

Original Article

Points to note when beginners make *Kumihimo* using the *Kumihimo* Disk -Factors affecting the evaluation of braided strings-

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Abstract

Purpose: Points to note when beginners make *Kumihimo* (a Japanese braid) using *Kumihimo* Disks were examined based on the relationships between the braided string's thickness and hardness.

Methods: University students braided the *Yatsu-kongoh* Z-spiral using the *Kumihimo* Disk, and the length and thickness of the braided strings were measured. The hardness and flexibility of the braided strings were evaluated by touching them using a five-point scale. The evaluations for flexibility and hardness were nearly consistent. Therefore, the flexibility was defined as the hardness of the string.

Results: Significant negative correlations were indicated between hardness and length, thickness, and thickness variation. The results of simple correlation analysis and multiple regression analysis indicated a significant effect of the number of mistakes and thickness variation on appearance evaluation. On the other hand, simple correlation analysis results indicated that the number of mistakes, thickness variations, and hardness significantly affected comprehensive evaluations. Moreover, multiple regression analysis results indicated a significant effect of the number of mistakes and thickness variations on the comprehensive evaluation.

Conclusion: Although appearance evaluation is essential from an aesthetic perspective, the string's hardness and thickness are critical when considering braided strings' functions in the comprehensive evaluation. The results of the present study indicated that harder and thinner strings were more highly evaluated. Therefore, beginners should try to braid harder and thinner strings.

Keywords: *Kumihimo* Disk, the thickness of braided strings, the hardness of braided strings, appearance evaluation, the evaluation of braided strings

Introduction

Kumihimo is a textile-making technique. It is made by diagonally crossing more than three strings or thread bundles opposite the already braided strings' direction. Braids have been made worldwide, and various studies and workshops have been conducted on braiding in each country (The Braid Society, 2016; The Kumihimo Society, 2019). In Europe, strings came to be produced using braiding machines between the 17th and 18th centuries. The braiding machine was imported to Japan from Germany around 1888 (Tada, 2004). Studies on the braids

produced using braiding machines have been conducted, and various achievements and specialized books have been published on this topic (Adanur,1995; Potluri, 2011; Soares, 1999; Yordan, 2015; Wulfhorst, 2006).

There are two methods of making braids, either by hand or using tools. At first, people braided strings using only their hands and gradually began using tools for efficiency. Different types of *Kumi-dai* (a braiding stand) are used according to the use of the string. *Kumi-dai* includes *Maru-dai*, *Kaku-dai*, *Ayatake-dai*, *Taka-dai*, and *Karakumi-dai* (Figure 1). Skills and training are required to properly use *Kumi-*

dai (The Kumihimo Society, 2011; Tada, 2014). The most common *Kumi-dai* is *Maru-dai*. The *Kumihimo* Disk was developed by utilizing *Maru-dai*'s characteristics so that even beginners could easily braid strings.



Figure 1: Braiding Tools (by courtesy of The Kumihimo Society, 2011)

The *Kumihimo* Disk is a donut-type disk made of polyethylene form with 1 cm thickness and a diameter of 15 cm, having 32 numbered slits around the circumference. It is a small, lightweight, and inexpensive tool for braiding. Anyone can easily make a braid using the disk anytime and anywhere (Tada, 2007) by putting a thread bundle through the center hole and inserting a thread in a specified slit to hold the thread. Thus, even inexperienced users can easily braid threads. Diversified braiding disks have been developed internationally, and several books have been published on relevant topics (James, 2009).

The *Kumihimo* Disk is assumed to be used by beginners. However, few studies have been conducted regarding the points to note when braiding strings using the disk. Moreover, the characteristics of strings braided by beginners using the disk have not been clarified to date. Previous studies on braiding focused mainly on experts that produce *Kumihimo* using *Kumi-dai* (Tada, 2002; Tada, 2003a; Tada, 2003b), and it is challenging to obtain findings useful for beginners. Moreover, *Kumihimo* has been used initially to tie knots, and the “hardness” is

essential for making knots that would not untie easily. However, methods of efficiently evaluating the hardness of strings have yet to be developed. Also, the effects of hardness on the braided string’s appearance have not been clarified. The present study examined points that should be noted by people inexperienced in *Kumihimo* when using the *Kumihimo* Disk, based on the relationship between the thickness and hardness of the braided string.

