

International Comparison of Women's Rhythmic Gymnastics from the Perspective of Performance Time of "Body Difficulty"

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Abstract

The purpose of this study was to clarify trends of rhythmic gymnastics performance and to obtain fundamental data for the composition of routines. The study surveyed women's individual games and four events at the 2013 All-Japan Rhythmic Gymnastics Championships (27 gymnasts), the 2013 World Championships (10 gymnasts), the 2014 World Championships (12 gymnasts), the Olympic Games in 2016 (10 gymnasts) and found the number of body difficulty performed, performance time, and duration of single difficulty on each routine. Further, the study examined BD performance time by group. A two-way analysis of variance (ANOVA) was conducted by using championships as between-subjects factors and gymnastic apparatus as within-subject factors. In terms of difficulty performance time and duration of single difficulty, there were significant interactions between the 2013 Japan Championships and the 2013 World Championships. While no significant interaction was found among the 2013-2014-2016 world championships, there were significant main effects in gymnastic events (All $p < .05$).

Keywords

Rhythmic Gymnastics, Performance, Body Difficulty, Performance Time

1. Introduction

1.1. Trends of Competition and Rules of Rhythmic Gymnastics

Rhythmic gymnastics are sporting events associated with the International Gymnastics Federation (acronym: F.I.G.). Judges, based on the code of points, evaluate routines performed to instrumental music and on apparatus per the D

panel and the E panel. The code of points was altered extensively after the conclusion of 2017 Rio de Janeiro Olympic Games. Especially, with the abolishment of applications, judges are required to instantly assign value to gymnastic elements being performed before their eyes.

An upper limit and a lower limit of the number of performing body difficulty (BD) elements are outlined in the conventional code of points. Time allocation is the key to keep pace with the code of points system covering diversified difficulty value of elements.

A newsletter issued by the F.I.G. Rhythmic Technical Committee in June 2017 describes the followings.

The Rhythmic Technical Committee would like to provide the following information for coaches and judges following the analysis of the official World Cups and World Challenge Cups for the new Olympic cycle to clarify understanding and help improve evaluation:

Noted improvements in the compositions:

- More equal distribution among the Body Difficulty groups
- More variety in apparatus handling
- R elements are a more realistic reflection of what the gymnast can perform

The TC also notes that judges have demonstrated an ability to evaluate without official forms.

ANALYSIS:

There are 2 different Difficulty panels and 2 different Execution panels: all 4 components are different and independent. The ability for different rankings in each component of the score is one of the goals of the Code of Points. Coaches and judges must change the mindset that the same gymnast must have the same level of score in all 4 components of the score (The Rhythmic Technical Committee, 2017b).

Routines are evaluated out of a maximum score of ten points for Difficulty and Execution respectively, equaling a final score of a maximum of 20 points (Table 1).

In the 2017 code of points system, difficulty consists of four categories: Body Difficulty (hereafter referred to as BD), Dance Step Combination (hereafter referred to as S), Dynamic Elements with Rotation (hereafter referred to as R), and Apparatus Difficulty (hereafter referred to as AD). BD consists of three types: jumps, balance, and rotations (Table 2).

The Difficulty judges identify and record Difficulties in order of their performance. D1, D2 judges: evaluate the number and value of the BD, number and value S and number of Fundamental Apparatus elements and record them in symbol notation, and D3, D4 judges: evaluate the number and value of the R and

Table 1. Final score calculation (F.I.G. 2017).

Final Score: 20.00 points
By addition: D score of 10.00 points maximum + E score of 10.00 points maximum

Table 2. Requirements for difficulty (F.I.G. 2017).

Difficulty Components connected with apparatus technical elements	Body Difficulty	Dance Steps Combination	Dynamic Elements with Rotation	Apparatus Difficulty
Symbol	BD Min.3; Max.9	S Min.1	R Min.1	AD Min. 1
Body Difficulty Groups	Jump/Leaps-Min.1 Balances-Min.1 Rotations-Min.1			

number and value AD and record them in symbol notation. The D-Judges evaluate the Difficulties, apply the partial score and deduct possible penalties, respectively.

