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The relationship between judo specific test performances and physical fitness in prepubescent male judo athletes

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ORIGINAL PAPER

Abstract

The aim of this study was to investigate the relationship between judo specific test performances and physical fitness of prepubescent judo athletes. Forty male judo athletes aged 10-13 voluntarily participated. Athletes completed special judo fitness test (SJFT), hikisdashi uchi-komi test (HUT), judogi grip strength tests, and performance-related physical fitness components tests (aerobic power, strength, agility, explosive power, body composition). Correlation coefficients were used to analyze the relationship between the judo specific tests and physical fitness performances. Significant correlations were found between total throw numbers during SJFT, HUT performance, isometric and dynamic judogi grip strength test performance and general performance-related physical fitness tests. Also, negative correlations were found between judo specific tests performances and body fat percent. It can be concluded from the study that total throws in SJFT, 20 s HUT and dynamic judogi grip strength tests can be used to monitor performances of prepubescent judo athletes as these tests present large significant correlations with performance related physical fitness tests.

Keywords: Martial arts; combat sports; judo; children; physical fitness tests.

Relación entre rendimiento en test específicos de judo y condición física en atletas de judo varones preadolescentes

Resumen

El objetivo de este estudio fue investigar la relación entre el rendimiento en test específicos de judo y la condición física en atletas de judo preadolescentes. Cuarenta atletas masculinos de 10 a 13 años de edad participaron voluntariamente. Todos ellos completaron el special judo fitness test (SJFT), el hikisdashi uchi-komi test (HUT), pruebas de fuerza de agarre de judogi y test de componentes de aptitud física relacionados con el rendimiento (potencia aeróbica, fuerza, agilidad, fuerza explosiva, composición corporal). Se utilizaron coeficientes de correlación para analizar la relación entre los test específicos de judo y los test generales de aptitud física. Se encontraron correlaciones significativas entre el número total de proyecciones en el SJFT, el rendimiento en el HUT, el rendimiento en los test de fuerza de agarre de judogi isométrico y dinámico y las pruebas generales de aptitud física. Además, se encontraron correlaciones negativas entre el rendimiento en los test específicos de judo y el porcentaje de grasa corporal. Puede concluirse, a partir de este estudio, que el número total de proyecciones en el SJFT, el 20 s HUT y los test dinámicos de fuerza de agarre del

Relação entre o desempenho em testes específicos de judo e a aptidão física em atletas de judo masculinos pré-adolescentes

Resumo

O objetivo deste estudo foi investigar a relação entre o desempenho em testes específicos de judo e a aptidão física de judocas pré-adolescentes. Quarenta atletas de judo do sexo masculino com idades entre 10 e 13 anos participaram voluntariamente. Os atletas completaram o special judo fitness test (SJFT), o hikisdashi uchi-komi test (HUT), testes de força de preensão do judogi e testes de componentes de aptidão física relacionados ao desempenho (potência aeróbica, força, agilidade, força explosiva, composição corporal). Coeficientes de correlação foram usados para analisar a relação entre os testes do judo e o desempenho da aptidão física. Foram encontradas correlações significativas entre o número total de arremessos durante o SJFT, o desempenho do HUT, o desempenho do teste de força de preensão isométrica e dinâmica do judogi e os testes gerais de aptidão física. Além disso, foram encontradas correlações negativas entre o desempenho em testes específicos de judo e o percentual de gordura corporal. Pode-se concluir do estudo que o arremesso total no SJFT, 20s HUT e os testes dinâmicos de força de preensão do judogi podem

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judogi pueden utilizarse para monitorizar el rendimiento de los jóvenes atletas de judo, ya que estos test presentan importantes correlaciones significativas con los test generales de aptitud física relacionados con el rendimiento.
Palabras clave: Artes marciales; deportes de combate; judo; niños; test de condición física.

ser usados para monitorar o desempenho de atletas pré-adolescentes de judo, pois apresentam correlações significativas com testes de aptidão física relacionados com o desempenho.
Palavras-chave: Artes marciais; desportos de combate; judo; crianças; testes de aptidão física.

