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COACHING

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Intensive specific maximal judo drills improve psycho-motor ability but may impair hand grip isometric strength

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Key words: judokas, explosive strength, multiple choice time responses, handgrip strength, preparatory training

Abstract

Introduction. This study aimed to examine the effect of a 5-week preparatory training period on arm explosive strength, isometric hand grip strength force and multiple choice time responses among elite male judo contestants.

Material and methods. Eleven senior male judokas were enrolled to the study twice, i.e. before and after a 5-week preparation to a competition. During these sessions judokas performed in a randomized order three tests separated by 15-minute intervals for recovery: (i) the test of series of maximal motions performed separately and vigorously by left and right upper extremity. These type of motions (jerks) are usually part of some offensive actions (throws) in a judo struggle. The jerks were evoked by two types of light stimuli, during which concurrent measurements of time movement and maximal strength generated by left or right hand during the test were conducted, (ii) multiple visuo-motor time responses to series of 49 various consecutive light stimuli, (iii) maximal hand grip strength. Plasma cortisol (C) and testosterone (T) were determined in capillary blood sampled prior to and 5 minutes after the test of jerks. Age-and weight-matched students (n=8) examined twice served as a control group for the comparisons with judokas regarding handgrip strength and visuo-motor ability.

Results. After the training period significant improvements were noted for time movement in the test of jerks (by 10%) and shorter visuo-motor time responses (by 7.6%). During the 2nd examination peak of force in the test of jerks was unchanged, while maximal grip strength for right hand was significantly declined from 51.8±11.3 to 50.7±11.5 kg. The test of judo jerks did not affect C but elicited a rise in T during the 2nd examination. Scores of time movements recorded in judo jerks and visuo-motor time responses correlated significantly (r=0.827). Compared to control group judokas demonstrated significantly higher isometric hand grip strength but comparable scores in visuo-motor ability. Moreover, the control group showed very similar scores of the tests during both examinations.

Conclusions. The training period with intensive judo-specific drills that engage cognitive functions and require hand's maximal static efforts improve psycho-motor ability but may impair hand grip strength.

Introduction

Successful judo fight is based on various technical actions, attacks and counterattacks, in which upper and lower body limbs are engaged to the series of short-term movements performed with maximal power and velocity. Coaches and sports scientists search for psychological, physiological, technical and biomechanical predictors of winning in this sport, based on competitive scores and standings over a period of the sports activity. It was found that developing sports careers and maintaining the highest competitive level throughout a 10-year period is uncertain. Only 7% of male and 5% of female judokas after 10-year sports activity may be considered as successful as at the beginning of this period [Julio *et al.* 2011]. Obviously, it is easier to win at home than

away from it [Ferreira *et al*. 2013] but elite athletes at an international level often have to participate in high rank tournaments not held at home. The most reliable way of rating judokas' skill levels are their scores achieved during judo competitions. Success in this sport is dependent on a number of various well-used technical actions, mainly throws [Franchini *et al*. 2008]. On the other hand, during a training period coaches of judokas ought to examine the progress of the level of such biometric variables whose physical structures are in accordance with characteristics of typical judo actions. So far, some scientists have believed that useful parameters discriminating physical ability in combat sport athletes are maximal anaerobic power and aerobic capacity examined during leg cycling and arm cranking. These abilities have been examined extensively in judo contestants [Thomas *et al.* 1989; Little 1991, Borkowski, Faff, Starczewska-Czapowska 2001; Franchini *et al*. 2011; Pocecco *et al.* 2012] and in wrestlers [Hübner-Woźniak 2004]. One of the most frequently used parameters is hand grip strength determined by hand dynamometer. This examination is widely applied among various athletes [Leyk *et al.* 2007], including those practising combat sports. These measures sometimes allow to discriminate more or less successful boxers [Ramirez Garcia *et al*. 2007; Čepulènas *et al*. 2011] and Brazilian Jiu-Jitsu contestants [Da Silva *et al*. 2012]. Moreover, revealed impaired hand grip strength shows an extent of acute fatigue or a hand's micro-injury after a competition or other exhausting exertions among contestants [Andreato *et al*. 2011; Chiodo *et al*. 2011; Andreato *et al.* 2013]. Isometric handgrip strength is especially important in judo, since the majority of offensive actions, especially throws or immobilization of an opponent require strong gripping of a judogi [Franchini *et a*l. 2005; Franchini *et al.* 2011; Sánchez *et al.* 2011; Bonitch-Góngora *et al*. 2012; Bonitch-Góngora *et al*. 2013; Cortell-Tormo *et al*. 2013]. It is possible that excess of specific judo drills of maximal intensity (*randori, kakari-gaiko*) may have a detrimental effect on grip strength resulting from the accumulation of micro-injury or chronic fatigue of muscles and tendons. It has been reported that special therapy may reverse that effect among judokas [Botelho, Andrade 2012].