The Execution Jury demands that elements be performed with aesthetic and technical perfection. And the E-jury is not concerned with the difficulty of an exercise. The jury is obligated to deduct equally for any error of the same magnitude regardless of the difficulty of the element or the connection. All deviations from correct performance are considered artistic or technical errors and must be evaluated accordingly by the judges. The amount of the deduction for small, medium, or large errors is determined by the degree of deviation from the correct performance. Penalties for Artistic and Technical faults are added together and then deducted from 10.00 points to determine the final E-score (RG Code of Point 2017-2020).

1.2. The Problem and Purpose

Japan won the bronze medal in the team all-around, five bronze medals on hoop, two silver medals on rope, and three silver medals on balls at the World Rhythmic Gymnastics held in September 2017, earning medals in all categories entered. Concerning individual categories, Kaho Minakawa, a national certified gymnast, came in fifth in the individual all-around and Sumire Kita advanced to the final and came 12th in her first competition. Minakawa won the bronze medal and Kita came in seventh in the event hoop final, while Minakawa came in eighth place on balls, achieving big success (Yamasaki, 2017a).

The national squad (Fairy Japan POLA) has made All Star System steady since 2005 by switching to a year-round training since 2006 and moving to Russia for training after 2009 (Yamasaki, 2017b). On the individual level, national certified gymnasts followed suit by moving to Russia for training.

In this way, while Japan's top athletes are increasingly equipped with capabilities sufficient enough to compete for top in world championships, they have less chance to enter domestic meets. Hence, it is considered important to study and analyze performance in order that rhythmic gymnastics officials in Japan, who need to be trained in the future, can learn about methods of composing strategic

and world-level routines.

Analysis of routine composition elements from temporal perspectives was conducted in the study of composition elements of rhythmic gymnastics team events (Takahashi, 1994, 2014). However, studies of individual performance are limited to analyzing in line with the past code of points (Sekita, 1994; Takahashi, 2011) or analyzing performance of national athletes (Hashimoto et al., 2017). Thus, further study is needed.

In light of the above, this study extracted BD from attempts made at national and international women's rhythmic gymnastics individual apparatus competitions and analyzed the time taken to perform BD. By comparing trends of performance among countries and championships, the study aimed at obtaining fundamental materials for examining routine composition.

The study covered routines performed in accordance with the 2013–2016 code of points. However, difficulty elements (value points) were not the subject for analysis, which is deemed to pose no issue in finding out trends of routines and strategic knowledge after 2017.

2. Method

2.1. Participants and Method

The study covered the total of 236 attempts by 27 gymnasts at the 2013 All-Japan Rhythmic Gymnastics Championships, ten gymnasts at the 2013 World Championships, 12 gymnasts at the 2014 World Championships, ten gymnasts at the Olympic Games in 2016, and four apparatus routine attempts on hoop, balls, clubs, and ribbons by gymnasts who entered respective women's individual all-around championships.

2.2. Method of Data Collection and Analysis

Concerning attempts made by national gymnasts, the floor of 13 meters square, which was to be used entirely for performing routines, was shot with a digital video camera (Panasonic, HX-WA20, 29.97 fps) during championships from a photographing area on the second floor stands allocated for event officials. Video shooting was conducted with permission of Japan Gymnastics Association.

With regard to attempts by world's top gymnasts, performance videos released by FIG were used with approval of the F.I.G. Technical Committee.

In terms of BD, based on "a list of difficulty" in the code of points, BD performance time was defined as the time taken to perform single difficulty from the preparatory aspect to the final aspect (Hashimoto et al., 2017).

The study found scores per attempt, the number of BD performed and performance time, and the duration of single difficulty, along with BD performance time by group.

2.3. Comparison

In making international comparison among national and world's top gymnasts,

the study conducted a two-way ANOVA by using two levels of the 2013 All-Japan Championships and the 2013 World rhythmic gymnastics as between-subjects factors and four levels of apparatus (hoops, balls, clubs, and ribbons) as within-subject factors. To compare championships between 2013 and 2016, a two-way ANOVA was conducted by using three levels of the 2013 world rhythmic gymnastics, the 2014 world rhythmic gymnastics, and the 2016 world rhythmic gymnastics as between-subjects factors and four levels of apparatus as within-subject factors.

