourth-order low-pass Butterworth filter with a frequency cutoff of 8 Hz was used for smoothing coordinate data (56). Digitized position data were imported into a custom software program, where an embedded right-hand Cartesian segment coordinate system was used for calculation of joint positions. A custom software program was established a knee joint coordinate system (JCS) based on an anatomical segment coordinate system (ASCS) from the relative motions between the thigh and shank segments (57). The knee angles for each of the three angular directions during the net lift and jump smash trials were expressed relative to the corresponding natural standing knee angles. The data were exported to a spreadsheet (Microsoft Excel) where averaged knee joint angles were determined from three trials for each participant. The high-speed cameras used in the Motion Analysis are infrared-based system, no visual recording is available. Therefore, a digital video camera (Sony Handycam DCR-HC90E) was used to record the badminton player motion for aid in visual analysis of the participants' movements during the test and confirm the phase of movement. The knee movement in the landing phase that was analyzed in this study represented the movement phase from foot contact with the floor to the end of the stance phase.

Reliability of 3D kinematics measurement

The reliability of the kinematics measurement was evaluated from six badminton players. All of knee kinematics data were obtained following the protocols used for actual test. The reliability of kinematics measures was evaluated by intraclass correlation coefficients ($ICC_{(3,3)}$) from three trials of jump smash and three trials of net lift data. ICCs values of the knee angle measurements of jumps smash and net lift showed excellent reliability (0.80 – 0.98). More detail was in Appendix C.

4.2 Muscle strength measurement

Participant preparation

Participants were informed the purpose and the procedures of this session. The participants were allowed 10 minutes for warm-up on a stationary bicycling followed by passive stretching of their hamstrings and quadriceps muscles prior to strength testing.

Data collection

The ConTrex MJ isokinetic dynamometer (CMV AG, Dubendorf, Switzerland) was used to assess the hamstrings and quadriceps peak torques. The order of limb tested was randomized. Each participant sat in an up-right position (trunk angle of 110º) on the ConTrex dynamometer chair with the arms across the chest. The trunk, waist, and thigh of the tested leg were stabilized with Velcro straps, and another leg was stabilized with a bar in order to prevent any compensatory movement. The axis of the rotation of the dynamometer was aligned with the centre of the lateral femoral condyle that passes transversely through both femoral condyles. The resistance pad was placed two centimeters proximal to the participant's lateral malleolus. A standardized testing protocol was followed for each participant with consistent verbal instructions. The participant was tested for the maximal effort of concentric muscle contraction at angular velocities of 180º first and followed by 60º/ sec through a range of 5º – 95º of knee flexion. All torques were corrected for gravity effect on the lower leg segment.

At each speed, a practice trial of three repetitive submaximal concentric contractions was performed by the participant to familiarize with the experimental setup. Then, five repetitive maximal concentric contractions were performed for a test trial. A 90 seconds resting period was given between the trials and a 180 seconds recovery period between speeds (58). The maximal concentric peak force of quadriceps and hamstrings were recorded as peak torque values. The knee muscle torques were normalized relative to body mass (Nm/kg).

Reliability of strength measurement

The reliability of isokinetic assessments of the knee extensor and the flexor muscle strength using the ConTrex MJ isokinetic dynamometer was performed before the knee muscle strength testing session. Sixteen participants (8 males, 8 females) were tested and retested at least 24 hours later for maximal strength followed the testing protocol described above. The intra-class correlation coefficients ($ICC_{(3,1)}$) were used to determine the between session test-retest reliability. The ICC classifications of Fleiss (less than 0.4 was poor, between 0.4 and 0.75 was fair to good, and greater than 0.75 is excellent) were used to describe the range of ICC values (59). ICCs values were high for hamstrings muscle strength for both legs and both speeds (0.88-0.98). The quadriceps muscle strength from both legs and speeds were highly reliable (0.91-0.96) (see Appendix C).

