Kinematic Analysis of Taekwondo Koryo Poomsae for Accurate Scoring in Competition

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Abstract

The purpose of this study was to identify aspects of Koryo poomsae that affect judges' decisions in order to quantify a more accurate scoring system in Taekwondo poomsae competition. Twenty male Taekwondo poomsae athletes aged 18-20 yr participated in this study. Subjects were divided randomly into two equally-sized groups (Group A and B). All participants performed Koryo poomsae twice, and the best performance was used for analysis. The poomsae performance was evaluated by 5 judges, then the average score was calculated without the highest and lowest scores. Kinematic variables included performed time, center of mass (CM) range, kick height, and stance length of four phases in Koryo poomsae. The results showed that a significant difference was obtained for the time required between Phases 3 and 4 in Group A. There was a significant difference for the ratio of yopchagi (Taekwondo side kick) height to body height between Phases 3 and 4 in Group A. Angle change of knee joint during yopchagi was significantly different between Phases 3 and 4 in Group A. However, no difference was found for CM range and stance length between the groups. The results of this study suggest that kinematic parameters such as the time required, ratio of yopchagi height relative to body height, and the angle change of the knee joint should be considered significant indicators to establish a more accurate scoring system for Koryo poomsae competition.

Introduction

Taekwondo poomsae competition has been growing rapidly in participation since the 1st World Taekwondo Federation (WTF) World Taekwondo Poomsae Championships in 2006. Since that time, the interest in evaluating poomsae techniques is increasing in the subdiscipline of Taekwondo poomsae research as well as in the overall field of Taekwondo itself. Taekwondo poomsae are predesigned sequences of techniques that consist of the various fundamental stances, blocks, punches, and kicks logically arranged in a meaningful order to represent responses to imaginary attacks from multiple assailants. For the purposes of this study, techniques shall refer to individual Taekwondo skills (e.g., “side kick” or “backward inflection stance, knife-hand trunk block”), while movements shall refer to either the execution techniques or movements between the execution of individual Taekwondo techniques (i.e., juchumseogi hu apkkoaseogi yeopchagi [side kick preparatory kicking motion] [4]). Poomsae are composed of Taekwondo fundamental techniques and are accordingly a quintessential component of Taekwondo practice.

Poomsae competition consists of two categories, Recognized and Free Style, which have individual, pair, team, and mixed team match divisions divided by age and sex. Athletes perform two poomsae from the designated compulsory poomsae decided by a WTF Technical Delegate for each division for all competitions. The duration of contest varies between 30 and 90 seconds according to the categories and divisions. Each poomsae has different offense and defense skills that are conducted along prescribed a yeonmu-seon (lines of movement formulated in patterns traced across the floor) (5). Scoring criteria are based on a ten-point scale, which are

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divided into accuracy (4.0) and presentation (6.0) (15). Accuracy is determined by performance of the fundamental techniques and tracing the yonmu-seon as well as other factors like the competitor’s balance.

Unlike gymnastics and figure skating, poomsae do not have different difficulty levels. Gymnastics takes a combination of the difficulty score (D score) for assessing a routine’s difficulty level and performance score (E score) to evaluate its technical, artistic, and constructive elements; these two scores are combined to calculate a final score (10). On the other hand, free style figure skating competition evaluates the technical difficulty and certainty of a routine as items of “technical merit,” while its artistic aspects of program composition, expressiveness, and originality are evaluated as items of “presentation;” again, these two scores are added together for the final score (6). Gymnastics and figure skating competitions, in which the outcome of the competition is determined by the expert’s judgment, are scored by a panel of judges in order to improve objective evaluation (3).

Poomsae are evaluated similarly but without objective criteria and a reference scale of how accurate a poomsae is performed. They are judged by 5 or 7 judges. Average scores excluding the highest and the lowest points are used for the final decision (15). Nevertheless, concerns have been made about the subjective accuracy criteria that determine judges’ final decisions (2, 3). At present, elite poomsae competitors’ performance levels are so advanced that a minor error determines victory and defeat (14). In this regard, Kim (9) reported that validating the evaluation criteria is necessary, because objective judgment is impossible by relying solely on various judges’ knowledge, experience, and subjective judgment. An and Ahn (1) suggested that there is a need to increase the objectivity of scoring by subdividing the competition rules and scoring criteria to distinguish performances between elite poomsae competitors.