3. Results

3.1. Scores

Scores awarded at each meet are as follows in the order of D Score, E Score, and Final Score. The 2013 All-Japan Championships: $5.35 \pm .68$, $7.21 \pm .41$, 12.52 ± 1.02 . The 2013 World Rhythmic Gymnastics: $8.73 \pm .43$, $8.81 \pm .30$, $17.54 \pm .71$. The 2014 World Rhythmic Gymnastics: $8.63 \pm .44$, $8.92 \pm .24$, $17.56 \pm .65$. The 2016 World Rhythmic Gymnastics: $9.01 \pm .38$, $8.97 \pm .38$, $17.98 \pm .73$ (**Table 3**).

3.2. BD Performance Time

3.2.1. BD Performance Time

The duration of difficulty and the total BD performance time by championship are displayed in **Table 1**. Of 90 seconds of performance time, BD performance time was approximately 28 - 39 seconds.

After examining differences on the international level, world's top gymnasts were found to have a significantly short value compared to the Japanese counterpart. World's top gymnasts presented no differences over three years.

By group (jumps, balance, rotations), balance was significantly longer compared to jumps, while rotations were significantly longer than balance across all attempts. As this finding illustrates trends that are similar to those generated in prior study (Hashimoto et al., 2017), it is considered to be an attribute of BD in each group, thus group comparison is excluded in subsequent analyses.

Table 3. Scores and the between apparatus comparison of the body difficulty.

	2013 Japan	2013 World	2014 World	2016 World
Score				
D Score	$5.35 \pm .68$	$8.73 \pm .43$	$8.63 \pm .44$	$9.01 \pm .38$
E Score	$7.21 \pm .41$	$8.81 \pm .30$	$8.92 \pm .24$	$8.97 \pm .38$
Final Score	12.52 ± 1.02	$17.54 \pm .71$	$17.56 \pm .65$	$17.98 \pm .73$
Body Difficulty				
Time per one Difficulty	$4.22 \pm .29$	$3.33 \pm .36$	$3.29 \pm .40$	$3.13 \pm .31$
Performance Time(s)	36.38 ± 2.77	30.01 ± 3.28	29.59 ± 3.64	28.00 ± 2.67

3.2.2. Total BD Performance Time

The result of a two-way ANOVA on international comparison (Figure 1) presented significant interactions ($F_{(3,105)} = 7.30, p < .01$). In examining simple main effects, there were significant differences between Japan and other countries. World's top gymnasts presented a significantly short value on all apparatus other than balls, compared to the Japanese counterpart. In terms of differences among apparatus, Japanese gymnasts showed a significantly short value on hoop and clubs, while no difference was found among world's top gymnasts.

After conducting a two-way ANOVA on world's top gymnasts over three years (Figure 2), no significant interactions were found ($F_{(6,87)} = 1.20, n.s.$), while

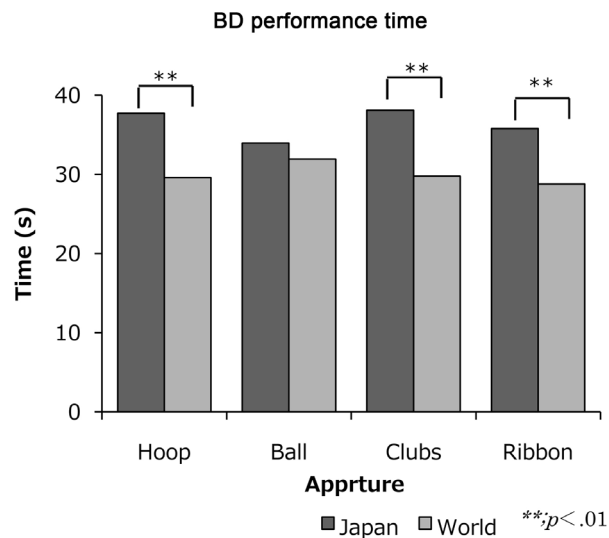


Figure 1. International comparison of total BD performance time.