Apart from muscle strength and endurance abilities, appropriate cognitive functions also play an important role in judokas' successes. Cognitive functions are responsible for several mental processes and include such components as attention, working memory, perception and information processing. During a judo match all of the mentioned mental functions have to take part in problem solving and decision making. The above suggestion was confirmed by the study, which showed significant better performance of psychometric test, type of GO/NOGO by judokas from the National Team in comparison to performance by the others [Supiński *et al*. 2014]. One of the most frequent examined parameters that is a derivative of mental processes is the assessment of simple or choice time response. These features are usually examined by various electronic devices that measure the time of hand or leg responses to a visual or auditory stimulus. It seems that examination of visuo-movement time responses accurately determines specific psychomotor abilities in boxing [Darby *et al.* 2014], karate [Del-Percio *et al*. 2009] and judo [Sterkowicz *et al*. 2000, Lech *et al.* 2011]. Traditional measures of simple or choice time responses among judokas, showed shorter time responses among judo practitioners than in the age-matched control group (students) [Cojocariu, Abalasei 2014]. Taking into consideration the above-mentioned psycho-motor ability and handgrip strength we used a special battery of laboratory trials for evaluating the progress of comprehensive psycho-motor fitness after a training period among judo contestants. In addition, hormonal responses in blood were recorded prior to-and after the laboratory test, which seemed to be a strong psycho-physical stimulus.

Material and methods

Eleven male senior judo contestants (aged 23-27 years old) were subjected to the studies twice, before and two days after completing a 5-week competitive period prior to the main competition (European Championships). The second part of this period was oriented at an improvement in technical and psycho-motor skills to a great extent. This part characterized itself by the predominance of short-term, very intensive exercise, mainly simulated judo fights (*randori* and *kakari-geiko*). Thus, typical daily training load activities were somewhat lower but their intensity was higher as compared to that during the previous phase. The psycho-motor examination test was carried out forenoon in lab conditions. Two psychometric tests (A and B) and maximal hand grip contractions were separated by 15-minute rest intervals and they were executed on the same day. The second study session was carried out 2 days after the last training session of the 5-month training period.

Prior to each test subjects were familiarized with the task. Test A lasted 60 seconds and consisted of overall successive 14 jerks performed with maximal force and velocity by left and right upper extremities. Standing in front of specially designed mechanical-electronic devices equipped with two hydraulic dampers, each coupled with the sensors, each examined judoka strongly kept the loop by his left and right hand, and was asked to jerk an appropriate loop towards himself vigorously responding to red (left hand) or yellow (right hand) light from an appropriate bulb. These signals appeared in a randomized order, with irregular time intervals between the stimuli. It caused these sequences of the stimuli to be unexpected. The electronic system recorded maximum force (peak) and the time, which is needed for

its attainment (time to attain peak of force=TPM) separately for each of 14 jerks performed (7 with the left, 7 with the right hand). The frequency of sampling of force development and time movement (TM) to attain peak of force was 1000 Hz. This yielded very low mean relative error (0.27%) of the measurements. Prior to test A (-5min) and after its completion (+5 min) capillary blood was sampled to determine plasma cortisol (C) and testosterone (T) levels by commercially available kits (ELISA, DRG-GERMANY).