Preliminary research on poomsae has mainly focused on grouping subjects according to their individual careers or competition results and then comparing the morphological mechanisms of their side kick movements (4, 12, 14). However, these are not the only criteria needed to score poomsae competition effectively as there are many variables that can affect performance evaluation. It is also necessary to analyze the motions connecting the individual techniques in addition to the performance of those techniques to evaluate athletes’ performances objectively.

The purpose of this study is to investigate the kinematical variables of Koryo poomsae, which is performed by all Taekwondo practitioners after promotion to first dan (first degree black belt) regardless of age (11). To do so, an effort was made to reconstruct all Koryo poomsae movements and techniques according to athletes’ skills levels. Athletes’ skill levels were
divided according to their Taekwondo ranks: geup (under black belt) and dan holders. This effort may, in turn, result in fair judgments in poomsae competitions.

Method

Subjects

Twenty collegiate male Taekwondo poomsae athletes participated in this study. The subjects were divided randomly into two groups and each group was scored by two judges in order to eliminate bias and ensure reliability among poomsae evaluators. The inclusion criteria were all subjects needed to be 1) males aged 18-22 yr, 2) registered with the Korea Taekwondo Association, and 3) have medaled in national or international competitions within 2 years of data collection. Physical characteristics of subjects are shown in Table 1.

Experimental procedure and method

For kinematic data acquisition, 8 infrared cameras (Oqus 500, Qualisys, Switzerland) were used, and frame rate was set at 100 Hz. Figure 1 indicates the location of the cameras. Seventy-seven passive reflective markers

<table>
<thead>
<tr>
<th>Phase 1 (left)</th>
<th>Techniques</th>
<th>Phase 2 (right)</th>
<th>E1</th>
<th>E6</th>
<th>E11</th>
<th>E16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Backward inflection stance, knife-hand trunk block</td>
<td></td>
<td>E2</td>
<td>E7</td>
<td>E12</td>
<td>E17</td>
</tr>
<tr>
<td></td>
<td>The moment where a knee forms the minimum angle just before executing a side kick</td>
<td></td>
<td>E3</td>
<td>E8</td>
<td>E13</td>
<td>E18</td>
</tr>
<tr>
<td></td>
<td>Side kick fully extended</td>
<td></td>
<td>E4</td>
<td>E9</td>
<td>E14</td>
<td>E19</td>
</tr>
<tr>
<td></td>
<td>Forward inflection stance, outer knife-hand strike</td>
<td></td>
<td>E5</td>
<td>E10</td>
<td>E15</td>
<td>E20</td>
</tr>
<tr>
<td></td>
<td>Backward inflection stance, inner forearm block</td>
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</tbody>
</table>

Figure 2. The kinematic factors of Koryo poomsae calculated by Visual 3D (C-motion, U.S.A.) software. Kukkiwon (11) terminology was used to describe the Taekwondo techniques.

E = Event.
20

with a diameter of 1.5 cm were attached to bodies of the
subjects to obtain three-dimensional coordinates of their
joints. After the calibrating the passive reflective markers
to a subject’s center of balance, the markers attached
to the lower extremities were removed, and all the subjects
were instructed to perform Koryo poomsae as if in an
elite-level competition.

Block randomization was applied for assigning
groups. The order of performance was determined at
random, and all subjects performed Koryo poomsae twice.
As in a real competition, 5 referees scored the
performances. Of the two scoring items in poomsae
competition (accuracy and presentation), only accuracy
was analyzed. Presentation was excluded in this study,
because it cannot be assessed objectively. The highest
and lowest points were excluded from subjects’ scores,
and the average was used for the results. The better score
was used for analysis.

