CHAPTER IV

RESULTS

1. Characteristics of the participants

Initially, twenty-eigth junior badminton players were recruited from several training sites in Chiang Mai province including the northern badminton training center, the Lanna badminton club, and the ThaiSmile badminton club. All potential players were screened according to the inclusion and exclusion criteria of the study. Twenty one players (12 female and 9 male) who are right-handed were selected to participate in this study. The mean age, height, and body mass for female were 15.3±1.5 years, 1.6 ± 0.1 m, and 50.8 ± 6.1 kg, respectively. The corresponding values were 15.9 ± 1.5 years, 1.7 ± 0.1 m, and 57.4 ± 4.2 kg for male participants. The characteristics of the participants in both groups are shown in Table 1. There were no significant differences for age, height, BMI, thigh circumference, Q-angle, and training frequency between the two groups. Independent t-test showed that female group had lesser mean body mass compared with male group ($p=0.012$). Playing experience of female group was significantly longer than male group ($p=0.014$).

Table 1. Characteristics of junior badminton players

Variables	Female (n=12)	Male (n=9)	p-value
Age (years)	15.3 ± 1.5	15.9 ± 1.5	0.405
Height (m)	1.6 ± 0.1	1.7 ± 0.1	0.053
Body mass (kg)	50.8 ± 6.1	57.4 ± 4.2	0.012*
BMI (kg/m^2)	19.2 ±2.1	20.2 ±1.4	0.257
Right thigh circumference (cm)	50.2 ± 3.9	49.7 ± 1.7	0.703
Left thigh circumference (cm)	48.8 ± 4.2	48.9 ± 1.8	0.910
Right Q-angle (degree)	13.4 ± 2.9	12.5 ± 2.7	0.453
Left Q-angle (degree)	11.7 ± 3.2	11.2 ± 2.5	0.736
Playing experience (years)	7.1 ± 2.1	4.0 ± 3.1	0.014*
Training frequency (time/week)	5.4 ± 1.2	6.1 ± 0.3	0.100

Values are means ± SD * Significant difference at $p<0.05$.

2. Knee joint kinematics

All participants performed the test that simulating the badminton play emphasizing on the jump smash and net lift movement.

2.1 <u>Knee kinematics during landing from jump smash</u>

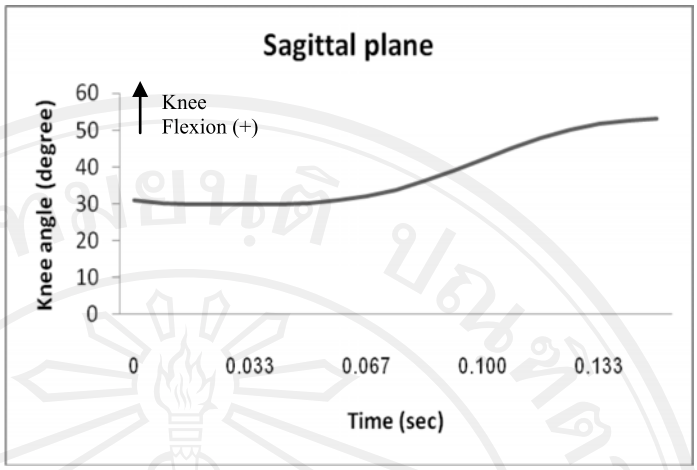
For landing task, all participants landed on the left foot following the jump smash movement. Knee joint positions during the task were evaluated from foot contact to the end of landing phase. Figure 4 illustrates typical time-angle profile in three-dimension knee angles for jump smash. Comparison of the knee angle positions between female and male in three planes of motion are presented in Tables 2 – 4. All participants landed with slightly flexed knee. In the sagittal plane, female had greater knee flexion angle at foot contact compared to the male counterpart (p=0.033). However, the maximum knee flexion angle was not significantly different between gender (p=0.722) as show in Table 2.

Table 2. Knee kinematºics variables in the sagittal plane during landing from jump smash

Variables (degree)	Female (n)	Male (n)	p-value
• Angle at foot contact	27.9 ± 8.9 (12)	19.4 ± 7.3 (9)	0.033*
• Maximum flexion angle	55.0 ± 9.2 (12)	52.2 ± 10.0 (9)	0.722

Values are means ± SD * Significant difference at p<0.05.

a)



