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研究資料

Body Composition, Muscle Strength, Power, and Endurance of Elite Male Japanese Freestyle Wrestlers
レスリング競技・男子フリースタイルにおける日本人エリート選手の体組成・筋力・パワー・筋持久力特性

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Abstract : Wrestlers are categorized into a series of weight classes to ensure fair competition. Since the implementation of new rules in January 2018, weight categories and the timings of weigh-ins have changed. The purpose of the study was to establish baseline physical profiles, such as body composition, muscle strength, power, and endurance for Japanese elite freestyle wrestlers in each of the new weight classes. We collected a total of 242 data points from 70 elite Japanese male freestyle wrestlers at 14 training camps over two years. Body composition measurements, one-repetition maximum tests (bench press, parallel back squat, one-handed dumbbell snatch, and weighted chin-up) and muscle endurance tests (pull-up) were performed. Body fat percentages for wrestlers in the 86-kg class or below were from 9.1% to 11.6%, whereas body fat percentages for wrestlers in the 92-, 97-, and 125-kg classes were 14.0 ± 3.5, 19.8 ± 6.9, and 26.6 ± 3.4%, respectively. This result suggests that the wrestlers in the heavier weight classes have a higher capacity to reduce body fat and increase muscle mass, which is essential if they improve strength and power. Absolute muscle strength and power performance tended to increase with heavier classes (the major results were as follows: 1RM bench press: 88.0 ± 13.0 kg in the 57-kg class and 142.0 ± 13.0 kg in the 125-kg class), whereas these relative values tended to decrease with heavier classes. Muscle endurance performance tended to decrease with heavier classes (the pull-up test: 23.8 ± 1.5 repetitions in the 61-kg class and 10.0 ± 5.4 repetitions in the 125-kg class). This study provides baseline data that can be used in the prescription of individual training programs for wrestlers, assessing areas of strength and weakness, and developing the wrestler's technical-tactical strategies.

Key words : combat sports, rule change, weight category, resistance training
キーワード：格闘技，ルール変更，体重階級制，レジスタンストレーニング

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Ⅰ. Introduction

Wrestling is a combat sport that involves repetitive bouts of high-intensity activity for 6 minutes (two 3-minute rounds with a 30-second rest between rounds). Freestyle wrestlers are permitted to use their whole body and need to master various techniques such as leg attacks, push outs, and throws[2),6),17)]. Because of the nature of these activities, wrestling requires highly developed capacities of strength, power, and endurance[1)]. A survey of the practices of Iranian Wrestling League strength and conditioning coaches found that they believed that muscle strength, endurance, and power testing were essential to evaluate their wrestlers[14)]. Therefore, wrestlers require high levels of strength, power, and endurance, and further exploring these attributes can assist strength and conditioning coaches in tailoring training programs to minimize weakness while maximizing strength.

Wrestlers are categorized into a series of weight classes to ensure fair competition. New rules were implemented on January 1, 2018[31)], which included two significant amendments that affect the performance of wrestlers (Table 1). First, the number of weight categories increased from 8 to 10. Second, for the two-day competition, weigh-ins are conducted every morning daily to allow for a fair competition. Previously, wrestlers were required to weigh-in the day before they participated in the one-day competition. Consequently, many wrestlers, especially in the light-weight classes, attempted rapid weight loss before weigh-in and rapid weight gain after weigh-in[33)]. The revised rules give wrestlers only a few hours for post-weigh-in recovery. As such, many wrestlers had to change their body weight and/or weight classes to perform better according to the new rules. These rule changes may have altered not only wrestlers' body mass but also body composition, muscle strength, power, and endurance.

Many previous studies have revealed that the physical characteristics of elite wrestlers and divided them into three groups: light-, middle-, and heavy-weight groups. Pallares et al.[9)] showed that elite junior wrestlers had a higher absolute and relative one-repetition maximum (1RM) in the bench press and squat in each of the three groups compared to non-elite wrestlers. However, these strength levels were different within each of the three weight groups; for example, the difference in 1RM bench press in elite Iranian wrestlers was 23 kg between 50- and 60-kg classes[20)], which would both be categorized in the light-weight group.