1. Introduction

Many specific tests for judo have been developed to monitor performance of judo athletes. Judo specific aerobic tests include the Santos Test, Judo specific incremental test, lactate minimum intensities for judo or randori maximal time to exhaustion, while anaerobic tests include special judo fitness test (SJFT), hikidashi uchi-komi test (HUT), and uchi-komi fitness test (Ceylan & Balci, 2018; Chaabene et al., 2018; Detanico & dos Santos, 2012). SJFT is the most used judo specific test to monitor performance changes of judo athletes from different levels (Franchini et al., 2015; Marques et al., 2017). It has been suggested that judo specific tests provide an idea about training and match performances of judo athletes as they comprise of elements specific to a judo match (Kons et al., 2019). Many studies regarding judo specific tests whose validity and reliability were already proven with laboratory tests focus mainly on elite and adult judo athletes (Ceylan et al., 2022; Chaabene et al., 2018; Franchini et al., 2007; Garbouj et al., 2016; Sterkowicz et al., 1999). Also, the number of studies related to the relationship between fitness tests and judo specific tests in the young judo athletes is very limited (Agostinho et al., 2018; Fukuda et al., 2013; Kons et al., 2020). Moreover, there are complicated relationships among body size, biological maturity, strength, and motor fitness in children unlike adults (Katzmarzyk et al., 1997). The maturation effect on physical performance seems to be more relevant than the age effect in adolescent judokas (Giudicelli, Luz, Santos, et al., 2021). In young judo athletes, maturation status is associated with aerobic capacity and strength (Giudicelli, Luz, Sogut, et al., 2021); however these relationships may be affected by anthropometric variables (Giudicelli et al., 2020). It was reported that the somatic maturity, menarcheal status and anthropometric variables were predictors of judo-specific test performance (Athayde et al., 2021; Detanico et al., 2020). Nonetheless, the maturity status did not discriminate competitive levels in young judo athletes (Detanico et al., 2022).

Field-based physical fitness tests are often used to measure fundamental motor skills in young judo athletes (Lidor et al., 2006; Sertić et al., 2006). Also, sport-specific testing may be used for talent identification and the development of young athletes, as well as the identification of athletes' strengths and weaknesses (Chaabene et al., 2018). It is of great importance to determine practicality of judo specific tests in young judo athletes and their relationship with general performance tests. In this way, they can be used to monitor performance of pre-and pubescent judo athletes. Kons et al. (2020) examined the relationship between SJFT and judogi grip strength tests with only neuromuscular tests in young judo atheletes (11-16 years) and stated that neuromuscular tests can moderately predict SJFT performance. In current study, apart from neuromuscular tests, other components of physical performance such as cardiovascular fitness, agility and body composition were also included. Also, these relationships between sport specific tests and general performance tests may be affected by training experiences, so it is important to establish a homogeneous research group in such research designs. Thus, the aim of this study was to investigate the relationship between judo specific and physical fitness test performances of prepubescent judo athletes. The study has two hypotheses: (1) Athletes who have higher performance in physical fitness tests would present higher performance in judo specific tests; (2) The motor fitness performances are negatively affected by body fat and positively related to skeletal muscle mass (Giudicelli et al., 2020). Similarly, it was predicted that there would be negative relationships between body fat and judo specific test performances.

2. Methods

2.1. Experimental design

A descriptive, cross-sectional study was implemented to examine the relationship between judo specific performance and general physical fitness test performances of prepubescent judokas.

Athletes' judo training experience and athletic background were determined according to the information provided by athletes and coaches. Body composition measurements included body height, body mass and four-site skinfold measurements. Child judo athletes performed the SJFT, HUT, isometric and dynamic judogi grip strength tests, standing long jump (SLJ), vertical jump (VJ), Illionis agility test (IAT), sit-up, push-up and 20-m shuttle run for aerobic fitness, all of which are mostly used for talent identification and/or monitoring athletes' development (Ceylan & Balci, 2018; Marques et al., 2021). These tests were applied randomly at the same time of the day by the same researchers with at least 2 and at most 4-day intervals. The *tori* (judo athlete executing the techniques) and *uke* (judo athlete receiving the techniques) were selected from the same weight category and had similar body height during the SJFT and HUT tests. All participants had past experience in performing judo-specific and general fitness tests; nevertheless, they were informed about test procedures.