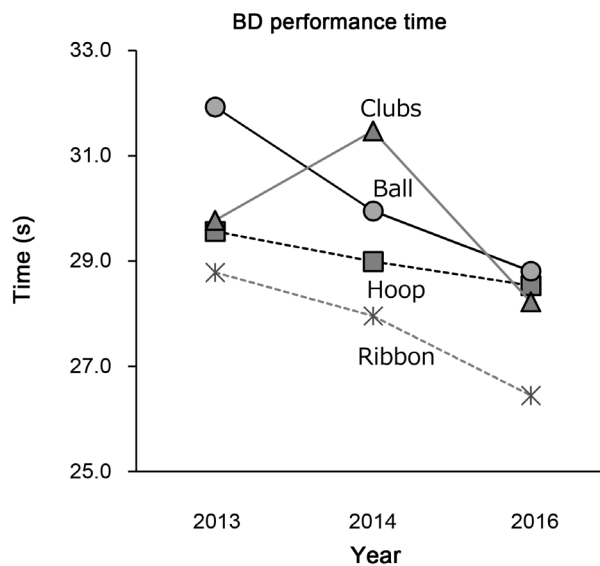


Figure 2. Three-year comparison of total BD performance time by world's top gymnasts.

significant main effects were present among apparatus ($F_{(3,87)} = 5.51, p < .01$). Multiple comparisons resulted in ribbons having a significantly shorter value than balls or clubs ($p < .05$). There were no significant main effects among championships ($F_{(2,29)} = 1.08, n.s.$).

3.2.3. Performance Time of Single Difficulty by Group

1) Jumps

The result of a two-way ANOVA on international four apparatus (**Figure 3**) presented significant interactions ($F_{(3,105)} = 3.05, p < .05$). In examining simple main effects, world's top gymnasts presented a significantly short value on all apparatus compared to the Japanese counterpart. In terms of differences among apparatus, Japanese gymnasts showed a significantly short value on balls and ribbons compared to hoop, while no difference was found among world's top gymnasts.

After conducting a two-way ANOVA on world's top gymnasts on four apparatus over three years (**Figure 4**), no significant interactions were found ($F_{(6,87)} = .95, n.s.$), while no significant difference was present among championships or apparatus. (Championship $F_{(2,29)} = 1.01, n.s.$, Apparatus $F_{(3,87)} = 1.26, n.s.$).

2) Balance

The result of a two-way ANOVA on international four apparatus presented significant interactions ($F_{(3,105)} = 2.29, p < .05$). In examining simple main effects, world's top gymnasts presented a significantly short value on all four apparatus compared to the Japanese counterpart. In terms of differences among apparatus, Japanese gymnasts showed a significantly short value on balls compared to hoop and clubs, while no difference was found among world's top gymnasts (**Figure 5**).

After conducting a two-way ANOVA on world's top gymnasts on four apparatus over three years, no significant interactions were found ($F_{(6,87)} = .28, n.s.$), while main effects were present among championships ($F_{(3,87)} = 7.48, p < .01$).

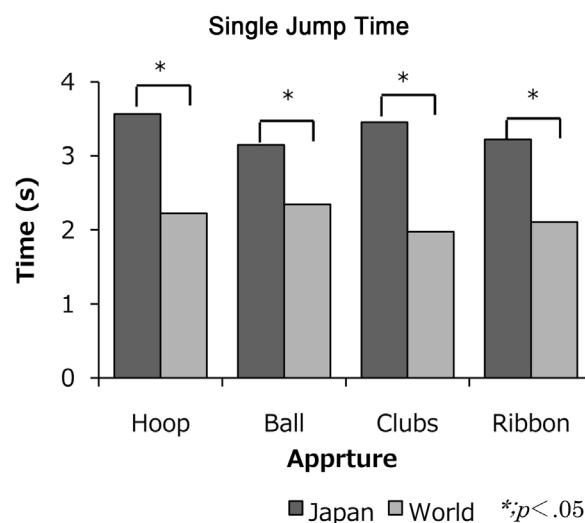


Figure 3. International comparison of single jump BD duration.