Test B is also known as the examination of eye-hand co-ordination or visuo-motor co-ordination, visual-search or special-orientation test. However, the most adequate descriptive definition is multiple choice time responses to several stimuli appearing with the imposed rate. This test is executed using the so-called cross-shaped devices. In fact, this is widely used by Polish researchers, who examine psycho-motor among judokas [Sterkowicz, Blecharz, Lech 2000]. It is based on recording corrected responses to a series of multiple various consecutive 49 signals. Each of those signals comes from an appropriate pair of bulbs placed on the vertical (7 bulbs) and on the horizontal axis (7 bulbs). A signal appears one after the other with previously fixed and constant frequency, and it shows which button has to be pressed until the next signal appears. The time of response to a stimulus should be longer than the interval between stimuli. Otherwise, an omitted signal as well an incorrectly pressed button are recorded as errors. The ultimate score of this test is the total number of correct responses. The device offers three levels of imposed frequency of signals (0.83 Hz, 1.17Hz and 1.50Hz). It is always the case that the higher the frequency, the worse the score of the test. However, after several repeated trials one may note an improvement in the scores (effect of motor learning). In our study the rate of stimuli was 50s/min. Hand grip strength was measured with a commercially-made hand grip dynamometer (GRIP-D TKK 5401, Takei Scientific Instruments CO). The distance between the grips was self-adjusted by judokas according to the size of their examined hands, and the hands were directed downward. Maximal isometric strength was exerted over 4-6 seconds Three trials separated by 1-min interval were performed successively and alternately with the left and the right hand and the best scores were taken into account.

Measurements of C and T were made in duplicates, in one run to avoid between-assay errors. Mean within-assay errors of assessments were calculated from the appropriate results of duplicates and it was 4.1% for cortisol and 4.3% for testosterone assessments. Between-session differences in mean body mass (BM), force peak (FP) and its relative value (RFP), time movements and between- and within session hormonal levels were compared using Wilcoxon's signed rank test. The relationships between variables were tested with Spearman correlations. The control group included eight students of the similar age and body mass were examined twice throughout 1-month period. They performed Test B (visuo-motor ability) and maximal isometric handgrip with the left and the right hand. The Shapiro-Willk statistical test revealed lack of normal distribution of all parameters, therefore, the non-parametric statistical analysis, Wilcoxon and Mann-Whitney tests were used for the comparison of between-session differences in judokas and for between-group differences, The protocol study was approved by the Ethical Commission at the Institute of Sport.

Results

Mean data of peak of force (PF), time to attain peak of force (TPF) and blood hormone levels, cortisol (C) and testosterone (T) expressed in nmol/L pre- (1) and after (2) the jerk test together with between-session differences in measurements are displayed in Table 1.

A 60-second psychomotor task (test A, test of jerks) did not significantly affect C levels during both the 1st session (T=28, Z=0.44, p=0.660) and the second one (T=23, Z=0.93, p=0.352). Mean absolute peak of force in the jerk-test was significantly related (r=0.850 -1st examination r=0.853-2nd examination) to the body mass but

Table 1. Between-session differences in mean scores in test A (psycho-motor and hormonal variables), in test B (total number of correct responses (CR) at imposed frequency of stimuli- 50stimuli/min), and right (RHGS) and left (LHGS) handgrip isometric strength