2.2. Participants

Forty boys participated in the study. Physical characteristics of the athletes are presented in Table 1.

Table 1. Participants' physical characteristics (*n*=40)

Variables	*M*	±	*SD*	95% CI		
Age (years)	11.70	±	0.98	11.41	to	12.00
Maturity off-set (from years of PHV)	-1.48	±	1.00	-1.78	to	-1.17
Body height (cm)	150.96	±	12.39	147.19	to	154.72
Body mass (kg)	46.30	±	15.59	41.56	to	51.04
Body mass index (kg/m^2)	19.79	±	3.96	18.59	to	20.99
Body fat percent (%)	22.44	±	11.32	18.99	to	25.88
Fat free mass (kg)	34.63	±	8.52	32.04	to	37.22
Experience in judo (years)	2.45	±	0.50	2.30	to	2.61

PHV = peak height velocity.

All participants were trained athletes (blue or brown belt) who competed in national championships at light and middleweight class (75%), or heavyweight class (25%) in their age categories. Eligibility criteria for participation included regular training participation (3 days a week), being between the ages of 10-13, absence of an injury history for the last one year, at least two years of judo experience and/or at least a green belt level. The study was approved by the local ethical committee and was carried out in accordance with the latest version of Declaration of Helsinki (October 2013). All participants were affiliated to the National Judo Federation and underwent regular medical checks. All procedures of the study were explained to the athletes and their legal guardians in detail and a signed informed consent was provided from both the participants and at least one of the athletes' parents or legal guardians. Biological maturity status (maturity offset) was calculated from participants' age and height (Moore et al., 2015) through the following formula:

$$Maturity\ offset\ for\ boys = -7{,}999994 + (0{,}0036124 \times (age \times height))$$

2.3. Procedures

2.3.1. Judo Specific Tests

- *Special Judo Fitness Test (SJFT):* The test was comprised of three periods of 15, 30, and 30 s with 10 s intervals between them. During each period, *tori* throws two *uke*, who are 6 meters apart from each other, as many throws as possible with *ippon-seoi-nage* technique. Athletes' heart rates were recorded by telemetry (Polar RS 400TM) immediately after the test and 1 min later. The SJFT index was calculated through the following formula (Franchini et al., 1998):

$$SJFT\ index = \frac{HR\ immediately\ after + HR\ 1\ min}{Total\ throws}$$

- *Hikidashi Uchi-komi Test (HUT):* The number of *uchi-komis* (repetitions of technique) executed by the athletes during 20, 30 and 40s were recorded. While executing the technique, *tori* was required to move the feet of *uke* from the ground, contact hips and trunk to the *uke* with partial rotation. For standardization, the test was implemented with an *uke* who was in same weight category and had similar height than *tori* (Del Vecchio et al., 2014).
- *Isometric and Dynamic Judogi Grip Strength Tests:* During isometric judogi grip strength test, athletes were required to hold a *judogi* (judo uniform) rolled around a bar and keep this position as much as possible with the elbow joint in maximal flexion. In case of voluntary failure, the test was ended, and the time was recorded. Any movement change which helped athletes to keep the position longer was forbidden. During dynamic judogi grip strength test, athletes were required to perform the maximum number of repetitions from a fully flexed to a fully extended elbow position. When athletes failed to carry out more repetitions or voluntarily ended the test, the test was finished. The numbers of repetitions were recorded (Franchini, Miarka, et al., 2011)

2.3.2 Physical Fitness Tests

- *Body composition:* Body height and body mass (BM) were measured, and body mass index (*BMI = kg/m²*) was calculated. Body fat percent (BFP) was estimated with skinfold thickness measurements by Holtain Caliper at two sites (Slaughter et al., 1988).
- *Standing long jump (SLJ):* Each athlete's longest jump distance from the starting point (from the big toe) to the end point (from the heel) was measured in centimeters. When athletes fell on the floor or other parts of the body except for feet touched on the floor, the measurement was repeated. The best result of two attempts was recorded (Castro-Piñero et al., 2010).
- *Vertical jump test (VJ):* The athletes tried to jump as high as possible in front of a platform hanged on the wall. Athletes' heights were recorded with elbows fully extended. The difference between the first measurement and jump height was calculated and recorded in centimeters. All athletes repeated the test twice and the best results were recorded for calculation (Amonette et al., 2012):

$$\textit{Peak power for children (watt)} = (61.9 \times \textit{VJ distance (cm)}) + (40.8 \times \textit{BM (kg)}) - 1.680$$