Few studies have focused on senior wrestlers who qualified for senior competitions aged 18 years and above. They have shown that elite wrestlers have less body fat percentage, greater muscle strength, and endurance than non-elite wrestlers[21),24)]. However, in these previous studies that compared elite and non-elite senior wrestlers, most of them averaged fitness measures of several weight classes, regardless of the different requirements of body weight and physical capacity in the adjacent weight classes. Therefore, physical characteristics in each weight class are essentially helpful to strength and conditioning coaches as they help in tailoring training programs that aim to minimize weakness while maximizing strength and developing the wrestler's technical-tactical strategies.

Thus, the purpose of this study was to establish baseline body composition, muscle strength, power, and endurance of Japanese elite freestyle wrestlers. This is the first study to reveal the physical characteristics of elite senior wrestlers in each of the ten weight classes, which were newly selected in 2018. Japan is one of the leading nations in freestyle wrestling in the light-weight classes (the 70-kg class and below). Japanese light-weight wrestlers won seven medals in the recent three Olympic Games; however, no heavy-weight wrestlers (the 90-kg class and above) have participated in the Olympic Games for the past 30 years. Recently, however, Japan ranked 3rd and 4th in the 2018 and 2019 World Cup, respectively. The World Cup is a team-based competition, in which rank is determined by the combined results of all weight classes.

Table 1. Previous and new weight class rules for Men's Freestyle Wrestling.

	Previous rule (Jan 2014 to Dec 2017)[a]	New rule (Jan 2018 to present)[b]
Competition format	1-day	2-day
Timing of weigh-in	the previous day	each competition day
Time of weigh-in	17:15-17:45	8:30-9:15
Weight classes	57 OR	57 OR
	61	61
	65 OR	65 OR
	70	70
	74 OR	74 OR
		79
	86 OR	86 OR
		92
	97 OR	97 OR
	125 OR	125 OR

[a], 2017 Senior World Championships [30, 32].
[b], 2019 Senior World Championships [30, 31].
OR, Olympic weight class.

Thus, these results suggest that the Japanese freestyle team is growing, and this study will also provide a baseline for Japanese elite wrestlers in each weight category to improve international competitiveness.

Ⅱ. Methods

1. Participants

National training camps have been periodically held throughout the year by the Japan Wrestling Federation at the Japan Institute of Sports Sciences and the National Training Center in Tokyo, wherein the body composition and fitness tests of the wrestlers were measured at the training gym. Approximately thirty Japanese male freestyle wrestlers were invited to each training camp. In this study, we selected data collected between November 2017 and August 2019 because the new rules were in effect since the national championship (The Emperor's Cup) in December 2017. As an exception, the data of wrestlers in the 125-kg class was included since February 2017, because they were all below 125 kg and did not need to change their weight class. In this study, we collected the data of the wrestlers who had ranked within the top 4 in the national invitational championship (The Meiji Cup) in June or The Emperor's Cup in December, who were at least 18 years of age. As a result, we collected a total of 242 data points from 70 Japanese male freestyle wrestlers at 14 training camps. All these camps were aimed for training, not for recovery, tapering, and weight loss for an upcoming competition. The tests were held at least 25 days before and ten days after the major national and international competitions (Emperor's Cup, Meiji Cup, Asian Championship, Asian Games, and World Championship), which ensured that all wrestlers were not in a recovery or tapering period. None of these wrestlers were involved in rapid weight loss approaches for a competition. They provided written informed consent to undergo experimental procedures. This study was conducted in accordance with the Declaration of Helsinki and was approved by the ethics committee of our institute (H26-034).

2 . Procedures

Measurements were implemented early in the morning (6:30-7:30) before breakfast[8] to minimize the intra-participant variability in height and body composition. Standing height was measured using a stadiometer (DC-250, Tanita, Tokyo, Japan). Body composition was assessed by a multifrequency bio-impedance-analysis device with eight-point contact electrodes using a commercially available apparatus (InBody 730, InBody Japan Inc., Tokyo, Japan).

