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Physical Fitness Profile and Differences Between Light, Middle, and Heavy Weight-Class Groups of Japanese Elite Male Wrestlers

Toshiyuki Ohya,¹ Wataru Takashima,¹ Masahiro Hagiwara,¹ Marie Oriishi,² Masako Hoshikawa,¹ Shigeaki Nishiguchi,³ and Yasuhiro Suzuki¹

ABSTRACT. We investigated the physical fitness of Japanese elite male wrestlers and compared results by groupings of weight classes. Twenty-two elite Japanese male wrestlers (*light*, participants' body weight 59–65 kg, $n = 7$; *middle*, 71–88 kg, $n = 8$; and *heavy*, 99–122 kg, $n = 7$) recruited from wrestling squads participating in national training camps participated in this study. The 90-s maximal anaerobic power test (90-MAT) and maximal graded exercise test (MGT) were performed on a cycle ergometer. Relative peak power during the 90-MAT did not differ among groups (light: $9.0 \pm 0.4 \text{ W}\cdot\text{kg}^{-1}$, middle: $9.3 \pm 0.4 \text{ W}\cdot\text{kg}^{-1}$, heavy: $9.0 \pm 0.5 \text{ W}\cdot\text{kg}^{-1}$, $p > 0.05$), but mean relative power in the heavy group was lower than that in the other groups (heavy: $4.5 \pm 0.5 \text{ W}\cdot\text{kg}^{-1}$ vs. light: $5.3 \pm 0.3 \text{ W}\cdot\text{kg}^{-1}$, $P = 0.006$, effect size [ES] = 1.83; vs. middle: $5.3 \pm 0.4 \text{ W}\cdot\text{kg}^{-1}$, $P = 0.009$, ES = 1.61). Relative $\dot{V}O_{2\text{peak}}$ during the MGT was lower in the heavy group than that in the other groups. The present study provides baseline physiological data that can be used in the prescription of individual training programs for wrestlers.

Keywords: aerobic capacity, anaerobic capacity, Olympics, oxygen uptake, wrestling.

INTRODUCTION

The International Olympic Committee voted to reinstate wrestling to the Olympic program for the 2020 Olympic Games in Tokyo. Japanese heavyweight wrestlers have not won a medal in the Olympic Games from 1992 in Barcelona to 2012 in London; improved performance of Japanese heavyweight wrestlers is necessary to ensure that they medal at the 2020 games in Tokyo.

Wrestling is an intermittent combative sport requiring technical, tactical, and psychological skill that creates great muscle-strength and -power demands on both the upper and lower body (Cipriano, 1993; Yoon, 2002). Both the anaerobic and aerobic energy systems are employed to various degrees in wrestling (Callan et al., 2000; Cinar & Tamer,

1994). The anaerobic system provides explosive power during the match, while the aerobic system contributes to sustained effort for the duration of the match and to recovery between periods (Callan et al., 2000). Greco-Roman wrestling can elevate blood lactate concentrations to over 17 mmol/L and heart rate (HR) to 190 beats per minute (bpm; Barbas et al., 2011); freestyle wrestling can cause lactate to reach 18 mmol/L and HR to reach 180 bpm (Kraemer et al., 2001).

A number of wrestling regulations have been modified since 2013 by the International Federation of Associated Wrestling Styles (FILA). Specifically, the structure of a match is now two 3-min periods rather than three 2-min periods. Judging criteria have been modified; for example, in Greco-Roman style, the first passive violation is a warning; the second results in a caution; the third violation results in a technical point for the opponent; and at the fourth passive violation, the bout is terminated and the active wrestler is awarded a victory by fall. These changes have promoted more aggressive wrestling (Tunnemann, 2013). Hence, because more aggressive wrestling is required under the modified regulations, greater anaerobic and aerobic capacities will be required to win.

Several studies have investigated physical fitness profiles for wrestlers at different competitive levels to identify in-

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dicators of success (García-Pallarés, López-Gullón, Muriel, Díaz, & Izquierdo, 2011; García-Pallarés, López-Gullón, Torres-Bonete, & Izquierdo, 2012; Song & Garvie, 1980). Significant differences have been observed in maximal anaerobic power (García-Pallarés et al., 2011; Horswill, Scott, & Galea, 1989), but not in maximal oxygen uptake (Horswill et al., 1989; Yoon, 2002), between successful and less successful wrestlers. By examining the physical fitness profiles of elite wrestlers, training programs can be optimized and wrestling performance improved; therefore, the purpose of this study was to investigate the physical fitness of Japanese elite male wrestlers and to compare fitness levels by weight-class group. For the purpose of this study, we defined *light* as the first two, *middle* as the middle two, and *heavy* as the highest two weight classes for both wrestling styles. We hypothesized that the anaerobic and maximal oxygen uptake relative to body weight of Japanese elite wrestlers in the heavy group would be less than that of wrestlers in the lighter groups because of higher percentage of body fat (Mirzaei, Curby, Rahmani-Nia, & Moghadasi, 2009).