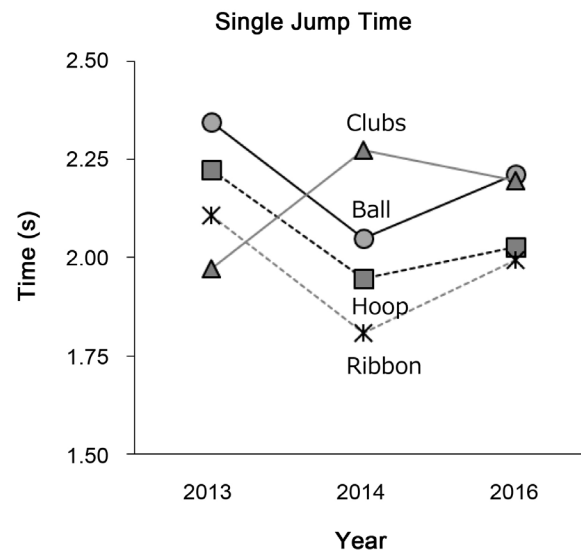


Figure 4. Three-year international comparison of single jump BD duration.

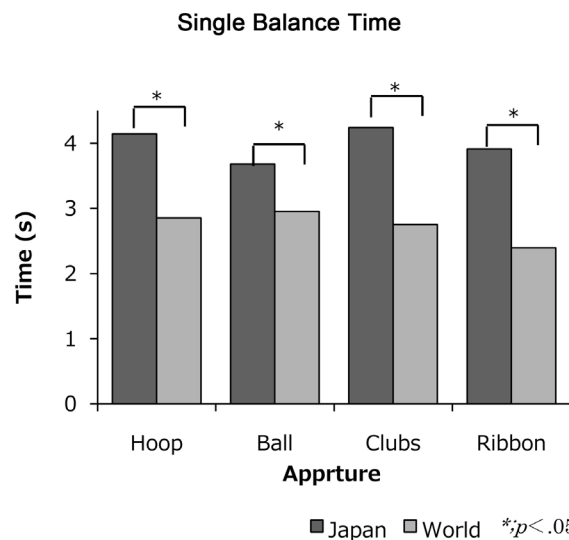


Figure 5. International comparison of single balance BD duration.

Multiple comparisons resulted in ribbons having a significantly shorter value than hoop, balls, and clubs. ($p < .05$) There were no significant differences among championships ($F_{(2,29)} = .97$, n.s.) (Figure 6).

3) Rotation

The result of a two-way ANOVA on international four apparatus presented significant interactions ($F_{(3,105)} = 3.47$, $p < .05$). In examining simple main effects, there were no significant differences between Japan and other countries. In terms of differences among apparatus, Japanese gymnasts showed a significantly shorter value on balls compared to clubs, while no difference was found among world's top gymnasts (Figure 7).

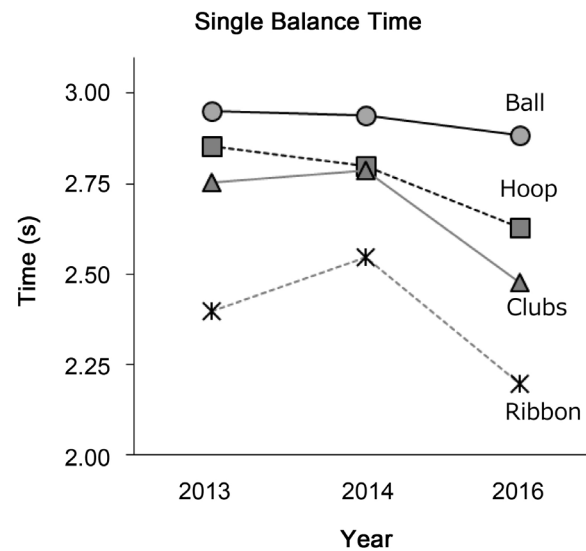


Figure 6. Three-year international comparison of single balance BD duration.