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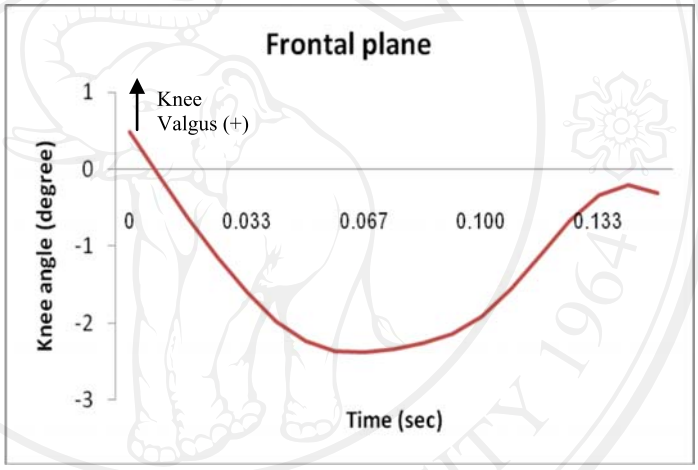


c)

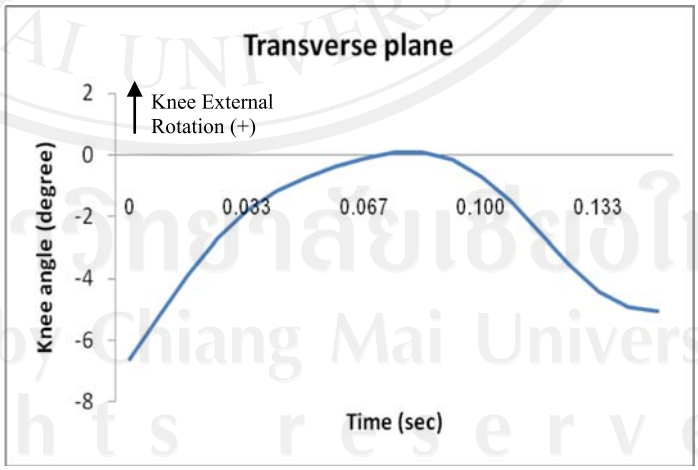


Figure 3. Representative time – angle profile from single trial for knee flexion (a), knee valgus (b), and knee external rotation (c) for jump smash.

In frontal plane, all knee angle positions at foot contact and at maximum angle were similar for both female and male. Thereby, no significant differences between group were found (Table 3). At foot contact, almost all participants (female=10, male=8) landed in knee valgus position.

Table 3. Knee kinematics variables in the frontal plane during landing from jump smash

Variables (degree)	**Female (n)**	**Male (n)**	**p-value**
• Knee in valgus (+) at foot contact	2.4 ± 1.8 (10)	3.0 ± 1.4 (8)	0.110
• Knee in varus (-) at foot contact	-3.3 ± 1.7 (2)	-2.2 (1)	1.000
• Maximum valgus angle (+)	3.0 ± 3.7 (12)	3.6 ± 3.5 (9)	1.000
• Maximum varus angle (-)	-0.8 ± 3.8 (12)	-1.1 ± 3.1 (9)	0.722

Values are means ± SD * Significant difference at $p<0.05$.

Kinematic results in the transverse plane are shown in Table 4. Eight females landed with knee in an internal rotation position. A difference in internal rotation angle at foot contact approached significant level when compared between gender (p=0.062). Internal rotation angles at foot contact of female and male groups were 6.2 ± 4.1 degrees and 2.1 ± 2.0 degrees, respectively. Both maximum external and internal rotation angles were not significantly different between genders. One maximum internal rotation angle from male was excluded as an outlier.

Table 4. Knee kinematics variables in the transverse plane during landing from jump smash

Variables (degree)	**Female (n)**	**Male (n)**	**p-value**
• Knee in external rotation (+) at foot contact	4.4 ± 2.8 (4)	5.8 ± 3.9 (5)	0.624
• Knee in internal rotation (-) at foot contact	-6.2 ± 4.1 (8)	-2.1 ± 2.0 (4)	0.062
• Maximum external rotation (+) angle	1.3 ± 5.9 (12)	4.0 ± 6.2 (9)	0.776
• Maximum internal rotation (-) angle	-10.2 ± 4.2 (12)	-8.9 ± 7.2 (8)	0.970

Values are means ± SD * Significant difference at p<0.05.