Data processing method

A Qualisys Tracking Manager was used to track the
data taken from each marker. The nonlinear
transformation (NLT) method was applied for
transforming joint locations and space into coordinates.
Figure 1 shows where 77 passive reflection markers
were attached to indicate joint points of human body as
coordinates. The parameters of the segments were based
on Plagenhoef (13). A Butterworth 4th order low-pass
filter was used to remove noise, and the cut-off frequency
was set at 6 Hz. After converting tracked data into C3D,
kinemetic factors were calculated by Visual 3D (C-
motion, U.S.A.) software to produce data.

Koryo poomsae was performed along the
predetermined 45°-shaped yeonmu-seon (16). At the
beginning position of Koryo poomsae, the front-to-back
direction was set as the X-axis, the left-to-right direction
was set as the Y-axis, and a line perpendicular to the
ground was set as the Z-axis.

Setting analysis phases

A total 20 events in 4 phases were set. Phases 1 and
2 consisted of the same bilateral symmetric series of
techniques, as did and Phases 3 and 4. Each phases had
five events (fundamental techniques) with preparatory
motions connecting each event. The kinematic factors
analyzed included performed time for the poomsae,
center of mass (CM) range, ratio of yopchagi
(Taekwondo side kick) height, and stance length. Figure
2 illustrates the phases and techniques.

Statistical analysis

Data was processed by SPSS 22 for Windows. A
dependent t-test was applied to compare the left and right
sides of a phase in Koryo poomsae, and an independent
t-test was used for the movements and kinematic factors
between the groups. The significance level was set at p <
0.05.

Results

Table 2 shows the difference between the left and
right sides in Phases 1 and 2 as well as Phases 3 and 4.
Group A performed Phase 3 0.08 sec longer than Phase 4
and showed a significant difference (0.02), while there
was no significant difference in their performance of
Phases 1 and 2 (0.06). On the other hand, Group B did
not show any significant difference between their left and
right sides (Phases 1 and 2: 0.55, Phases 3 and 4: 0.89).
The comparison between the two groups in terms of

<table>
<thead>
<tr>
<th>Phase</th>
<th>Group A</th>
<th>Group B</th>
<th>Between</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>t-value (p-value)</td>
</tr>
<tr>
<td>1</td>
<td>3.96 ± 0.18</td>
<td>4.08 ± 0.20</td>
<td>-2.16 (0.06)</td>
</tr>
<tr>
<td>2</td>
<td>4.02 ± 0.14</td>
<td>4.11 ± 0.14</td>
<td>-0.61 (0.55)</td>
</tr>
<tr>
<td>3</td>
<td>6.09 ± 0.32</td>
<td>6.08 ± 0.14</td>
<td>2.97 (0.02)</td>
</tr>
<tr>
<td>4</td>
<td>6.01 ± 0.32</td>
<td>6.09 ± 0.13</td>
<td>-0.15 (0.89)</td>
</tr>
</tbody>
</table>

Table 2. Comparison of performed time within and between Group A and B
(Unit: sec) (Mean ± SD)
performance time showed no significant difference in all phases (Phase 1: 0.20, Phase 2: 0.19, Phase 3: 0.93, Phase 4: 0.49).

As shown in Table 3, no significant difference was obtained for CM range in all phases for Groups A and B between the left and right directional movements in a phase performed along the X-axis (Group A, Phases 1 and 2 = 0.27, Phases 3 and 4 = 0.38; Group B, Phases 1 and 2: 0.71, Phases 3 and 4 = 0.15). The comparison between Groups A and B also produced no significant difference (Phase 1: 0.95, Phase 2: 0.71, Phase 3: 0.83, Phase 4: 0.90), since they matched by less than 0.01 m in each phase. As for the difference between left and right sides of the directional movements in a phase, which was performed along the Y-axis, both groups showed no significance (Group A, Phases 1 and 2: 0.18, Phases 3 and 4: 0.84; Group B, Phases 1 and 2: 0.77, Phases 3 and 4: 0.18), and the comparison between the two groups showed no significance in all four phases (Phase 1: 0.55, Phase 2: 0.71, Phase 3: 0.83, Phase 4: 0.25).