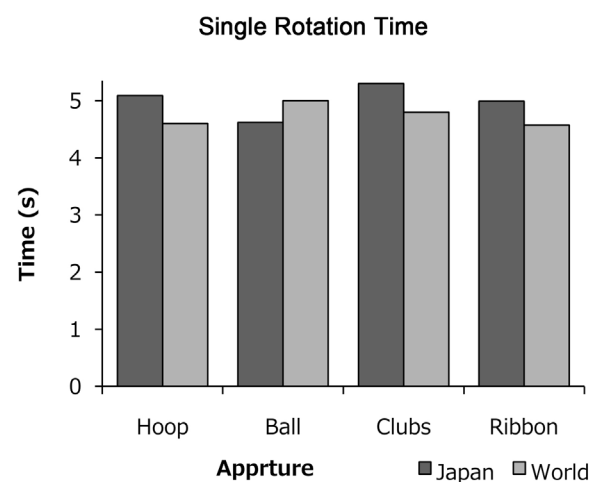


Figure 7. International comparison of single rotation BD duration.

After conducting a two-way ANOVA on world's top gymnasts on four apparatus over three years, no significant interactions were found ($F_{(6,87)} = 1.15$, n.s.), while there were no significant differences among championships or apparatus (Championship $F_{(2,29)} = .04$, n.s. , Apparatus $F_{(3,87)} = .35$, n.s.) (**Figure 8**).

4. Discussion

4.1. Examination of Scores

Considering that there are small variations in scores in all attempts at each meet, the validity of attempts extracted in this study was supported with the 2013 All-Japan Rhythmic Gymnastics Championships being top level performance in Japan and the 2013-2014-2016 rhythmic gymnastics championships being as

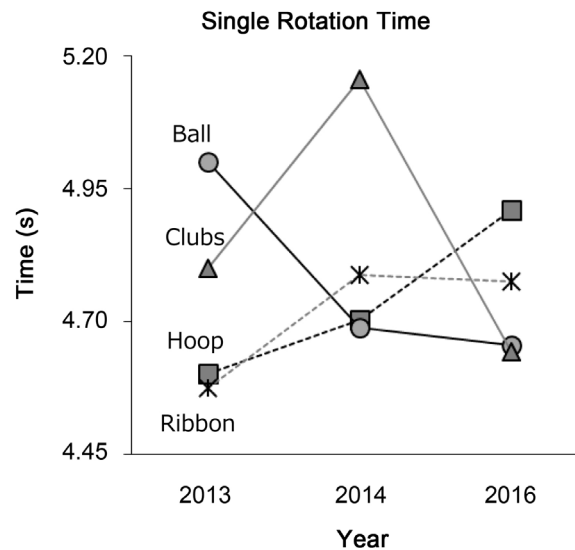


Figure 8. Three-year international comparison of single rotation BD duration.

world's top level performance. Further, that little difference was found among world rhythmic gymnastics championships suggests that judges, in accordance with the 2013-2016 code of points, impartially perform precise and highly accurate evaluation.

With regard to differences in the level of competition on the international level, score comparison points to a gap of 3.5 points in D Score out of a margin of approximately five points in Final Score. It is deemed highly beneficial to focus on D Score from a strategic point of view and examine how to enhance it.

4.2. Examination of BD Performance Time Comparison

BD performance time was found to account for approximately 28 - 39 seconds out of 90 seconds of performance time, while duration of single difficulty was found to be approximately 3 - 5 seconds.

Further, BD performance time is related to two factors; the number of performance and the duration of single difficulty. The number of BD performed was found to be 8.8 on average and an upper limit of numbers were performed in approximately 85 percent of target attempts (200 attempts out of 236), pointing to the importance of adding points in BD.

Therefore, it is assumed that the length of BD performance time is affected by the duration of single difficulty.

Moreover, it is assumed that the duration of single difficulty is related to the speed of performing difficulty itself as well as operating characteristics of apparatus used and preparatory movements (Hashimoto et al., 2017).