Variables	Session 1	Session 2	T	Z	P
BM (kg)	76.6±10.8 (61.8-95.1)	76.8±10.9 (62.0-94.7)	27.5	0.00	1.000
FP (N)	945±164 (750±1234)	943±157 (755-1219)	29.0	0.36	0.722
RFP (N/kg)	12.4±1.1 (11.1-15.0)	12.2±1.1 (11.2-15.1)	18.0	1.33	0.182
TFP (sec)	0.424±0.08 (0.366-0.493)	0.381±0.04 (0.342-0.438)	4.0	2.58	0.010*
C1 (nmol/L)	370±98 (233-534)	425±61 (345-521)	13.0	1.78	0.075
C2 (nmol/L)	384±71 (367-487)	402±63 (321-494)	19.0	1.24	0.213
T1 (nmol/L)	20.5±5.9 (11.3-28.4)	21.7±5.9 (13.4-31.5)	17.0	1.42	0.155
T2 (nmol/L)	21.2±6.0 (10.4-28.7)	23.2±5.9 (14.8-33.6)	10.0	2.04	0.041*
CR (scores)	40.7±4.9 (34-48)	43.8±3.1 (41-49)	8.0	1.98	0.047*
RHGS (kg)	51.8±11.3 (39.3-73.6)	50.7±11.5 (38.3-72.4)	10.5	2.00	0.046*
LHGS (kg)	48.2±9.2 (38.1-69.9)	47.6±8.8 (38.4-68.4)	9.6	1.78	0.058

movement time was not. After the competitive training period absolute (FP) and relative force peak (RFP) were unchanged, however, the significant post training improvement was found for the psycho-motor abilities, TFP and CR. Significant post-training differences in grip strength were for right and left hand. TFP and FP for the left and the right hand were similar, therefore, those data of FP and TFM for the left and the right hand were summarized. Taking into account two sessions together (n=22 measurements), TFP and CR scores correlated significantly (r=0.827). Moreover, the highest relative improvement in TFM and CR scores after the training was observed among those athletes whose scores before training were below the values of the median.

The effort which was realized during the jerk tests triggered a significant rise in blood testosterone (Z=2.93, p=0.041) during the second examination, but non-significant change (Z=1.96, p=0.051) during the first one. Handgrip strength correlated significantly with body mass, r=0.879 for the right, and r=0.844 for the left respectively. After the training period right hand grip strength significantly decreased and left hand grip strength tended to decline.

A non-exercising, control group (76.9±9.3 kg) showed very similar mean scores in handgrip strength and visuo-motor abilities during both examinations, therefore those data were summarized and compared with the group of judo contestants before the training period (Mann-Whitney U test) The results of control group (16 scores) demonstrated significant lower isometric strength of the right (dominant) hand (44.9±8.5kg) and the left non-dominant hand (43.1±7.7 kg) as compared to judokas, while there were no significant differences between the level of performance of Test B by students (40.8±9.3 scores). Taking together the both examinations in the control group, there were significant correlations between body mass and isometric hand grip strength for the right (0.815) and left (0.796) extremity.

Discussion

Our previous study on male senior judokas showed that long-lasting training with the predominance of anaerobic exercises performed during the late phase of the period improved both anaerobic capacity and increased contribution of the aerobic process during the performance of Wingate test by lower body limbs. These changes were accompanied with elevated morning blood testosterone level [Obmiński *et al.* 2013]. The current study revealed that intensive specific judo drills practiced over a longer time had no effect of maximal explosive strength . Seeking the reason for that we cannot exclude the hypothesis that the examined judokas were not engaged in the development of maximal strength during repetitive jerks. Moreover, during the second examination the judokas might have assumed that a successful action in judo attack is more dependent on the shortest time movement instead of maximal strength. Hence, they focused rather on speed than on strength. In fact, as it was mentioned, psycho-motor abilities especially time response and its maintain on a high level during a physical effort are the undisputed attributes of highly skilled and successful judo [Sterkowicz *et al.* 2000; Lech *et al.* 2011], karate [Del Percio *et al.* 2009] wrestling [Kraemer *et al.* 2001, Barbas *et al.* 2011 and boxing [Obmiński, Karpiłowski, Wiśniewska 2008, Darby *et al.* 2014]. However, to our knowledge, this is the first strong evidence showing delayed beneficial effects of *randori, kakari-gaiko* (simulated, non-judged judo training fights) on laboratory tests of multiple time responses. It indicated that sensory-movement drills also improved visuo-movement responses. That finding showed positive effects of typical judo drills on some cognitive functions, mostly attention and motor co-ordination. The same beneficial effects on development of some mental abilities have been reported in young karate practitioners [Alesi *et al.* 2014].