2.2 Knee kinematics during net lift

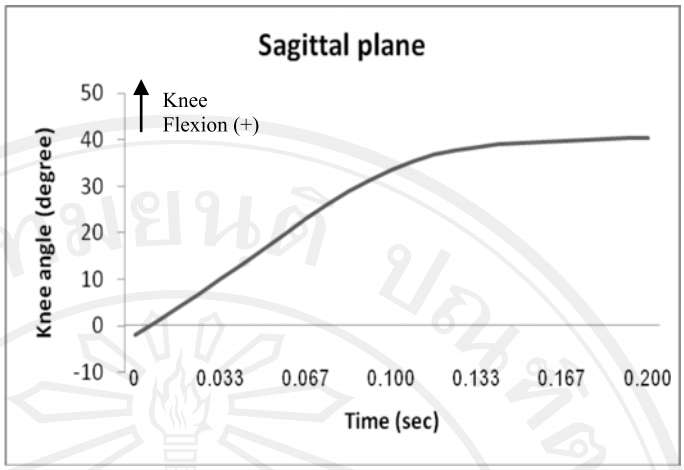
For the net lift task, all participants approached the net at the right front corner of the court with their dominant (right) leg. During returning the shuttle cock, the knee was moved from extended to flexed position known as lunging. Therefore, the knee joint kinematic was analyzed from foot contact to finish the lunging movement. Figure 4 illustrates typical time-angle profiles in three-dimension knee angles for net lift. The approach speed to the net during lunging did not differ between genders ($p = 0.383$). The mean approach run speeds were 2.1 ± 0.2 and 2.2 ± 0.4 m/s for female and male groups, respectively. Comparison of the knee angle positions between female and male during lunging in three planes of motion are presented in Tables 5 – 7. In sagittal plane, knee angle at foot contact and maximum flexion angle were not different between groups. Angles at foot contact of female and male group were 3.5 ± 4.2 and 2.0 ± 4.7 degrees, respectively. Female and male groups approached the net with similar maximum knee flexion angle as presented in Table 5.

Table 5. Knee kinematics variables in the sagittal plane during net lift

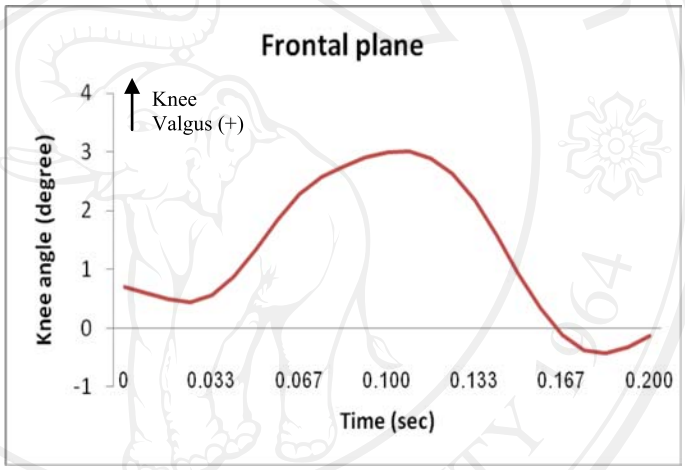
Variables (degree)	Female (n)	Male (n)	p-value
• Angle at foot contact	3.5 ± 4.2 (12)	2.0 ± 4.7 (9)	0.722
• Maximum flexion angle	54.8 ± 9.2 (12)	56.4 ± 10.6 (9)	0.522

Values are means ± SD * Significant difference at $p<0.05$.

a)



b)



c)

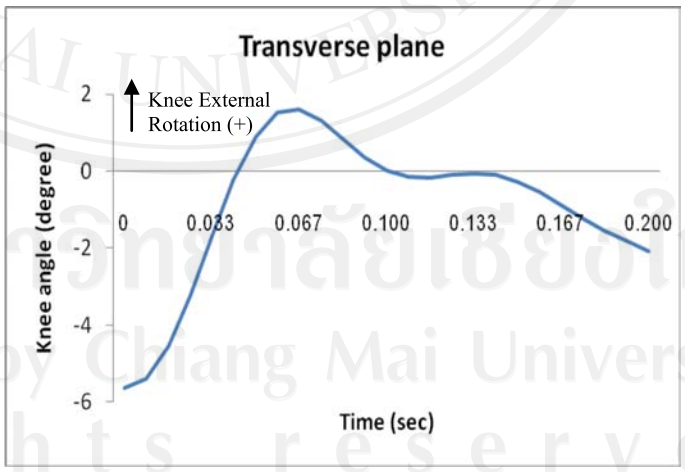


Figure 4. Representative time – angle profile from single trial for knee flexion (a), knee valgus (b), and knee external rotation (c) for net lift.

Most female (9 from 12) had knee valgus position during foot contact. On the other hand, most male (8 from 9) showed knee varus during foot contact. There were no significant differences in knee angles in the frontal plane between female and male groups except maximum varus angle (Table 6). Female had lesser maximum varus angle compared with male group (p=0.045). Maximum varus angles of female and male groups were 4.3 ± 6.4 degrees and 8.5 ± 5.3 degrees, respectively. One maximum varus angle of one male was excluded as outlier.