Participants and methods

1. Participants

University students ($N = 120$) without the experience of braiding *Kumihimo* participated in the study. The experiment's purpose and content were explained to the participants, and their consent was obtained in advance.

2. Tools and procedures

The *Kumihimo* Disk (HAMANAKA Co., Ltd.; Kumihimo Disk H205-568) and 100% acrylic yarn (HAMANAKA Co., Ltd.; HAMANAKA BONNY) with a length of 500mm were used. The disk diameter was 150mm, that of the center hole was 24mm, and the thickness of the disk was 10mm. The ends of eight woolen threads (2 colors x 4) were tied up (Figure 2).

Kumihimo Disk HAMANAKA Co. Ltd Kumihimo Disk (H205-568)



8 woolen threads

Diameter of Kumihimo Disk: 150 mm
Diameter of center hole: 24 mm
Thickness: 10 mm
Weight: 24.5 g

Figure 2: *Kumihimo* Disk (by courtesy of HAMANAKA Co. Ltd.)

Participants were instructed to make a braid named *Yatsu-kongoh Z-spiral*, which is the most basic braiding style, using the *Kumihimo* Disk. They inserted eight woolen threads in the slits numbered 32, 1, 8, 9, 16, 17, 24, and 25, and braided *Yatsu-kongoh Z-spiral* until all the thread was used. Based on a previous study using *Maru-dai* (Kimura, 2018), one movement in the production process is called a "step," and one process is called a "cycle." When braiding *Yatsu-kongoh Z-spiral* using the *Kumihimo* Disk, users hold the disk in one hand and move the threads with the other hand. Figure 3 shows the process of braiding *Yatsu-kongoh Z-spiral* (Tada, 2017a). Step 1: moving a thread from 1 to 15. Step 2: moving the thread from 17 to 31 and rotate the disk 90 degrees clockwise. Step 3: moving the thread from 25 to 7. Step 4: moving the thread from 9 to 23 and rotating the disk 90 degrees clockwise. The four steps above compose one cycle. The following URL shows the procedure described above; <https://youtu.be/2p0CndJPYbY>.

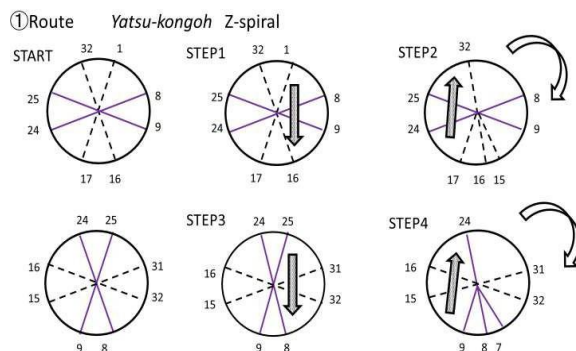


Figure 3: Route for moving the thread

3. Guidance content

Guidance for beginners was provided using a video teaching material to give each student the same guidance. The video content included (1) explanations about the *Kumihimo* Disk, (2) how to hold the disk, (3) how to hold the threads, (4) the procedure of setting threads, (5) the route of

moving threads, (6) the rotation angle of the disk, (7) the rotation direction of the disk, (8) how to identify the braiding part if lost, (9) points to note when moving threads, and (10) how to finish braiding after using up all the thread. The video was recorded from the instructor's viewpoint holding the disk, and the video and audio were simultaneously reproduced.

Participants watched the video, read handouts, and practiced for 10-20 minutes using the threads. The handouts were developed based on Tada's (2017b) book about how to use the *Kumihimo* Disk for beginners. After practice, participants braided *Yatsu-kongoh Z-spiral* using woolen threads for the actual performance. Participants were instructed not to look at the handouts when braiding.

4. The shape of the braided strings

Experimenters collected the braided strings, took photos, and measured their length and thickness. The external diameter of the string at each 10mm distance from the beginning was measured, and the mean and variations were calculated (Figure 4). The length of a string was measured based on the photo. The external diameter of a string was measured by digitalizing the photo of the braided string, referring to the calibration point embedded in the photo at each 1mm distance, and calculating the external diameter's values (Figure 4).



Figure 4: Evaluation of the braided string
(Length, Thickness, Appearance)

5. Hardness, appearance, and comprehensive evaluation

The hardness, appearance, and comprehensive evaluation of the braided strings

were made by a person producing braids such as *Obijime* (a decorative string used to hold a kimono sash in place) and had a Grade 1 license for the written and a Grade 2 license for the skills test, who participated in *Kumihimo* Disk workshops several times a year.