All performance tests were completed either during a morning (begins between 9 and 10 AM) or afternoon session (starts between 3 and 4 PM) under the supervision of a Certified Strength and Conditioning Specialist (CSCS). Tests of muscle strength, power, and endurance were performed: bench press, parallel back squat, one-handed dumbbell snatch, pull-up, and weighted chin-up. These tests were discussed and selected by researchers and national team coaches. The selected exercises and their variations were familiar to most national team wrestlers because these were prescribed in national training camps and were used in many previous studies for wrestlers. Maximal strength and power tests were assessed using a standardized one-repetition maximum (1RM) test following the National Strength and Conditioning Association's 1RM Testing Protocol[11]. For the bench press, no bouncing was permitted, as this would have artificially boosted strength results. For the parallel back squat, all subjects squatted to a depth where the thigh level was lower than parallel with the floor[18),26)]. For the one-handed dumbbell snatch, which is used as a variation of explosive power training[4),13)], the sequence of the movement is almost the same as the barbell snatch[16)]. The start position involves squatting down and grasping the dumbbell with a pronated grip with the elbow fully extended (Figure 1). The height of the dumbbell was below the knees at a height that the participant felt most comfortable with, and the dumbbell was placed approximately in the centerline of the body. Next, the ankle, knee, and hip joints were extended, and the movement was completed by catching the dumbbell directly over the shoulder with flexed lower limb joints and a locked elbow. The arm not holding the dumbbell was not supported on the thigh or knee. A certified specialist viewed the motion until completion, which was then followed by viewing the video to judge the success or failure of the trial (specifically whether the elbow joint remained locked out). The one-handed dumbbell snatch was performed with both right and left hands, and the best values were used for data analysis. The absolute and relative values (normalized by their body mass measured in the morning) of these 1RM tests were used for data analysis.

For both the pull- and chin-up, the start position was grasping an overhead horizontal bar slightly wider than shoulder-width with fully extended arms. The end position of both the pull-up and chin-up was the same as a previous study[3)], whereby the proximal inferior aspect of the mandible was required to pass the horizontal plane of the bar. They were instructed to avoid all swinging, kicking, and twisting leg motions[28)]. The Pull-up repetition test and the 1RM weighted chin-up test were performed to evaluate muscle endurance[20)] and strength[7)] of the arms, shoulders, and upper back, respectively. The pull-up test was performed with a pronated (palms forward) grip (Figure 2). The 1RM weighted chin-up was performed by adding the wrestler's body mass (measured in the morning) to an additional mass by suspending the plate mass from a standard belt (Model B5008 Black Dip Belt, Schiek Sports Inc., USA) worn around the waist (Figure 3). The chin-up test was performed with a supinated (palms toward the body) grip. During the chin-up test, an experimenter captured the trials using an iPad Pro (Apple, Cupertino, CA) at the bar height, to confirm that they met the test completion criteria. The plate mass and the total mass (body mass + plate mass) were used for data analysis.

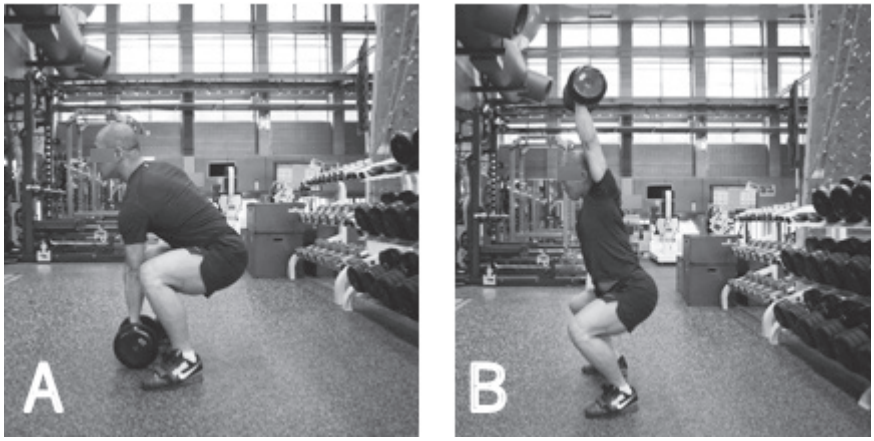

Figure 1. One-handed dumbbell snatch. A, start position. B, finish position.

Figure 2. Pull-up. A, start position. B, finish position.