METHODS

Experimental Approach to the Problem

This study was designed to determine the physical fitness of Japanese elite male wrestlers and to identify differences between weight-class groups. Participants visited the laboratory on two occasions. During the first visit, anthropometric measurements were taken and participants performed a 90-s maximal anaerobic power test (90-MAT). During the second visit, at least 24 h later, a maximal graded exercise test (MGT) was administered. A standardized warmup was performed prior to both tests.

Subjects

Twenty-two Japanese elite male wrestlers (light [$n = 7$]: body weight 59–65 kg; age 23 ± 3 years; middle [$n = 8$]: body weight 71–88 kg, age 22 ± 3 years; and heavy [$n = 7$]: body weight 99–122 kg, age 23 ± 3 years) participated in this study. They were recruited from wrestling squads participating in national training camps; four participated in the 2014 FILA World Wrestling Championships in Uzbekistan and one in the 17th Asian Games in Incheon. Written consent to participate was obtained from all subjects after informing them of the purpose of the experiment, the procedure, and the possible risks. This study was approved by the Human Subjects Committee at the Japan Institute of Sports Sciences.

Anthropometric Measurements

Anthropometric measurements included the following: standing height, body weight, and percentage body fat.

Standing height was measured to the nearest 0.1 cm and body weight to the nearest 0.05 kg. Percentage body fat was measured to the nearest 0.1% using a bioelectrical-impedance device (MC-190; Tanita, Tokyo, Japan) to determine body composition.

90-MAT

The 90-MAT was performed on a cycle ergometer (POWERMAX-V III; Konami Sports & Life Co., Ltd., Tokyo, Japan) to determine maximal anaerobic capacity. A 90-MAT potentially allows a more complete assessment of anaerobic capability than shorter procedures such as the Wingate test (Gastin, Costill, Lawson, Krzeminski, & McConell, 1995). A standardized warmup was performed prior to the test. Participants were instructed to perform a hard sprint at maximum speed against a braking force corresponding to $50 \text{ g} \cdot \text{kg}^{-1}$ of body weight during the entire 90 s. Strong verbal encouragement was provided to each subject during the sprint. Peak power was defined as the highest power reading and mean power was defined as the average power over the 90 s. The mean power relative to body weight were averaged every 10 s. To assess fatigue during the test, percentage decrease in power was calculated as follows: $100 - ([\text{mean power/peak power}] \times 100)$ (Glaister, Stone, Stewart, Hughes, & Moir, 2004).

MGT

The MGT was performed on a cycle ergometer to determine peak oxygen consumption ($\dot{V}O_{2\text{peak}}$). A standardized warmup was performed prior to the test. After the warmup, pedaling load was adjusted to 90 W. Power output was increased by 30 W each minute to 300 W, and then increased by 18 W each minute until exhaustion. Participants were asked to maintain a cadence of 60 rpm during the test. The test was terminated when the subject could not maintain the required cadence despite vigorous encouragement. Breath-by-breath respiratory gas-exchange values were measured using an automated gas-analysis system (AE-310s; Minato Medical Science, Osaka, Japan) to determine minute ventilation ($\dot{V}E$), oxygen uptake ($\dot{V}O_2$), and carbon dioxide production ($\dot{V}CO_2$) during the test. Respiratory gas-exchange values were averaged every 30 s. HR was monitored (RS800; Polar Electro, Kempele, Finland) during the test. The gas-analysis system was calibrated before each test using a gas mixture of known O_2 and CO_2 concentrations. The volume transducer was calibrated before each test using a 2-L syringe (Minato Medical Science). $\dot{V}O_{2\text{peak}}$ was defined as the highest $\dot{V}O_2$ attained during the MGT.