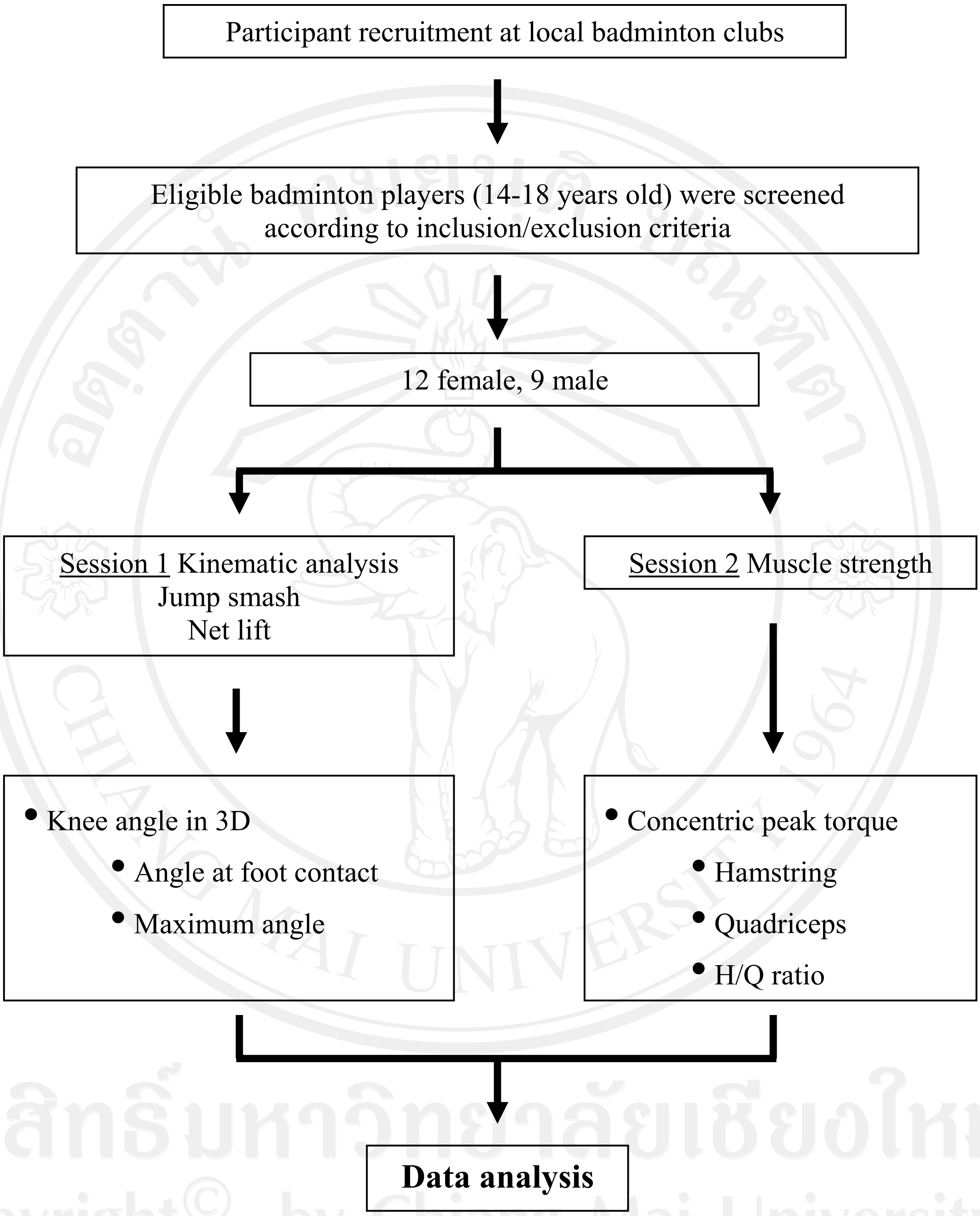

Figure 3. Diagram of data collection procedure

5. Statistical analysis

Descriptive statistics were reported for all outcome parameters measured. Using Shapiro-Wilk test, most of physical characteristics and knee muscle strength data of the participants were normality. Thus, the independent t-test was used to compare characteristic and knee muscle strength data between genders. Due to a small sample size, Mann-Whitney U test was used to compare all knee kinematics data between gender, the alpha level set at $p<0.05$ for all statistical tests.

6. Location

The 3D kinematics measurements were conducted at the College of Arts, Media and Technology, Chiang Mai University and the muscle strength measurements were administered at the Department of Physical Therapy, Faculty of Associated Medical Sciences, Chiang Mai University during the period of May – June 2009.