In Group A, Phase 3 showed a higher ratio of yopchagi height by 2.5% than Phase 4, which was a significant difference (0.01). In the case of Group B, Phase 3 showed a higher ratio by 0.8% than Phase 4; however, this was not statistically significant (0.22). The comparison between the two groups showed no significant difference, indicating the difference of 1% all over the phases (Phase 1: 0.55, Phase 2: 0.71, Phase 3: 0.83, Phase 4: 0.25).

Table 4 shows the comparisons of backward inflection, riding, and forward inflection stances between Groups A and B during Phases 1 and 4. Group A produced a difference of 0.01 m in their backward inflection stances between Phases 1 and 2, while Group

Table 3. Comparison of front-back or left-right CM range and ratio of yopchagi height within and between Groups A and B (Unit: m, %) (Mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th></th>
<th>B</th>
<th></th>
<th>Within</th>
<th>Mean ± SD</th>
<th></th>
<th>Within</th>
<th>Mean ± SD</th>
<th></th>
<th>t-value</th>
<th>p-value</th>
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<td>(p-value)</td>
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<td><strong>CM X range</strong></td>
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<tr>
<td>P1</td>
<td>1.03 ± 0.05</td>
<td>1.17 (0.27)</td>
<td>1.03 ± 0.06</td>
<td>0.38 (0.71)</td>
<td>-0.06</td>
<td>(0.95)</td>
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<tr>
<td>P2</td>
<td>1.01 ± 0.08</td>
<td></td>
<td>1.02 ± 0.11</td>
<td></td>
<td>-0.38</td>
<td>(0.71)</td>
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<tr>
<td>P3</td>
<td>1.51 ± 0.09</td>
<td>-0.92 (0.38)</td>
<td>1.51 ± 0.08</td>
<td>-1.58 (0.15)</td>
<td>0.21</td>
<td>(0.83)</td>
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<td>P4</td>
<td>1.55 ± 0.18</td>
<td></td>
<td>1.54 ± 0.08</td>
<td></td>
<td>0.21</td>
<td>(0.90)</td>
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<tr>
<td><strong>CM Y range</strong></td>
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<tr>
<td>P1</td>
<td>0.21 ± 0.08</td>
<td>1.44 (0.18)</td>
<td>0.19 ± 0.09</td>
<td>0.31 (0.77)</td>
<td>-0.38</td>
<td>(0.71)</td>
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<td>P2</td>
<td>0.16 ± 0.08</td>
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<td>0.17 ± 0.09</td>
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<tr>
<td>P3</td>
<td>0.46 ± 0.17</td>
<td>0.21 (0.84)</td>
<td>0.44 ± 0.14</td>
<td>-1.44 (0.18)</td>
<td>0.22</td>
<td>(0.83)</td>
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<tr>
<td>P4</td>
<td>0.44 ± 0.14</td>
<td></td>
<td>0.52 ± 0.16</td>
<td></td>
<td>-1.19</td>
<td>(0.25)</td>
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<tr>
<td><strong>Ratio of yopchagi height</strong></td>
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<tr>
<td>P1</td>
<td>104.8 ± 4.9</td>
<td>0.95 (0.37)</td>
<td>105.1 ± 3.1</td>
<td>1.73 (0.12)</td>
<td>-0.20</td>
<td>(0.85)</td>
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<tr>
<td>P2</td>
<td>103.8 ± 2.6</td>
<td></td>
<td>104.1 ± 2.6</td>
<td></td>
<td>-0.26</td>
<td>(0.80)</td>
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<tr>
<td>P3</td>
<td>105.4 ± 3.4</td>
<td>3.24 (0.01)</td>
<td>104.3 ± 2.0</td>
<td>1.33 (0.22)</td>
<td>0.85</td>
<td>(0.40)</td>
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<tr>
<td>P4</td>
<td>102.9 ± 3.6</td>
<td></td>
<td>103.5 ± 2.6</td>
<td></td>
<td>-0.45</td>
<td>(0.65)</td>
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</table>