The evaluator touched all the braided strings and evaluated the hardness of the strings three times using a five-point scale ranging from 1 (very soft) to 5 (very hard). The strings' flexibility was evaluated by visual inspection using this five-point scale, by standing the strings vertically and checking the degree of bending. The evaluator held a string at a point of 100mm from the end and stood it vertically. A preliminary survey had indicated that all the braided strings stood straight when held 50mm from the end, whereas almost all the strings bent when held 150mm from the end. Therefore, the evaluator was requested to hold the string at a 100mm point. If a string stood unbending, it given a score of 5 points, bending less than 30 degrees earned a score of 4, between 30 and 45 degrees a score of 3, between 45 and 60 degrees a score of 2, and bending over 60 degrees was scored as 1 point (Figure 5). The degree of bending and the hardness assessed by touching were nearly consistent. Therefore, the degree of bending was regarded as the hardness of the string.

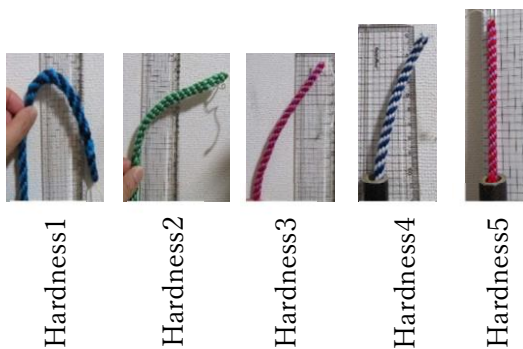


Figure 5. Evaluation of the hardness of braided strings

The evaluation of the appearance was conducted based on the size of each stitch of the string, the degree of a twist of the string, design, and thickness variations, among others, using a five-point scale ranging from 1 (very bad) to 5 (very good). See Figure 4. Moreover, a comprehensive evaluation was made by taking each string in hand and observing it, based on the sense of touch, the number of mistakes, thickness variations, and the size of each stitch of the string by using a five-point scale ranging from 1 (very bad) to 5 (very good).

The evaluation's reproductivity was confirmed by the evaluator assessing the braids made by 18 different people from the study participants over three times. Intraclass correlation coefficients (ICC) were calculated, which indicated $ICC(1, 3) = 0.955$ for hardness evaluation, $ICC(1, 3) = 0.953$ for appearance evaluation, and $ICC(1, 3) = 0.964$ for comprehensive evaluation, all of which were over 0.9. Therefore, the mean values of the three evaluations were regarded as the evaluation value.

Results

Participants that braid *Yatsu-kongoh Z*-spiral following the instructions were 118 among 120. Two participants could not complete braiding; one kept braiding by winding the already braided part in the currently braided string. The other participant did not follow the instructions. Therefore the data of 118 participants were analyzed.

1. Shape

The number of mistakes made by participants was as follows; 105 participants did not make a mistake, 6 participants made one mistake, and 7 participants made two mistakes. The average length of the braided strings was 210.3 mm ($SD = 30.3$). The longest was 287 mm, and the shortest was 135 mm. The average thickness of

the braided strings was 7.5 mm ($SD = 0.9$). The thickest was 10.8 mm, and the thinnest was 5.5 mm. The average thickness variation was 0.48 mm, the minimum was 0 mm, and the maximum was 2.49 mm.

The degree of flexibility (hardness) of the braided strings were as follows; very hard (5 points) = 11 participants, hard (4 points) = 38 participants, medium (3 points) = 43 participants,

soft (2 points) = 21 participants, and very soft (1 point) = 5 participants. The hardness had significant negative correlations with length, thickness, and thickness variation (Table 1). Moreover, thickness variation had a significant positive correlation with thickness. Therefore, the variation coefficient was calculated by dividing by thickness, which was regarded as the thickness variation.