- *Illionis agility test (IAT):* The athletes completed the test course whose length is 10 meters and width is 5 meters with cones in the center spaced 3.3 meters apart. Athletes lay on their front with hands by their shoulders. With the start command, they moved and finished the course as fast as possible. Before the test athletes were familiarized to the course with two-three trials at a slow pace. The duration of the test was recorded with a chronometer and recorded in seconds (Raya et al., 2013). The test was performed twice, and the best score was recorded.
- *Sit-up test:* The athlete lays on a clean mat with knees flexed and feet 30 cm apart from the hips. A partner assisted the athlete by anchoring the feet to the ground when the athlete raised the trunk from the ground in a smooth motion keeping the arms in position and curling up the desired position. The trunk was lowered back to the floor so that the shoulder blades and upper back touched the floor. The number of sit-ups with correct form within 30 seconds were recorded (Morrow Jr et al., 2015).
- *Push-up test:* The athlete lays on the floor on their front and then took the push up position with only the hands and the toes touching the floor, the body and legs in straight line, feet slightly apart, the arms at shoulder width apart, extended and at a right angle to the body in the starting position. Keeping the back and knees straight, the athletes lower their body to ground with their elbows at a 90-degree angle and then returned to the starting position. After a trial, athletes started the test with a 'go' command and the number of repetitions were counted. The test lasted for 30 seconds, and number of executions with correct form were recorded.
- *The multistage 20 m shuttle run test for aerobic fitness:* Starting speed for this test was 8.5 km/h and after each minute speed was increased about 0,5 km/h. If the athletes reached the line before the beep sounds, they were required to wait until the beep sounds before continuing. If the athletes could not reach the line before the beep sounds, the subject was given a warning and told

to continue to run to the line, then turn and try to catch up with the pace within two more 'beeps'. When the athletes failed to reach the line (within 2 meters) after the second warning they were eliminated (Leger & Lambert, 1982). Maximum oxygen consumption (VO_{2max}) of the judo athletes was calculated (Mahar et al., 2018):

$$VO2max\ (ml/kg/min) = 49.642 + (Laps \times 0.338) - (Age\ (year) \times 0.867) - (BMI \times 0.333)$$

2.6. Statistical analyses

The results are presented as means and standard deviations with 95% confidence intervals (95% CI). The Shapiro-Wilk test was used to determine normality of the data and the coefficient of the skewness and kurtosis was evaluated with descriptive methods. Pearson's correlation test was used to determine the bivariate relationships between normally distributed variables while Spearman's correlation test was used to determine the relationships between non-normally distributed variables. Effect size (ES) of the correlation between two variables was classified according to Cohen (Cohen, 1992). The correlational effect of r = 0.10, 0.30, and 0.50, can be considered as small, medium, and large effect sizes, respectively. Also, the multi linear regression to examine the association among judo specific test and performance related physical fitness test variables. The significant level was set at 0.05. All statistical analysis was carried out with Statistical Package for the Social Sciences (SPSS) 16.0 (SPSS Inc. Chicago, II. USA)

3. Results

Table 2 presents the athletes' physical fitness and judo specific tests performances.

Table 2. Athletes' physical fitness, SJFT, HUT, isometric and dynamic judogi grip strength tests results (n=40).