CM: center of mass.
Yopchagi: Taekwondo side kick.
P1, P2, P3, P4 = Phase 1, Phase 2, Phase 3, Phase 4, respectfully.
Table 4. Comparison of backward inflection, riding, and forward inflection stances between Groups A and B (Unit: m)

<table>
<thead>
<tr>
<th>Stance</th>
<th>Phase</th>
<th>A</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Mean ± SD</td>
<td>Within t-value (p-value)</td>
<td>Mean ± SD</td>
<td>Within t-value (p-value)</td>
<td>t-value (p-value)</td>
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<tr>
<td>Backward inflection stance</td>
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<tr>
<td></td>
<td>1-1</td>
<td>0.46 ± 0.03</td>
<td>0.92 (0.38)</td>
<td>0.47 ± 0.05</td>
<td>1.54 (0.16)</td>
<td>-0.20 (0.84)</td>
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<tr>
<td></td>
<td>2-1</td>
<td>0.45 ± 0.05</td>
<td></td>
<td>0.45 ± 0.04</td>
<td>-0.04 (0.97)</td>
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<td></td>
<td>1-2</td>
<td>0.40 ± 0.06</td>
<td>-1.90 (0.09)</td>
<td>0.41 ± 0.05</td>
<td>-0.79 (0.45)</td>
<td>-0.38 (0.71)</td>
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<tr>
<td></td>
<td>2-2</td>
<td>0.43 ± 0.04</td>
<td></td>
<td>0.42 ± 0.03</td>
<td>0.23 (0.82)</td>
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<tr>
<td>Riding stance</td>
<td>3-1</td>
<td>0.64 ± 0.05</td>
<td>-1.80 (0.11)</td>
<td>0.63 ± 0.04</td>
<td>-1.11 (0.30)</td>
<td>0.65 (0.52)</td>
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<tr>
<td></td>
<td>4-1</td>
<td>0.66 ± 0.02</td>
<td></td>
<td>0.64 ± 0.04</td>
<td>1.07 (0.30)</td>
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<tr>
<td></td>
<td>3-2</td>
<td>0.69 ± 0.06</td>
<td>0.59 (0.57)</td>
<td>0.65 ± 0.04</td>
<td>-0.53 (0.61)</td>
<td>1.56 (0.14)</td>
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<td></td>
<td>4-2</td>
<td>0.68 ± 0.03</td>
<td></td>
<td>0.66 ± 0.04</td>
<td>1.13 (0.27)</td>
<td></td>
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<tr>
<td>Forward inflection stance</td>
<td>1</td>
<td>0.77 ± 0.06</td>
<td>-0.53 (0.61)</td>
<td>0.81 ± 0.07</td>
<td>-0.20 (0.85)</td>
<td>-1.15 (0.26)</td>
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<td></td>
<td>2</td>
<td>0.78 ± 0.06</td>
<td></td>
<td>0.81 ± 0.06</td>
<td>-1.04 (0.31)</td>
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<td></td>
<td>3</td>
<td>0.81 ± 0.04</td>
<td>-0.46 (0.66)</td>
<td>0.81 ± 0.05</td>
<td>-0.38 (0.98)</td>
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<td>4</td>
<td>0.82 ± 0.07</td>
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<td>0.82 ± 0.05</td>
<td>0.16 (0.88)</td>
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Phase 1-1: Phase 1, 1st performance; Phase 2-1: Phase 2, 1st performance; Phase 1-2: Phase 1, 2nd performance; Phase 2-2: Phase 2, 2nd performance; Phase 3-1: Phase 3, 1st performance; Phase 4-1: Phase 4, 1st performance; Phase 3-2: Phase 3, 2nd performance; Phase 4-2: Phase 4, 2nd performance.
E1, E6: Event 1 and Event 6, respectfully (backward inflection stance, knife-hand trunk block; see Figure 2).
E5, E10: Event 5 and Event 10, respectfully (backward inflection stance, inner forearm block; see Figure 2).
E11, E16: Event 11 and Event 16, respectfully (riding stance, single knife-hand block; see Figure 2).
E15, E20: Event 15, Event 20 (riding stance, trunk elbow strike; see Figure 2).

