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A comparative study on changes in physical fitness characteristics of judo athletes according to their careers

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Abstract

The purpose of this study was to compare judo-related physical fitness, body composition, and isokinetic knee functions of male judo athletes from different age groups. Subjects for this study were thirty male judo athletes and randomly divided into three groups: cadet judo athletes (CJA, n=10), junior judo athletes (JJA, n=10) and senior judo athletes (SJA, n=10). Body composition, physical fitness, anaerobic wingate test, and isokinetic knee strength test were analyzed for comparing characteristics of judo athletes with age. Statistical analysis was performed using one-way ANOVA followed Scheffe post hoc test. As the result of this study, body weight and muscle mass were significantly higher in the SJA group than those in the CJA group. The SJA group had significantly higher sit-up, vertical jump, side step and sit-and-reach values than the CJA and JJA groups, and the JJA group had significantly higher sit-up and back strength values than the CJA group. The absolute values of peak power (PP) and average power (AP) and relative values of PP in the SJA group showed significant differences compared to the CJA and JJA groups. Therefore, present findings provided research evidence that anaerobic power, maximal muscle strength and endurance would positively regulate performance of judo athletes with increasing age and athletic experience. Coaches and trainers in the field should try to provide a periodic training program to improve judo-related physical fitness and succeed.

Key words: Judo athlete, Cadet, Physical fitness, Wingate test, Isokinetic function

Introduction

Judo is an Olympic combat sport requiring tactics, technique and physical fitness (Zhao et al., 2019; Lech et al., 2015). In judo competition, grip dispute is very important technique to break the balance and throw the opponent to the ground (Franchini et al., 2019), and these techniques such as gripping the opponent's uniform and landing a fighter on a tatami mat is continuously performed for a duration of four minutes. In other words, maximum muscle strength and endurance as well as anaerobic power are essential to winning judo match (Casals et al., 2017). Branco et al. (2021) suggested that maximum muscular strength is a fundamental capacity to improve anaerobic power and

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muscular endurance of judo players (Ghrairi et al., 2014), developing this fitness by the periodic training program based on scientific evidence (Franchini et al., 2015; Marques et al., 2017). Another previous studies on performance-related fitness of judo athletes have been reported that junior athletes under 21 years of age showed higher relative performance compared to cadet athletes who is under 18 years of age, due to greater maximal isometric hand-grip strength, muscle endurance and anaerobic power in junior athletes (Agostinho et al., 2018; Franchini et al., 2014; Sterkowicz-Przybycien et al., 2017).

In addition, judo is also advantageous for athletes with strong muscular strength in a lower weight class because of a weight-categorized sport. Many researchers have studied various weight management programs to rapidly regulate percentage body fat and muscle mass over five to seven days according to gender, age and athletic experience (Artioli et al., 2010; Branco et al., 2021; Kons et al., 2017). And Torres-Luque et al. (2016) suggested that the highest performing male and female judo athletes should maintain an ideal body composition with approximately 10% and 16% body fat, respectively.

With these findings reported by previous studies, elite judo athletes must maintain an outstanding level of physical fitness and body composition, and assessment of athletes' physical condition is considered to be crucial in setting training goals. However, despite a lot of information needed to succeed as a judo athlete, no studies have been found that provide the criterion for maximum muscle strength, anaerobic power and muscular endurance as grade rise. Therefore, the aim of our research was to compare judo-related physical fitness, body composition and isokinetic knee functions of male judo athletes from different age. Our hypothesis was that anthropometric characteristics and physical variables would be statistically different between the age groups.

Methods

Participants

Thirty male judo athletes were taken part in this study and evaluated: cadet judo athletes (CJA, n=10), junior judo athletes (JJA, n=10) and senior judo athletes (SJA, n=10). Characteristics of participants were shown in Table 1. Before beginning the study, all participants had a detailed explanation of this study and submitted their written informed consent to researchers. This research was conducted ethically according to international guidelines.

Methodology

Body composition analysis

All participants visited to the center of sports science by 9:00 am with fasting for eight hours. Height and body weight were measured in light clothing and without wearing shoes using Jenix (DS-103M, Dong Sahn Jenix, Seoul, Korea) and body composition was measured by multi-frequency, whole-body bioimpedance device (Inbody 770, Inbody, Seoul, Korea) to confirm the body fat, body fat percentage (%Fat), muscle mass.