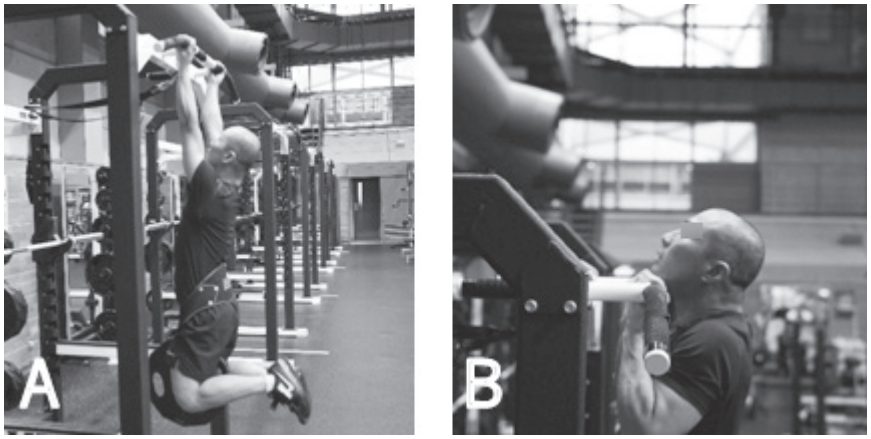

Figure 3. Weighted chin-up. A, start position. B, finish position.

3 . Data collection

Most wrestlers participated in the performance tests several (one to thirteen) times during the data collection period (training camps). Age, height, body mass, body fat percentage, and fat-free mass were averaged and used as representative values. For the performance variables, the best attempts of each wrestler were used for data analysis. Five wrestlers changed their weight classes during the period; all of the data in two different weight classes were used for the analysis. Data are presented as mean ± standard deviation (SD). The sample size of each variable in the same weight class differed due to 1) the content of the tests differing between the 14 training camps due to the schedule and the purpose of the camps, and 2) the wrestlers being allowed to skip some parts of the tests due to their conditions (acute and/or chronic injury). We did not perform statistical analysis because of the small sample size.

Ⅲ. Results

Body composition values are shown in Table 2. Body fat percentages for wrestlers in the 86-kg class or below were from 9.1% to 11.6%; whereas body fat percentages for wrestlers in the 92, 97, and 125-kg classes were 14.0, 19.8, and 26.6%, respectively. The muscle strength (bench press, parallel back squat, and weighted chin-up), power (one-handed dumbbell snatch), and endurance (pull-up) measures are presented in Table 3. Absolute muscle strength and power measurements tended to increase with heavier classes, whereas muscle relative strength and endurance performance tended to decrease.

Ⅳ. Discussion

This is the first study to reveal the physical characteristics of elite senior wrestlers in each of the newly established ten weight classes. These results may also provide information for training plans that aim to minimize weakness while maximize strength, and develop the wrestler's technical-tactical strategies.

Body fat percentages for wrestlers in the 86-kg class or below were less than 11.6%, whereas body fat percentages for wrestlers in the 92-, 97-, and 125-kg classes were 14.0, 19.8, and 26.6%, respectively. This is the same tendency as Iranian wrestlers – the heaviest (120-kg) weight class wrestlers have been observed with body fat percentages of 20.1% using the caliper method; still, those of the other (96-kg and below) classes were observed below 11.4%[19]. A previous study showed the positive correlation between body fat percentage and body mass in elite combat sports athletes[27]. Thus, the wrestlers in the lighter weight classes (86-kg class or below) are less able to reduce fat mass, whereas the heavier wrestlers (92-kg class or above) have a greater capacity to decrease body fat and increase muscle mass to meet weight requirements.

A previous study measured body fat percentage using the same device in this study, and reported that body fat percentage of light-weight elite wrestlers (former 55-, 60-, and 66-kg classes, body mass: 67.5 ± 4.4 kg) was 13.4 ± 2.4 %[34]. Our results (no greater than 10.4% in the 57-, 61-, and 65-kg classes) appear to be slightly lower than the previous study. One possible reason is the difference in the period measured. The previous study reported that the measurement was held one to two months after a national championship, but did not indicate whether the wrestlers were on or off their training season. If the data included off-season wrestlers, the value would be slightly higher than that recorded during the training season. Another reason is that the rule change prevents wrestlers from attempting severe weight loss as they are required to undergo weigh-ins on the morning of the match. In the previous rules, wrestlers had 12 hours to re-gain their weight after having gone through rapid weight loss before weigh-in. Contrary to the current rule, wrestlers only have a few hours for post-weigh-in recovery. Only two hours of recovery after rapid weight loss is known to impact an athletes' match performance[12].