It is worth mentioning that the process of motor skill learning occurring during repetitive motor memory tasks in sport and other activities e.g. piano play or dancing, is based on memory encoding which is mediated by brain dopamine system. That system permits synaptic plasticity in corticostratal synapses, and its efficiency is gene-dependent [Isaias *et al.* 2011; Huertas *et al.* 2012; Kawashima et al. 2012; Pearson-Fuhrhop *et al.* 2013]. Various individual effectiveness of that mechanism results may elucidate high between-subject variability in movement learning speed.

The test of jerks did not affect significant changes both for cortisol and testosterone because 14 repeated short-term explosive contractions were too weak stimulus for highly trained young men. Contrary to that, testosterone significantly increased after the test, especially during the 2nd examination. These elevations were probably caused by the activation of adrenergic system. It is a question to be discussed whether higher androgenic state after the period training had any association with better performance of time responses. Such examinations have been undertaken among middle-aged men and older ones but results were controversial. Using various tests for evaluating components of cognitive abilities, especially these executive functions which are responsible for visual attention, perceptual discrimination, working memory and reaction time measures, some authors found beneficial effects of free testosterone on the cognitive abilities [Fontani 2003; Van Strien 2009], while others reported negative influence [Martin *et al.* 2008]. Considering relatively small differences in testosterone levels recorded during two examinations, we assume that the putative effect of blood androgen on the performance of the tests may be omitted.

The most surprising finding of our study is that intensive judo drills impaired resting hand grip strength.

An acute post-exercise impairment of isometric hand grip strength was found in taekwondo [Chiodo *et al*. 2011] and judo contestants [Bonitch-Góngora *et al*. 2012], but not in the terms of the resting state among non-injured and non-fatigued athletes. The factors affecting performance of hand grip contraction are well recognized. It depends on hands' sizes and shapes [Obmiński *et al.* 2013] and elbow position [Alkurdi, Dweiri 2010; España-Romero 2010]. Interestingly, non-dominant hand is less susceptible to fatigue during prolonged gripping with maximal isometric force [España-Romero 2010]. The central fatigue resulting in repetitive hand grip maximal contractions may impair maximal strength in non-exercised muscles [Kennedy 2009]. The examinations of hand grip force in sports that engage gripping (basketball) or wrestling provide important information about the functional state among these athletes [Gerodimos 2012; Gerodimos *et al.* 2013; Ratamess *et al*. 2013]. It is assumed that an acute post-exercise drop of hand`s force of gripping is associated with lowered muscle sympathetic nerve activity [Saito *et al*. 2009; Hachiya *et al*. 2012]. However, it does not explain why the decrease in grip strength was observed in our study among athletes who had full rest for a few days prior to the second examination. A similar phenomenon was reported by Fukuda and co-authors [Fukuda *et al*. 2013], who reported inverse correlation between the performance of Special Fitness Judo Test and hand grip strength in judokas after their preparatory training period [Fukuda *et al*. 2013]. It enhances the hypotheses about the local chronic fatigue after a period of persistent specific judo drills. Although both groups (judokas and controls) were of the same average body mass, isometric strength in non-exercising students was significantly weaker as compared to that in athletes. This is the evidence that humans develop specific biomechanical features which are required for practicing their habitual activities. Hence, successful gripping in a judo fight strongly depends on a level of hand grip strength. Similar huge differences in hand grip strength were found in various sports in which that feature is more or less crucial. For instance, it was reported [Warrington *et al*. 2001] that athletes practising tug of war showed higher absolute hand grip strength than heavier rugby players.