Table 1. *Characteristics of the subjects*

	CJA[a]	JJA[b]	SJA[c]	*F*	*p*	*Post-hoc*
Age (year)	14.9±0.87	17.9±0.73	31.1±5.30	75.767	.000***	a<c
Height (cm)	167.23±10.88	171.39±7.18	175.84±11.64	1.820	.181	
Career (year)	2.99±1.58	4.77±1.07	19.16±5.03	81.207	.000***	a<b<c

Values are mean ± Standard Deviation
CJA, cadet judo athletes; JJA, junior judo athletes; SJA, senior judo athletes
*p<.05, **p<.01, *** p<.001

Physical fitness tests

The physical fitness test was composed of sit-up, vertical jump, side step, reaction time, backward flexibility, sit-and-reach, grip strength, and back strength. For muscular endurance capacity, the sit-up was performed by lying on the floor and bending the knees for 60 seconds, and side step (ST-110, Seed Tech, Korea) was used for twenty seconds to examine anaerobic power and agility. The vertical jump (ST-150, Seed Tech, Korea), reaction time (ST-140, Seed Tech, Korea), backward flexibility (TKK-1860, Takei, Japan), sit-and-reach (TKK 5403, Takei, Japan), grip strength (TKK 5401, Takei, Japan) and back strength (TKK 5402, Takei, Japan) were measured twice, and we recorded at the highest value. All participants took a rest for three minutes after preliminary test and then measured physical fitness.

Anaerobic Wingate test

Wingate test was applied for investigating the maximum anaerobic capability using a Monark bicycle (Ergomedic 823E, Monark Exercise AB, Vansbro, Sweden). After three minutes of a cycling warm-up, judo athletes accelerated pedals as fast as possible for 30 seconds with the 'start' signal. The peak power (PP) means the highest anaerobic pedaling power, the average power (AP) is the speed-endurance ability, and the fatigue index (FI) is the fatigue resistance quantification.

Isokinetic knee strength test

Isokinetic muscle function of the knee extensors and flexors was measured using HUMAC NORM (Humac Norm 776, CSMi, Boston, USA). The maximal isokinetic muscle strength of the knee extension and flexion was performed at an angular velocity of 60°/sec and 180°/sec, and repeated three times. To compare isokinetic muscle functions, we presented the relative value obtained by dividing the absolute value by the body weight.

Statistics

PASW (Statistical Package for Predictive Analytics Soft Ware) 18.0 program was used to confirm differences of maximum muscle strength and isokinetic knee muscle functions between groups. Statistical analysis was performed using one-way ANOVA followed Scheffe post hoc test, and All values are expressed as mean±standard deviation (SD). $p< 0.05$ was considered significant.

Results

Change in body composition according to age

To examine difference in body composition from different age groups, we examined body weight, the body fat percentage (%Fat), muscle mass using whole-body bioimpedance device. As shown in Table

Table 2. *Body composition of judo athletes from different age group*

	CJA[a]	JJA[b]	SJA[c]	*F*	*p*	*Post-hoc*
Weight (kg)	62.80±14.03	72.97±10.08	90.29±26.93	5.658	.009**	a<c
BMI (kg/m^2)	22.27±3.37	24.76±2.02	28.56±4.40	8.631	.001**	a<c
Body fat (%)	16.45±7.14	13.71±2.23	17.15±6.07	1.067	.358	
Muscle mass (kg)	28.90±5.84	35.72±4.55	41.79±10.10	7.947	.002**	a<c

Values are mean ± Standard Deviation
CJA, cadet judo athletes; JJA, junior judo athletes; SJA, senior judo athletes
*p<.05, **p<.01, *** p<.001

Table 3. Physical fitness of judo athletes from different age group

	CJA[a]	JJA[b]	SJA[c]	*F*	*p*	*Post-hoc*
sit-up (count)	47.7±4.16	56.3±6.11	57.7±6.49	9.075	.001**	a<b,c
vertical jump (cm)	53.2±5.65	54.4±3.34	58.3±3.40	3.901	.032*	a<c
side step (count)	40.7±4.08	40.7±4.27	47.9±3.17	11.517	.000***	a,b<c
reaction-time (sec)	0.291±0.039	0.267±0.023	0.271±0.027	1.812	.183	
backward flexibility (cm)	49.27±6.99	44.47±9.85	47.90±8.77	.822	.450	
sit-and-reach (cm)	9.90±6.50	15.25±9.36	20.29±3.43	5.711	.009**	a<c
grip-strength:L (kg)	33.91±5.96	41.54±5.14	41.61±14.56	2.143	.137	
grip-strength:R (kg)	35.79±8.47	44.02±6.06	42.86±9.44	3.009	.066	
back strength (kg)	104.30±14.90	135.85±14.69	123.25±26.49	4.445	.021*	a<b