Table 2. Body composition data (mean ± SD).

Weight class		Age (years)		Height (cm)		Body mass (kg)		% Body fat (%)		Fat free mass (kg)	
	n	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
57	10	22.8	2.2	164.4	3.2	62.0	2.3	9.1	2.2	56.3	2.9
61	6	23.5	1.4	166.1	4.9	65.4	1.2	9.8	3.6	59.0	2.2
65	10	23.0	2.2	167.3	7.7	68.5	2.1	10.4	3.0	61.4	2.7
70	7	22.0	1.9	173.3	3.5	74.0	1.0	11.6	1.9	65.5	2.1
74	7	23.2	1.7	172.4	3.8	77.3	3.4	10.9	2.0	68.9	3.3
79	5	24.8	4.1	178.1	3.2	81.4	1.8	9.8	1.8	73.5	2.4
86	7	23.5	2.6	178.4	3.0	86.3	2.0	10.1	2.1	77.7	1.8
92	6	23.9	4.9	179.1	3.0	91.0	2.5	14.0	3.5	78.2	3.6
97	7	25.8	3.0	177.9	5.1	101.3	3.4	19.8	6.9	81.2	6.5
125	5	26.1	3.3	181.3	4.8	117.7	4.5	26.6	3.4	86.2	3.6

Age, height, body mass, body fat percentage, and fat-free mass were averaged and used as representative values.

Table 3. 1RM and muscle endurance data (mean ± SD).

Weight class	Bench press (kg)			Bench press (kg/BM)		Parallel back squat (kg)			Parallel back squat (kg/BM)		Dumbell snatch (kg)			Dumbell snatch (kg/BM)	
	n	Mean	SD	Mean	SD	n	Mean	SD	Mean	SD	n	Mean	SD	Mean	SD
57	5	88.0	13.0	1.43	0.20	5	125.0	11.2	2.04	0.18	4	37.5	3.4	0.60	0.06
61	4	90.6	11.6	1.39	0.18	3	113.3	11.5	1.72	0.16	4	38.5	5.3	0.59	0.07
65	8	93.8	8.8	1.36	0.14	7	121.4	18.6	1.75	0.27	6	39.4	2.0	0.61	0.04
70	4	96.3	17.5	1.31	0.21	3	130.0	17.3	1.77	0.20	5	39.6	4.3	0.54	0.06
74	5	111.0	7.4	1.43	0.10	5	151.0	16.0	1.95	0.21	5	46.7	4.8	0.61	0.06
79	5	112.0	22.8	1.38	0.27	4	156.3	28.7	1.91	0.33	4	46.5	4.4	0.57	0.05
86	7	110.7	7.9	1.28	0.07	2	150.0	-	1.76	-	2	47.0	-	0.55	-
92	5	107.5	9.4	1.19	0.11	6	165.8	26.5	1.83	0.29	4	42.8	7.7	0.49	0.07
97	5	129.0	16.0	1.28	0.21	3	170.8	11.3	1.72	0.17	4	52.0	4.3	0.52	0.06
125	5	142.0	13.0	1.21	0.10	4	195.0	19.6	1.64	0.18	4	53.0	6.2	0.45	0.06

Weight class	Weighted chin-up PM (kg)			Weighted chin-up PM + BM (kg)		Pull-up (reps)		
	n	Mean	SD	Mean	SD	n	Mean	SD
57	9	44.4	7.3	106.5	8.3	2	31.5	-
61	4	46.9	9.0	112.9	9.4	4	23.8	1.5
65	9	40.0	10.6	109.1	10.4	7	27.0	8.2
70	5	43.0	11.0	118.0	11.0	1	13.0	-
74	6	53.3	16.7	131.4	18.2	2	34.0	-
79	5	51.0	7.4	132.4	6.6	5	28.0	9.1
86	6	47.5	5.2	133.5	4.7	4	18.5	1.9
92	4	27.5	9.6	117.7	7.5	3	14.0	3.5
97	5	40.8	16.6	143.6	16.3	4	14.0	4.2
125	5	14.0	10.7	133.9	10.5	4	10.0	5.4

BM, body mass. PM, plate mass. For performance variables, the best attempts of each wrestler were used for data analysis. Relative values of these 1RM tests were calculated by normalizing their body mass in the morning).