The result of this study illustrates that world's top level gymnasts, compared to the Japanese counterpart, are inclined to have shorter BD performance time with little difference among apparatus, while having no difference over three

years. Moreover, the effect of operational characteristics of apparatus was restricted to each BD group of Japanese gymnasts and balance performed by world's top gymnasts.

In view the above, by adding the speed of BD performance time and reducing BD preparatory movements, it is assumed that gymnasts with higher technical skills are able to shorten the duration of single difficulty, leading to the reduction of BD performance time. By reducing BD performance time, difficulty elements can be augmented, allowing for an increased chance of incorporating diversified difficulty elements into routine composition and earning higher D Score. This will contribute to earning E Score in artistic evaluation on performance diversity, the deciding factor of improved levels of competition.

4.3. Study of BD Performance Time Comparison by Group

As for single BD performance time, the faster the speed of rotations is, the shorter the performance time becomes. An increased number of rotations consume more performance time. Hence, an analysis of the duration simply does not reflect differences in the level of competition. A further study is needed to clarify rotation skills by analyzing movements reflecting the level of difficulty.

Concerning jumps and balance that require gymnasts to perform compulsory positions accurately, performance time is greatly influenced by preliminary movements including preparatory movements and connections.

In terms of jumps and balance in BD group, world's top gymnasts indicated significantly shorter time than the Japanese counterpart, while having no significant difference in rotations.

In light of the above, it is assumed that the gap in skill level is prominent during the time taken per difficulty, especially owing to the presence or absence of preparatory movements or the length of time.

As for jumps, world's top gymnasts, compared to the Japanese counterpart, frequently demonstrated a sequence of difficulty elements. Moreover, an accurate movement from a short distance running to difficult positions contributed to performing difficulty in a short time. In performing balance, maintaining an immediate heel raise directly from the previous movement was performed accurately with the satisfactory angle of splits. It can be said that Japanese gymnasts will need to improve in these areas.

In examining differences in BD performance time among apparatus, national gymnasts took relatively short time on balls, while world's top gymnasts took relatively short time on ribbons. In jumps/rotations, there was no difference among apparatus performed by world's top gymnasts.

To clarify relations between BD performance and apparatus handling, BD value is not recognized if not accompanied by apparatus. While BD is being performed, a fundamental technical group, that is specific to apparatus, is essential. Some apparatus require gymnasts to perform with the left hand. It is very important to have a strategic viewpoint in studying which apparatus to combine

for BD performance.

In view of the above, jumps/rotations, if skill level is enhanced, fall into BD group regardless of apparatus operating characteristics. Conversely, balance is regarded as BD group that can reduce BD performance time by taking advantage of apparatus operating characteristics and controlling of selected apparatus.

5. Recommendation

From the results of this study, by understanding characteristics of respective BD group and of apparatus operating characteristics and combining them strategically, it can be possible to aim for reducing BD performance time from a viewpoint different from the technique level of physical skills.

For example, BD difficulty time can be reduced by taking apparatus operation and apparatus flows into consideration when studying routine composition. It is possible to develop strategies by incorporating other elements, while constructing difficulty levels by making use of characteristics of apparatus and devising orders of performing a sequence or a mix of difficulty.

Concerning world's top gymnasts, none of BD indices of routine composition elements changed over three years. It is deemed important to promptly respond to new trends of routines in the first year, should the code of points be renewed once in every four years.

Regarding the 2017-2020 code of points, no change was made to the limit of the number of BD. An upper limit of other elements consisting the D Score was abolished. Further, although F.I.G. has not officially announced at present, a maximum score of ten points may be abolished and an open-ended point-addition scoring system may be adopted.

This suggests that with greater flexibility to select difficulty to be incorporated into performance, the range of routine composition has expanded. Strategically, it is required to perform nine BD in an accurate and speedy manner and allocate as much time as possible to other difficulty elements.

Based on the results of this study, we analyzed the trend of the world in 2017, and as a measure for the Tokyo Olympic Games in 2020, it is important to understand scientific training to build a strategic performance composition and to strengthen the technology of rhythmic athletes.

In the light of BD performance time, it is also necessary to additionally examine relations between the difficulty level of difficulty performed and technical evaluation in the future.

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