Values are mean ± Standard Deviation
CJA, cadet judo athletes; JJA, junior judo athletes; SJA, senior judo athletes
*p<.05, **p<.01, *** p<.001

Table 4. Anaerobic power of judo athletes from different age group

	CJA[a]	JJA[b]	SJA[c]	*F*	*p*	*Post-hoc*
Fatigue index (%)	54.26±6.55	60.72±8.26	58.08±10.64	1.409	.262	
Average power (W)	351.10±82.52	459.83±84.26	604.11±128.81	15.852	.000***	a,b<c
Peak power (W)	471.19±114.91	636.58±131.48	807.16±144.27	16.500	.000***	a,b<c
Average power (W/kg)	5.58±0.79	6.28±0.61	6.87±0.95	6.419	.005**	a<c
Peak power (W/kg)	7.51±1.21	8.67±0.88	9.23±1.53	5.045	.014*	a<c

Values are mean ± Standard Deviation
CJA, cadet judo athletes; JJA, junior judo athletes; SJA, senior judo athletes
*p<.05, **p<.01, *** p<.001

2, body weight (F=5.658, p=0.009), BMI (F=8.631, p=0.001), and muscle mass (F=7.947, p=0.002) were significantly higher in the SJA group than those in the CJA group. %Fat (F=1.067, p=0.358) showed no significant differences between groups.

Change in physical fitness according to age

Changes in judo related physical fitness, including muscular endurance, power, agility, flexibility and muscle strength, with age groups are shown in Table 3. The SJA group had significantly higher sit-up (F=9.075, p=0.001), vertical jump (F=3.901, p=0.032), side step (F=11.517, p=0.000) and sit-and-reach (F=5.711, p=0.009) values than the CJA and JJA groups, and the JJA group had significantly higher sit-up (F=9.075, p=0.001) and back strength (F=4.445, p=0.021) values than the CJA group.

Change in anaerobic power according to age

Wingate test is one of the most well-known methods for measuring anaerobic power. As shown in Table 4, absolute values of PP (F=16.500, p=0.000) and AP (F=15.852, P=0.000) and relative values of PP (F=5.045, p=0.014) and AP (F=6.419, p=0.005) in the SJA group showed significantly differences compared to the CJA and JJA groups. But there was no significant difference between all groups in FI.

Change in isokinetic knee functions according to age

We performed isokinetic knee muscle testing at 60°/sec and 180°/sec for identifying quadriceps and hamstring muscle strength and balance. As shown in Table 5, unlike relative peak torque at 60°/sec, absolute peak value of isokinetic left (F=6.713, p=0.004; F=5.083, p=0.013) and right (F=5.459, p=0.010; F=3.672, p =0.039) knee extensor and flexor strength showed significant differences in the SJA group compared to CJA group. At the angular velocity of 180°/sec, there was significant difference between groups in relative average power of isokinetic left (F=3.533, p=0.043) and right (F=3.403, p=0.048) knee flexor muscle.

Discussion

Because it is very important for judo athletes to determine their weight category for their success, many athletes are trying to lose weight through body fat reduction (Franchini et al., 2011; Torres-Luque et al., 2016). The ideal weight loss, which has a positive effect on judo performance, is known to decrease %Fat and increase FFM (Casals et al., 2017; Clarys et al., 2011). Our study examined body composition of judo athletes from different age groups, and confirmed that body weight and FFM had a significant higher in the SJA group than those in the CJA group, but %Fat showed no difference between groups. In previous studies on body composition and anthropometrical profile of judo athletes, arm circumference in male cadets was smaller than that of junior and senior judo athletes (Franchini

Table 5. *Isokinetic knee muscle strength of judo athletes from different age group*