Therefore, light-weight wrestlers are required to reduce their body mass to avoid rapid weight loss. They especially have to reduce their fat mass while retaining their fat-free mass to perform better while adhering to the new rules, regardless of how hard it is to reduce fat mass[27]. However, it must be noted that severe weight control behaviors can expose athletes to detrimental health and performance practices, such as disordered

eating patterns[29], and prolonged periods of inadequate energy availability, resulting in muscle loss[5]. If a wrestler with less body fat wants to engage in gradual weight loss, it is recommended to consult a registered dietitian to implement a proper weight loss program, thereby reducing the adverse risks of weight loss.

Previous studies showed that absolute and relative strength must be essential for elite wrestlers[1),10)]. Interestingly, our results appear to be significantly higher than the elite senior wrestlers in Spain (average body mass: 70.6 kg) who have an average of 77.7 kg in the bench press and 98.8 kg in squat[21]. The Spanish national freestyle team has never participated in the world cup[30], and these factors may contribute to the differences in competitive levels among countries.

Moreover, absolute and relative strength are different among weight classes. In this study, absolute strength values were typically higher in heavier classes, whereas the relative values were higher in lighter classes, aligning with previous research[20]. Only one study revealed the physical characteristics of elite-level wrestlers in each category[20]. Compared to previous research involving Iranian elite junior wrestlers (18–21 years)[20], the 1RM bench press of the Japanese wrestlers seems to be slightly lower in most of the weight classes (for example, 93.8 ± 8.8 kg in 65-kg class Japanese wrestlers and 105.8 kg in 66-kg class Iranian wrestlers). Conversely, the 1RM back squat of the Japanese wrestlers seems to be slightly higher in most weight classes (for example, 195.0 ± 19.6 kg in 125-kg class Japanese wrestlers and 166.8 kg in 120-kg class Iranian wrestlers)[20]. Iran has been one of the top nations in freestyle wrestling for a long time. The Iranian national freestyle team has won seven gold medals in the last 20 years in World Cup team competitions[30]. Generally, junior elite athletes have a greater capacity to develop muscle strength than elite senior athletes. A previous study revealed that French elite junior wrestlers improved 1RM bench press by 6% and squat by 23% during the 15 weeks of training[25]. Therefore, elite Iranian senior wrestlers may have superior muscle strength than junior wrestlers. Comparing the results of top-level athletes globally would provide helpful information for strength coaches[35]. Further studies are needed to establish the physical characteristics of elite senior wrestlers in each weight class.

There are no previous studies in the 1RM chin-up and dumbbell snatch of wrestlers. The maximum strength of upper-limb pulling is considered beneficial for catching and pulling the opponent's legs during leg attacks[34]. The weightlifting lifts are useful for performance improvement in wrestling because they improve power output without the undue increase in body mass[22] and require high levels of coordination, which are very similar to the throws and several other techniques in wrestling[15]. With the information provided, it could be beneficial for these performance tests as a baseline for Japanese elite wrestlers and help set training goals, develop overall power output, and upper body strength for the wrestlers.

Similar to previous research, our study showed that the pull-up repetition test was superior in lighter classes[20]. However, the results of the elite Iranian junior wrestlers seem to be higher than our findings in each weight class. The differences in the training plan of these national teams may influence the difference in pull-up repetitions. Generally, this test is used to assess muscle endurance for wrestlers[1], but these maximum repetition tests depend on several variables, such as muscle strength and power[23]. For example, the 125-kg class wrestlers performed only 10.0 ± 5.4 repetitions for pull-ups, but the 65-kg class wrestlers performed 27.0 ± 8.2 repetitions. For these heavy-weight wrestlers, muscle strength, rather than muscle endurance, might be a key attribute to improve the performance.