Statistical Analysis

Values are expressed as mean \pm standard deviation (SD). Statistical analysis was performed using IBM SPSS Statis-

tics for Windows, Version 19.0 (IBM Corp., Armonk, NY, USA). Comparisons of anthropometric and the two maximal test parameters among the three weight classes were analyzed using a one-way analysis of variance (ANOVA). Significant differences were then analyzed using the Bonferroni post hoc test. Analysis of relative mean power values (weight classes and time) every 10 s during the 90-MAT was conducted using two-way ANOVA with repeated measures. Significant interactions were then analyzed using the Bonferroni post hoc test. Significance was set at $p < 0.05$.

RESULTS

Anthropometric Measurements

Subjects' anthropometric measurements are presented in Table 1. All anthropometric measurements differed significantly among the weight groups ($p < 0.01$) except for height between the middle and heavy groups and percent body fat between the light and middle groups.

90-MAT

Figure 1 shows peak and mean power during the 90-MAT. Absolute peak and mean power were significantly different among weight groups ($p < 0.01$). Although no significant differences in peak power relative to body weight were observed among the weight groups (light: $9.0 \pm 0.4 \text{ W}\cdot\text{kg}^{-1}$, middle: $9.3 \pm 0.4 \text{ W}\cdot\text{kg}^{-1}$, heavy: $9.0 \pm 0.5 \text{ W}\cdot\text{kg}^{-1}$, $p > 0.05$), mean power in the heavy group was significantly lower than that in the other groups (heavy: $4.5 \pm 0.5 \text{ W}\cdot\text{kg}^{-1}$ vs. light: $5.3 \pm 0.3 \text{ W}\cdot\text{kg}^{-1}$, $P = 0.006$, effect size [ES] = 1.83; vs. middle: $5.3 \pm 0.4 \text{ W}\cdot\text{kg}^{-1}$, $P = 0.009$, ES = 1.61). Relative mean power values for each 10-s interval after the first 10 s, except for the last 10 s, during the 90-MAT were significantly lower for the heavy group than for the other groups (Figure 2). The percentage decrease in power in the heavy group was sig-

TABLE 1 Subjects' Anthropometric Measurements

Variable	Groups ¹		
	Light (n = 7)	Middle (n = 8)	Heavy (n = 7)
Height (cm)	162.8 ± 2.7*	174.7 ± 3.6	179.5 ± 7.0
Body weight (kg)	62.4 ± 1.9*	78.3 ± 5.5†	112.6 ± 10.0
Lean body weight (kg)	56.5 ± 1.3*	68.4 ± 3.5†	83.1 ± 5.6
Percent body fat (%)	9.5 ± 1.7	12.6 ± 2.7	26.0 ± 2.6*

¹Light = first two, middle = middle two, heavy = highest two weight classes for both wrestling styles. Values are expressed as mean ± standard deviation. Statistical significance set at $p < 0.05$. *Significant difference versus other groups. †Significant difference versus heavy group.

nificantly greater than that in the other groups (heavy: $49.8 \pm 3.4\%$ vs. light: $41.0 \pm 2.8\%$, $P = 0.0001$, ES = 2.84; vs. middle: $43.8 \pm 2.4\%$, $P = 0.002$, ES = 2.07).

MGT

Figure 3 shows $\dot{V}O_{2\text{peak}}$ during the MGT. Absolute $\dot{V}O_{2\text{peak}}$ was significantly higher in the heavy than in the light group ($4143 \pm 486 \text{ mL}\cdot\text{min}^{-1}$ vs. $3371 \pm 338 \text{ mL}\cdot\text{min}^{-1}$, $P = 0.03$, ES = 1.84). However, relative to body weight, $\dot{V}O_{2\text{peak}}$ in the heavy group was significantly lower than that in the other weight groups (heavy: $36.9 \pm 4.4 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ vs. light: $52.8 \pm 5.9 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, $P = 0.0001$, ES = 3.05; vs. middle: $48.0 \pm 6.7 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, $P = 0.005$, ES = 1.95).