Variables	*M*	±	*SD*	95% CI		
Long jump (cm)	176.34	±	14.09	172.06	to	180.63
Vertical jump (cm)	30.50	±	3.82	29.34	to	31.66
Peak anaerobic power (watt)	2097.02	±	675.34	1891.70	to	2302.34
Illinois agility (s)	18.84	±	1.23	18.47	to	19.22
Sit-up (number)	23.27	±	4.83	21.81	to	24.74
Push-up (number)	21.93	±	7.88	19.54	to	24.33
Maximal oxygen uptake ($ml \cdot kg^{-1} \cdot min^{-1}$)	57.56	±	5.54	55.88	to	59.25
SJFT total throw (rep)	20.27	±	2.15	20.33	to	21.00
SJFT index (point)	17.14	±	2.12	16.50	to	17.79
HUT 20 second (rep)	17.23	±	1.63	16.73	to	17.72
HUT 30 second (rep)	25.59	±	2.25	24.91	to	26.28
HUT 40 second (rep)	32.18	±	3.36	31.16	to	33.21
JSGT dynamic (rep)	4.57	±	3.26	3.58	to	5.66
JSGT relative dynamic (rep/kg)	0.11	±	0.08	0.09	to	0.14
JSGT isometric (sec)	28.57	±	14.91	24.03	to	33.10
JSGT relative isometric (sec/kg)	0.72	±	0.43	0.59	to	0.85

SJFT = Special judo fitness test, HUT = Hikidashi uchi-komi Test, JSGT = Judogi grip strength tests.

Significant negative correlations ranging from medium to large were found between total number of throws in SJFT and BM (r = -0.48; p < 0.001; ES = Medium), total skinfold (TS) (r = -0.62; p < 0.001; ES = Large) and BFP (r = -0.60; p < 0.001; ES = Large). Significant positive correlations were found between SJFT index and BM (r = 0.53; p < 0.001; ES = Large, BMI (r = 0.70; p < 0.001; ES = Large), TS (r = 0.68; p < 0.001; ES = Large) and BFP (r = 0.64; p < 0.001; ES = Large).

There were significant negative correlations between the number of repetitions in HUT 20, HUT 30, HUT 40 and body composition parameters (p < 0.05). Similarly, significant negative correlation was found between numbers of repetitions in all the HUTs and duration of the agility test (p < 0.001). Significant correlations were found between the number of repetitions in HUT 20, HUT 30, HUT 40 and SLJ, VJ, sit-up, push-up and VO_{2max} (p < 0.01).

Significant negative correlations were found between dynamic judogi grip strength and BM (r = -0.32; p = 0.03; ES = Medium), BMI (r = -0.45; p = 0.002; ES = Medium), TS (r = -0.58; p < 0.001; ES = Large), and BFP (r = -0.53; p < 0.001; ES = Large) and positive significant correlation was found with age (r = 0.34; p = 0.03; ES = Medium). Also, significant negative correlations were found between relative dynamic judogi grip strength and body height (r = -0.39; p < 0.001; ES = Medium), BM (r = -0.60; p < 0.001; ES = Large), TS (r = -0.70; p < 0.001; ES = Large), BFP (r = -0.64; p < 0.001; ES = Large) and FFM (r = -0.34; p = 0.02; ES = Medium). There were significant negative correlations between isometric judogi grip strength test results and BM (r = -0.39; p < 0.001; ES = Medium), TS (r = -0.61; p < 0.001; ES = Large), and BFP (r = -0.57; p < 0.001; ES = Large). Also, negative significant correlations between relative isometric strength and body height (r = -0.50; p < 0.001; ES = Large), BM (r = -0.70; p < 0.001; ES = Large), TS (r = -0.72; p < 0.001; ES = Large), BFP (r = -0.66; p < 0.001; ES = Large) and FFM (r = -0.47; p < 0.001; ES = Medium).

Correlation results regarding judo specific tests variables and performance-related physical fitness tests are presented in Table 3**.** SLJ, VJ, sit-up, push-up, VO_{2max} presented significant positive correlations with total throw number of SJFT while negative correlation was found between IAT and throw number (p < 0.001). Also, SLJ, VJ, sit-up, push-up showed significant negative correlations with VO_{2max} and SJFT index (p < 0.001).