Table 1: Correlations among length, thickness, thickness variations, and hardness

	Length		Thickness		Thickness variation	
	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>
Thickness	-.124	.182				
Thickness variation	.110	.238	.308	.001 **		
Hardness	-.377	.000 **	-.470	.000 **	-.289	.002 **

** : $p < .01$

Table 2: Appearance and Comprehensive evaluation
(Mistakes, Length, Thickness variation, and Hardness)

	Appearance evaluation score				Comprehensive evaluation score			
	<i>r</i>	<i>p</i>	β	<i>p</i>	<i>r</i>	<i>p</i>	β	<i>p</i>
Mistake	-.296	.001 **	-.288	.001 **	-.317	.000 **	-.305	.000 **
Length	-.034	.713	.006	.948	.025	.786	.138	.134
Thickness variation	-.226	.014 *	-.209	.020 *	-.219	.017 *	-.196	.023 *
Hardness	.080	.391	.058	.541	.227	.014 *	.256	.006 **
* R^2			.106	.002 **			.173	.000 **

* : $p < .05$, ** : $p < .001$

2. Appearance and comprehensive evaluation

Firstly, the appearance was evaluated by showing the photos of braided strings to the evaluator. No participant got the highest score of 5 points, three got 4 points, 39 got 3 points, 68 got 2 points, and 8 participants got 1 point. Next, the evaluator took each braided string in hand and comprehensively evaluated it based on appearance and the sense of touch, among others. One participant got the highest score of 5 points, 18 got 4 points, 92 got 3 points, 7 got 2 points, and no participant got 1 point.

Simple correlation analysis and multiple regression analysis were conducted to examine each shape variable's effects on appearance and comprehensive evaluation. The number of mistakes, length, thickness variation, and hardness were regarded as explanatory variables in the multiple regression analysis to avoid a multicollinearity problem because a strong negative correlation was shown between thickness and hardness. The multiple regression analysis results indicated a significant multiple correlation coefficient in both appearance evaluation and comprehensive evaluation. Moreover, a significant partial regression coefficient was shown regarding the number of mistakes and thickness variation in the appearance evaluation scores. On the other hand, a significant partial regression coefficient was shown regarding the number of mistakes, thickness variation, and hardness in comprehensive evaluation scores (Table 2).

Discussion

Intraclass correlation coefficients (ICC) of hardness, appearance, and comprehensive evaluation exceeded 0.9, suggesting sufficient reproductivity and reliability of evaluation methods. The evaluator was also considered appropriate because the person had a license and touched strings almost every day.

The hardness of the strings braided using the *Kumihimo* Disk is discussed. First, we will explain Maru-dai's mechanisms, which consists of a round disk (*Kagami*) with a hole in the center, supported by four legs. Bobbins (*Tama*) are suspended around *Kagami*. The braided string is put into the center hole after attaching a counterweight called *Omori*. The braided string's tension is continuously maintained by balancing the weight of *Omori* and *Tama*, which affects the appearance and mechanical characteristics of the braid. As the weight of *Omori* increases, the length of the braid increases, and hardness decreases. Moreover, the tensile force in the vertical direction forms the length of the braid. It has been reported that the braid becomes thicker when the *Omori* weight's percentage is over or under 40% of *Tama*'s total weight (Matsunashi, 2020). The tensile force in the horizontal direction decreases if slits do not tightly hold threads or threads are not pulled tight when using the *Kumihimo* Disk, leading to decreasing tightness of the braid, which produces a soft and long braid. It is crucial to apply a constant force and pull threads tight when braiding using the *Kumihimo* Disk. The braid structure becomes tight when appropriately balanced force is applied to the threads, resulting in a hard and thin string. In the present study, hardness was defined as the degree of bending when holding the braid 100mm from the end. Although the length and hardness were negatively correlated, the degree of bending was considered to be affected by braiding, not the weight of the string.

The hardness had a significantly negative correlation with both thickness and thickness variation. Moreover, thickness and thickness variation had a significantly positive correlation, suggesting that thick strings are soft and vary widely in thickness. Large thickness variations mean that a constant force was not applied to the threads. It is essential to apply a constant force

for braiding hard and thin strings.

Simple and multiple regression analysis indicated that the number of mistakes and thickness variation affected the evaluation of appearance. On the other hand, the simple correlation analysis indicated that the comprehensive evaluation was significantly affected by the number of mistakes, thickness variation, and hardness. In other words, hardness did not affect the appearance evaluation, whereas it affected the comprehensive evaluation. A strong correlation was shown between hardness and thickness. Therefore, it is considered that using the thickness was effective for simply evaluating *Kumihimo*. Appearance evaluation is essential when perceiving *Kumihimo* as an artwork. However, the braid's hardness is crucial when considering the function of a braid, such as tying knots. The results of the present study indicated a harder and thinner braid was highly evaluated. Therefore, beginners should try to make harder and thinner braids.

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