B produced a difference of 0.02 m. No difference was obtained by either group (Group A, Phase 1-1: 0.38, Group B, Phase 1-1: 0.16). Both groups showed similar results with their backward inflection stances during Phase 2 (Group A: 0.09, Group B: 0.45). The comparison between the two groups produced no significant difference, showing a difference of less than 0.01 m over all of the phases (Phase 1: 0.84, Phase 2: 0.97, Phase 3: 0.71, Phase 4: 0.82). The comparison of riding stances in Phases 1 and 2 within each group produced no significant difference (Group A, Phases 1 and 2: 0.11 and 0.5, respectively; Group B, Phases 1 and 2: 0.30 and 0.61, respectively). The comparison between Groups A and B also showed no significant difference (Phase 1: 0.52, Phase 2: 0.30, Phase 3: 0.14, Phase 4: 0.27). The comparison of forward inflection stances within Groups A and B revealed no significant difference between Phases 1 and 2 as well as 3 and 4 (Group A, Phases 1 and 2: 0.61 and 0.66, respectively; Group B, Phases 1 and 2: 0.85 and 0.71, respectively). The comparison between the two groups also showed no significant difference (Phase 1: 0.26, Phase 2: 0.31, Phase 3: 0.98, Phase 4: 0.88).

**Discussion**

This study was conducted to analyze the kinematic variables to improve the objectivity related to the accuracy evaluation in Koryo poomsae. The analyzed
variables were time required, angular change of the knee joint, CM range, ratio of body height to height of yeopchagi, and stance length.

Since Phases 1 and 2 of Koryo poomsae are performed in the opposite direction of Phases 3 and 4, all techniques and performance times should be identical (15). In Group A, the performed time of Phase 3 was longer than that of Phase 4 by an average of 0.08 sec, and a significant difference was observed (0.02). On the other hand, there was no significant difference in performed time between left and right directions in Group B in Phases 3 and 4 (Phase 1-2: 0.55, Phase 3-4: 0.89). There was no significant difference between the two groups for all phases (Phase 1: 0.20, Phase 2: 0.19, Phase 3: 0.93, Phase 4: 0.49).

Heo et al. (4) reported that the performance of a riding stance followed by side kick of the excellent group was shorter than that of non-excellent group by average 0.12 sec. Most studies between excellent and non-excellent athletes indicate that the time required for excellent athletes to perform side kicks was shorter than that of the non-excellent group subjects (7, 8, 12). In the current study, the time required for Group A, which had a high accuracy score, was shorter than that of Group B. However, a significant level between two groups was not reached. This result was consistent with previous studies. Consequently, it can be seen that the time required for side kicks or other particular techniques of excellent athletes is shorter than that of non-excellent athletes. Yet, the subjects of Group A were inconsistent in execution time, because of the large deviation of time required in all phases. Therefore, it can be confirmed that the degree of coincidence between the left and right performance times should not considered in the evaluation of accuracy. The points awarded by referees are merely based on quick performance movement.

Koryo poomsae should have a constant range of front-back movement and a small range of left-right movement along the ±-shaped yeonmu-seon. The WTF (15) states that movement ranges between left and right sides should be small, and the balance of the body should be stable.

In the current study, the CM movement range in forward-backward (X-axis) and left-right (Y-axis) directions showed no significant difference both between and within Groups A and B. The range of forward-backward (X-axis) movements showed that the deviation among Group A was twice that of Group B. Within each group, a deviation greater than 0.10 m was found in Phase 4 of Group A and Phase 2 of Group B. In the range movement to the left-right direction (Y-axis), the movement of Phases 3 and 4 was twice as large as that of Phases 1 and 2.

The difference in the range of movement along the X-axis was due to the difference in subjects’ stance lengths. However, the difference in the range of movement along the Y-axis was caused by a motion defined as juchumseogi hu apkkoseogi yeopchagi (side kick preparatory kicking motion) that is performed just prior to the side kick where the athlete steps in front of one foot, crossing the legs at the shins (4). Therefore, it is difficult to select the movement range of the X-axis and Y-axis directions as an objective item for the evaluation of accuracy.