Table 6. Knee kinematics variables in the frontal plane during net lift

Variables (degree)	**Female (n)**	**Male (n)**	**p-value**
• Knee in valgus (+) at foot contact	1.7 ± 0.8 (9)	1.14 (1)	0.384
• Knee in varus (-) at foot contact	-2.3 ± 1.0 (3)	-1.4 ± 1.6 (8)	0.307
• Maximum valgus (+) angle	2.3 ± 3.2 (12)	1.1 ± 4.4 (9)	0.256
• Maximum varus (-) angle	-4.3 ± 6.40 (12)	-8.5 ± 5.3 (8)	0.045*

Values are mans ± SD * Significant difference at p<0.05.

At foot contact, most participants landed with knee in external rotation. Nine from twelve females presented external rotation of the knee while the other three presented internal rotation. Most males (7 from 9) performed knee external rotation and other two males performed internal rotation. The kinematics results of the transverse plane are shown in Table 7. Mann-Whitney U test showed that female group had lower maximum internal rotation angle compare with male group ($p=0.047$). Maximum internal rotation angles of female and male groups were 2.0 ± 2.8 degrees and 7.3 ± 7.4 degrees, respectively. Maximum external rotation angle data from one male was excluded as an outlier.

Table 7. Knee kinematics variables in the transverse plane during net lift

Variables (degree)	**Female** (n)	**Male** (n)	**p-value**
• Knee in external rotation (+) at foot contact	5.2 ± 3.5 (9)	5.9 ± 4.7 (7)	0.958
• Knee in internal rotation (-) at foot contact	-1.8 ± 2.6 (3)	-0.2 ± 0.1 (2)	0.248
• Maximum external rotation (+) angle	8.1 ± 3.6 (12)	7.0 ± 5.2 (8)	0.487
• Maximum internal rotation (-) angle	-2.0 ± 2.8 (12)	-7.3 ± 7.4 (9)	0.047*

Values are means ± SD * Significant difference at $p<0.05$

3. Knee muscle strength

All participants completed the knee strength test. Strength of the knee muscles was represented by the peak torque value of five maximum concentric contractions. Hamstrings and quadriceps muscle strength of both legs at speed 60º/sec and 180º/sec were reported in relation to body mass to allow comparisons across participants (peak torque per body mass).

Table 8 shows the results of knee muscle strength tested at speed 60º/sec and 180º/sec when compared between genders. Female group had significantly lesser strength than male group in all variables ($p<0.05$) except left quadriceps strength at speed 60º/sec. Table 9 shows the H/Q ratio that presented knee muscles balance of both legs at both slow and fast speeds. Most H/Q ratio variables showed no significant differences between genders. Only left H/Q ratio at 60º/sec of female group was less than male group ($p=0.039$). The left H/Q ratios at 60º/sec of female and male groups were 0.66 ± 0.12 and 0.77 ± 0.11, respectively.

Table 8. Comparison of peak torque per body mass between gender

Variables (Nm/kg)	Female (n=12)	Male (n=9)	p-value
60º/sec			
Right hamstrings	1.32 ± 0.16	1.65 ± 0.30	0.005*
Right quadriceps	2.10 ± 0.32	2.46 ± 0.38	0.030*
Left hamstrings	1.31 ± 0.27	1.70 ± 0.26	0.003*
Left quadriceps	1.98 ± 0.29	2.22 ± 0.29	0.080
180º/sec			
Right hamstrings	0.98 ± 0.14	1.35 ± 0.29	0.001*
Right quadriceps	1.55 ± 0.23	1.91 ± 0.30	0.005*
Left hamstrings	1.03 ± 0.16	1.29 ± 0.23	0.008*
Left quadriceps	1.40 ± 0.27	1.73 ± 0.21	0.008*

Values are means ± SD * Significant difference at $p<0.05$.

Table 9. Comparison of H/Q ratio between gender

Variables	Female (n=12)	Male (n=9)	p-value
60º/sec			
Right H/Q ratio	0.63 ± 0.07	0.67 ± 0.07	0.243
Left H/Q ratio	0.66 ± 0.12	0.77 ± 0.11	0.039*
180º/sec			
Right H/Q ratio	0.64 ± 0.11	0.71 ± 0.11	0.178
Left H/Q ratio	0.75 ± 0.13	0.75 ± 0.13	0.980

Values are means ± SD * Significant difference at $p<0.05$.