Table 3. Relationships between participants' SJFT, HUT, isometric, dynamic judogi grip strength tests and physical fitness tests results (n = 40)

Variables	SLJ	VJ	PP	IAT	Sit-up	Push-up	VO_{2max}
Total throw in SJFT	0.58**	0.61**	-0.24	-0.66**	0.53**	0.70**	0.62**
SJFT index	-0.55**	-0.55**	0.31*	0.61**	-0.34*	-0.59**	-0.40**
HUT 20	0.47**	0.61**	-0.28	-0.72**	0.40*	0.61**	0.33**
HUT 30	0.38*	0.44**	-0.30*	-0.48**	0.39**	0.45**	0.25
HUT 40	0.52**	0.50**	0.01	-0.51**	0.26	0.52**	0.06
Dynamic JSGT	0.66**	0.63**	-0.08	-0.67**	0.44**	0.82**	0.34*
Relative Dynamic JSGT	0.44**	0.45**	-0.41**	-0.67**	0.35*	0.73**	0.37*
Isometric JSGT	0.57**	0.55**	-0.18	-0.70**	0.39*	0.66**	0.21
Relative Isometric JSGT	0.30	0.32**	-0.54**	-0.67**	0.26	0.53**	0.28

*$p \leq 0.05$; **$p < 0.01$; r = Correlation coefficient; SLJ = Standing long jump; VJ = Vertical jump; PP =Peak power; IAT = Illionis agility test; VO_{2max} = Maximum oxygen consumption; SJFT = Special judo fitness test; HUT = Hikidashi uchi-komi Test; JSGT = Judogi grip strength tests.

While SLJ, VJ, sit-up, push-up, VO_{2max} presented positive significant correlations with dynamic judogi grip strength test performance (p < 0.05), negative significant correlation was found between IAT and dynamic judogi grip (p < 0.001). Similarly, SLJ, VJ, sit-up, push-up, VO_{2max} showed significant correlations with relative dynamic judogi grip strength test performance (p < 0.05). There were significant correlations between isometric judogi grip strength test performance and SLJ, VJ, sit-up, push-up (p < 0.05). Also, significant negative correlation was found between IAT and isometric judogi grip strength (p < 0.001). Significant correlations were found between relative isometric judogi grip strength test performance and SLJ, VJ, push-up, VO_{2max} (p < 0.05), while significant negative correlations were found between PP and IAT (p < 0.001).

The results of our regression analysis for total throws in SJFT demonstrate that maximum oxygen uptake, vertical jump and body mass index were significant predictors, since they explained 74.4 % of variability. Vertical jump and body mass index were significant predictors for the number of repetitions in HUT 20 (59.6 % of variability). Push-up was a significant predictor of the dynamic judogi grip strength test (67.2 % of variability). Also, body mass index and push-up were significant predictors for the isometric judogi grip strength test (50,6 % of variability).

4. Discussion

This study aimed to determine the practicality of judo specific tests in child athletes. Thus, the relationship between the most-used physical fitness tests and judo specific tests such as SJFT, HUT, isometric and dynamic judogi grip strength tests was investigated. The main findings of this

study are: 1) There were significant correlations ranging from medium to large between SJFT total throw, SJFT index, HUT performances, isometric and dynamic judogi grip strength tests and aerobic power, strength, agility, and explosive power. 2) Negative correlations ranging from medium to large were found between judo specific tests and body composition variables such as body mass, body mass index, total skinfold thickness and body fat percentage.

SJFT and HUT are aimed to evaluate anaerobic performance of judo athletes while isometric and dynamic judogi grip strength tests evaluate upper body strength endurance of judo athletes (Chaabene et al., 2018). SJFT is mostly used and studied judo specific test to evaluate judo athletes from different levels (Agostinho et al., 2018; Casals et al., 2016; Ceylan & Balci, 2018; Courel-Ibáñez et al., 2016; Detanico & dos Santos, 2012; Franchini et al., 1998; Franchini, Sterkowicz, et al., 2011). The correlations were determined between SJFT performance, and explosive power, muscle strength and endurance, agility, and aerobic power of children judo athletes. However, it is surprising that no correlation was found between peak anaerobic power and SJFT performance contrary to our expectation. Significant correlations have been reported between SJFT performances and aerobic, anaerobic power and other performance tests in the studies conducted on adult and child/young judo athletes (Franchini et al., 2007; Franchini, Sterkowicz, et al., 2011; Garbouj et al., 2016; Hesari et al., 2014; Kons et al., 2020; Sterkowicz et al., 1999). Garbouj et al. (2016) reported significant correlation between maximum oxygen consumption and SJFT performance and aerobic power was effective during both the test and recovery. With variables obtained from SJFT, positive significant correlations were found between number of throws and anaerobic capacity, maximum oxygen consumption and muscle strength and negative significant correlation was found between the SJFT index and the mentioned variables (Franchini et al., 2007; Franchini, Sterkowicz, et al., 2011; Hesari et al., 2014; Sterkowicz et al., 1999). Moreover, a study stated a relationship between strength and power test performances and SJFT performance in young judo athletes (Kons et al., 2020). Casals et al. (2016) conducted a study to cadet judo athletes and stated significant correlations between body mass, biceps skinfold thickness values and somatotype characteristics of the athletes and SJFT performance indices. Although SJFT is used to evaluate performance of judo athletes from all age categories, its index has been reported to be inadequate to evaluate child and young adolescent judo athletes and different classifications were suggested for this age group (Agostinho et al., 2018; Courel-Ibáñez et al., 2016). When correlation coefficients between physical fitness tests performance and SJFT index or total number of throws of our study were investigated, the total number of throws presented higher effect size though all variables had significant correlations.