		CJA[a]	JJA[b]	SJA[c]	*F*	*p*	*Post-hoc*
PT at 60°/sec (N.m)	L:extension	142.80±34.50	180.20±36.06	188.50±12.56	6.713	.004**	a<b,c
	L:flexion	82.30±14.69	88.90±16.04	107.00±22.17	5.083	.013*	a<c
	R:extension	143.60±34.30	181.00±45.28	192.20±18.20	5.459	.010*	a<c
	R:flexion	80.60±22.21	94.50±18.47	108.00±26.42	3.672	.039*	a<c
PT at 60°/sec (%BW)	L:extension	229.61±38.77	246.77±38.00	221.12±49.37	.951	.399	
	L:flexion	133.52±21.67	122.84±22.42	122.00±20.07	.899	.419	
	R:extension	230.76±40.73	246.33±44.79	223.56±42.53	.742	.486	
	R:flexion	130.79±32.26	129.68±19.05	121.97±17.65	.403	.672	
AP at 180°/sec (watt)	L:extension	147.50±25.69	156.20±32.49	172.20±44.65	1.269	.297	
	L:flexion	102.50±24.47	90.70±27.61	100.60±38.05	.429	.656	
	R:extension	141.90±31.06	154.30±41.17	179.10±40.31	2.511	.100	
	R:flexion	101.90±29.49	99.00±33.98	96.40±34.29	.071	.932	
AP at 180°/sec (%BW)	L:extension	240.68±45.28	214.05±33.93	201.71±69.76	1.475	.247	
	L:flexion	165.50±31.23	123.85±34.46	118.77±58.46	3.533	.043*	
	R:extension	232.51±54.34	210.54±45.33	212.11±75.74	.419	.662	
	R:flexion	166.64±47.28	134.54±38.08	113.15±52.00	3.403	.048*	

Values are mean ± Standard Deviation
PT, peak torque; %BW, body weight percentage; AP, average power; CJA, cadet judo athletes; JJA, junior judo athletes; SJA, senior judo athletes
*p<.05, **p<.01, *** p<.001

et al. 2011), and the maximal strength in bench press of the Brazilian judo players was regulated by cross sectional area and muscle mass of the upper limbs (Franchini et al. 2007). However, Clarys et al. (2011) reported that body fat in judo players did not differ among cadets, junior and senior athletes, and these results are because elite judo athletes who participated in the experiment had the appropriate percentage body fat levels (10~15%) for their weight category (Torres-Luque et al. 2016). Thus, we think that muscle mass and maximal muscle strength of judo athletes might be a critical factor for winning the competition.

Judo is a combat sport that requires high levels of physical capabilities, including anaerobic power, flexibility, maximum muscle strength and endurance (Franchini et al., 2014). Evaluation of physical fitness can classify performance levels and physical conditioning of judo athletes. Thus, many coaches in the field demanded an easy and reliable way to measure various physical fitness, and in 1995, Sterkowicz (1995) developed and proposed the special judo fitness test (SJFT). SJFT has verified to be suitable for identifying of the anaerobic power and recovery rate of judo players, and was similar to the results of Wingate anaerobic test (Casals et al., 2017). In present study, we applied Wingate and basic physical fitness tests to confirm the anaerobic power, muscle strength and muscle endurance of judo athletes. Agility and maximal muscle strength as well as anaerobic power were significantly higher in the SJA group than in the CJA group. According to previous study published by Chycki et al. (2021), muscle strength and anaerobic capacity were an important consideration that has a positive effect on performance in combat sport. And Bonitch-Gongora et al. (2012), Borkowski et. (2001), and Lech et al. (2015) suggested that changes in performance during judo competition was due to reduction of maximal strength of upper and lower extremities. In another previous studies, elite junior and senior judo athletes had a higher index in maximal isometric muscle strength and peak power compared to cadets, and these differences are highly associated with a high level of testosterone, increase in muscle mass and activation of glycolytic metabolism (Agostinho et al., 2018; Nindl et al., 1995). Although it is not possible to conclude performance factors from the results of various previous studies, we believe that maximal strength and anaerobic power abilities can contribute positively to judo competition.

Isokinetic muscle testing has been widely used for finding out muscle strength in athletes and showing the similarity between agonist and antagonist muscles (Willson et al., 2006; Yilmaz et al., 2020). We investigated isokinetic knee functions at 60°/sec and 180°/sec, and the SJA group had higher knee extensor and flexor strength compared to the CJA group. In previous study, Ghrairi et al. (2014) used an isokinetic dynamometer to determine the contribution of isokinetic knee muscle strength to judo athletes, and measured at 60, 180 and 240°/sec for the knee. Yilmaz et al. (2020) reported that isokinetic lower and upper extremity strength in elite judo athletes was higher as their performance is excellent. In specific, the isokinetic knee muscle strength obtained at 60°/sec angular velocity had the highest correlation with judo performance (Ghrairi et al., 2014). Our results regarding changes in isokinetic muscle function of judo athletes was consistent with some previous studies showing that isokinetic concentric strength of the knee should improve with age and athlete experience.

Given these results obtained in present study, anaerobic power, maximal muscle strength and endurance would positively regulate performance of judo athletes with increasing age and athletic experience. Therefore, coaches and trainers in the field should try to provide a periodic training program to increase judo related physical fitness and to succeed.

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