DISCUSSION

The purpose of this study was to investigate the physical fitness of Japanese elite male wrestlers and to compare results by weight-class group. The major findings of this study were that relative peak power during the 90-MAT was not significantly different among the three weight groups and that

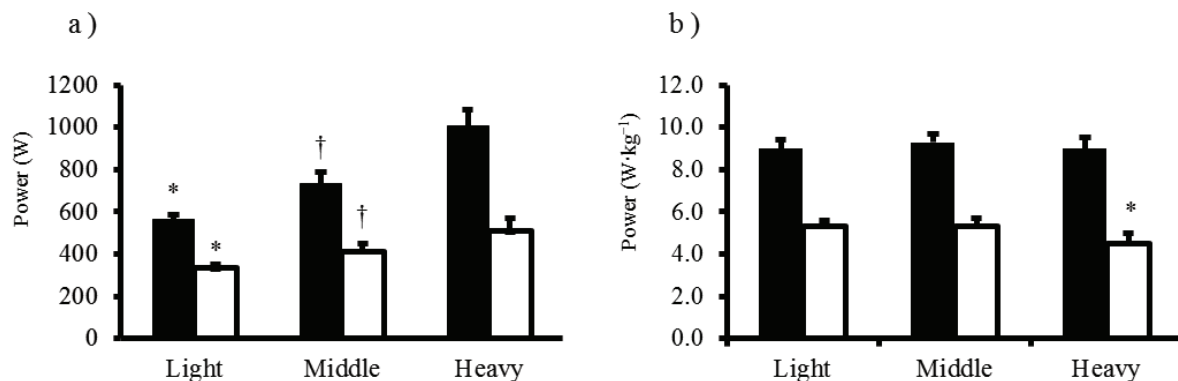


FIGURE 1 (a) Absolute and (b) relative peak (■) and mean (□) power values during the 90-MAT according to weight classes (light; $n = 7$, middle; $n = 8$, and heavy; $n = 7$). Values are expressed as mean ± SD. *Significant difference versus other groups ($p < 0.05$). †Significant difference versus heavy class ($p < 0.05$). 90-MAT, 90-s maximal anaerobic power test.

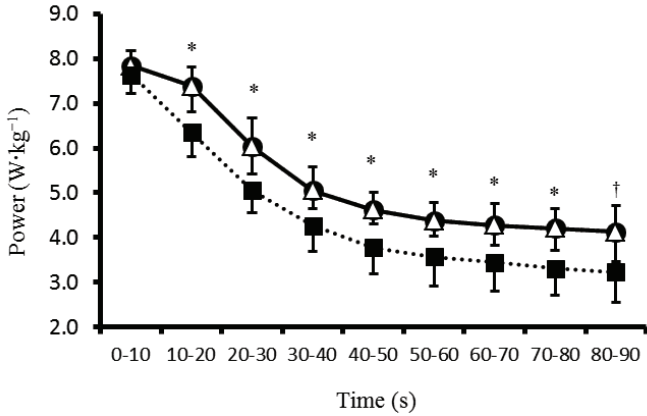


FIGURE 2 Relative mean power values every 10 s during the 90-MAT by weight group (● light; $n = 7$, △ middle; $n = 8$, and ■ heavy; $n = 7$). Values are expressed as mean \pm SD. *Significant difference, heavy versus other groups ($p < 0.05$). †Significant difference, heavy versus light group ($p < 0.05$). 90-MAT, 90-s maximal anaerobic power test.

relative mean power during the 90-MAT and relative $\dot{V}O_{2peak}$ during the MGT were lower in the heavy group than those in the other two groups.

Optimal body composition is a concern in wrestling because competitors are matched by body weight. The majority of wrestlers attempt to maximize the amount of lean tissue, minimize the amount of body fat, and minimize total body weight (Yoon, 2002). Some studies have reported the range of percent body fat to be 3–13% (Horswill, 1992; Yoon, 2002). Body fat percentages of wrestlers in the light and middle groups in this study ($9.5 \pm 1.7\%$ to $12.6 \pm 2.7\%$) were similar to those reported in other studies (Mirzaei et al., 2009; Sharratt, Taylor, Song, 1986). Mirzaei et al. (2009) reported that Iranian elite male junior wrestlers in the highest weight class (≥ 120 kg) were 20.1% body fat, compared with $26.0 \pm 2.6\%$ in the heavy group in the present study, whereas the remaining classes were from 7.4% to 11.4%. Wrestlers

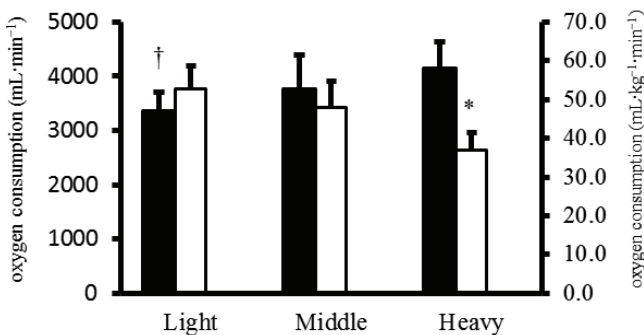


FIGURE 3 Absolute (■) and relative (□) peak oxygen consumption during the MGT by weight group (light; $n = 7$, middle; $n = 8$, and heavy; $n = 7$). Values are expressed as mean \pm SD. *Significant difference versus other groups ($p < 0.05$). †Significant difference versus heavy group ($p < 0.05$). MGT, maximal graded exercise test.

in the higher weight classes may have a higher percentage of body fat than wrestlers in other weight classes.