Japanese heavy-weight wrestlers have not been performing as well as their light-weight counterparts at international competitions. One might argue that this

is due to the heavy-weight wrestlers' inferior relative strength, power, and muscle endurance. However, it seems to be undesirable for heavy-weight wrestlers to match the physical characteristics of their light-weight counterparts. For instance, elite Iranian junior heavy-weight wrestlers tended to show lower values of relative strength and muscle endurance than their light-weight counterparts[20], but the Iranians are excellent wrestlers in both heavy- and light-weight classes. To the authors' knowledge, there are also no comparable studies to provide information on the physical characteristics of senior elite wrestlers in each weight class. It is still recommended for the Japanese heavy-weight wrestlers to reduce body fat percentage, and increase their muscle mass. This approach will hopefully improve their relative strength, power, and muscle endurance.

There are some limitations to this study. One is that the number of national team wrestlers is limited, even though we have collected from 14 training camps over almost two years. Moreover, some of the wrestlers did not test all the variables due to acute and/or chronic injuries. However, if we collected the data of more wrestlers that were not of a high-level, the values would be worse. Also, there were some exceptions to the tendency due to the small sample size. For example, the result of the pull-up repetition test for one 70-kg class wrestler was 13, but the results in the adjacent weight classes were much superior; 27.0 repetitions in the 65-kg class and 34.0 repetitions in the 74-kg class, respectively. Second, although the selected tests were familiar to most national team wrestlers because of their training experience in the national training camps, some performed these exercises for the first time, especially one-handed dumbbell snatch. This may influence the underestimation of the current results. Third, these testing variables do not necessarily predict success in wrestling, where strategy and technique are essential for success. Future studies are needed to verify the baselines of these variables, comparing a variety of groups based on age and competitive level.

In conclusion, this study established baseline body composition, muscle strength, power, and endurance for Japanese elite freestyle wrestlers in all ten weight classes. These values can be used for tailoring training programs for wrestlers and assessing areas of strength and weakness.

References

1) Chaabene H, Negra Y, Bouguezzi R, Mkaouer B, Franchini E, Julio U, Hachana Y. Physical and physiological attributes of wrestlers: An update. J Strength Cond Res, 31(5) : 1411-1442, 2017.
2) Cipriano N. A technical-tactical analysis of freestyle wrestling. J Strength Cond Res, 7(3) : 133-140, 1993.
3) Coyne J, Tran T, Secomb J, Lundgren L, Farley O, Newton R, M Sheppard J. Reliability of pull up & dip maximal strength tests. J Aust Strength Cond 23: 21-27, 2015.
4) Cross T. MOTIVATION: Rationale and coaching points for Olympic style lifting to enhance volleyball performance. Strength Cond J, 15(6) : 59-61, 1993.
5) Fagerberg P. Negative consequences of low energy availability in natural male bodybuilding: A review. Int J Sport Nutr Exerc Metab, 28(4) : 385-402, 2018.
6) Fujiyama K, Yamashita D, Nishiguchi S, Ito M. Technical-tactical analysis of men's wrestling: A case study of the 72nd National Athletic Meet of 2017 in Japan. Int J Wrestl Sci, 9(1) : 1-6, 2019.
7) Gabbett TJ, Ullah S, Finch CF. Identifying risk factors for contact injury in professional rugby league players--application of a frailty model for recurrent injury. J Sci Med Sport, 15(6) : 496-504, 2012.
8) Gallagher M, Walker KZ, O'Dea K. The influence of a breakfast meal on the assessment of body composition using bioelectrical impedance. Eur J

Clin Nutr, 52(2) : 94-97, 1998.

9) Garcia-Pallares J, Lopez-Gullon JM, Muriel X, Diaz A, Izquierdo M. Physical fitness factors to predict male Olympic wrestling performance. Eur J Appl Physiol, 111(8) : 1747-1758, 2011.

10) Garcia Pallares J, Lopez-Gullon JM, Torres-Bonete MD, Izquierdo M. Physical fitness factors to predict female Olympic wrestling performance and sex differences. J Strength Cond Res, 26(3) : 794-803, 2012.

11) Haff GG, Triplett NT. Essentials of strength training and conditioning 4th edition. Human kinetics, 2015.

12) Hall CJ, Lane AM. Effects of rapid weight loss on mood and performance among amateur boxers. British Journal of Sports Medicine, 35(6) : 390-395, 2001.

13) Hedrick A. Dumbbell training for football at the U.S. Air Force Academy. Strength Cond J, 20(6) : 34-39, 1998.