The side kicks in Koryo poomsae should be performed with the same movement using the opposite legs on the left and right sides. The side kick height should be consistent on both sides (15). Side kick heights were standardized to the heights of subjects, and the heights of their side kicks were compared between Phases 1 and 2 and Phases 3 and 4. As a result, a significant difference (p < 0.05) was observed for side kick to body height in Group A. They performed side kicks 2.5% higher in Phase 3 than in Phase 4.

In the comparison of the heights of the subjects’ left and right yeopchagi, there was no significant difference in Group B, but Group A showed a significant difference only between Phases 3 and 4 (0.01). Group A’s average accuracy score was 0.02 higher than in Group B, even though there was a difference in yeopchagi height between Group A’s left and right kicks.

In Koryo poomsae, the backward inflection stance should be performed 4 times in total: twice in Phase 1 (Figure 2, E1 and E5) and Phase 2 (Figure 2, E6 and E10). The length of the stance should remain consistent each time it is performed (15). In the current study, there was no significant difference in backward inflection stance in either Group A or B (Group A: 0.38, Group B: 0.16) and between the groups (Phase 1-1: 0.84, Phase 1-2: 0.97, Phase 2-1: 0.71, Phase 2-2: 0.82). In the case of Koryo poomsae, the second backward inflection stance of Phase 2 (Figure 2, E5 and E10) is shorter than that of Phase 1, because the foot position is shorter when the direction is changed from left to right. On the other hand, the second backward inflection stance was shorter than the first backward inflection stance, which was caused when subjects pulled their foot back while executing an inner forearm block (Figure 2, E5 and E10) as prescribed by the Kukkiwon (11), the educational center for Olympic-style Taekwondo.

As shown in Table 4, there was no significant difference within groups in the first and second riding
stances (Group A, Phases 3-1 and 4-1: 0.11, Phases 3-2 and 4-2: 0.57; Group B, Phases 3-1 and 4-1: 0.30, Phases 3-2 and 4-2: 0.61) and between groups (Phase 3-1: 0.52, Phase 4-1: 0.30, Phase 3-2: 0.14, Phase 4-2: 0.27). In Phases 3 and 4, the length of the second riding stance (Figure 2, E15 and E20) was longer than that of the first riding stance (Figure 2, E11 and E16), due to the movement that connects the forward inflection stance with an upset fingertip thrust (Figure 2, E14 and E19) to the second riding stance (Figure 2, E15 and E20).

The length of the forward inflection stance showed no significant difference between Phases 1-2 and 3-4 in both groups (Group A: Phases 1 and 2: 0.61, Phases 3 and 4: 0.66; Group B, Phases 1 and 2: 0.85; Phases 3 and 4: 0.71). There was also no significant difference between the groups (Phase 1: 0.26, Phase 2: 0.31, Phase 3: 0.98, Phase 4: 0.88) (see Table 4).

There was a difference in length of subjects’ forward inflection stance between Phases 1-2 (Figure 2: E4 and E9) and Phases 3-4 (Figure 2: E14 and E19). The differences were caused by the various placements of the foot as it landed after executing a side kick to make a forward inflection stance (Figure 2: E13 and E19). Therefore, the consistency of length in forward inflection stance can be used as an objective indicator in evaluating accuracy.

Conclusion

The results from this study suggest that time required and ratio of body height to the height of yopchagi were significantly different between different phases in Koryo poomsae. Yet, the stance lengths were inconsistent while it was performed. It should be considered that time required to execute a technique, the height of yopchagi relative to an athlete’s height, and stance length should be important components when determining the accuracy score in poomsae competition to ensure objectivity in the judges’ evaluations. Additionally, further studies are needed to improve the objectivity and reliability in the accuracy evaluation of poomsae competition.

Limitations

There were two limitations to this study. Namely, we did not consider 1) the degree of coincidence between subjects’ left and right side performances and 2) the subjects’ consistency of motion.

References