It seems that some judo coaches, focusing their attention on an optimal tactical and technical strategy [Adam *et al*. 2013] may ignore the fact that repeated intensive typical judo drills (gripping) conducted during simulated struggles may lead to the development of chronic fatigue or micro-injuries of a small part of skeletal muscles and tendons. Impaired hand grip strength, which is considered as an important factor of general strength in judo, may lower a chance of success if the time of full recovery is inadequate. The result of our study, hence, provides a new insight into important details regarding preparation to the main judo competition.

Conclusions

1. A 5-week training period of specific judo drills highly improved time movements and multiple choice time responses but it did not improve explosive strength.
2. Two days after the end of the training period isometric hand grip force was significantly temporarily impaired probably due to state local chronic fatigue or a micro-injury. Hence, it seems that after intensive judo training sessions the contestants need more than 2 days of rest period to achieve full recovery of handgrip strength.
3. The use of standardized, specific tests seems to be a diagnostic tool for the rating of psycho-motor abilities in judo contestants.

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Intensywne, specyficzne, maksymalne ćwiczenia judo poprawiają psychomotoryczne zdolności, ale mogą pogorszyć siłę izometryczną uchwytu dłoni

Słowa kluczowe: judocy, siła eksplozywna, wielokrotny czas reakcji z wyborem, siła uchwytu dłoni, trening przygotowawczy

Abstrakt

Wprowadzenie. Celem pracy było zbadanie wpływu 5-tygodniowego okresu przygotowawczego na siłę eksplozywną ramion, izometryczną siłę ścisku dłoni i wielokrotny czas reakcji z wyborem u zawodników judo.

Materiał i metody. Jedenastu zawodników judo zbadano dwukrotnie, przed i po 5-tygodniowym kresie przygotowawczym do zawodów. W czasie tych sesji badania obejmowały (i) test serii szarpnięć wywoływanych dwoma różnymi sygnałami świetlnymi, w czasie których mierzono jednocześnie czas ruchu i maksymalną siłę generowaną przez lewą i prawą rękę, (ii) wielokrotne wzrokowo-motoryczne czasy reakcji na serię 49 różnych bodźców świetlnych, (iii) pomiary maksymalnej, izometrycznej siły uchwytu dłoni. Oznaczano stężenie kortyzolu (C) i testosteronu (T) w próbkach osocza krwi kapilarnej pobieranej przed i po teście szarpnięć. Grupa kontrolna złożona z 8 studentów Politechniki badana była dwukrotnie w odstępie miesiąca. Zbadano u nich izometryczną siłę uchwytu obu dłoni wielokrotne wzrokowo-motoryczne czasy reakcji.

Wyniki. Odnotowano znaczące skrócenie czasu ruchu w teście szarpnięć oraz krótsze czasy odpowiedzi wzrokowo-motorycznych u sportowców po okresie treningowym. W czasie drugiego badania maksymalna siła w teście szarpnięć pozostała niezmieniona, podczas gdy siła uchwytu prawej (dominującej) dłoni znacząco zmalała, a spadek siły lewej był nieznaczny. Test szarpnięć nie wpłynął na wartość C, ale wywołał wzrost wartości T w drugim terminie badań. Wyniki czasu ruchu w teście szarpnięć i wielokrotnych czasów odpowiedzi z wyborem korelowały ze sobą znacząco w obu grupach, eksperymentalnej i kontrolnej. Grupa kontrolna uzyskała bardzo podobne wyniki w obu terminach

Wnioski. Okres treningowy z intensywnymi, specyficznymi dla judo ćwiczeniami, które angażują funkcje poznawcze i wymagają maksymalnych, statycznych wysiłków dłoni poprawiają zdolności psycho-motoryczne ale mogą pogorszyć siłę uchwytu dłoni.