Uchi-komi is a basic part of judo training. It is frequently used method which includes different applications and comprises of technique repetitions (Franchini et al., 2013; Santos et al., 2015). It was suggested that HUT applied for different durations at high intensity is a reliable tool to discriminate elite and non-elite athletes. It was demonstrated that the negative correlations between HUT performance and body mass, total skinfold, and body fat percentage in adult athletes. Besides, the authors found high positive correlations between HUT performance and muscle endurance and vertical jump (Del Vecchio et al., 2014). Similarly, in our study positive significant correlations were found between HUT performance and muscle strength and endurance, explosive power, and agility. However, no significant correlation was found between HUT performance and anaerobic peak power. There is no other study found in the literature that investigated correlations between HUT performance and other performance test results in child or young age groups.

In this study, while negative correlations were determined between judogi grip strength tests and body composition of judo athletes, positive correlations were found with other physical fitness tests. Especially the correlation between judogi grip strength tests and push-up test which was developed to evaluate upper-body strength and endurance was higher. Moreover, significant correlations were found between judogi grip strength tests and repetition number of each set during HUT, SJFT total throw number and index. Therefore, it can be inferred that athletes who can present a better performance in one of these tests can also perform better in others. Judo athletes must effectively grip their opponents' judogi for a successful attack during the competition. Dynamic changes occur during a judo match and training. Judo athletes control the distance between themselves and their opponents with the grip (kumi-kata). Especially to catch and throw the opponent, judo athletes try to have the right grip particular to their special techniques, which includes a combination of strength and endurance (Marcon et al., 2010). The dynamic judogi grip

strength test is a valid way to discriminate judo athletes from different levels (Franchini, Miarka, et al., 2011). Young elite athletes presented better handgrip strength and the test could discriminate elite and non-elite judo athletes (Franchini et al., 2018). Branco et al. (2017) did not find any correlation between sum of handgrip strength and absolute dynamic/isometric judogi grip strength tests but stated positive correlation between relative dynamic/isometric judogi grip performances. When relationships were evaluated, positive significant correlations were determined between dynamic and isometric judogi grip strength tests and relative performances.

The age and/or biological maturity differences influence physical fitness test performance, which can be advantage or disadvantage for children while performing physical fitness tests (Jones et al., 2000). In the current research, all the participants did not reach peak height velocity. Also, neither classifications nor comparison was made according to age. Only the relationships between physical fitness test and judo specific performance were investigated. Therefore, we think that age has no effect on the results.

4. Conclusion and practical applications

The findings of this study in child judo athletes indicate that SJFT, HUT, dynamic and isometric judogi grip strength tests can be used to evaluate child judo athletes instead of standard physical fitness tests. It is thought that the use of judo-specific tests will be more practical when following child judo athletes' performance development. Our suggestions for judo coaches working with athletes aged 10-13 are as follows: a) While evaluating SJFT performance, they can use the total number of throws instead of index; b) HUT 20 is more appropriate and sufficient to evaluate performance; and c) Dynamic judogi grip strength test is thought to be more appropriate than isometric judogi grip strength test and it is advised that coaches should take body mass of athletes (relative) into account for evaluation.

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