In the present study, relative peak power during the 90-MAT was not significantly different among weight groups, but relative mean power of the heavy group was significantly lower than that of the other groups (Figure 1). Power in wrestlers is associated with quick explosive maneuvers that lead to control of the opponent (Lanksy, 1999). The sources of energy for their quick and explosive exertions are the alactic energy system (Hirvonen, Rehunen, Rusko, & Härkönen, 1987). Although wrestlers in the heavy group in this study had as much explosive power as those in the other groups, their ability to maintain the power output was limited. The relative mean power values of heavy wrestlers for each 10-s interval after the first 10 s of the 90-MAT, except for the last interval, was significantly lower than those of the other two groups in this study (Figure 2). In terms of energy system contribution, the aerobic and anaerobic energy-system contributions to the 90-MAT are almost equal (Medbø & Tabata, 1989; Serresse, Lortie, Bouchard, & Boulay, 1988). During the 90-MAT, the greatest fuel supply from 5 to 15 s is obtained from the alactic energy system, from 16 to 30 s from the lactate energy system, and from 61 to 75 s from the aerobic energy system (Serresse et al., 1988). The heavy group in this study might be lacking in lactate and aerobic-energy supply capacities.

In the present study, relative $\dot{V}O_{2peak}$ during the MGT was lower in the heavy group than in the other groups (Figure 3). A review of the wrestling literature revealed that relative $\dot{V}O_{2peak}$ of national and international wrestlers was $45.4\text{--}55.6$ mL·kg⁻¹·min⁻¹ for a cycle-ergometer protocol (Seals & Mullen, 1982; Song & Garvie, 1980). The mean relative $\dot{V}O_{2peak}$ of Canadian Olympic wrestlers in the highest weight class was 54.0 ± 13.2 mL·kg⁻¹·min⁻¹ (Song & Garvie, 1980). Although $\dot{V}O_{2peak}$ is not a major determinant of success (Horswill et al., 1989; Yoon, 2002), the heavy wrestlers in this study should improve their aerobic capacity.

As mentioned above, because of the change in match regulations, which lengthened a match period by 1 min, a greater contribution from the aerobic energy system is now required (McArdle, Katch, & Katch, 2014). Moreover, the aerobic energy system contributes to recovery between periods. Several studies reported that the higher aerobic capacity may contribute to improving power recovery over repeated anaerobic intervals (Dawson, Fitzsimmons, & Ward, 1993; McMahon & Wenger, 1998). Time-motion analysis has demonstrated that elite wrestlers performed a mean of 16 high-intensity activity sequences. Each attack sequence lasts approximately 3 s, with a mean recovery period of 23.6 s (Cipriano, 1993). Although aerobic performance cannot be considered as a basic requirement of success in wrestling (Horswill, 1992; Horswill et al., 1992; Yoon, 2002), improved aerobic capacity of Japanese elite wrestlers in the heavy weight classes may contribute to improving their wrestling performance.

In conclusion, in the present study, mean relative peak power during the 90-MAT was not significantly different among weight groups, but mean relative power of the heavy group was significantly lower than that of the other weight groups. Results of the MGT showed that relative $\dot{V}O_{2peak}$ of the heavy group was significantly lower than that of the other groups. Wrestling is an intermittent combative sport requiring produces great strength and muscle power demands on both the upper and lower body (Horswill, 1992; Yoon, 2002). Although physical fitness is not the only determinant of success in wrestling, Japanese elite male wrestlers in the heavy group in this study should improve their aerobic capacity to improve their performance.

PRACTICAL IMPLICATIONS/ADVICE FOR ATHLETES AND COACHES

The present study provides the physical fitness profiles of Japanese elite male wrestlers and compares these results by three combined weight classes. Individual coaches, national federations, and athletes can compare the data presented to those of other national and international elite male wrestlers to determine individual weaknesses and design training programs that will ensure wrestling success.

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