14) Jamshidi FS, Mirzeai B, Damirchi A. Strength and conditioning practices of Iran Wrestling League strength and conditioning coaches. Pedagog psychol med-biol probl phys train sports, 18(8) : 34-45, 2014.

15) Lansky RC. Wrestling and Olympic-Style Lifts: In-season maintenance of power and anaerobic endurance. Strength Cond J, 21(3) : 21-27, 1999.

16) Lauder MA, Lake JP. Biomechanical comparison of unilateral and bilateral power snatch lifts. J Strength Cond Res, 22(3) : 653-660, 2008.

17) López-González D-E. Technical profile of top four women's wrestling teams in the 2014 Senior World Championships and correlations with selected performance variables. Int J Wrestl Sci, 5(1) : 35-41, 2015.

18) Mclaughlin TM, Dillman CJ, Gardner TJ. A kinematic model of performance in the parallel squat by champion powerlifters. Med Sci Sports Exerc, 9(2) : 128-133, 1977.

19) Mirzaei B, Curby DG, Barbas I, Lotfi N. Anthropometric and physical fitness traits of four-time World Greco-Roman wrestling champion in relation to national norms: A case study. J Hum Sport Exer, 6(2) : 406-413, 2011.

20) Mirzaei B, Curby DG, Rahmani-Nia F, and Moghadasi M. Physiological profile of elite Iranian junior freestyle wrestlers. J Strength Cond Res, 23(8) : 2339-2344, 2009.

21) Morán-Navarro R, Valverde-Conesa A, López-Gullón JM, la Cruz-Sánchez D, Pallarés JG. Can balance skills predict Olympic wrestling performance? J Sport Health Res, 7(1) , 2015.

22) Murlasits Z. Special considerations for designing wrestling-specific resistance-training programs. Strength Cond J, 26(3) : 46, 2004.

23) Naclerio FJ, Colado JC, Rhea MR, Bunker D, Triplett NT. The influence of strength and power on muscle endurance test performance. J Strength Cond Res, 23(5) : 1482-1488, 2009.

24) Nikooie R, Cheraghi M, Mohamadipour F. Physiological determinants of wrestling success in elite Iranian senior and junior Greco-Roman wrestlers. J Sports Med Phys Fit, 57(3) : 219-226, 2017.

25) Passelergue PA, Lac G. Salivary hormonal responses and performance changes during 15 weeks of mixed aerobic and weight training in elite junior wrestlers. J Strength Cond Res, 26(11) : 3049-3058, 2012.

26) Pierce K. Basic back squat. Strength & Conditioning Journal, 19(2) : 20-21, 1997.

27) Reale R, Burke LM, Cox GR, Slater G. Body composition of elite Olympic combat sport athletes. Eur J Sport Sci, 20(2) : 147-156, 2020.

28) Ronai P, Scibek E. The pull-up. Strength Cond J, 36(3) : 88-90, 2014.

29) Thomas DT, Erdman KA, Burke LM. American college of sports medicine joint position statement. nutrition and athletic performance.

Med Sci Sports Exerc, 48(3) : 543-568, 2016.

30) Database. United World Wrestling. https://unitedworldwrestling.org/ (Retrieved November 24, 2019)

31) United World Wrestling. International Wrestling Rules (January 2018/Jdr). https://unitedworldwrestling.org/sites/default/files/2017-12/wrestling_rules_2018_1.pdf (Retrieved November 24, 2019)

32) United World Wrestling. International Wrestling Rules (March 2017). https://unitedworldwrestling.org/sites/default/files/media/document/wrestling_rules_9.pdf(Retrieved November 24, 2019)

33) Wroble RR, Moxley DP. Acute weight gain and its relationship to success in high school wrestlers. Med Sci Sports Exerc, 30(6) : 949-951, 1998.

34) Yamashita D, Arakawa H, Arimitsu T, Wada T, Yumoto K, Fujiyama K, Nagami T, Shimizu S. Physiological profiles of international-and collegiate-level Japanese male freestyle wrestlers in the lightweight classes. Int J Wrestl Sci, 7(1-2) : 21-25, 2017.

35) Yamashita D, Asakura M, Ito Y, Yamada S, Yamada Y. Physical characteristics and performance of Japanese top-level American football players. J Strength Cond Res, 31(9) : 2455-2461, 2017.